STUDY MATERIAL AND MODEL MULTIPLE CHOICE QUESTIONS ON ENVIRONMENTAL STUDIES

AECC - COMPULSORY PAPER

(FOR SEMESTER I STUDENTS)

PREPARED BY

DEPARTMENT OF ENVIRONMENTAL STUDIES
BHAIRAB GANGULY COLLEGE
BELGHARIA, KOLKATA – 700056

CONTRIBUTORS

Dr. Subharthi Pal
Dr. Rumdeep Kaur Grewal
Dr. Saurav Shome
Smt. Monisha Hembram
Sri. Shirsendu Sarkar
Sri. Tathagata Bhattacharya
Dr. Samit Majumder

DISCLAIMER

All the materials and MCQs present in this e-content have been collected from different textbooks and reference books and also from various freely available contents present in the internet.

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:

1. 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.
2. It provides the knowledge about ecological systems and cause and effect relationships.
3. It provides necessary information about biodiversity richness and the potential dangers to the species of plants, animals and microorganisms in the environment.
4. 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.
5. It enables one to evaluate alternative responses to environmental issues before deciding an alternative course of action.
6. 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.
7. 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.
8. The study tries to identify and develop appropriate and indigenous eco-friendly skills and technologies to various environmental issues.
9. 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.
10. 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:

1. Biology 2. Geology 3. Chemistry 4. Physics 5. Engineering 6. Sociology 7. Health 8. Anthropology 9. Economics 10. Statistics and 11. 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.

Climate Change

The rising concentrations of greenhouse gases (GHGs) of anthropogenic origin in the atmosphere such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) 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., CO_2 by 29 per cent, CH_4 by 150 per cent and N_2O 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.

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.

Pesticides 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.

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.

- 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.

- 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.

Hazardous Waste

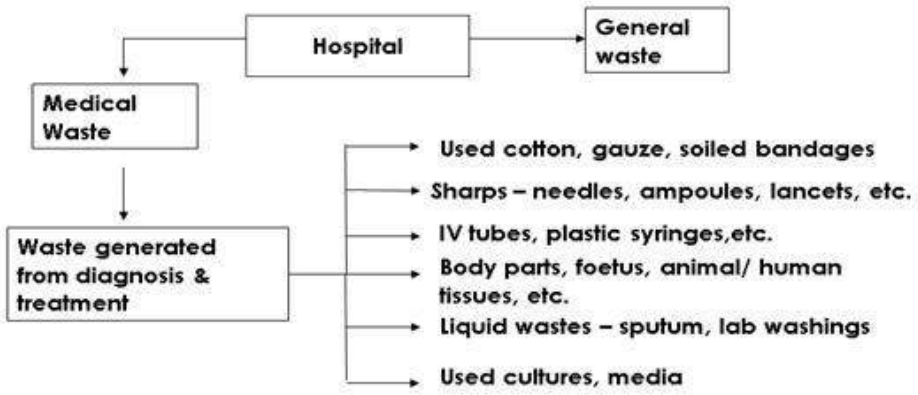
Hazardous waste may be liquid, solid or gas and all have one thing in common are dangerous and can pose a substantial hazard to human health and environment when not managed properly. In India, generation of hazardous waste to the tune of 6-7 million tonnes per year and may vary depending on the nature 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.

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 CO_2, SO_2, NO_2, 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 $1/4^{th}$ 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.

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 (CH_4) and nitrous oxide (N_2O) 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).

Soil Pollution: causes, effects and their control

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. The ideal remedy of total destruction of such pollutants is impossible. Hence, reduction of the residue levels through redeeming technology is desirable.

Pesticides serves as a source of nutrients (carbon / nitrogen / sulphur), or substrate for energy to many soil microorganisms. Certain pesticide chemicals are metabolized, but does not serve as a source of nutrient and the transformation is by co-metabolism.

Pesticides or their metabolites affect many soil microbes and their activities. Seed treatment mercuric fungicides are found to be inhibitory to *Rhizobium* (nodulation and nitrogen fixation), *Nitrosomonas and Nitrobacter* (nitrification).

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 biofertilizers 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 (NH_3). 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 and excessive 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.

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) C_6H_5Hg CH_3COO	Methyl mercury fungicides, electrical and electronic industries, PVC, plastics, paints.	Irreversible damage in disease Neurological man, Minamoto
2.	Lead Pb^{2+}, Pb^{4+}	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} CrO_3	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 H_2O and CO_2. 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 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.

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. In USA plastic are 7% in weight of all solid waste but 30% of the volume. Standard plastic takes several hundreds of years to disintegrate, over 400 years for the plastic bottles used for mineral water. 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.

Biodegradable plastic

Biodegradable plastic is made by adding at least 6% starch and an oxidizing agent (vegetable oil) to the polymers during manufacture. In the biologically active soil environment, the biodegradable plastic is decomposed easily. The metallic salts naturally present in soil interact with the oxidizing agent to form ferro oxides, which attack the polymer bonds and set the biodegradation of plastic in motion. Parallely, soil microbes break up the starch grains (amyloids), which results in an increased attack surface and accelerates the autoxidation process. The presence of starch reduces the water resistance of plastic. Addition of a fine protective layer to the starch based plastic, make it possible to obtain high degree of water-resistance. In future, plastics with 50% starch will appear in the market. Biodegradable plastics may offer many solutions to the pollution problems.

Excess Salts and Water

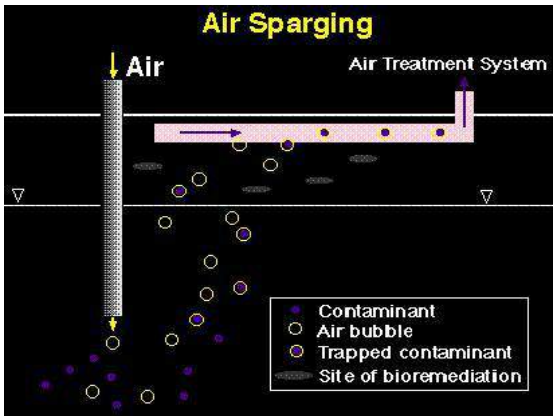
Irrigation water helps to produce more yield than rain fed land. Irrigation water contains dissolved salts and in dry season, water is in the form of saline solution evaporates leaving its salts such as NaCl in the top soil. This saline soil causes stunted plant growth, lower yield. Flushing out salts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

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.



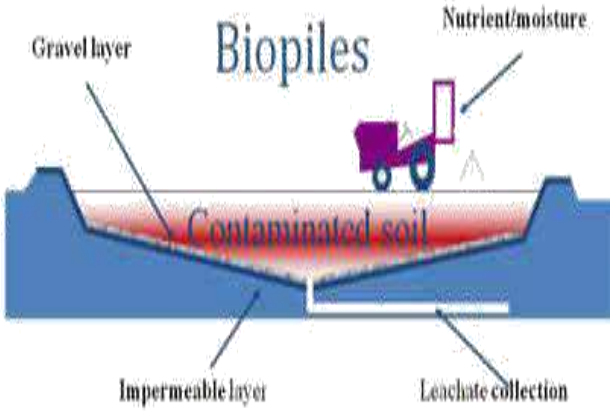
Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. The process removes contaminants from soils in one of the following two ways:

- 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.

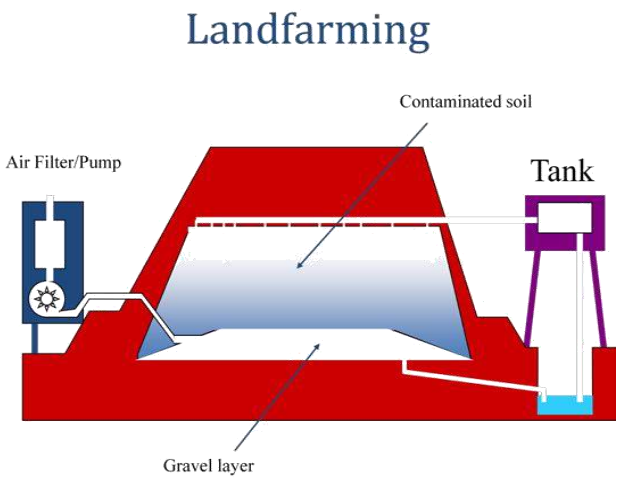
Biopile treatment is a technology in which excavated soils are mixed with soil amendments and placed on a treatment area that includes leachate collection systems and some form of aeration. It is used to reduce concentrations of petroleum constituents in excavated soils through the use of biodegradation. 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 and pesticides. The equipment employed in land farming is typical of that used in agricultural operations. These land farming activities cultivate and enhance microbial degradation 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
Dry farming	
Agrostological methods	
	Lay farming
	Retiring of land to gra

- **Mechanical methods**

1. Basin listing
2. Contour terracing

- **Other methods**

1. Gully control
2. Afforestation

Soil Amelioration

1. 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 wste 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.

d. 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.

Water Pollution : causes, effects and their control

Water is one of the most important commodities which man has exploited than any other resource for sustenance of his life. It has such a strong tendency to dissolve other substances and sometimes referred to as the universal solvent. This is largely because of its polar molecular structure. Pure water, that is, pure H_2O, is not found under natural conditions in streams, lakes, ground water, or the oceans. It always has something dissolved or suspended in it. Because of this, there is not any definite line of demarcation between clean water and contaminated water.

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.

In general terms, water is considered to be polluted when it contains enough foreign material to render it unfit for specific beneficial use, such as for drinking, recreation, or fish propagation. Actually human activity is the cause of the poor water quality and cause water pollution. 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.

Classification 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. First, a 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.

Types of water pollutants

In addition to being classified by their origin, water pollutants can be classified into groups of substances based primarily on their environmental or health effects. For example, the following list identifies nine specific types of water pollutants.

1. Pathogenic organisms
2. Oxygen – demanding substances
3. Plant nutrients

4. Toxic organics
5. Inorganic chemicals
6. Sediment
7. Radioactive substances
8. Heat and 9. Oil

Domestic sewage is a primary source of the first three types of pollutants. Pathogens, or disease – causing microorganisms, are excreted in the feces of infected persons and may be carried into waters receiving sewage discharges. Sewage from communities with large populations is very likely to contain pathogens of some type.

Sewage also carries oxygen demanding substances, the organic wastes that exert a biochemical oxygen demand as they are decomposed by microbes. BOD changes the ecological balance in a body of water by depleting the dissolved oxygen (DO) content. Conventional sewage treatment processes significantly reduce the amount of pathogens and BOD in sewage, but do not eliminate them completely. Certain viruses, in particular, may be somewhat resistant to the sewage disinfection process. To decrease the amounts of nitrogen and phosphorous in sewage, usually some form of advanced sewage treatment must be applied.

Toxic organic chemicals, primarily pesticides, may be carried into water in the surface runoff from agricultural areas. Perhaps the most dangerous type is the family of chemicals called chlorinated hydrocarbons. They are very effective poisons against insects that damage agricultural crops. Unfortunately, they can also kill fish, birds, and mammals, including humans. And they are not very biodegradable, taking more than 30 years in some cases to dissipate from the environment.

Toxic organic chemicals can also get into water directly from industrial activity, either from improper handling of the chemicals in the industrial plant or, as has been more common, from improper and illegal disposal of chemical wastes. Proper management of toxic and other hazardous wastes is a key environmental issue, particularly with respect to the protection of groundwater quality. Poisonous inorganic chemicals, specifically those of the heavy metal group, such as lead, mercury, and chromium, also usually originate from industrial activity and are considered hazardous wastes.

Oil is washed into surface waters in runoff from roads and parking lots, and ground water can be polluted from leaking underground tanks. Accidental oil spills from large transport tankers at sea occasionally occur, causing significant environmental damage. Blowout accidents at offshore oil wells can release many thousands of tons of oil in a short period of time. Oil spills at sea may eventually move toward shore, affecting aquatic life and damaging recreation areas.

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 (NO_3), which is itself not particularly dangerous. However, certain bacteria commonly found in the intestinal tract of infants can convert nitrates to highly toxic nitrites (NO_2). 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 $40m^3/s$ of cooling water by 10^0C 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 10^0C 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.

a) 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.

b) 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.

c) 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.

d) 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 PO_4-P per day is released through urine and faces by an average person, Phosphatic detergents in sewage are also important contributor of phosphorus.

e) 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.

f) 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.

g) 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 NO_3, SO_4^{-2} and CO_2 into N_2, NH_4^+, H_2S and CH_4 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.

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

Natural purification of chemically contaminated groundwater can take decades and perhaps centuries, and cleanup efforts are sometimes much too expensive to be practical. The best way, then, to control groundwater pollution is to prevent it from occurring in the first place. Laws related to solid and hazardous waste disposal now significantly reduce new contamination. Not only are physical barriers between the waste and the groundwater required, but monitoring wells must be installed in some cases to provide early warning of possible leakage.

Land-use management applied on the local level by towns and cities can be effective in preventing aquifer contamination. For example, zoning ordinances that prevent residential or industrial development in areas that are known groundwater recharge zones can reduce pollution problems. Strict enforcement of regulations pertaining to the siting, design, and construction of septic systems can reduce or eliminate the incidence of sewage contamination of private wells. Prudent application of pesticides and fertilizers in agricultural areas can also be effective in this regard.

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

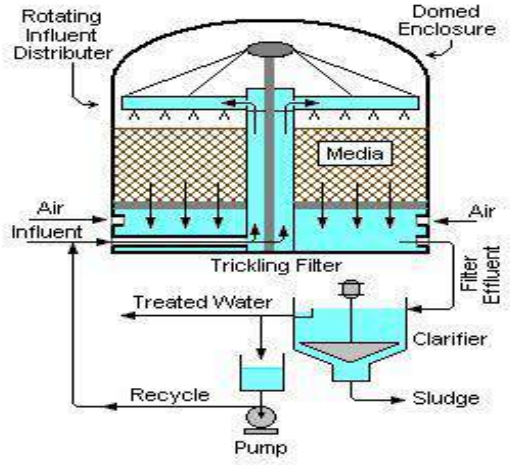
A trickling filter consists basically of a layer or bed of crushed rock about 2m (6ft) deep. It is usually circular in shape and may be built as large as 60 m (200 ft) in diameter. Trickling filters are always preceded by primary treatment to remove coarse and settleable solids. The primary effluent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

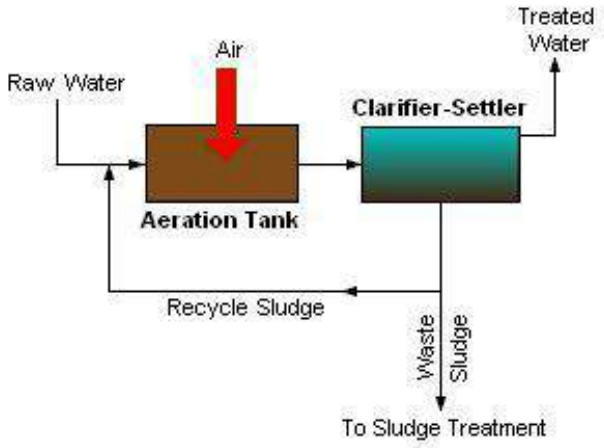
The basic components of an activated sludge sewage treatment system include an aeration tank a secondary settling basin or clarifier. Primary effluent is mixed with settled solids that are recycled from the secondary clarifier and then introduced into the aeration tank. Compressed air is injected continuously 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 (Al_2SO_4). 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 ($FeCl_3$), 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 (N_2), 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 CH_4 by reducing acetate and/or CO_2. **Biogas**, a mixture of different gases is produced by anaerobic microbes using domestic and agricultural wastes. Bulk (about 50 – 70%) of biogas is **methane** (CH_4) and other gases are in low proportions. These include CO_2 (25 – 35%), H_2 (1 – 5%), N_2 (2 – 7%) and O_2 (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 NH_3, CO_2 and H_2. Finally methanogens reduce acetate and/or CO_2 to CH_4. 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.

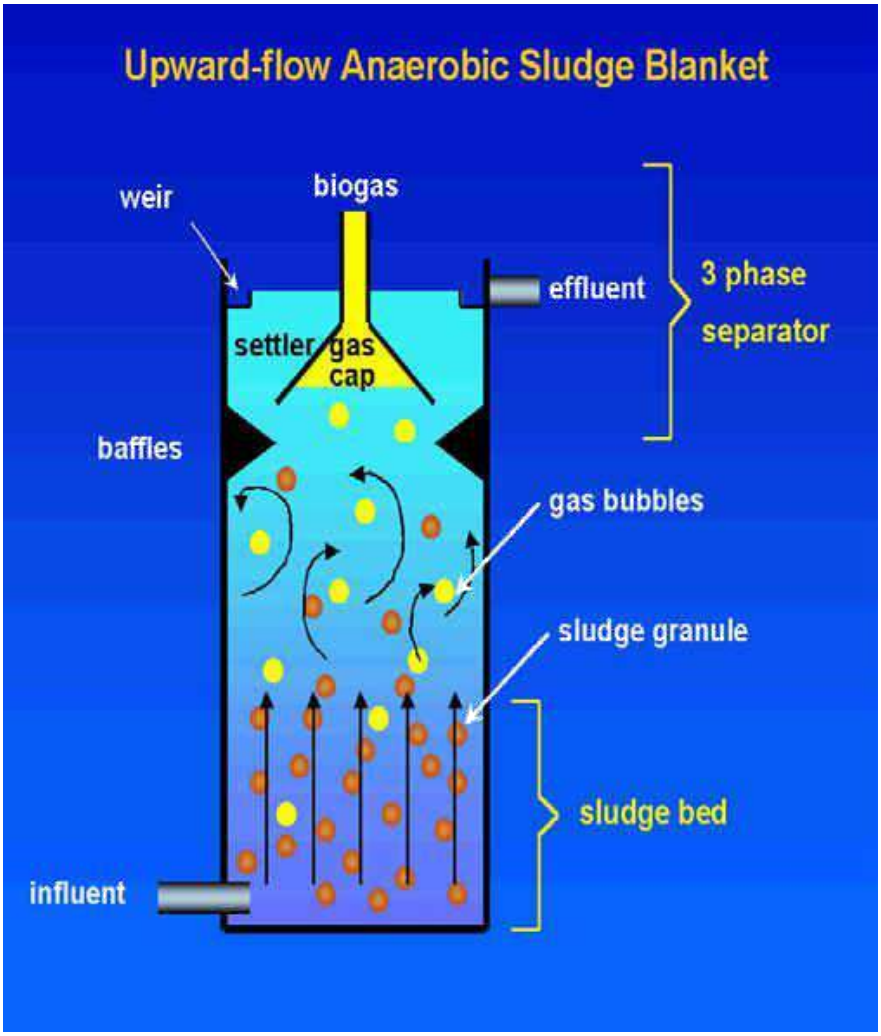
Anaerobic reactors for liquid waste

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

Upflow Anaerobic Sludge Blanket Reactor

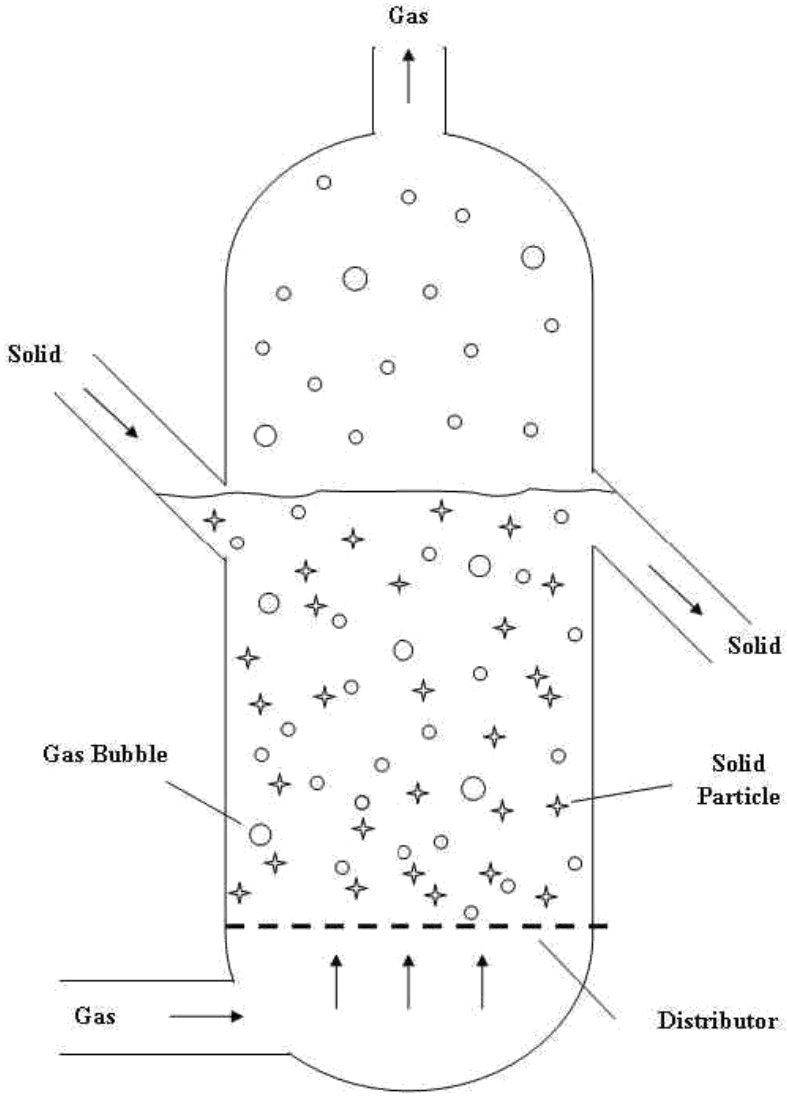
Developed at Wageningen Agricultural University, Netherlands (Lettinga, 1978), the UASB reactor employs anaerobic bacteria especially methanogens, which have a propensity to form self-immobilized granular structures with good settling properties inside the reactor. These anaerobic bacteria granules make 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

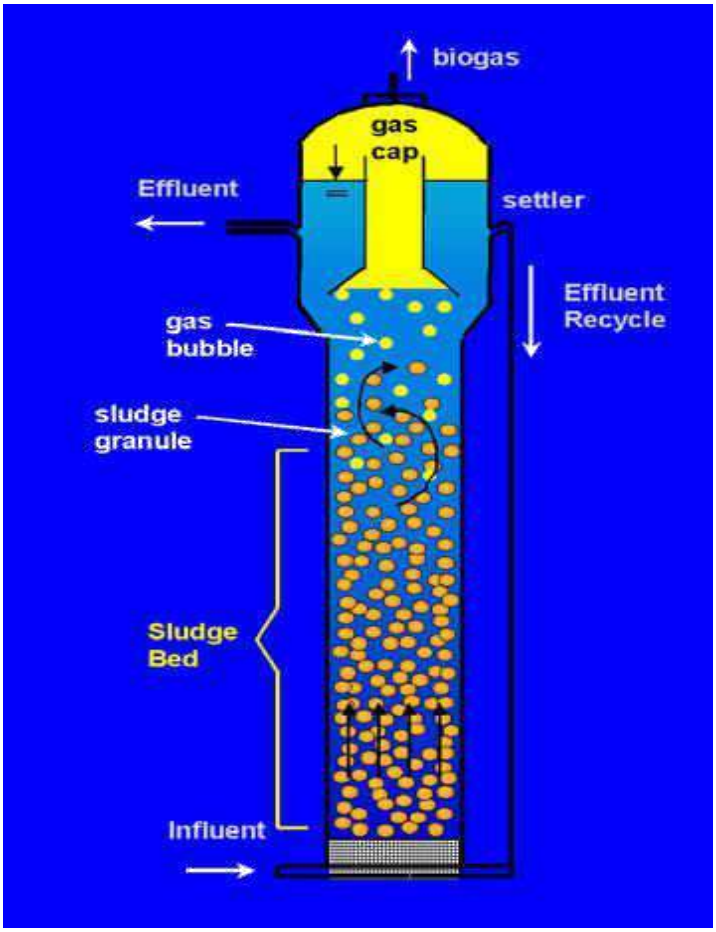
In these reactors mixed culture bacteria are made to grow as a film on the surface of some inert carrier particle. These particles are then maintained inside in a "fluidized" state using the energy of the incoming effluent stream. The linear velocity of the effluent is kept above the minimum fluidization 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/m^3 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.

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.

Chemical parameters of water quality

Dissolved oxygen

Dissolved oxygen is generally considered to be one of the most important parameters of water quality in streams, rivers and lakes. It is usually abbreviated simply as DO. Just as people need oxygen in the air they breathe, fish and other aquatic organisms need DO in the water to survive. With most other substances, the less there is in the water, the better is the quality. But the situation is reversed for DO. The higher the concentration of dissolved oxygen, the better is the water quality.

Oxygen is only slightly soluble in water. For example, the saturation concentration at $20^{o}C$ is about 9 mg / L or 9 ppm . Because of this very slight solubility, there is usually quite a bit of competition among aquatic organisms, including bacteria, for the available dissolved oxygen. Bacteria will use up the DO very rapidly if there is much organic material in the water. Trout and other fish soon perish when the DO level drops. Another factor to remember is that oxygen solubility is very sensitive to temperature. Changes in water temperature have a significant effect on DO concentrations.

Dissolved oxygen has no direct effect on public health, but drinking water with very little or no oxygen tastes flat and may be objectionable to some people. Dissolved oxygen does play a part in the corrosion or rusting of metal pipes; it is an important factor in the operation and maintenance of water distribution networks.

Dissolved oxygen is used extensively in biological wastewater treatment facilities. Air, or sometimes pure oxygen is mixed with sewage to promote the aerobic decomposition of the organic wastes.

The DO concentration can be determined by using standard wet chemistry methods of analysis or membrane electrode meters in the lab or in the field. Field instruments are available that have probes that can be lowered directly into a stream or treatment tank. The electrode probe senses small electric currents that are proportional to the dissolved oxygen level in the water.

Biochemical Oxygen Demand

Bacteria and other microorganisms use organic substances as food. As they metabolize organic material, they consume oxygen. The organics are broken down into simpler compounds, such as CO_2 and H_2O and the microbes use the energy released for growth and reproduction.

When this process occurs in water, the oxygen consumed is the DO. If oxygen is not continually replaced in the water by artificial or natural means, then the DO level will decrease as the organics are decomposed by the microbes. This need for oxygen is called the **biochemical oxygen demand**. In effect, the microbes "demand" the oxygen for use in the biochemical reactions that sustain them. The

abbreviation for biochemical oxygen demand is BOD; this is one of the most commonly used terms in water quality and pollution control technology.

Organic waste in sewage is one of the major types of water pollutants. It is impractical to isolate and identify each specific organic chemical in these wastes and to determine its concentration. Instead, the BOD is used as an indirect measure of the total amount of biodegradable organics in the water. The more organic material there is in the water, the higher the BOD exerted by the microbes will be.

In addition to being used as a measure of the amount of organic pollution in streams or lakes, the BOD is used as a measure of the strength of sewage. This is one of the most important parameters for the design and operation of a water pollution control plant. A strong sewage has a high concentration of organic material and a correspondingly high BOD. A weak sewage, with a low BOD, may not require as much treatment.

The complete decomposition of organic material by microorganisms takes time, usually 20 d or more under ordinary circumstances. The amount of oxygen used to completely decompose or stabilize all the biodegradable organics in a given volume of water is called the ultimate BOD, or BOD_L. For example, if one liter volume of municipal sewage requires 300 mg of oxygen for complete decomposition of the organics, the BOD_L, would be expressed as 300 mg/L. One liter of waste water from an industrial or food processing plant may require as much as 1500 mg of oxygen for complete stabilization of the waste. In this case, the BOD_L would be 1500 mg/L, indicating a much stronger waste than ordinary municipal or domestic sewage. In general, the BOD is expressed in terms of mg/L of oxygen.

The BOD is a function of a time. At the very beginning of a BOD test, or time = 0, no oxygen will have been consumed and the BOD = 0. As each day goes by, oxygen is used by the microbes and the BOD increases. Ultimately, the BOD_L is reached and the organics are completely decomposed. A graph of the BOD versus time has the characteristic shape illustrated in Fig .5.1. This is called the BOD curve.

The BOD curve can be expressed mathematically by the following equation.

$$BOD_t = BOD_L \text{ cx } (1\text{-}10^{-kt})$$

Where BOD_t = BOD at any time t, mg/L

BOD_L = ultimate BOD, mg/L

k = a constant representing the rate of the BOD reaction

t = time, d

The rate at which oxygen is consumed is expressed by the constant k. The value of this rate constant depends on the temperature, the type of organic material, and the type of microbes exerting the BOD. For ordinary domestic sewage, at a temperature of 20^oC, the value of k is usually about 0.15/d.

Chemical Oxygen Demand

The BOD test provides a measure of the biodegradable organic material in water, that is, of the substances that microbes can readily use for food. There also might be non-biodegradable or slowly biodegradable substances that would not be detected by the conventional BOD test.

The **chemical oxygen demand**, or COD, is another parameter of water quality, which measures all organics, including the non biodegradable substances. It is a chemical test using a strong oxidizing agent (potassium dichromate,) sulfuric acid, and heat. The results of the COD test can be available in just 2h, a definite advantage over the 5d required for the standard BOD test.

COD values are always higher than BOD values for the same sample, but there is generally no consistent correlation between the two tests for different wastewaters. In other words, it is not feasible to simply measure the COD and then predict the BOD. Because most wastewater treatment plants are biological in their mode of operation, the BOD is more representative of the treatment process and remains a more commonly used parameter than the COD.

Sl. 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.	BOD (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	-

Air pollution: causes, effects and their control

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 90^0C 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 – 80^0C. (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	20.948
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, every one 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*** : SO_2 □ H_2SO_3 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.

$H_2O + SO_2 \rightarrow H_2SO_3$, $SO_2 + O_2 \rightarrow SO_3$; $SO_3 + H_2O \rightarrow H_2SO_4$.

The acid rain reacts with marble stone ($CaCO_3$) 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 SO_2 and NO_x. 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, NO_x 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- sulfur dioxide (SO_2), nitrogen oxides (NO_X) and carbon monoxide (CO), solid or liquid particulates (smaller than 10 μm), and particulate lead.

Gaseous pollutants

Sulfur dioxide

Certain fossil fuels, particularly coal, may contain the element sulfur. When these fuels are burned for power or heat, the sulfur is also burned or oxidized. This chemical reaction can be described by the following equation:

Sulfur dioxide is a colorless gas with a sharp, choking odour. It is a primary pollutant because it is emitted directly in the form of SO_2.

The sulfuric acid (H_2SO_4) mist is a secondary pollutant because it is not emitted directly, but is formed subsequently in the atmosphere. It is a constituent of acid rain, an important regional air pollution problem.

- 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 (SO_2), but also with small amounts of sulfur trioxides (SO_3).

- SO_2, once released, can convert to SO_3 in a series of reactions which, once again, involve a free radical such as OH**.**

$$SO_2 + OH. \longrightarrow HO\,SO_2.$$

$$HO\,SO_2. + O_2 \longrightarrow SO_3 + HO_2.$$

- The HO_2 radical can then react with NO to return the initial OH. ($HO_2. + NO \rightarrow NO_2 + OH.$).
- Sulfur trioxide reacts very quickly with H_2O to form sulfuric acid, which is the principal cause of acid rain.

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

- Sulfuric acid molecules rapidly become particles by either condensing on existing particles in the air or by merging with water vapour to from $H_2O - H_2SO_4$ droplets.
- Often a significant fraction of particulate matter in the atmosphere consists of such sulfate (SO_4^{2-}) aerosols.
- The transformation from SO_2 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.
- SO_2 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 ($CaCO_3$) and mortar, as the carbonates in these materials are replaced by sulfates.

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$$

The calcium sulfate (gypsum) produced by this reaction is water soluble and easily washes away, leaving a pitted, eroded surface.

Nitrogen oxides

There are many forms of nitrogen oxides (characterized collectively as NO_x), but the one that is of greatest importance is nitrogen dioxide (NO_2). Most emissions are initially in the form of nitric oxide (NO), which by itself is not harmful at concentrations usually found in the atmosphere. But NO is readily oxidized to NO_2, which in the presence of sunlight can further react with hydrocarbons to form **photochemical smog**. Smog is, of course, harmful. NO_2 also reacts with the hydroxyl radical (OH^-) to form nitric acid (HNO_3), which contributes to the problem of acid rain. Although NO is colorless, NO_2 is pungent, irritating gas that tends to give smog a reddish brown color.

- 7 oxides of nitrogen are known to occur – NO, NO_2, NO_3, N_2O, N_2O_3, N_2O_4 and N_2O_5.
- Nitric oxide (NO) and Nitrogen dioxide (NO_2) are important in air pollution study.
- There are two sources of nitrogen oxides (or NO_x):
  i. *Thermal NO_x* are created when nitrogen and oxygen in the combustion air are heated to a high enough temperature (> 1000 K) to oxidise nitrogen.
  ii. *Fuel NO_x* 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 NO_x is often the dominant source of NO_x.
- Almost all NO_x emissions are in the form of NO, which has no adverse health effects.
- However, NO can oxidise to NO_2, which in turn may react with hydrocarbons in the presence of sunlight to form photochemical smog, which is injurious.
- NO_2 also reacts with hydroxyl radical (HO) in the atmosphere to form nitric acid (HNO_3) and results in acid rain.
- NO_2 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 NO_2 gives smog its reddish brown colour.
- Reductions in NO_x 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 NO_x problem worse and vice-versa. To control CO, it helps to increase the combustion air supply and to raise the temperature. To control NO_x, the opposite is true.

The NO-NO_2–O_3 photochemical reaction sequence

- NO is formed during combustion $N_2+O_2 \rightarrow 2NO$
- The nitric oxide thus emitted, can oxidise to NO_2. $2NO+O_2 \rightarrow 2NO_2$.
- If sunlight is available, NO_2 can photolyse, and the freed atomic oxygen can then help to form ozone:

$$NO_2 + h\nu \rightarrow NO + O$$
$$O+O_2+M \rightarrow O_3+M$$

Where hv represents a photon ($\lambda < 0.38$ μm) and M represents a molecule (usually O_2 or N_2) whose presence is necessary to absorb excess energy from the reaction.

- Ozone can then convert NO back to NO_2 : $O_3+NO \rightarrow NO_2+O_2$

- 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 NO_2 as NO gets converted to NO_2. As the sun's intensity increases toward noon, the rate of photolysis of NO_2 increases; thus NO_2 begins to drop while O_3 rises. Ozone is so effective in its reaction with NO that as long as O_3 is present, NO concentrations do not rise through the rest of the afternoon, even though there may be new emissions. If only NO_2 photolytic cycle is involved, O_3 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 O_3 to accumulate.

Carbon Monoxide

During complete combustion of fossil fuels, carbon atoms in the fuel combine with oxygen molecules to form carbon dioxide (CO_2). But the process of combustion is rarely complete. Incomplete combustion of the fuel may occur when the oxygen supply is insufficient, when the combustion temperatures are too low, or when residence time in the combustion chamber is too short. Carbon monoxide (CO), a product of incomplete combustion, is the most abundant of the criteria air pollutants.

Carbon monoxide is completely invisible; it is colorless, odorless, and tasteless. Almost 70 per cent of the total carbon monoxide emissions come from highway vehicles, and atmospheric concentrations are very much a function of urban traffic patterns. CO levels, which typically range from 5 to 50 ppm in city air, may often reach 100 ppm on congested highways (cigarette smoke contains more than 400 ppm of carbon monoxide).

- Carbon monoxide produced when carbonaceous fuels are burned under less than ideal conditions.
- Incomplete combustion, yielding CO instead of CO_2, results when any of the following variables are not kept sufficiently high:
    i. Oxygen supply
    ii. Flame temperature
    iii. Gas residence time at high temperature and
    iv. 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 brain function is affected and heart rate increased in an attempt to offset the oxygen deficit.

Solid or liquid particulates

Extremely small fragments of solids or liquid droplets suspended in air are called particulates. Most particulates range in size from 0.1 to 100 µm (one micrometer, or 1 µm, is one millionth of a meter; it may also be called a micron). The particulate materials of most concern with regard to adverse effects on human health are generally less than 10 µm in size and are referred to as PM_{10}.

Suspended solids roughly 1 to 100 µm in size are called dust particles, while smaller suspended solids (less than 1 µm) may be called either smoke or fumes. Dust is formed from materials handling activities or mechanical operations, including grinding, wood working, and sandblasting. Smoke is a common product of incomplete combustion; smoke particles consist mostly of carbonaceous material.

Fumes, usually consisting of very small metallic oxide particles, are typically formed during certain high temperature chemical reactions and vapor condensation.

Ozone and Photochemical smog

Ozone (O_3), a secondary air pollutant in the troposphere, is formed by a set of exceedingly complex chemical reactions between nitrogen dioxide (NO_2) 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.

- Ozone (O_3) 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.
- 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.
- 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 + NO_x + sunlight □ photochemical smog.

Lead particulates

This toxic metal, in the form of a fume (less than 0.5 µm in size), is one of the criteria pollutants. In the past, major sources of lead (Pb) fumes were motor vehicles that burned gasoline containing a lead based antiknock additive. Young children are particularly at risk form lead poisoning because even slightly elevated levels of lead in the blood cause learning disabilities, seizures, permanent brain damage, and even death.

- Most lead emissions in the past have been from motor vehicles burning gasoline containing the antiknock additive, tetraethyl lead, $(C_2 H_5)_4 Pb$.
- 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 $\mu g/m^3$.
- 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 some what 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.

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 0.0002□m in diameter), but smaller than 500□m.

- 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 10□m

- 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 10□m

- 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 10□m may be large enough to be deposited in the lungs by sedimentation. Sedimentation is most effective for particles between 2 and 4□m.
- Particulates <10□m 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).

Automobile emissions

The automobile, powered by piston-type internal combustion engine, is so widely used that it has become the dominant source of air pollutants in large urban cites.

Automotive engines generally operate on "fuel rich" mixtures, which mean that there is not quite enough oxygen to completely burn the fuel. As a result there is an excess of unburnt hydrocarbons, particularly along the cylinder walls, and substantial amounts of carbon monoxide. This efficient production of carbon monoxide has made automobiles the most important source of this poisonous gas in the urban atmosphere.

Many of the carcinogens found in the exhaust from diesel engines are polycyclic aromatic hydrocarbons (PAH) and are archetypical carcinogens. Best known of these is benzo-a-pyrene. Benzene represents a large part of the total volatile organic emissions from automobiles. Yet the compound is also recognized by many as imposing a substantial carcinogenic risk to modern society. Toluene, although by no means as carcinogenic as benzene, is also emitted in large quantities. Toluene proves a very effective compound at initiating photochemical smog and also reacts to form the eye irritant peroxybenzoyl nitrate. The highly dangerous compound dioxin can be produced in auto exhausts where chlorine is present (anti-knock agents often contain chlorine).

Many exotic elements that are added to improve the performance of automotive fuels produce their own emissions. The best known is the anti-knock agent tetraethyl lead, which was added in such large quantities that it became the dominant source of lead particles in the air. A wide range of long-term health

effects, such as lowering IQ, have been associated with exposure to lead. Although lead in urban populations is still rather high, the use of unleaded gasoline has decreased the problem somewhat.

Although huge quantities of fossil fuels are burnt in power generation and a range of industrial processes, automobiles make a significant and growing contribution to carbon dioxide emissions which enhance the greenhouse effect. The nitrogen oxides emitted by automobiles are ultimately converted to nitric acid and these are making an increasing contribution to rainfall acidity. Diesel-powered vehicles use fuel of higher sulfur content and can contribute to the sulfur compounds in urban air.

Thus while air pollution problems might well be cured by a wide range of sociological changes, a technological fix has been favoured, such as the use of catalytic converters. Although much attention is being given to lowering emissions of volatile organic compounds, it is likely that non-polluting vehicles will have to be manufactured and better a mass transmit system created.

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.

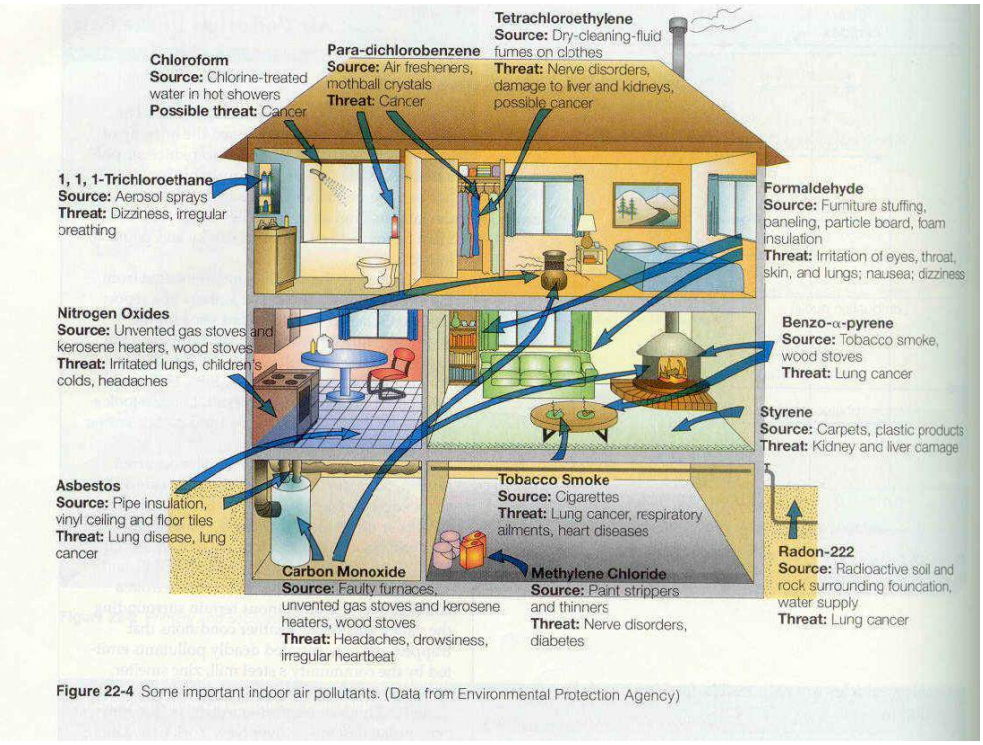


Figure 22-4 Some important indoor air pollutants. (Data from Environmental Protection Agency)

Sources of indoor air pollution

- Combustion (to heat water, cook and space heating) can produce elevated levels of CO and NO_X.
- 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 - **α**-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, NO_X, hydrocarbons and respirable particles and some emissions that are suspected carcinogens like benzo - **α**-pyrene.

Effects of ambient 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.

Health effects

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 either 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.

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.

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 SO_2 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.

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.

Air Pollution control strategies

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 curtail highway traffic if an air pollution episode is imminent or occurring.

Another option for air pollution control is source location in order to minimize the adverse impacts in a particular locality.

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. Air pollution control strategies can be divided into two categories, the control of particulate emissions and the control of gaseous emissions. There are many kinds of equipment which can be used to reduce particulate emissions. Physical separation of the particulates from the air using settling chambers, cyclone collectors, impringers, wet scrubbers, electrostatic precipitators, and filtration devices, are some processes that are typically employed.

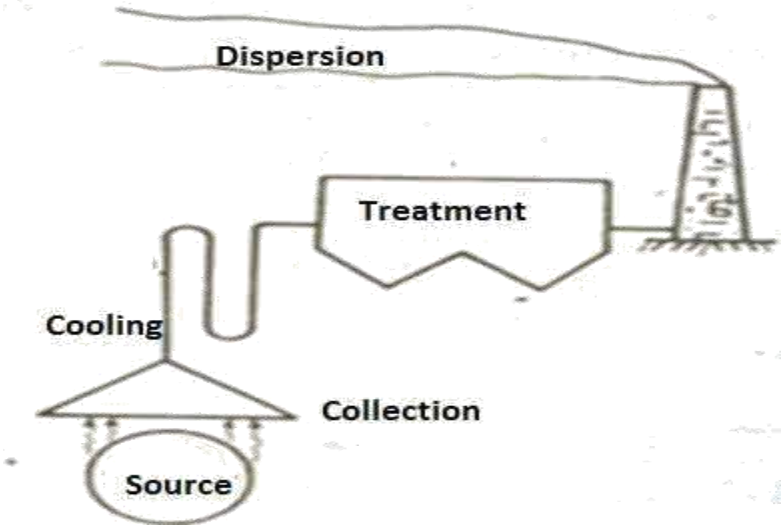
Gaseous emissions are controlled by similar devices and typically can be used in conjunction with particulate control options. Such devices include scrubbers, adsorption systems, condensers, flares, and incinerators.

Scrubbers utilize the phenomena of adsorption to remove gaseouse pollutants from the air stream. There is a wide variety of scrubbers available for use, including spray towers, packed towers, and venturi scrubbers. A wide variety of solutions can be used in this process as absorbing agents. Lime, magnesium oxide, and sodium hydroxide are typically used.

Adsorption can also be used to control gaseous emissions. Activated carbon is commonly used as an adsorbent in configurations such as fixed bed and fluidized bed absorbers.

Another means of controlling both particulate and gaseouse air pollutant emission can be accomplished by modifying the process which generates these pollutants. For example, modifications to process equipment or raw materials can provide effective source reduction. Also, employing fuel cleaning methods such as desulfurization and increasing fuel-burning efficiency can lessen air emissions.

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 blowby 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:

(a) **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.

(b) **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.

(c) **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.

(d) **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.

(e) **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.

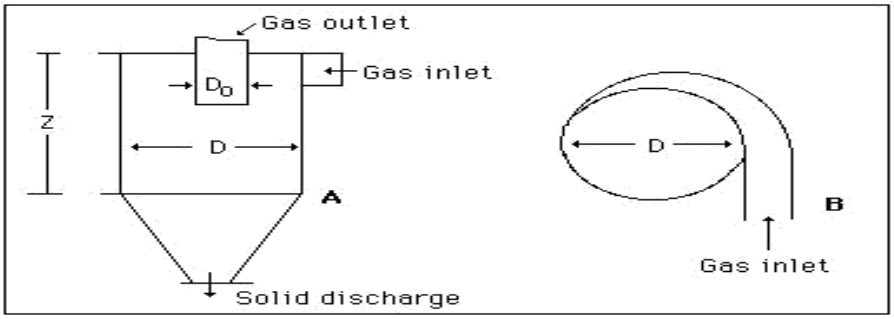
(f) **Gas scrubbers** are simply wet collectors as described above but are used for dissolving the gases.

(g) **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.

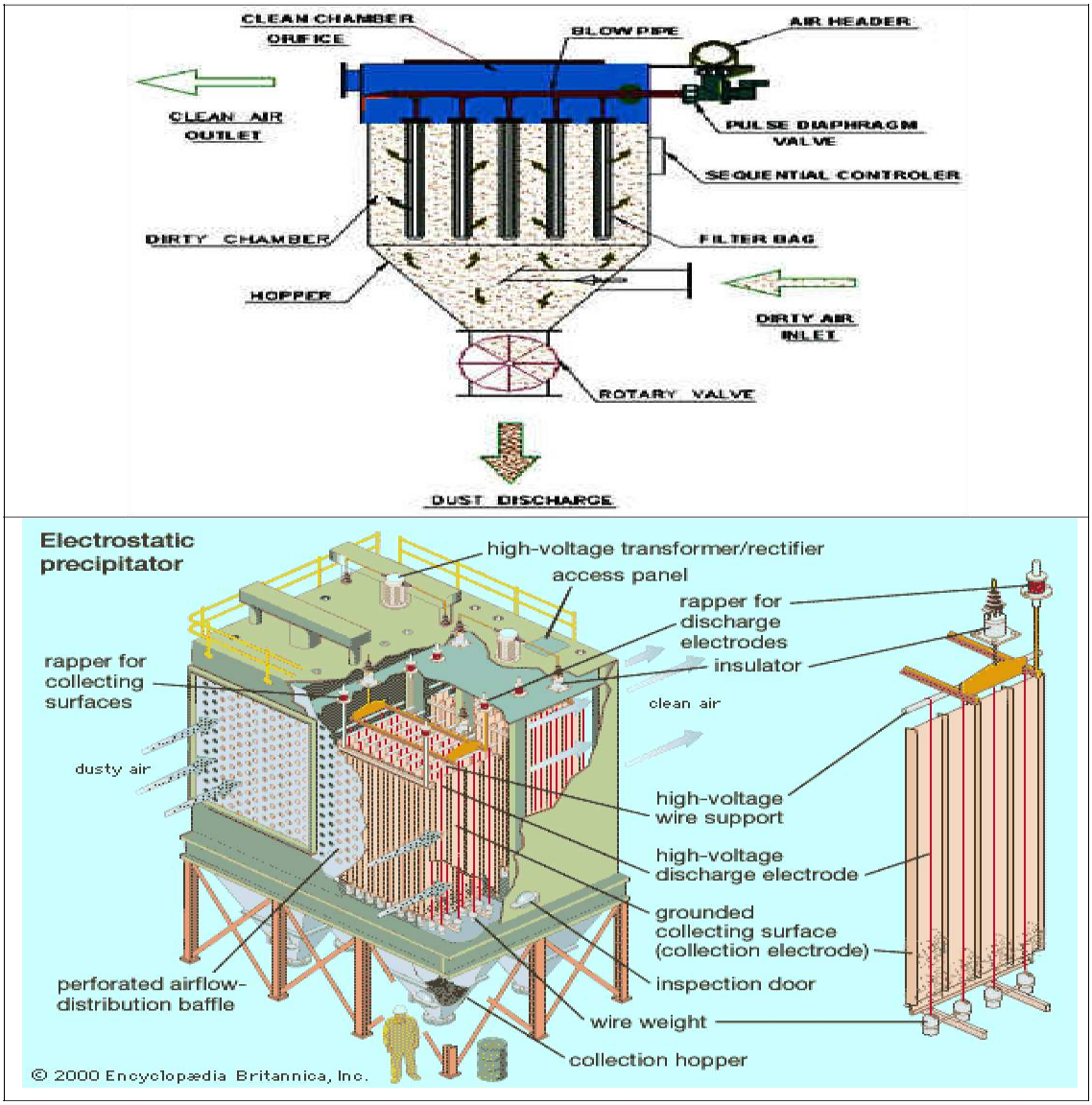
(h) **Incineration** is a method for removing gaseous pollutants by burning them to CO_2, H_2O and inerts. This works only for combustible vapours.

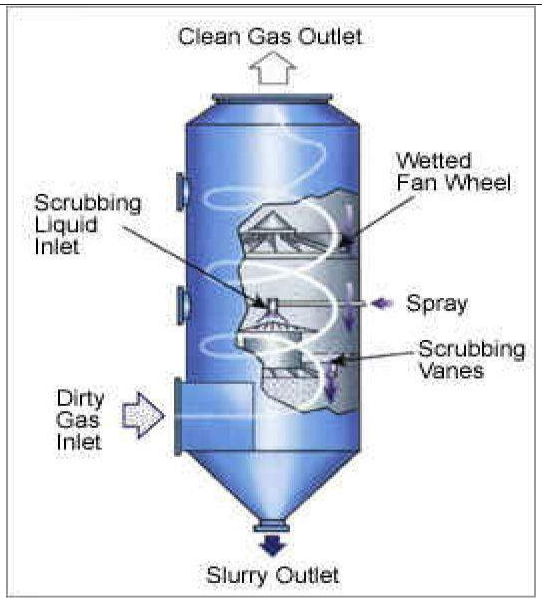
(i) **Catalytic combustion** involves the use of a catalyst to adsorb or chemically change the pollutants.

Cyclone separator



Bag Filter


CLEAN CHAMBER ORIFICE
BLOW PIPE
AIR HEADER
CLEAN AIR OUTLET
PULSE DIAPHRAGM VALVE
SEQUENTIAL CONTROLER
DIRTY CHAMBER
FILTER BAG
HOPPER
DIRTY AIR INLET
ROTARY VALVE
DUST DISCHARGE
Electrostatic precipitator
high-voltage transformer/rectifier
access panel
rapper for discharge electrodes
insulator
rapper for collecting surfaces
clean air
dusty air
high-voltage wire support
high-voltage discharge electrode
grounded collecting surface (collection electrode)
inspection door
perforated airflow-distribution baffle
wire weight
collection hopper
© 2000 Encyclopædia Britannica, Inc.


Clean Gas Outlet
Wetted Fan Wheel
Scrubbing Liquid Inlet
Spray
Scrubbing Vanes
Dirty Gas Inlet
Slurry Outlet

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 (□g /m^3)**	**SO_2 (□g /m^3)**	**CO (□g /m^3)**	**NO_x (□g /m^3)**
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.

Biofilters and Bioindicators

Biofiltration refers to the removal and oxidation of organic gases (i.e. volatile organic compounds, or VOCs) from contaminated air by vapour phase biodegradation in beds (**biofilters**) of compost, soil, or other materials such as municipal waste, sand, bark peat, volcanic ash, or diatomaceous earth. As contaminated air (such as air from a soil vapour extraction process) flows through the biofilter, the VOCs sorb onto surfaces of the pile and are degraded by microorganisms. Nutrient blends or exogenous microbial cultures can be added to a biofilter to enhance its performance. Moisture needs to be continually supplied to the biofilter to counteract the drying effects of the gas stream. The stationary support media that make up the biofiltration bed should be porous enough to allow gas flow through the biofilter and should provide a large surface area with high wetting and sorptive capacities. This support media should also provide adequate buffering capacity and may also serve as a source of inorganic contaminants. Compared to incineration and carbon adsorption, biofilters do not require land filling of residuals or regeneration of spent materials.

The soil-type biofilter is similar in design to a soil compost pile. Fertilizers are preblended into the compost pile to provide nutrients for indigenous microorganisms, which accomplish the biodegradation of the VOCs.

Another type of biofilter is the disk biofilter, which consists of a series of humidified, compressed disks placed inside a reactor shell. These layered disks contain activated charcoal, nutrients, microbial cultures, and compost material. The waste air stream is passed through the disk system. Collected water condensate from the process is returned to the humidification system for reuse.

1. Bioindicators

A bioindicator is a plant or animal species that is known to be particularly tolerant or sensitive to pollution. Based on the known association of an organism with a particular type or intensity of pollution, the presence of the organism can be used as a tool to indicate polluted conditions relative to unimpacted reference conditions. Sometimes a set of species or the structure and function of an entire biological community may function as a bioindicator. In assessing the impacts of pollution, bioindicators are frequently used to evaluate the "health" of an impacted ecosystem relative to a reference area of reference conditions. Field- based, site-specific environmental evaluation based on the bioindicator approach generally are complemented with laboratory studies of toxicity testing and bioassay experiments.

2. Biological Monitoring in Lakes and Streams

Small insects and other organisms that live on the bottom of streams and lakes form an important part of the aquatic food web. Ecologists call them benthic (which means "bottom-dwelling") macro invertebrates. They are sensitive to many factors in their environment and are useful as indicators of the condition or "health" of streams and lakes. Routine macro invertebrate monitoring or sampling can indicate problems that may not easily be detected by chemical testing, and can detect pollution problems that may no longer be evident in water samples. Macro invertebrates depend on adequate water quality for survival. The time required for insect communities to return to their natural

state after disturbances, such as those form point-source industrial pollutants, can be on the order of many years for streams and decades for lakes. As a result, changes in their numbers and species can indicate pollution from various sources.

Biological sampling and monitoring of these communities provides an effective method for determining if a watercourse has been impacted by pollution. More than 4000 species of aquatic insects have been reported. These benthic macro invertebrates are therefore a highly diverse group, which makes them excellent candidates for studies of changes in biodiversity. Changes in population numbers or behavior of these organisms can indicate that the physical or chemical conditions are outside their preferred limits. Also, the presence of numerous families of highly tolerant organisms usually indicates poor water quality.

3. Bio amelioration of problem soils

Rehabilitation of problem soils through vegetation has a number of benefits, particularly with regard to the developing countries in the tropics. It is environment friendly and cost effective and it needs no costly or imported inputs or technology. It can generate employment for unskilled people, in particular women and site beautification can also be accomplished in the process.

Grasses, legumes, shrubs and trees are available to rehabilitate almost any soil in various agroclimatic settings. Some examples are as follows: saline tailings – *Atriplex lentiformis*; nickel tailings – *Atriplex nummularia*; gold tailings – *Tamarix pentandra*; rapid growth on tailings – *Acacia saligna, Cynodon dactylon, Sporobolus virginicus, Panicum repens, etc*.

The waste dumps in coastal areas can be grown with cashew trees. Cashew yields excellent economic returns, while providing the same kind of environmental benefits as other trees. The cashew tree has a life span of 30 years. It is usually planted with spacing 8 m x 8m. It yields highly valuable nuts (150 kg ha^{-1} in the fifth year, going up to 750 kg ha^{-1} in the tenth year). The expense incurred for preparing the land for cashew cultivation (leveling, grading, drainage, digging pits, use of fertilizers and pesticides, etc.) can be easily recovered. Techno economic evaluation shows that at discount rates of 5%, 10% and 12%, the current net value of cashew is 3 times more than that of *Acacia*.

4. Phytoremediation – Biotechnology of cleaning up the environment by plants

The process of recovery of hazardous substances from soil or groundwater contaminated with municipal or industrial wastes etc. by using plants is called **phytoremediation**. Among vascular plants, some aquatic weeds such as species of *Salvinia, Lemna, Azolla*, sedges and even tree species are also known to tolerate, uptake and even accumulate heavy metals and other toxicants in their cells. Besides microorganisms plants are also being studied for their potential of environmental cleanup. Green plants are not only the lungs of nature with unique ability of purifying impure air by photosynthesis, releasing oxygen to sustain aerobic life in the biosphere, but it has also been only quite recently demonstrated that they could also be very useful in cleaning up the hazardous waste sites.

Though phytoremediation has a long history, its industrial application is quite recent. Plants are being tested for their ability to clean up contaminated soil and even genetically engineered varieties are on the horizon.

Bioremediation

Bioremediation is a treatment process that uses naturally occurring microorganisms (bacteria, fungi) to break down or degrade hazardous substances into less toxic or nontoxic substances. Microbes digest organic substances, such as fuels or solvents that are hazardous to human, for their nutrients and energy. They degrade these organic contaminants into harmless products mainly CO_2 and water. Bioremediation is the technological process whereby biological systems are employed to effect the cleanup of environmental pollutants.

Primarily bacteria and fungi mediate degradation of organic materials in natural environment. They represent diverse groups of organisms with ubiquitous distribution at varied habitats. They could degrade most of the environmental pollutants by their effective enzyme systems. The indigenous microbes already living at a site are stimulated to degrade a pollutant by providing proper growth temperature, oxygen and nutrients. If the microbe needed to degrade a particular contaminant is not present in the site, the organisms from other locations (exogenous organisms), whose effectiveness has been tested have to be added to the contaminated habitat. The conditions at the new site are to be adjusted to ensure the activities of exogenous organisms.

1. Bio-mining of metals

Bio-mining or bioleaching is the process of microbial extraction of metals from low grade ores and mining wastes. Applications of biotechnology in bio-mining would resolve an environmental problem, while making valuable metals available to industries. Bio-mining is effectively applied to recover metals from tailing dumps accumulated at the mine site over the years accounting to several million tonnes. *Thiobacillus ferroxidans* is commercially used for the recovery of metals like copper, uranium and gold from low grade ores.

2. Bio-decolourization of dyes

Recycling the solid and liquid wastes in eco-friendly way is gaining importance in recent years to reduce environmental pollution and at the same time to cope up with the shortage of resources. Textile and dyeing industry contributes much to water and soil pollution. Apart from chemicals, about 10,000 different dyes and pigments are being used in dyeing process. In this, nearly 10 to 15 per cent of the dye is lost as effluent during the dyeing process. Pulp mill and tannery industry are also having coloured effluents. Presence of even small quality of dyes in waste water affects the aesthetic quality, transparency and gas solubility of water systems. Hence, the removal of colour from the effluent before discharge is often more important than the removal of the soluble colourless organic substances. In order to minimize the pollution potential, the effluent is treated chemically in effluent treatment plants. But they have not been properly implemented largely due to high installation cost and low efficiency. So, economically feasible and environmentally friendly technique should be developed for the treatment of coloured effluents. Reports on biodegradation and decolourization of azo and heterocyclic dyes by biological systems like *Phanerochaete chrysosporium* indicated the feasibility of decolourization of effluent by biological waste water treatment system.

The bacterial decolourization is associated with azo-reductase enzyme activity. The colour removal was due to the structural alteration of chromophoric azo group and reduction of azo linkage to single bond (-N-N-) . The decolourization by the fungal strains is mainly due to lignin degrading enzyme system as well as adsorption to cell mass of the strains .The fungal enzyme possessing both oxidase and peroxidase activities and these enzymes oxidize the chromophores and remove the colour from waste water. Results from the microbial decolourization technique for treating the dyeing effluent are encouraging and also cheaper in terms of treatment cost. With further intensive research in this line, an efficient and environmentally safer method for treating the coloured effluents can easily be developed. The fungus *Cyathus bulleri* is found to decolourize triphenylmethane dyes, crystal violet, malachite green,

bromophenol blue and polymeric dye, Poly R-478. Biodegradation of industrial effluent containing malachite green, navy blue, magenta dyes by white rot fungus, *Phaenerochaete chrysosporium* has been successfully demonstrated.

3. Removal of heavy metals

The heavy metals from aquatic system can be removed by adsorption on the fungal dead biomass. The bioaccumulation of copper by *Aspergillus niger* and *Rhizopus arrhizus* in industrial waste water had been demonstrated. Mutants of *Aspergillus nidulans* could remove nickel from effluents. A species of *Aspergillus* isolated from soil could able to remove chromium from tannery effluents.

4. Biodegradation of organic matter

The bio-degradation of organic matter by micro-organisms occurs by way of a number of stepwise, microbially catalyzed reactions. These reactions will be discussed individually with examples.

4.1. Bio oxidation

Oxidation occurs by the action of oxygenase enzymes. The microbially catalyzed conversion of aldrin to dieldrin is an example of epoxide formation, a major step in many oxidation mechanisms. Epoxidation consists of adding an oxygen atom between two C atoms in an unsaturated system .

4.1.1. Microbial Oxidation of Hydrocarbons

The degradation of hydrocarbons by microbial oxidation is an important environmental process because it is the primary means by which petroleum wastes are eliminated from water and soil. Bacteria capable of degrading hydrocarbons include *Micrococcus, Pseudomonas, Mycobacterium* and *Nocardia.*

The most common initial step in the microbial oxidation of alkanes involves conversion of a terminal – CH_3 group of a CO_2 group. More rarely, the initial enzymatic attack involves the addition of an oxygen atom to a nonterminal carbon, forming a ketone. After formation of a carboxylic acid from the alkane, further oxidation normally occurs by a process illustrated by the following reaction, a â-oxidation:

Hydrocarbons vary significantly in their biodegradability and micro-organisms show a strong preference for straight – chain hydrocarbons. A major reason for this preference is that branching inhibits â-oxidation at the site of the branch. The presence of a quaternary carbon (below) particularly inhibits alkane degradation.

Despite their chemical stability, aromatic rings are susceptible to microbial oxidation.

The biodegradation of petroleum is essential to the elimination of oil spills (about 5×10^6 metric tons per year). This oil is degraded by both marine bacteria and filamentous fungi. In some cases, the rate of degradation is limited by available nitrate and phosphate.

4.2. Hydrolysis

Hydrolysis, which involves the addition of H_2O to a molecule accompanied by cleavage of the molecule into two products, is a major step in microbial degradation of many pollutant compounds, especially pesticidal esters, amides, and organophosphate esters. The types of enzymes that bring about hydrolysis are **hydrolase** enzymes; those that enable the hydrolysis of esters are called **esterases,** whereas those that hydrolyze amides are **amidases**.

4.3. Bio-reductions

Reductions are carried out by reductase enzymes; for example, nitroreductase enzyme catalyzes the reduction of the nitro group.

1. ENVIRONMENTAL SCIENCE AND AGROECOLOGY

The word environment is derived from the French verb environner, which means to "encircle" or "surround." Thus, our environment can be defined as the physical, chemical and biological world that surrounds us, as well as the complex of social and cultural conditions affecting an individual or community. This broad definition includes the natural world and the technological environment, as well as the cultural and social contexts that shape human lives.

The earth is the only known planet habited by man and other life forms, plants and vegetation. Man and nature have lived together and so 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 and so shamelessly 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.

For many environmentalists the rapid growth of human populations is of overriding importance. In 1997, the world population reached some 5.8 billion people, and more are being added to an increasingly over-crowded world at a rate of about 90 million per year. Most demographers predict that the world population will double, or even triple, before stabilizing sometime in the twenty-first century. The adverse environmental impacts of a population that large are of great concern.

After global climate change, the greatest environmental concern for most biologists is the worldwide loss of biological diversity. Research studies suggest that we are losing species hundreds or perhaps thousands of times faster than would normally result from natural processes. Habitat destruction, pollution, introduction of exotic species, and excessive harvesting of commercially important species all contribute to these losses. Millions of species, most of which have never even been named by science, may disappear in the next century as a result of our actions. We know little about the biological roles of these organisms in the ecosystems and their loss could result in an ecological tragedy.

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.

1.1. Environmental science

Environmental science is essentially the application of scientific methods and principles to the study of environmental issues, so it has probably been around in some form as long as science itself. Environmental science is often confused with other fields of related interest, especially ecology, environmental studies, environmental education, and environmental engineering. Environmental science is not constrained within any one discipline and it is a comprehensive field. A considerable amount of environmental research is accomplished in specific department such as chemistry, physics, civil engineering, or the various biology disciplines.

Environmental science is not ecology, though that discipline may be included. Ecologists are interested in the interactions between some kind of organism and its surroundings. Most ecological research and training does not focus on environmental problems except as those problems impact the organism of interest. Environmental scientists may or may not include organisms in their field of view. They mostly focus on the environmental problem, which may be purely physical in nature. For example,

acid deposition can be studied as a problem of emissions and characteristics of the atmosphere without necessarily examining its impact on organisms. An alternate focus might be on the acidification of lakes and the resulting implications for resident fish. Both studies require expertise from more than one traditional discipline.

1.2. Agro ecology

Agro ecology is an interdisciplinary field of study that applies ecological principles to the design and management of agricultural systems. Agro ecology concentrates on the relationship of agriculture to the biological, economic, political, and social systems of the world. Agro ecological principles shift the focus of agriculture from food production alone to wider concerns, such as environmental quality, food safety, the quality of rural life, humane treatment of livestock, and conservation of air, soil and water. Agro ecology also studies how agricultural processes and technologies will be impacted by wider environmental problems such as global warming, desertification, or salinization.

2. ECOLOGY AND ENVIRONMENT

Ecology is the branch of biological science concerned with the relationships and interactions between living organisms and their physical surroundings or environment. Living organisms and the environment with which they exchange materials and energy together make up an **ecosystem,** which is the basic unit of ecology. An ecosystem includes **biotic components** – the living plants and animals – and **abiotic components** – the air, water, minerals, and soil that constitute the environment. A third and essential component of most natural ecosystems is **energy**, usually in the form of sunlight.

Familiar examples of land-based or **terrestrial** ecosystems include forests, deserts, jungles, and meadows. Water-based or **aquatic** ecosystems include streams, rivers, lakes, marshes, and estuaries. There is no specific limitation on the size or boundaries of an ecosystem. A small pond can be studied as a separate ecosystem, as can a desert comprising hundreds of square kilometers. Even the entire surface of earth can be viewed as an ecosystem; the term **biosphere** is often used in this context.

If earth is imagined to be about the size of an apple, then the layer of air surrounding it would not be much thicker than the skin of that apple. This thin envelope of air and the shallow crust of land and water just beneath it provide the abiotic components that support life in the biosphere. It is a closed ecosystem because there is essentially no transfer of material into or out of it. Only the constant flow of energy from the sun provides power to sustain the life cycles within the bio-sphere. Nutrients are continually recycled are reused.

2.1. Structural units of ecology

For many ecologists the basic structural units of ecological organization are **species** and **populations**. A biological species consists of al the organisms potentially able to interbreed under natural conditions and to produce fertile offspring. A population consists of all the members of a single species occupying a common geographical area at the same time. An **ecological community** is composed of a number of populations that lie and interact in a specific region.

Ecological succession, the process of ecosystem development, describes the changes through which whole communities progress as different species colonize an area and change its environmental. A typical successional series starts with pioneer species such as grasses or fireweed that colonize bare ground after a disturbance. Organic material from these pioneers helps build soil and hold moisture, allowing shrubs and then tree seedlings to become established. Gradual changes in shade, temperature, nutrient availability, wind protection, and living space favour different animal communities as one type of plant replace its predecessors. Primary succession starts with a previously unoccupied site. Secondary succession occurs on a site that has been disturbed by external forces such as fires storms, or humans. In many cases, succession proceeds until a mature "climax" community is established. Introduction of new

species by natural processes, such as opening of a land bridge, or by human intervention can upset the natural relationships in a community and cause catastrophic changes for indigenous species.

Homeostasis (dynamic steady-state equilibrium), complexity, and stability are endpoints in ecological succession. Ecological processes, if allowed to operate without external interference, tend to create a natural balance between organisms and their environment.

2.2. Energy flow and productivity in an ecosystem

There are two basic principles or **laws of ecology** that involve the one way flow of energy and the circulation of materials. Energy is the capacity to do work and it can be transformed from one form to another. Energy cannot be recycled in an ecosystem; it can only flow one way. On the other hand, nutrient materials needed to sustain life can be reused over and over again. They are constantly recycled or circulated through the ecosystem. The movement of organic matter and energy from the producer level through various consumer levels makes up a **food chain.** Food chains and food webs are methods of describing an ecosystem by describing how energy flows from one species to another. First proposed by the English zoologist Charles Elton in 1927, food chains and food webs describe the successive transfer of energy from plants to the animals that eat them, and to the animals that eat those animals, and so on. A food chain is a model for this process which assumes that the transfer of energy within the community is relatively simple. A food chain in a grassland ecosystem, for example, might be: Insects eat grass, and mice eats insects, and fox eats mice. But such an outline is not exactly accurate, and many more species of plants and animals are actually involved in the transfer of energy. Rodents often feed on the both plants and insects, and some animals, such as predatory birds, feed on several kinds of rodents. This more complex description of the way energy flows through an ecosystem is called a **food web**. Food webs can be thought of as interconnected or intersecting food chains.

In addition to energy, living organisms need certain chemicals from the environment, called nutrients, in sufficient quantities. All organisms need water, and most require gaseous oxygen. In addition, plants and animals require carbon, hydrogen, phosphorus, potassium, as well as other elements in smaller amounts. For animals, some of these elements must be in the form of organic molecules, such as carbohydrates or proteins.

2.3. 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. Ecological of pyramids are of the three general types (i) **pyramid of numbers**, showing the number of individual organisms at each level (ii) **pyramid of biomass**, showing the total dry weight and other suitable measure of the total amount of living matter, and (iii) **pyramid of energy**, showing the rate of energy flow and/ productivity at successive trophic levels. 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.

2.4. Photosynthesis and respiration:

The biological and chemical process by which an organism sustains its life is called metabolism. Two fundamental metabolic processes of living organisms are photosynthesis and respiration. Green plants are autotrophic, which simply means that they are self-nourishing. They have the unique ability to convert carbon dioxide, water, and some basic nutrients into organic compounds that store the sun's energy. This natural process is called **photosynthesis**. A portion of the energy-rich organic compounds stored in the plant tissue is available for use by other organisms that consume the plants at the next trophic level. During the process of photosynthesis gaseous oxygen is released into the atmosphere. Oxygen is essential for the metabolic activities of the next trophic level in the food chain – the

consumers. Actually, the consumer organisms include several intermediate trophic levels including the herbivores, the carnivores, and the omnivores.

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.

The other major metabolic process, **respiration** may be viewed as a process of slow combustion or oxidation of organic material, in which energy is released. Essentially, respiration is the opposite of photosynthesis. Photosynthesis builds energy-rich organic substances and gives off oxygen; respiration requires oxygen. This is one of the fundamental balances in nature.

The simplified food chain is completed or closed by the decomposers, or decay organisms. These are primarily microscopic organisms such as bacteria and fungi. During their own metabolism, microorganisms break down the waste products and the remains of dead organisms into simpler inorganic substances which are then readily usable by the autotrophs. For example, nitrogen in ammonia is not available in plants as a nutrient until it is broken down and converted to inorganic nitrates by certain bacteria. The nitrates can be absorbed by the plants. The components of food chains and food webs exist at different stages in the transfer of energy through an ecosystem. The position of every group of organisms obtaining their food in the same manner is known as a tropic level. As energy moves through the ecosystem, much of it is lost at each tropic level. For example, only about 10 per cent of the energy stored in grass is incorporated into the body of a mouse that eats the grass. The remaining 90 per cent is stored in compounds that cannot be broken down by the mouse or is lost as heat during the mouse's metabolic processes.

There are two kinds of food chains; grazing food chain and detritus food chain. **Grazing food chain** goes from autotrophs to herbivores to carnivores. It is a sequence of organisms through which energy is transferred from its ultimate source, from a green plant, to the predator-prey pathway in which each organism eats the next link below and eaten by the next link above. ex. grass – grasshopper – frog – snake – hawk ; Small bacteria - *Bdellovibrio* – Protozoa; Clover - Snail - Thrush - Sparrowhawk. The chemical energy in organic matter is passed from one organism to another in the grazing food chain.

The **detritus food chain** begins with the dead plants and animals and their excretion products. The soil micro organisms consuming dead organic matter play a major role in the decomposition of organic matter and recycling of nutrients in the food web. The primary consumers are bacteria and fungi. Thus, energy flows continuously in the terrestrial ecosystem. Both pathways are important in accounting for the energy budget of the ecosystem. Actually, in many cases the food chains of the ecosystem overlap and interconnect, forming what ecologists call a **food web.** A group of interconnecting food chains (the complete cycle) is termed as **food web.**

3. BIODIVERSITY

Biodiversity or Biological Diversity is sum of all the different species of animals, plants, fungi, and microbial organisms living on Earth and the variety of habitats in which they live. Scientists estimate that upwards of 10 million and some suggest more than 100 million different species inhabit the Earth. Each species is adapted to its unique niche in the environment, from the peaks of mountains to the depths of deep-sea hydrothermal vents, and from polar ice caps to tropical rain forests. Biodiversity underlies everything from food production to medical research. Humans, the world over use at least 40,000 species of plants and animals on a daily basis. Many people around the world still depend on wild species for some or all of their food, shelter, and clothing. All of our domesticated plants and animals came from wild-living ancestral species.

3.1. Biodiversity loss

Extinction represents an irrevocable and highly regrettable loss of a portion of the biodiversity of Earth. Extinction can be a natural process, caused by random catastrophic events, biological interactions such as competition, disease, and predation, chronic stresses or frequent disturbance. In modern times, however, humans are the dominant force causing extinction, mostly because of over harvesting and habitat destruction. During the last 200 years, a global total of perhaps 100 species of mammals, 160 birds, and many other taxa are known to have become extinct through some human influence, in addition to untold numbers of undescribed, tropical species. The greatest value of biodiversity is yet unknown. Much of the Earth's great biodiversity is rapidly disappearing, even before we know what is missing. Most biologists agree that life on Earth is now faced with the most severe extinction episode since the event that drove the dinosaurs to extinction 65 million years ago. Species of plants, animals, fungi, and microscopic organisms such as bacteria are being lost at alarming rates-so many, in fact, that biologists estimate that three species go extinct every hour.

The recent wave of anthropogenic extinction includes such well-known cases as the dodo, passenger pigeon, great auk, and others. There are many other high profile species that humans have brought to the brink of extinction, including the plains buffalo, whooping crane, Eskimo curlews, ivory-billed woodpeckers, and various marine mammals. Most of these instances were caused by an insatiable over-exploitation of species that were unable to sustain a high rate of mortality, often coupled with an intense disturbance of their habitat.

Beyond these tragic cases of extinction or endangerment of large, charismatic vertebrates, the earth's biota is experiencing an even more substantial loss of biodiversity caused by the loss of habitat. In part, this loss is due to the conversion of large areas of tropical ecosystems, particularly moist forest to agricultural or otherwise ecologically degraded habitats

To date, about 1.7 million organisms have been identified and designated with a scientific name. About 6 per cent of identified species live in boreal or polar latitudes, 59 per cent in the temperate zones, and the remaining 35 per cent in the tropics. The knowledge of the global richness of species is very incomplete, particularly in the tropics. If a conservative estimate is made of the number of unidentified tropical species, the fraction of global species that live in the tropic would increase to at least 86 per cent.

3.2. Biodiversity benefits

3.2.1. Utilitarian value

Undoubtedly, there is a tremendous, undiscovered wealth of biological products that are of potential use to humans. Many of these natural products are present in the biodiversity of tropical species that have not yet been "discovered" by taxonomists. There are utilitarian reasons and we must take advantage of biodiversity in myriad ways for sustenance, medicine, shelter, and other purposes. If species become extinct, their unique services, be they biological, ecological, or otherwise, are no longer available for exploitation. There are many cases where research on previously unexploited species of plants and animals has revealed the existence of products of great utility to humans, such as food or medicinals. One example is the rosy periwinkle (*Catharantus roseus*), a plant native to Madagascar. During a screening of many plants for possible anti-cancer properties, an extract of rosy periwinkle was found to counteract the reproduction of cancer cells. Research identified the active ingredients as several alkaloids, which are now used to prepare the important anti-cancer drugs vincristine and vinblastine. This once obscure plant now allows treatment of several previously incurable cancers and is the basis of a multi-million-dollar economy.

3.2.2. Diversity and ecosystem stability

The major benefit of biodiversity is the stability and integrity of ecosystems, i.e., in terms of preventing erosion and controlling nutrient cycling, productivity, tropic dynamics, and other aspects of ecosystem structure and function.

Each species of living organism occupies a particular habitat and serves a particular function in an ecosystem. The function and habitat constitute the organism's **ecological niche**. A basic characteristic of a healthy or well-balanced ecosystem is an overlapping of niches occupied by different species. A stable ecosystem can withstand some external stress, such as pollution, construction, or hunting without being completely disrupted or damaged.

In a stable ecosystem, if any one species disappears because of natural or artificial causes, other species are available to occupy its niche and take over its role in the food chain. Actually, the term food web is more appropriate for a healthy ecosystem because of the overlapping nature and complexity of the eat-and-be-eaten by relationships. A tropical rain forest is a good example of a stable ecosystem because of the tremendous number of plant and animal species thriving in it. The loss of one species of tree or one species of animal is not likely to have a significant impact on the whole ecosystem.

In an ecosystem with little diversity, that is, only a few different species of organisms, the situation is more unstable and susceptible to the effects of stress. The disappearance of a group of organisms from the food web is more likely to break the chain of trophic levels and severely disrupt the ecosystem. Diversity of species provides a factor of safety or buffer against ecological disruptions by increasing the likelihood of adaptation to changing environmental conditions. The greater the diversity of species, the healthier is the ecosystem.

3.3. Preserving biodiversity

The biodiversity crisis is a very real and very important aspect of the global environmental crisis. All nations have a responsibility to maintain biodiversity within their own jurisdictions and to aid nations with less economic and scientific capability to maintain their biodiversity on behalf of the entire planet. The modern biodiversity crisis focuses on species-rich tropical ecosystems, but the developed nations of temperate latitudes also have a large stake in the outcome and will have to substantially subsidize global conservation activities if these are to be successful. Much needs to be done, but an encouraging level of activity in the conservation and protection of biodiversity is beginning in many countries, including an emerging commitment by many nations to the conservation of threatened ecosystems in the tropics.

As the scope and significance of biodiversity loss become better understood, positive steps to stem the tide of the sixth extinction have been proposed and, to some extent, adopted. Several nations have enacted laws protecting endangered wildlife. An international treaty known as the Convention on the International Trade of Endangered Species (CITES) went into effect in 1975 to outlaw the trade of endangered animals and animal parts. The Convention on Biological Diversity, held in Rio de Janeiro, Brazil, in 1992 and ratified by more than 160 countries, obligates governments to take action to protect plant and animal species. Conservation biologists also work with established industries to develop practices that ensure the health and the sustainability of the resources on which they depend. For example, conservation biologists work with fishers to determine how many fish the fishers can harvest without damaging the population and the ecosystem as a whole. The same principles are applied to the harvesting of trees, plants, animals, and other natural resources.

Preserving biodiversity also takes place at the molecular level in the conservation of genetic diversity. All around the world efforts are being made to collect and preserve endangered organisms' DNA, the molecule that contains their genes. These collections, or *gene banks*, may consist of frozen

samples of blood or tissue, or in some cases, they may consist of live organisms. Biologists use gene banks to broaden the gene pool of a species, increasing the likelihood that it will adapt to meet the environmental challenges that confront it. Many zoos, aquariums, and botanical gardens work together to carefully maintain the genetic diversity in captive populations of endangered animals and plants, such as the giant panda, the orangutan, or the rosy periwinkle. Captive animals are bred with wild populations, or occasionally released in hopes that they will breed freely with members of the wild population, thus increasing its genetic diversity. These gene banks are also an essential resource to replenish the genetic diversity of crops, enabling plant breeders and bioengineers to strengthen their stocks against disease and changing climate conditions

4. BIOSPHERE

Biosphere refers to the realm of living organisms and their interactions with the environment, *viz.*, atmosphere, hydrosphere and lithosphere. The biosphere is the largest possible earthly organismic community. It is a terrestrial envelope of life, or the total global biomass of living matter. The biosphere incorporates every individual organism and species on the face of the earth -those that walk on the ground or live in the crevices of rock and down into the soil, those that swim in rivers, lakes and oceans, and those that move in and out of the atmosphere. Biosphere is divided into three major ecosystems *viz.*, lithosphere, hydrosphere and atmosphere.

4.1. Lithosphere

Lithosphere is the terrestrial environment and life inhabited in soil, rocks and sediments. The physical and chemical forces reduce the rock to rigolith (rock rubble). Microbes play a central role in weathering of rock and the formation of raw soil. They mediate weathering by the production of organic and inorganic acids. Rock silicates are degraded by citric acid and oxalic acid produced by fungi. The increased surface area encourages water retention and colonization, first by autotrophic microorganisms. Lichens, algae, fungi and bacteria participate in the formation of soil, the outer loose material of earth's surface.

When the soil formed from the rigolith, a series of distinct horizons are formed from plant and animal materials deposited on the soil surface. The decomposition of organic material by the microorganisms results in the formation of soil organic matter, humus. In the top soil (A horizon) mineral soil is mixed with humus and also contains silicate clays and oxides. B horizon with minerals and little organic matter forms subsoil, and the C horizon is the bedrock.

Soil constitutes the major habitat of lithosphere and is generally a favourable habitat for the growth and multiplication of microorganisms. It is the region in which many of the biochemical reactions of organic matter degradation, plant nutrition and weathering of rocks occur. The soil is one of the most dynamic sites of biological interactions in nature. Microbes normally occur as micro colonies on the clay fraction of soil particles.

The microorganisms found in soil include bacteria, fungi, algae, protozoa and viruses. Soil being a nutrient and organic matter rich environment, the number and diversity of heterotrophic microorganisms especially bacteria and fungi are usually high. Typically 10^6 to 10^9 bacteria, 10^4 fungi and 10^2 protozoa per gm are found in fertile soils. The amount of microbial biomass is 500 to 4000 kg per hectare, depending on the type of soil and its organic matter content. Eventhough bacteria are dominant in number, as they are unicellular and minute sized with low mass (10^{-13} g per cell,), amount to only 10 per cent of total microbial mass. Fungi being multicellular and large in size amount to 90 per cent of total microbial mass in soil.

4.2. Hydrosphere

Water is the dominant environment of this planet, as oceans cover 71 per cent of the earth's surface. The aquatic environment comprises of fresh water (springs, rivers, ponds, lakes) and salt water (estuaries and oceans). In hydrosphere about 97 per cent is is oceans and only 3 per cent is fresh water. Fresh water habitats are called as limnetic and the study of fresh water environment is '**Limnology'.** Aquatic environment includes ground water, acid mine waters, sewage lagoons and other aquatic habitats.

4.2.1. Aquatic ecosystem

Although aquatic ecosystems such as streams and lakes are generally stable, they are sensitive to disruption form human activity. A diagram of an aquatic system is shown in Figure 2.4. Most desirable organisms, from the fish down to the microscopic plankton and bacteria need oxygen to survive.

In studying the health or quality of a stream or lake, ecologists may use a formula to compute a diversity index for the ecosystem. In a field survey the number of different species is counted and the population of each species is estimated by sampling limited areas. These data are used in the diversity index formula, and a single number or index is determined to characterize the condition of the ecosystem.

Generally, a low diversity index is indicative of a polluted ecosystem, and the pollution-tolerant species are readily identified. In a clean stream, for example, many different species of fish may be found, including trout. But in a polluted stream, only a few species of more tolerant organisms, such as catfish, may be found.

It is important to realize that even healthy or well-balanced ecosystems change over time in a process called natural succession. For example, a lake will eventually become shallower as silt and organic material accumulate in bottom sediments. As time goes on, the lake will eventually turn into a marsh and finally a meadow. Although the lake, marsh, and meadow may be stable and healthy ecosystems during their individual lifetimes, natural geological and biological processes will cause the succession from one stage to another. If geological and weather conditions are suitable, the process of natural succession will continue until a climax stage is reached. For example, the meadow, once a lake, will eventually become a hardwood forest in many temperate ecosystems. Natural succession, though, takes place over very long periods of time, and the changes are not ordinarily visible during a human life span.

4.2.2. Hydrology

Hydrology is the science and study of water, including its physical and chemical properties and its occurrence on earth. It includes the study of rainfall, snow accumulation and melt, water movement over and through the soil, the flow of water in saturated, underground geologic materials (groundwater), the flow of water in channels (called stream flow), evaporation and transpiration, and the physical, chemical and biological characteristics of water. Solving problems concerned with water excesses, flooding, water shortages and water pollution are in the domain of hydrologists. With increasing concern about water pollution and it effects on human and on aquatic ecosystems, the practices of hydrology has expanded into the study and management of chemical and biological characteristics of water.

4.2.3. Hydrological cycle

The natural circulation of water on earth is called the hydrologic cycle. Water cycle from bodies of water, via evaporation to the atmosphere, and eventually returns to the oceans as precipitation, runoff from streams and rivers, and groundwater flow. Water molecules are transformed from liquid to vapor and back to liquid within this cycle. On land, water evaporates from the soil or is taken up by plant roots and eventually transpired into the atmosphere through plant leaves. The sum of evaporation and transpiration is called evapotranspiration.

Water is recycled continuously. The molecules of water in a glass is used to quench our thirst today, at some point in time may have dissolved minerals deep in the earth as groundwater flow, fallen as rain in a tropical typhoon, been transpired by a tropical plant, been temporarily stored in a mountain glacier, or quenched the thirst of people thousands of years ago.

The hydrologic cycle has no real beginning or end but is a circulation of water that is sustained by solar energy and influenced by the force of gravity. Because the supply of water on earth is fixed, there is no net gain or loss of water over time. On an average annual basis, global evaporation must equal global precipitation. Likewise, for any body of land or water, changes in storage must equal the total inflow minus the total outflow of water. This is the hydrologic or water balance.

At any point in time, water on earth is either in active circulation or in storage. Water is stored in icecaps, soil, groundwater, the oceans, and other bodies of water. Much of this water is only temporarily stored. The residence time of water storage in the atmosphere is several days and is only about 0.04 per cent of the total freshwater on earth. For rivers and streams, residence time is weeks; for lakes and reservoirs, several years, for groundwater, hundreds to thousands of years; for oceans, thousands of years; and for icecaps, tens of thousands of years. As the driving force of the hydrologic cycle, solar radiation provides the energy necessary to evaporate water from the earth's surface, almost three-quarters of which is covered by water. Nearly 86 per cent of global precipitation originates from ocean evaporation. Energy consumed by the conversion of liquid water to vapor cools the temperature of the evaporating surface. This same energy, the latent heat of vaporization, is released when water vapor changes back to liquid. In this way, the hydrologic cycle globally redistributes heat energy as well as water.

Understanding processes of the hydrologic cycle can help us develop solutions to water problems. The implications of global warming or greenhouse effects on the hydrologic cycle raise several questions. The possible changes in frequency and occurrence of droughts and floods are of major concern, particularly given projections of population growth. The hydrologic cycle influences nutrient cycling of ecosystem, processes of soil erosion and transport of sediment, and the transport of pollutants. Water is an excellent liquid solvent; minerals, salts, and nutrients become dissolved and transported by water flow. The hydrologic cycle is an important driving mechanism of nutrient cycling. As a transporting agent, water moves minerals and nutrients to plant roots. As plants die and decay, water leaches out nutrients and carries them downstream. The physical action of rainfall on soil surfaces and the forces of running water can seriously erode soils and transport sediments downstream. Any minerals, nutrients, and pollutants within the soil are likewise transported by water flow into groundwater, streams, lakes, or estuaries.

4.3. Atmosphere

The atmosphere is the envelope of gas surrounding the earth which is for the most part permanently bound to the earth by the gravitational field. It is composed primarily of nitrogen (78 pr cent by volume) and oxygen (21 per cent). There are also small amounts of argon, carbon dioxide, and water vapor, as well as trace amounts of other gases and particulate matter.

Trace components of the atmosphere can be very important of atmospheric functions. Ozone amounts on average for 2 parts per million of the atmosphere but is more concentrated in the stratosphere. This stratospheric ozone is critical to the existence of terrestrial life on the planet. Particulate matter is another important trace component. Aerosol loading of the atmosphere, as well as changes in the tiny carbon dioxide component of the atmosphere, can be responsible for significant changes in climate.

The composition of the atmosphere changes over time and space. Outside of water vapor (which can vary from 0-4 per cent in the local atmosphere) the concentrations of the major components varies little in time. Above 31 miles (50 km) from sea level, however, the relative proportions of component

gases change significantly. As a result, the atmosphere is divided into two compositional components: below 31 miles (50 km) is the homosphere and above 31 miles (50 km) is the heterosphere.

The atmosphere is also divided according to its thermal behaviour. By this criteria, the atmosphere can be divided into several layers. The bottom layer is the *troposphere*, it contains most of the atmosphere and is the domain of weather. The predominant gases in troposphere are nitrogen and oxygen. Troposphere usually interfaces both lithosphere and hydrosphere. The air-lithosphere interface is called 'soil atmosphere' and air-hydrosphere interface as 'neuston'. Troposphere is characterized by steady decrease in temperature with altitude, $0.6^{o}C$ for every 100 m. Above the troposphere is a stable layer called the stratosphere. This layer is important because it contains much of the ozone which filters ultraviolet light out of the incident solar radiation. In this region, ozone molecules (O_3) absorb UV rays from sun and decompose into molecular oxygen and single oxygen atoms, (O_3 UV O_2 + O). Ozone layer protects the earth from UV radiation. The next layer is the *mesosphere*, which is less stable. Finally, there is the thermosphere, this is another very stable zone, but its contents are barley dense enough to cause a visible degree of solar radiation scattering. Microbes found above troposphere are killed due to high intensities of light and the presence of ozone, a strong oxidizing agent. Hence, generally no microbial cells are encountered above troposphere

4.4. Ecosystem biomes

A large easily recognizable terrestrial ecosystem characterized by distinctive kinds of plants and animals and maintained by a distinct climate and soil conditions is known as **biome**. In a given biome the life form of the climax is uniform, and is the key to recognition. Thus, the dominant climax vegetation in the grassland biome is grass, although the species of dominant grasses will vary in different geographical regions where the grassland biome occurs.

The desert biome is characterized by low annual rainfall and high rates of evaporation, resulting in dry environmental conditions. Plants and animals that thrive in such conditions include cacti, lizards, insects, and small rodents. Special adaptations, such as waxy plant leaves, allow organisms to survive under low moisture conditions. Other examples of biomes include tropical rain forest, arctic tundra, grasslands, temperate deciduous forest, coniferous forest, tropical savanna and Mediterranean chaparral.

The distribution of six major biomes in relation to temperature and rainfall is shown in Figure 2.3. If we check the mean annual temperature and rainfall of our locality we can determine from Figure 2.3, which biomes we live in, even if we are now sitting in the middle of a city with no climax vegetation anywhere around. Several other biomes (not shown Figure), such as chaparral, tropical savanna, thorn shrub, and tropical monsoon forests are related to seasonal distribution of rainfall rather than annual means.

For the past 6 years most nations of the world have taken part in what is known as the "International Biological Program" involving governmental grant support for interdisciplinary team research and systems modeling of major biomes.

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.

a) 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.

b) 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.

c) 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.

d) 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 PO_4-P per day is released through urine and faces by an average person, Phosphatic detergents in sewage are also important contributor of phosphorus.

e) 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.

f) 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.

g) 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 NO_3, SO_4^{-2} and CO_2 into N_2, NH_4^+, H_2S and CH_4 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.

GLOBAL AIR POLLUTION

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.**

Global warming

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 CO_2 concentration, the thick layer of the gas prevents the heat from being reradiated out. This thick CO_2 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 CO_2 concentration was 280 ppm, today it is 408 ppm and by the year 2040 it is expected to reach 450 ppm. Certain gases in the atmosphere, known as 'green house' gases like NO, CO_2, CH_4 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 $0.5^{o}C$ ($1^{O}F$) since the end of the 19^{th} 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.

Greenhouse Gases

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 (CO_2)** 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.

Potential impacts of global warming

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 $4^{2o}C$ ($7.5^{o}F$) 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 20^{th} century, with most of the rise occurring since 1930. Some scientists believe that, because of global warming, average sea levels may rise 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.

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.

Methane emission and Mitigation options

Methane is second in importance to CO_2 as a greenhouse gas. Continued increase in atmospheric CH_4 is likely to contribute more to future climatic change than any other gas except CO_2. Rice paddies are an important man-made ecosystem for the global CH_4 budget. Worldwide, about 80 million ha of rice is grown under irrigated condition. Though the irrigated rice is the largest source of CH_4, it is also considered as the most promising target for mitigating CH_4 emissions. To reduce the global warming effects and to minimize the climate changes, emission from all anthropogenic sources including rice fields have to be mitigated. CH_4 is produced in the predominantly anaerobic bulk soil layers. The various controls of CH_4 emission from this ecosystem depend on the structure of plant and microbial communities and their interactions within the physical and chemical limits of soil environments.

Large number of studies from various countries indicated the possibility of substantial reductions in methane emissions from actual field situations. The options available differ from the practices that are followed which include management of the crop, soil and irrigation requirements, varietal choice, and agrochemical usage. The options that are available towards the reduction of methane emission largely depend upon the situations and component factors. Mitigation options are broadly related to:

a) Cultural practices
b) Field management
c) Plant related
d) Agrochemical application
e) Organic residue management
f) Irrigation schedules
g) Crop protection and
h) Microbial manipulations.

Mid-season drainage substantially reduces methane emissions by about 30-50% as compared to continuous flooding or water logging. The practice of intermittent irrigation or cycles of alternate flooding and drying as occur in rain fed rice situations led to significant reductions in the methane emissions from rice fields. Emissions are low in soils with higher percolation rates. Application of rice straw, which undergoes aerobic decomposition during winter crop season greatly reduces the subsequent methane emission. Rice straw and possibly green manure application at a suitable application time not only sustains soil fertility but also prevents the emission of large amounts of methane.

Use of sulphate fertilizers has been suggested as a way to reduce methane emissions by increasing the size of the soil pool of alternative electron acceptors. Several pesticides are reported to have influence on methane production in soils systems. Though these agrochemicals are applied to the system as plant protection measures, studies indicate their role in mitigating the methane production and its resultant emission. Compounds like carbofuran, hexachlorocyclo- hexane, butachlor etc are known to reduce methane production. Also some of the nitrification inhibitors have been shown to have potential to reduce methane emissions. Methane emission from rice fields and the possible mitigation options should be evaluated within the perspective of overall context of rice cultivation of the region and ecosystem. The practices, depending upon their suitability and adoption, should be an integral part of the rice production system. This would, in the long run, serve to protect the environment through reduced emission and as well improve the crop yield.

Acid deposition/Acid rain

Since the early 1970s, problems associated with acidic precipitation have gained world wide attention. Acid rain as it is also called, is believed to 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 vapour in the air to form sulfuric acid; nitrogen dioxide reacts with water vapour 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. Contributions of these gases from natural sources, such as 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.

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, H_2S 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 10^{39} 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

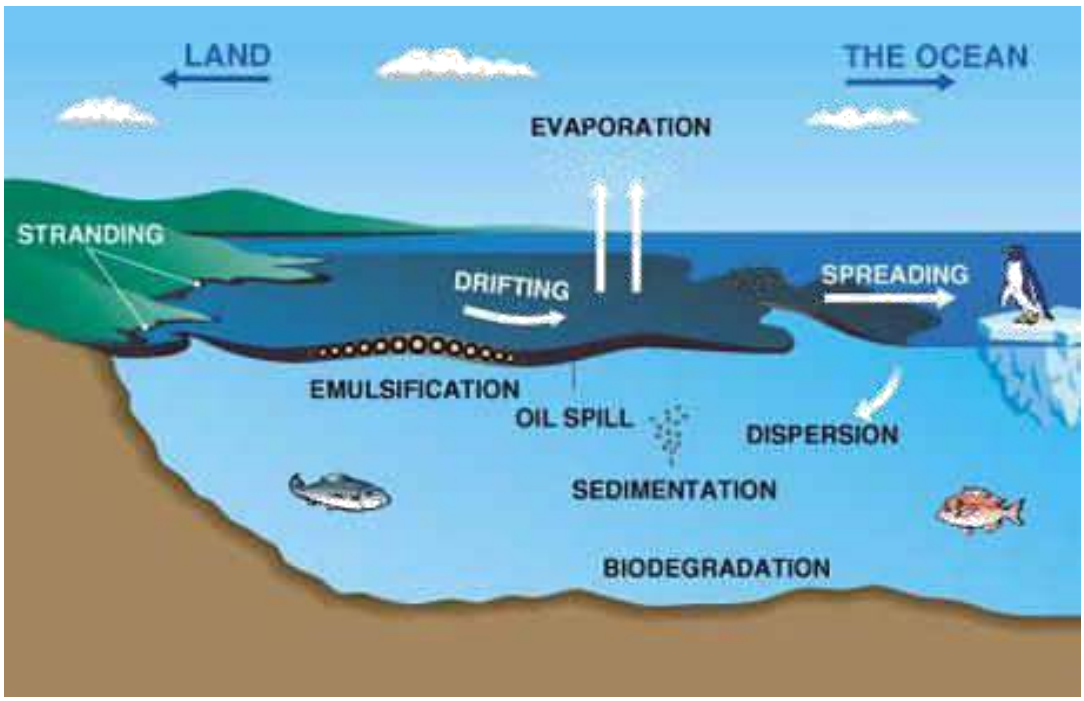
These pollutants comes from various sources. The Marine pollution may also off natural origin.

Sources of pollutants

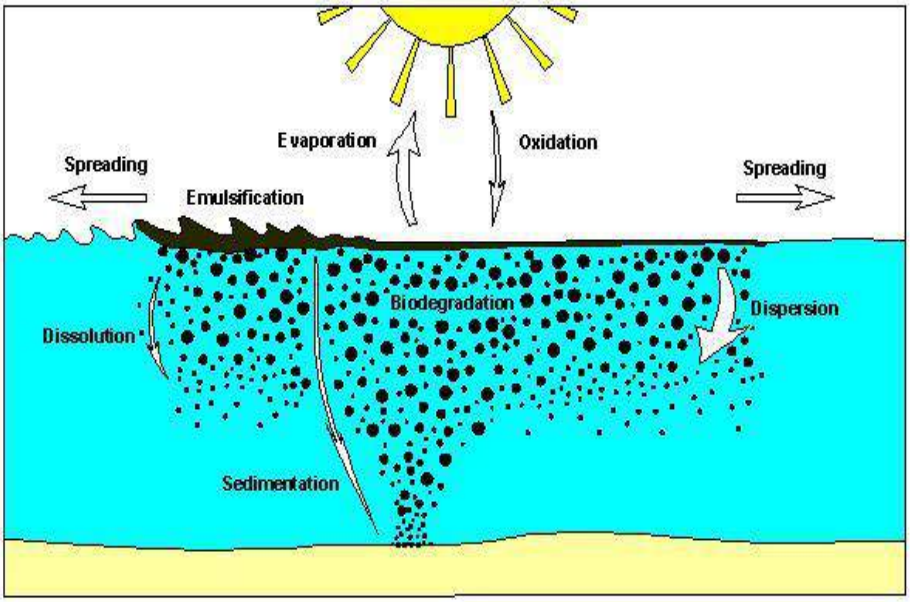
- Marine commerce
- Industry
- Electircal Power generation
- Sewage treatment
- Other Non Industrial Wastes
- Recreation
- Construction

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

Behaviour 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

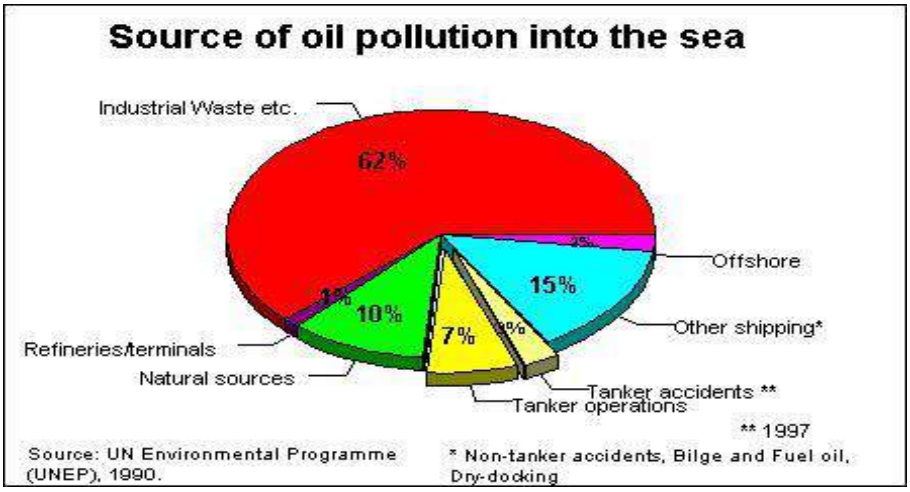
As ballast tanks take up valuable space, additional ballast is sometimes carried in empty fuel tnaks. While being pumped overboard it carries into the sea. Individually, the quantity of oil released may be small, but it sometimes becomes a considerable amount when all the shipping operations are taken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

Organizations and Agencies for Environmental Protection

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.

1. 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 Protein Agency (EPA). This is an independent Federal Agency of the U.S. Government established in 1970. It deals with protection of environment by air, water, solid wastes, 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 16^{th} 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.

2. 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.

2.1. 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.

Pollution and Pollutant

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 defined as 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 and cultural assets.

The pollution control board defined pollution as unfavourable alteration of our surrounding, largely as a by-product of human activities.

The pollution may be due to human activities or natural ecosystems. Natural pollution contaminates the air by storms, forest fire, volcanoes and natural processes (methane from marshy lands). Nature by and large treats, recycles and makes good use of the pollutants and renders them less harmful, whereas man-made pollutants threaten the integrity of the nature. 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.

The substances, which cause pollution, are called pollutants. Pollutant is defined as any substance that is released intentionally or inadvertently by man into the environment in such a concentration that may have adverse effect on environmental health. Environment Protection Act, 1986 (EPA, 1986) defines pollutant, as any solid, liquid or gaseous substance present in such a concentration as may be, or tend to be, injurious to environment.

Environmental Pollutants

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

(1) Deposited matter – soot, smoke, tar, dust, grit etc.
(2) Gases – Oxides of nitrogen (NO, NO_2), sulphur (SO_2), carbon monoxide, halogens, (chlorine, bromine, iodine),
(3) Acids droplets – sulphruric, acid nitric acid etc.
(4) Fluorides
(5) Metals – Mercury, lead, iron, zinc, nickel, tin, cadmium, chromium etc.
(6) Agrochemicals – Biocides (pesticides, herbicides, fungicides, nematicides, bactericides, weedicides etc), and fertilizers.
(7) Complex organic substances – Benzene, ether, acetic acid, benzopyrenes etc.
(8) Photochemical oxidants – Photochemical smog, ozone, peroxyacetyl nitrate (PAN), peroxybenzoil nitrate (PBzN), nitrogen oxides, aldehydes, ethylene etc.
(9) Solid wastes
(10) Radioactive waste
(11) Noise

Types of pollution

The various types of pollution are classified based on the environment, based on sources of pollutant or nature of pollutants. Soil pollution, water pollution, air pollution, are the three major types of pollution based on environment. Based on sources of pollutants, they are classified as automobile pollution, agricultural pollution and industrial pollution (tanneries, nuclear power plants, chemical industries, etc.). Based on nature of pollutants, pollution is classified as pesticide pollution, plastic pollution, heavy metal pollution, radiation pollution, oil pollution, sewage 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).

(iii) It helps in bringing sustainable development and continued economic develop

(iv) Knowledge of environmental studies is a must for conservation of life biodiversity of our earth.

(v) In our ecosystem environmental problems are of very recent origin. Therefor knowledge of the subject 'environmental studies' help people to understand the effects of any recent environmental problems and to counter these problems

(vi) It creates an awareness among the people about the importance of soun utilization and conservation of the resources.

(vii) It provides every person with the opportunities to acquire knowledge, values, attitude and commitment to protect, improve and conserve the environment for benefit of themselves.

(viii) It examines major environmental issues in National and International level a creates so a new dimensions of behaviour of individuals and society as a w towards a better environment.

M.C.Q.

1. The earliest continent was :
(a) Gondwanaland ☐ (b) Pangaea ☐ (c) Laurasia ☐

2. The lowest layer of the atmosphere is :
(a) Ionosphere ☐ (b) Troposphere ☐ (c) Stratosphere ☐

3. Earth originated approximately
(a) 10 billion years back ☐ (b) 5 billion years back ☐ (c) 2 billion years ba

4. Water of the oceans comprises :
(a) 63 per cent of the total water of earth ☐
(b) 73 per cent of the total water of earth ☐
(c) 93 per cent of the total water of earth ☐

5. The earliest traces of life on earth have been found about
(a) 2·5 billion years ago ☐ (b) 3·5 billion years ago ☐
(c) 4·5 billion years ago ☐

6. The region where life is found on earth is called
(a) Atmosphere ☐ (b) Hydrosphere ☐ (c) Biosphere ☐

7. Biosphere is made of
(a) Atmosphere ☐ (b) Lithosphere ☐
(c) Hydrosphere ☐ (d) All of them ☐

8. Biosphere which accommodates plants and organisms consists of
(a) Lithosphere ☐ (b) Hydrosphere ☐ (c) Atmosphere ☐

9. The part of atmosphere where temperature increases with increasing altitude is
(a) Stratosphere and Thermosphere ☐ (b) Troposphere ☐ (c) Mesosphere ☐

10. What is the name of the super continent which broke into the present day continents?
(a) Pampas ☐ (b) Palaearctic ☐ (c) Pangaea ☐

11. World environment day is celebrated on
(a) 5th September ☐ (b) 5th November ☐ (c) 5th June ☐

12. Much of the atmospheric air is present in the
(a) Stratosphere ☐ (b) Mesosphere ☐ (c) Troposphere ☐

13. 22nd April is celebrated as
(a) Earth Day ☐ (b) Biodiversity Day ☐ (c) Wetland Day ☐

14. The net amount of solar energy on the earth's surface is about :
(a) 0·9 kw/m² (0·9 kilowatt per square meter) ☐
(b) 0·8 kw/m² (0·8 kilowatt per square meter) ☐
(c) 0·7 kw/m² (0·7 kilowatt per square meter) ☐

15. Hydrosphere on the globe covers nearly :
(a) 351,059,200 sq.km. ☐ (b) 361,059,200 sq. km. ☐
(c) 164,060,200 sq. km. ☐

16. The total mass *ot* the atmosphere is approximately :
(a) $6{\cdot}2\times10^{2}$ tonnes ☐ (b) $6{\cdot}2\times10^{12}$ tonnes ☐ (c) $5{\cdot}2\times10^{15}$ tonnes ☐

17. The mean temperature of Earth is approximately
(a) 10°C ☐ (b) 15°C ☐ (c) 20°C ☐

18. Earth is a
(a) Planet ☐ (b) Galaxy ☐ (c) Star ☐

19. Ozone layer is found in
(a) Troposphere ☐ (b) Stratosphere ☐ (c) Ionosphere ☐

20. Which of the following layers of the atmosphere has the lowest temperature?
(a) Mesosphere ☐ (b) Troposphere ☐ (c) Stratosphere ☐

21. Lithosphere means
(a) Layer of gases ☐ (b) Layer of sands ☐ (c) Layer of gravels

22. No. of species present on the earth is about
(a) 1·4 crores ☐ (b) 1·7 crores ☐ (c) 2·7 crores ☐

23. No. of species which have been identified are
(a) 19·5 Lakhs ☐ (b) 17·5 Lakhs ☐ (c) 18·5 Lakhs ☐

ANSWER

1.(b) Pangaea, 2.(b) Troposphere, 3.(b) 5 billion years back, 4.(b) 73 per cent
total water of earth, 5.(b) 3·5 billion years ago, 6.(c) Biosphere, 7.(d) All
8.(a) Lithosphere, 9.(a) Stratosphere and Thermosphere, 10.(c) Pangaea, 11.
June, 12.(c) Troposphere, 13.(a) Earth Day, 14.(a) 0·9 kw/m^2 (0·9 kilowatt per
meter), 15.(b) 361,059,200 sq. km., 16.(c) $5{\cdot}2 \times 10^{15}$ tonnes, 17.(b) 15°C, 18.(a)
19.(b) Stratosphere, 20.(b) Troposphere, 21.(c) Layer of gravels, 22.(a) 1
23.(b) 17·5 Lakhs.

(ঘ) **জীবের অভিযোজন :** কোনো নির্দিষ্ট ভৌত পরিবেশে টিকে থাকার জন্য জীবের কী-ধরনের অভিযোজন হয়েছে তা পরিবেশ বিজ্ঞান পাঠের মাধ্যমে জানা যায়।

(ঙ) **জীববৈচিত্র্য সম্পর্কে ধারণা :** পরিবেশ বিজ্ঞান পাঠের মাধ্যমে কোনো ভৌগোলিক অঞ্চলে কত ধরনের প্রজাতির বসতি রয়েছে কিংবা কীরূপ জীববৈচিত্র্য অবস্থান করছে, সেইসব বিষয়ে বিস্তারিত তথ্য পাওয়া যায়।

প্রশ্নোত্তর পর্ব

▶ বহুবিকল্পভিত্তিক প্রশ্নোত্তর (MCQ) প্রশ্নমান 1

♦ সঠিক উত্তরটি নির্বাচন করো :

	প্রশ্ন	উত্তর
1.	'পরিবেশ' শব্দটির উৎপত্তিগত অর্থ হল— a. প্রবাহ b. পারিপার্শ্বিক c. আধার d. আবর্তন	b. পারিপার্শ্বিক।
2.	আর্মস-এর লেখা 'এনভায়রনমেন্ট সায়েন্স' গ্রন্থটি প্রকাশিত হয়— a. 1994 খ্রিস্টাব্দে b. 1995 খ্রিস্টাব্দে c. 1999 খ্রিস্টাব্দে d. 1994 খ্রিস্টাব্দে	a. 1994 খ্রিস্টাব্দে।
3.	নিম্নলিখিত বিষয়গুলির মধ্যে ভৌত পরিবেশের অন্তর্ভুক্ত নয়— a. বায়ুমণ্ডল b. বারিমণ্ডল c. শিলামণ্ডল d. সৌরমণ্ডল	d. সৌরমণ্ডল।
4.	বায়ুমণ্ডলের সর্বাধিক গ্যাসীয় উপাদানটি হল— a. নাইট্রোজেন b. অক্সিজেন c. কার্বন ডাই-অক্সাইড d. হাইড্রোজেন	a. নাইট্রোজেন।
5.	বায়ুমণ্ডলে উপস্থিত গ্যাসীয় উপাদানগুলির মধ্যে নাইট্রোজেনের পরিমাণ প্রায়— a. 20 শতাংশ b. 40 শতাংশ c. 72 শতাংশ d. 78 শতাংশ	d. 78 শতাংশ।
6.	বায়ুমণ্ডলে উপস্থিত গ্যাসীয় উপাদানগুলির মধ্যে অক্সিজেনের পরিমাণ প্রায়— a. 20·6 শতাংশ b. 25·1 শতাংশ c. 30·2 শতাংশ d. 35·1 শতাংশ	c. 20·6 শতাংশ।

	প্রশ্ন	উত্তর
7.	বায়ুমণ্ডলে উপস্থিত গ্যাসীয় উপাদানগুলির মধ্যে কার্বন ডাই-অক্সাইড-এর পরিমাণ প্রায়— a. 20·6 শতাংশ b. 1·4 শতাংশ c. 0·53 শতাংশ d. 0·03 শতাংশ	d. 0·03 শতাংশ।
8.	বায়ুতে উপস্থিত গ্যাসীয় উপাদানগুলির মধ্যে নিষ্ক্রিয় গ্যাসের পরিমাণ প্রায়— a. 0·003 শতাংশ b. 0·94 শতাংশ c. 1·40 শতাংশ d. 7·16 কিমি	a. 0·003 শতাংশ।
9.	ভূপৃষ্ঠ থেকে ওপরের দিকে সমমণ্ডল বিস্তৃত প্রায়— a. 20 কিমি পর্যন্ত b. 50 কিমি পর্যন্ত c. 88 কিমি পর্যন্ত d. 120 কিমি পর্যন্ত	c. 88 কিমি পর্যন্ত।
10.	বায়ুমণ্ডলে প্রাপ্ত বিভিন্ন উপাদানগুলির প্রায় 97% ভূপৃষ্ঠ থেকে— a. 3 কিমি উচ্চতার মধ্যে থাকে b. 9 কিমি উচ্চতার মধ্যে থাকে c. 29 কিমি উচ্চতার মধ্যে থাকে d. 18 কিমি উচ্চতার মধ্যে থাকে	c. 29 কিমি উচ্চতার মধ্যে থাকে।
11.	বায়ুমণ্ডলের সর্বশেষ সীমাটি— a. 500 কিমি উচ্চতা পর্যন্ত বিস্তৃত b. 5,000 কিমি উচ্চতা পর্যন্ত বিস্তৃত c. 10,000 কিমি উচ্চতা পর্যন্ত বিস্তৃত d. 15,000 কিমি উচ্চতা পর্যন্ত বিস্তৃত	c. 10,000 কিমি উচ্চতা পর্যন্ত বিস্তৃত।
12.	বায়ুমণ্ডলের ভূপৃষ্ঠ সংলগ্ন স্তরটির নাম— a. ট্রপোস্ফিয়ার b. স্ট্র্যাটোস্ফিয়ার c. মেসোস্ফিয়ার d. থার্মোস্ফিয়ার	a. ট্রপোস্ফিয়ার।
13.	বায়ুমণ্ডলের প্রতি 1000 মিটার উচ্চতায় উষ্ণতা হ্রাসের স্বাভাবিক হার হল— a. 4·56° সেন্টিগ্রেড b. 5·45° সেন্টিগ্রেড c. 6·45° সেন্টিগ্রেড d. 7·65° সেন্টিগ্রেড	c. 6·45° সেন্টিগ্রেড।
14.	উষ্ণতার স্বাভাবিক হ্রাসের হার লক্ষ করা যায়— a. মেসোস্ফিয়ারে b. স্ট্র্যাটোস্ফিয়ারে c. আয়নোস্ফিয়ারে d. ট্রপোস্ফিয়ারে	d. ট্রপোস্ফিয়ারে।

	প্রশ্ন	উত্তর
15.	ট্রপোস্ফিয়ারের শেষ সীমায় অবস্থিত স্তরটি হল— a. ট্রপোপজ b. স্ট্র্যাটোপজ c. মেসোপজ d. থার্মোপজ	a. ট্রপোপজ।
16.	নিরক্ষীয় অঞ্চলে ভূপৃষ্ঠ থেকে ওপরের দিকে ট্রপোস্ফিয়ারের বিস্তৃতি— a. 15 কিমি পর্যন্ত b. 18 কিমি পর্যন্ত c. 20 কিমি পর্যন্ত d. 25 কিমি পর্যন্ত	b. 18 কিমি পর্যন্ত।
17.	মেরু সংলগ্ন অঞ্চলে ভূপৃষ্ঠ থেকে ওপরের দিকে ট্রপোস্ফিয়ারের বিস্তৃতি প্রায়— a. 9 কিমি b. 15 কিমি c. 18 কিমি d. 20 কিমি	a. 9 কিমি।
18.	ট্রপোপজের বিস্তৃতি প্রায়— a. 1 কিমি b. 3 কিমি c. 5 কিমি d. 9 কিমি	b. 3 কিমি।
19.	বৈপরীত্য উত্তাপ বায়ুমণ্ডলের যে স্তরটিতে লক্ষ করা যায়, তা হল— a. ট্রপোস্ফিয়ার b. স্ট্র্যাটোস্ফিয়ার c. মেসোস্ফিয়ার d. থার্মোস্ফিয়ার	b. স্ট্র্যাটোস্ফিয়ার।
20.	বায়ুমণ্ডলের যে স্তরটির মধ্য দিয়ে জেট বিমান চলাচল করে তা হল— a. ট্রপোস্ফিয়ার b. স্ট্র্যাটোস্ফিয়ার c. মেসোস্ফিয়ার d. থার্মোস্ফিয়ার	b. স্ট্র্যাটোস্ফিয়ার।
21.	ওজোনস্তরটি বায়ুমণ্ডলের যে স্তরটিতে লক্ষ করা যায়, তা হল— a. ট্রপোস্ফিয়ার b. স্ট্র্যাটোস্ফিয়ার c. মেসোস্ফিয়ার d. থার্মোস্ফিয়ার	b. স্ট্র্যাটোস্ফিয়ার।
22.	স্ট্র্যাটোস্ফিয়ারের শেষ সীমাটির নাম হল— a. ট্রপোপজ b. স্ট্র্যাটোপজ c. মেসোপজ d. থার্মোপজ	b. স্ট্র্যাটোপজ।

	প্রশ্ন	উত্তর
23.	মহাকাশ থেকে আসা উল্কাপিণ্ড বায়ুমণ্ডলের যে স্তরে এসে পুড়ে ছাই হয়ে যায়, তা হল— a. ট্রপোস্ফিয়ার b. স্ট্র্যাটোস্ফিয়ার c. মেসোস্ফিয়ার d. থার্মোস্ফিয়ার	c. মেসোস্ফিয়ার।
24.	বেতারতরঙ্গ বায়ুমণ্ডলের যে স্তর থেকে প্রতিফলিত হয়, সেটি হল— a. আয়নমণ্ডল b. ম্যাগনেটোস্ফিয়ার c. ওজোনস্তর d. বিষমমণ্ডল	d. আয়নমণ্ডল।
25.	সুমেরু এবং কুমেরু প্রভা বায়ুমণ্ডলের যে স্তরটিতে দেখা যায়, সেটি হল— a. আয়নোস্ফিয়ার b. ম্যাগনেটোস্ফিয়ার c. ওজোনস্তর d. বিষমমণ্ডল	a. আয়নোস্ফিয়ার।
26.	মেসোস্ফিয়ারের শেষ সীমাটির নাম হল— a. মেসোপজ b. স্ট্র্যাটোপজ c. ট্রপোপজ d. থার্মোপজ	b. মেসোপজ।
27.	বায়ুমণ্ডলের উষ্ণতম স্তরটি হল— a. ট্রপোস্ফিয়ার b. স্ট্র্যাটোস্ফিয়ার c. মেসোস্ফিয়ার d. থার্মোস্ফিয়ার	d. থার্মোস্ফিয়ার।
28.	ওজোন গ্যাসের রং— a. হলুদ b. নীলাভ c. সাদা d. লাল	b. নীলাভ।
29.	অতিবেগুনি রশ্মির প্রভাবে ওজোন ভেঙে তৈরি হয়— a. হাইড্রোজেন পরমাণু b. অক্সিজেন অণু ও পরমাণু c. নাইট্রোজেন অণু d. কার্বন ডাই-অক্সাইড ও পরমাণু	b. অক্সিজেন অণু ও পরমাণু।
30.	যে মৌলিক পদার্থটি শিলামণ্ডলে বেশি পাওয়া যায়, তার নাম হল— a. অক্সিজেন c. সিলিকা b. কার্বন d. লৌহ	a. অক্সিজেন।

	প্রশ্ন	উত্তর
31.	সিয়াল ও সিমাকে যে বিযুক্তি তল পৃথক করেছে, সেটি হল— a. কনরাড বিযুক্তি b. মোহ বিযুক্তি c. গুটেনবার্গ বিযুক্তি d. লেম্যান বিযুক্তি	a. কনরাড বিযুক্তি।
32.	ভূত্বক ও গুরুমণ্ডলকে যে বিযুক্তি তল পৃথক করেছে, সেটি হল— a. কনরাড বিযুক্তি b. মোহ বিযুক্তি c. গুটেনবার্গ বিযুক্তি d. লেম্যান বিযুক্তি	b. মোহ বিযুক্তি।
33.	কেন্দ্রমণ্ডল ও গরুমণ্ডলকে যে বিযুক্তিরেখা আলাদা করেছে, সেটি হল— a. কনরাড বিযুক্তি b. মোহ বিযুক্তি c. উইশার্ট গুটেনবার্গ বিযুক্তি d. লেম্যান বিযুক্তি	c. উইশার্ট গুটেনবার্গ বিযুক্তি।
34.	অন্তঃকেন্দ্রমণ্ডল ও বহিঃকেন্দ্রমণ্ডলকে যে বিযুক্তি তল পৃথক করেছে, সেটি হল— a. কনরাড বিযুক্তি b. মোহ বিযুক্তি c. গুটেনবার্গ বিযুক্তি d. লেম্যান বিযুক্তি	d. লেম্যান বিযুক্তি।
35.	ভূপৃষ্ঠ থেকে সিয়ালের গভীরতা প্রায়— a. 5-7 কিমি b. 20-25 কিমি c. 30-45 কিমি d. 70-80 কিমি	c. 30-45 কিমি।
36.	ভূত্বকে সিমার গভীরতা প্রায়— a. 5-7 কিমি b. 20-25 কিমি c. 30-45 কিমি d. 70-80 কিমি	a. 5-7 কিমি।
37.	শিলামণ্ডলের মৌলিক উপাদানগুলির মধ্যে অক্সিজেনের পরিমাণ— a. 46·6 শতাংশ b. 27·7 শতাংশ c. 5 শতাংশ d. 8·1 শতাংশ	a. 46·6 শতাংশ।
38.	শিলামণ্ডলের মৌলিক উপাদানগুলির মধ্যে সিলিকার পরিমাণ— a. 27·7 শতাংশ b. 46·6 শতাংশ c. 8·1 শতাংশ d. 5 শতাংশ	a. 27·7 শতাংশ।

	প্রশ্ন	উত্তর
39.	শিলামণ্ডলের মৌলিক উপাদানগুলির মধ্যে অ্যালুমিনিয়ামের পরিমাণ— a. 27·7 শতাংশ b. 46·6 শতাংশ c. 8·1 শতাংশ d. 5 শতাংশ	c. 8·1 শতাংশ।
40.	শিলামণ্ডলের মৌলিক উপাদানগুলির মধ্যে লৌহের পরিমাণ— a. 5 শতাংশ b. 46·6 শতাংশ c. 8·1 শতাংশ d. 27·7 শতাংশ	a. 5 শতাংশ।
41.	উইশার্ট-গুটেনবার্গ বিযুক্তি ভূ-অভ্যন্তরের যে গভীরতায় অবস্থিত, সেটি হল— a. 1000 কিমি b. 2,900 কিমি c. 3,500 কিমি d. 4,000 কিমি	b. 2,900 কিমি।
42.	সমুদ্রজলে খনিজ লবণগুলির মধ্যে সবচেয়ে বেশি যে খনিজ লবণটি পাওয়া যায়, সেটি হল— a. সোডিয়াম ক্লোরাইড ($NaCl$) b. ম্যাগনেসিয়াম ক্লোরাইড ($MgCl_2$) c. সোডিয়াম সালফেট (Na_2SO_4) d. ক্যালসিয়াম ক্লোরাইড ($CaCl_2$)	a. সোডিয়াম ক্লোরাইড ($NaCl$)।
43.	সমুদ্রজলে দ্রবীভূত লবণের পরিমাণ গড়ে— a. 20% b. 30% c. 35% d. 45%	c. 35%।
44.	প্রতি কিলোগ্রাম সমুদ্রজলে সোডিয়াম ক্লোরাইডের পরিমাণ— a. 10 গ্রাম b. 14 গ্রাম c. 15 গ্রাম d. 27 গ্রাম	d. 27 গ্রাম।
45.	বারিমণ্ডলীয় পরিবেশের প্রধান উপাদান হল— a. শিলামণ্ডল b. বায়ুচাপ c. সমুদ্রজল d. মৃত্তিকা	c. সমুদ্রজল।
46.	শিলামণ্ডলীয় পরিবেশের উপাদান হল— a. সমুদ্র b. ভূ-প্রকৃতি c. আবহাওয়া d. ভৌমজল	b. ভূ-প্রকৃতি।

	প্রশ্ন	উত্তর
47.	বায়ুমণ্ডলীয় পরিবেশের প্রধান উপাদান হল— a. উষ্ণতা b. মাটি c. ভৌমজল d. শিলা	a. উষ্ণতা।
48.	শিলামণ্ডলের সিলিকা ও অ্যালুমিনিয়াম সমৃদ্ধ স্তরকে বলা হয়— a. সিয়াল বা সায়াল b. সিমা c. নিফে d. কোর	a. সিয়াল বা সায়াল।
49.	শিলামণ্ডলের সিলিকা ও ম্যাগনেশিয়াম সমৃদ্ধ স্তরকে বলা হয়— a. সিয়াল b. সিমা c. কোর d. নিফে	d. সিমা।
50.	নিকেল ও লৌহসমৃদ্ধ স্তরটির নাম— a. সিয়াল b. সিমা c. কোর d. নিফে	d. নিফে।
51.	ভৌত পরিবেশের একটি সজীব উপাদানের নাম হল— a. জল b. মৃত্তিকা c. মানুষ d. শিলা	c. মানুষ।
52.	সমুদ্রপৃষ্ঠ থেকে যে গভীরতা পর্যন্ত জীবের কেন্দ্রীভবন ঘটেছে, তা হল— a. 200 মিটার b. 400 মিটার c. 600 মিটার d. 800 মিটার	d. 200 মিটার।
53.	সমুদ্রপৃষ্ঠ থেকে যে উচ্চতা পর্যন্ত জীবের সর্বাধিক সমাবেশ ঘটেছে, সেটি হল— a. 200 মিটার b. 300 মিটার c. 500 মিটার d. 700 মিটার	b. 300 মিটার।
54.	ভূত্বক, বারিমণ্ডল ও বায়ুমণ্ডলের যে অংশে জীবের সৃষ্টি, বৃদ্ধি ও অস্তিত্ব লক্ষ করা যায়, তাকে বলা হয়— a. শিলামণ্ডল b. বায়ুমণ্ডল c. বারিমণ্ডল d. জীবমণ্ডল	d. জীবমণ্ডল।

	প্রশ্ন	উত্তর
55.	মাটির নীচে যে গভীরতা পর্যন্ত জীবমণ্ডল বিস্তৃত, তা হল— a. 10 মিটার b. 20 মিটার c. 30 মিটার d. 40 মিটার	a. 10 মিটার।
56.	জীবমণ্ডলের বিভিন্ন উপাদানগুলির মধ্যে শিলামণ্ডল, বায়ুমণ্ডল ও বারিমণ্ডলকে এককথায় বলা হয়— a. সজীব উপাদান b. নির্জীব উপাদান c. জৈব উপাদান d. অজৈব উপাদান	d. অজৈব উপাদান।
57.	পৃথিবীতে প্রাপ্ত মোট জলের মধ্যে লবণাক্ত জলের পরিমাণ হল— a. 3 শতাংশ b. 50 শতাংশ c. 75 শতাংশ d. 97 শতাংশ	d. 97 শতাংশ।
58.	পৃথিবীতে প্রাপ্ত মোট জলের মধ্যে স্বাদু বা মিষ্টি জলের পরিমাণ হল শতকরা— a. 3 ভাগ b. 50 ভাগ c. 75 ভাগ d. 97 ভাগ	a. 3 ভাগ।
59.	ভৌত পরিবেশের প্রধানতম উপাদান হল— a. মৃত্তিকা b. উদ্ভিদ c. প্রাণী d. সংস্কৃতি	a. মৃত্তিকা।
60.	সামাজিক পরিবেশের অন্যতম উপাদান হল— a. উদ্ভিদ b. প্রাণী c. মৃত্তিকা d. সংস্কৃতি	d. সংস্কৃতি।
61.	জৈব পরিবেশের অন্যতম উপাদান হল— a. ধর্ম b. সংস্কৃতি c. উদ্ভিদ ও প্রাণীজগৎ d. কোনোটিই নয়	c. উদ্ভিদ ও প্রাণীজগৎ।
62.	জীবজগৎ ও পরিবেশের মধ্যে চক্রাকারে প্রয়োজনীয় মৌলিক উপাদানগুলির আবর্তনের প্রক্রিয়াকে বলা হয়— a. পুষ্টিচক্র b. শক্তিপ্রবাহ c. জৈব ভূ-রাসায়নিক চক্র d. জলচক্র	c. জৈব ভূ-রাসায়নিক চক্র।

	প্রশ্ন	উত্তর
63.	সজীব ও জড় উপাদানগুলি একত্রে যে পরিবেশ সৃষ্টি করে, তাকে বলা হয়— a. প্রাকৃতিক পরিবেশ b. সাংস্কৃতিক পরিবেশ c. সামাজিক পরিবেশ d. অপ্রাকৃতিক পরিবেশ	a. প্রাকৃতিক পরিবেশ।
64.	মানুষ দ্বারা তৈরি পরিবেশকে বলা হয়— a. প্রাকৃতিক পরিবেশ b. সামাজিক পরিবেশ c. ভৌত পরিবেশ d. অপ্রাকৃতিক পরিবেশ	b. সামাজিক পরিবেশ।
65.	পৃথিবীতে প্রাপ্ত মোট জলের মধ্যে সমুদ্রজলের পরিমাণ— a. 70·2% b. 99·2% c. 97·2% d. 90·2%	c. 97·2%।
66.	পৃথিবীতে প্রাপ্ত মোট জলের মধ্যে ভৌমজলের পরিমাণ— a. 42% b. 0·31% c. 0·81% d. 1·42%	b. 0·31%।
67.	মানুষ নির্মিত পরিবেশকে বলে— a. টেকনোস্ফিয়ার b. বায়োস্ফিয়ার c. হাইড্রোস্ফিয়ার d. ন্যানোস্ফিয়ার	a. টেকনোস্ফিয়ার
68.	বাস্তুতন্ত্রে শক্তি প্রবাহ আলোচনা প্রসঙ্গে বিজ্ঞানের যে দুটি শাখার ব্যবহার হয় সেগুলি হল— a. জীববিদ্যা ও পদার্থবিদ্যা b. সংখ্যাতত্ত্ব ও দর্শন c. ভূগোল ও আইনশাস্ত্র d. ওপরের কোনোটিই নয়	a. জীববিদ্যা ও পদার্থবিদ্যা।
69.	পরিবেশ আইন প্রনয়নের জন্য পরিবেশবিদ্যায় যে শাখাটির সাহায্য নেওয়া হয় সেটি হল— a. অর্থনীতি b. রসায়ন c. আইনশাস্ত্র d. পদার্থবিদ্যা	c. আইনশাস্ত্র।

	প্রশ্ন	উত্তর
70.	পরিবেশের মূল্যায়ন করার জন্য যে শাস্ত্রটির সাহায্য নেওয়া হয় সেটি হল— a. অর্থনীতি b. রসায়ন c. আইনশাস্ত্র d. পদার্থবিদ্যা	a. অর্থনীতি।
71.	পৃথিবীর আনুমানিক গড় বয়স হল— a. 100 কোটি বছর b. 200 কোটি বছর c. 460 কোটি বছর d. 800 কোটি বছর	c. 460 কোটি বছর।
72.	পৃথিবীতে মানুষের আবির্ভাব হয়েছে মোটামুটি— a. 10 লক্ষ বছর আগে b. 20 লক্ষ বছর আগে c. 40 লক্ষ বছর আগে d. 5 লক্ষ বছর আগে	b. 20 লক্ষ বছর আগে।
73.	বিশ্ব পরিবেশ দিবস পালন করা হয়— [বর্ধমান-2016, গৌরবঙ্গ-2015] a. 5 মে b. 5 জুন c. 5 সেপ্টেম্বর d. 10 ডিসেম্বর	b. 5 জুন।
74.	বায়োস্ফিয়ার বা জীবমণ্ডল শব্দটি প্রথম ব্যবহার করেন— [বর্ধমান-2017] a. ল্যামার্ক b. সুয়েস c. ভার্নাদস্কি d. হেকেল	b. সুয়েস।
75.	মানুষের পরিবেশ বলতে বোঝায়— [বর্ধমান-2016] a. পরিবেশের জৈব উপাদান b. পরিবেশের আর্থ-সামাজিক উপাদান c. পরিবেশের অজৈব উপাদান d. ওপরের সবকটি	d. ওপরের সবকটি।
76.	পৃথিবীর গভীরতম হ্রদটির নাম— [বর্ধমান-2016] a. টিটিকাকা হ্রদ b. বৈকাল হ্রদ c. কাসপিয়ান সাগর d. সুপিরিয়র হ্রদ	b. বৈকাল হ্রদ।
77.	পৃথিবীর বৃহত্তম হ্রদটির নাম হল— a. বৈকাল হ্রদ b. কাসপিয়ান সাগর c. সুপিরিয়র হ্রদ d. মিচিগান হ্রদ	b. কাসপিয়ান সাগর।

Unit 2: Natural Resources
Model Questions

1. Which of the following bacteria can fix nitrogen?
    a. **Azotobacter**
    b. Nitrobacter
    c. Nitrococcus
2. Free floating aquatic microscopic organisms are known as -
    a. **Phytoplankton**
    b. Necton
    c. Periphyton
3. Bhopal gas disaster was caused by the gas which gas ?
    a. **Methyl isocyanate**
    b. Methyl isocyanide
    c. Chlorofluorocarbon
4. Which of the following is not a micronutrient?
    a. Magnesium
    b. Molybdenum
    c. **Chromium**
5. Chipko movement is the resurgence of ecological concern and took place in -
    a. Kumaon
    b. **Tehri Garhwal**
    c. Himachal
6. The Silent Valley movement was organised by which group?
    a. Medha Patekar
    b. **Kerala Sasthra Sahithya Parishad**
    c. Sunderlal Bahuguna
7. Which organ is affected by silicosis?
    a. Heart
    b. **Lungs**
    c. Brain
8. Lotic water means..
    a. Lake water
    b. **Running water in rivers**
    c. Ocean water
9. Activated sludge is associated with…
    a. air purification process
    b. **wastewater treatment**
    c. solid waste treatment
10. Which one of the following is not related to acid rain..
    a. **Carbon monoxide**
11. Sulphur dioxide
    a. oxides of Nitrogen
12. SPM in air is measured by…
    a. **high volume sampler**
    b. Hygrometer

c. Barometer

13. The seismograph is used to measure the intensity of..
    a. Sea wave
    b. Cyclone
    c. Earthquake
14. Photosynthesis is a major component in..
    a. Carbon cycle
    b. Nitrogen cycle
    c. Sulphur cycle
15. Out of the following which disease is not caused by bacteria..
    a. Chicken pox
    b. Tuberculosis
    c. Leprosy
16. Sandfly is responsible for..
    a. Plague
    b. Amoebisis
    c. Kala Azar
17. The element responsible for Itai-Itai disease is..
    a. Mercury
    b. Arsenic
    c. Cadmium
18. What percentage of geographical area of a country should be under forest cover?
    a. 23%
    b. 33%
    c. 13%
19. Narmada bachao movement was organised by..
    a. Sunderlal Bahuguna
    b. Medha Patekar
    c. R.K. Pachauri
20. The Silent Valley movement occurred in..
    a. Uttarakhand
    b. Gujarat
    c. Kerala
21. Plants tolerant to Desert conditions are..
    a. Xerophytes
    b. Epiphyte
    c. Mesophyte
22. The RAMSAR site of West Bengal is..
    a. Sundarbans
    b. Rabindra sarobar
    c. East Kolkata wetland
23. The number of biodiversity hotspot in India are.
    a. 2
    b. 3
    c. 4.
24. Climatic phenomenon where a mass of warm water moves along the Pacific coast of South America is..
    a. Tornado

b. Hurricane
c. El Nino

25. Example of tropical Savanna biome is..
    a. Dooars
    b. Grasslands of Australia
    c. Terai
26. Disease caused by Protozoa is..
    a. Bacillary dysentery
    b. **Amoebiosis**
    c. Typhoid
27. Sundar Sarovar Dam is situated in..
    a. Madhya Pradesh
    b. Gujarat
    c. Rajasthan
28. The water body with very high nutrient content is known as..
    a. Mesotrophic
    b. Oligotrophic
    c. Eutrophic
29. Which one is not a renewable energy source..
    a. Geothermal energy
    b. Solar energy
    c. Fossil fuel
30. Montreal protocol was made in order to reduce..
    a. Greenhouse gases
    b. Ozone depleting chemicals
    c. Suspended particulate matter
31. El Nino results in…
    a. cold ocean wave
    b. hot ocean wave
    c. Tsunami
32. Control of pest population by natural predators, parasites or pathogens is called..
    a. Biological pest control
    b. Chemical pest control
    c. Integrated pest management
33. Jim Corbett National Park is situated in..
    a. Uttar Pradesh
    b. Uttarakhand
    c. Madhya Pradesh
34. Which one of the following is not a organochlorine compound..
    a. Aldrin
    b. Brine
    c. Hexachlorobenzene
35. Chemical physical or biological agents that cause birth-defects are called..
    a. Carcinogen
    b. Teratogen
    c. Mutagen
36. Confinement of species in a particular area is described as..
    a. Endemic

b. Epidemic
c. Exotic

37. The term RAMSAR is related to..
    a. forest ecosystem
    b. **wetland ecosystem**
    c. grassland ecosystem
38. Biogas is composed of..
    a. only methane
    b. Methane and hydrogen
    c. **Methane carbon dioxide and other gases**
39. Which Indian community follows the 29 rules relating to sustainable lifestyle?
    a. Jaroas
    b. Bishnoi
    c. Santhals
40. The earliest continent was..
    a. Laurasia
    b. Pangaea
    c. Gondwanaland
41. Example of epiphyte is..
    a. Water chestnut
    b. Dodder
    c. Cactus
42. The book ‘Silent Spring’ was written by..
    a. Rachel Carson
    b. Charles Darwi
    c. E.P. Odum
43. State specific population density in India is highest in
    a. Kerala
    b. West Bengal
    c. Uttar Pradesh
44. Ostrich is found in..
    a. Australia
    b. South America
    c. Africa
45. Neritic zone is associated with ..
    a. river
    b. lake
    c. ocean
46. Orchid is a type of..
    a. Epiphyte
    b. Xerophyte
    c. Halophyte
47. The bird Dodo which had been extinct since 1681 inhabited..
    a. Philippines
    b. Mauritius
    c. West Indies
48. Minamata disease is due to pollution by..
    a. Cadmium

b. Lead
c. Mercury

49. Selva is a tropical rainforest in..
a. South America
b. Mexico
c. Myanmar

50. Life originated on earth..
a. 2.5 Billion years ago
b. 3.5 Billion years ago
c. 4.5 Billion years ago

51. Which of the following is a micronutrient..
a. Boron
b. Carbon
c. Molybdenum

52. Bharat Stage II is related to which of the following
a. Solid waste management
b. Automobile emission
c. Noise pollution

53. Non-conventional sources of energy is
a. Nuclear energy
b. **Wind energy**
c. Fossil fuels

54. The scale that measures the magnitude of earthquake is..
a. Kelvin scale
b. Fahrenheit scale
c. Richter scale

55. Organic matter is decomposed by..
a. Birds
b. Bacteria
c. Fish

56. Which one of the following is a producer..
a. Sparrow
b. Lion
c. Phytoplankton

57. The source of oxygen in the atmosphere is due to..
a. Respiration
b. Photosynthesis
c. Chemosynthesis

58. Dr Salim Ali is a renowned..
a. Herpetologist
b. Ornithologist
c. Entomologist

59. The speed of wind is measured by.
a. Anemometer
b. Hygrometer
c. Barometer

60. The dynamo was discovered by..
a. **Michael Faraday**

b. James Watt
c. Eli Whitney

61. Kalapakkam is a..
    a. Hydel power station
    b. **Nuclear power station**
    c. Thermal power station
62. Estuary is..
    a. Inland wetland
    b. Deforested area
    c. Coastal wetland
63. India is a mega diversity country with..
    a. 4 ecological hotspot
    b. 3 ecological hotspot
    c. 2 ecological hotspot
64. The permissible upper limit of arsenic in water is..
    a. **0.05 mg per litre**
    b. 0.005 mg per litre
    c. 0.0005 mg per litre
65. What is the content of Nitrogen in atmosphere..
    a. 90%
    b. **80%**
    c. 70%
66. What is the name of the lowest layer of atmosphere?
    a. Stratosphere
    b. Ionosphere
    c. **Troposphere**
67. The minerals are resources of which type?
    a. non renewable resources
    b. renewable resources
    c. continuous resources
68. Which type of energy is fixed by autotrophic organisms?
    a. mechanical Energy
    b. chemical energy
    c. light energy

ইউনিট **2:** প্রাকৃতিক সম্পদ
মডেল প্রশ্ন

1. নিচের কোন ব্যাকটেরিয়া নাইট্রোজেন ঠিক করতে পারে?
    a. Azotobacter
    b. Nitrobacter
    c. Nitrococcus
2. ফ্রি ফ্লোটিং জলজ আণুবীক্ষণিক অর্গানিজমের হিসাবে পরিচিত হয় -
    a. ফাইটোপ্ল্যাঙ্কটন
    b. Necton
    c. Periphyton
3. ভোপাল গ্যাস বিপর্যয় গ্যাস গ্যাস দ্বারা সৃষ্ট হয়েছিল?
    a. মিথাইল আইসোসায়ানেট
    b. মিথাইল আইসোসায়ানাইড
    c. ক্লোরোফ্লুরোকার্বন
4. নিচের কোনটি মাইক্রোনিউট্রিয়েন্ট নয়?
    a. ম্যাগনেসিয়াম
    b. মলিবডেনাম
    c. ক্রোমিয়াম
5. চিপকো আন্দোলন হল পরিবেশগত উদ্বেগের পুনরুত্থান এবং সংঘটিত হয়েছিল -
    a. কুমায়ুন
    b. তেহরি গাড়ওয়াল
    c. হিমাচল
6. দ্য সাইলেন্ট ভ্যালি আন্দোলন কোন দল দ্বারা সংগঠিত হয়েছিল?
    a. মেধা পাটেকর
    b. কেরালা রাষ্ট্র সাহিত্য পরিষদ
    c. সুন্দরলাল বহুগুনা
7. কোন অঙ্গ সিলিকোসিসে আক্রান্ত হয়?
    a. হৃৎপিণ্ডের
    b. ফুসফুস
    c. মস্তিষ্ক
8. লোটিক জল মানে..
    a. হ্রদের জল
    b. নদীতে
    c. প্রবাহিত জল মহাসাগরের জল
9. সক্রিয় স্লাজ এর সাথে যুক্ত...
    a. বায়ু পরিশোধন প্রক্রিয়া
    b. বর্জ্য জল চিকিত্সা
    c. কঠিন বর্জ্য চিকিত্সা নীচের
10. কোনটি অ্যাসিড বৃষ্টির সাথে সম্পর্কিত নয়..
    a. কার্বন মনোক্সাইড
    b. সালফার ডাই
    c. নাইট্রোজেনএরঅক্সাইড অক্সাইড
11. বায়ুতেSPMপরিমাপ করা হয়...
    a. উচ্চ আয়তনের স্যাম্পলার
    b. হাইগ্রোমিটার

c. ব্যারোমিটার

12. সিসমোগ্রাফ ব্যবহার করা হয় এর তীব্রতা পরিমাপ করার জন্য..
    a. সমুদ্র তরঙ্গ
    b. ঘূর্ণিঝড়
    c. ভূমিকম্প
13. সালোকসংশ্লেষণ একটি প্রধান উপাদান।
    a. কার্বন চক্র
    b. নাইট্রোজেন চক্র
    c. সালফার চক্র
14. নিম্নলিখিতগুলির মধ্যে কোন রোগ ব্যাকটেরিয়া দ্বারা সৃষ্ট নয়..
    a. চিকেন পক্স
    b. যক্ষ্মারোগের
    c. কুষ্ঠ
15. জন্য দায়ী স্যান্ডফ্লাই..
    a. প্লেগ
    b. অ্যামিবিসিসইটাই-ইটাই
    c. কালা আজার
16. রোগের জন্য দায়ী উপাদান হল..
    a. পারদ
    b. আর্সেনিক
    c. ক্যাডমিয়াম
17. একটি দেশের ভৌগোলিক এলাকার কত শতাংশ বনভূমির আওতায় থাকা উচিত ?
    a. 23%
    b. 33%
    c. 13%
18. নর্মদা বাঁচাও ..আন্দোলনেরআয়োজন করা হয়েছিল
    a. সুন্দরলালের বহুগুনা
    b. Medha Patekar
    c. আর কে Pachauri
19. আন্দোলনে..ঘটেছেদ্য সাইলেন্ট ভ্যালি
    a. উত্তরাখন্ডে
    b. গুজরাত
    c. কেরল
20. মরুভূমি অবস্থারচারাগাছ সহনশীল..
    a. জাঙ্গল
    b. পরাশ্রয়ী উদ্ভিদ্
    c. Mesophyte
21. পশ্চিমবঙ্গেরদ্য রামসার সাইট। ।
    a. সুন্দরবন
    b. রবীন্দ্রসরোবর
    c. ইস্ট কলকাতাজলাভূমি
22. ভারতে জীববৈচিত্র্য হটস্পট সংখ্যাআছে।
    a. 2
    b. 3
    c. 4.
23. জলবায়ু ঘটনা যেখানে উষ্ণ জলের একটি ভর দক্ষিণ আমেরিকার প্রশান্ত মহাসাগরীয় উপকূলে চলে যায়..
    a. টর্নেডো
    b. হারিকেন

c. এল নিনো

24. গ্রীষ্মমন্ডলীয় সাভানা বায়োমের উদাহরণ হল..
    a. ডুয়ার্স
    b. অস্ট্রেলিয়ারতৃণভূমি
    c. তেরাই
25. রোগ প্রোটোজোয়া দ্বারা সৃষ্ট হয়..
    a. ব্যাসিলারি
    b. ডিসেন্ট্রি অ্যামিবায়োসিস
    c. টাইফয়েড
26. সুন্দর সরোবর বাঁধ ..অবস্থিত
    a. মধ্য প্রদেশ
    b. গুজরাত
    c. রাজস্থান
27. খুব বেশী পুষ্টির কন্টেন্ট সঙ্গে পানি শরীরের হিসাবে ..পরিচিত হয়
    a. Mesotrophic
    b. Oligotrophic
    c. Eutrophic
28. কোনটি একটি নবায়নযোগ্য শক্তির উৎস ..নয়
    a. ভূ শক্তি
    b. সৌর শক্তি
    c. জীবাশ্ম জ্বালানি
29. মন্ট্রিয়েল প্রোটোকল করে করা হয়েছেকমানোর জন্য..
    a. গ্রীনহাউস গ্যাস
    b. ওজোন ক্ষয়কারী রাসায়নিক পদার্থ
    c. স্থগিত কণা পদার্থ
30. এল নিনো ফলে…
    a. ঠান্ডা সমুদ্রের তরঙ্গ
    b. গরম মহাসাগরের তরঙ্গ
    c. সুনামি
31. প্রাকৃতিক শিকারী, পরজীবী বা রোগজীবাণু দ্বারাবলা হয়..
    a. কীটপতঙ্গ নিয়ন্ত্রণজৈবিক কীট নিয়ন্ত্রণ
    b. রাসায়নিক কীটপতঙ্গ নিয়ন্ত্রণ
    c. সমন্বিত কীটপতঙ্গ ব্যবস্থাপনা
32. জিম করবেট জাতীয় উদ্যান অবস্থিত..
    a. উত্তর প্রদেশ
    b. উত্তরাখণ্ড
33. মধ্য প্রদেশ
34. নিচেরকোনটি একটি organochlorine যৌগ নয় ..
    a. অল্ড্রীন
    b. Brine
    c. Hexachlorobenzene
35. রাসায়নিক শারীরিক বা জৈব এজেন্ট যে কারণ জন্ম-অপূর্ণতা বলা হয় ..
    a. কার্সিনোজেন
    b. Teratogen
    c. মুটাজেন
36. একটি নির্দিষ্ট এলাকায় প্রজাতিরকারাবাস যেমন ..বর্ণনা করা হয়েছে
    a. কবলিত
    b. এপিডেমিক

c. বহিরাগত

37. দ্যRAMSAR শব্দটি এর সাথে সম্পর্কিত।
    a. বন বাস্তুতন্ত্র
    b. জলাভূমি ইকোসিস্টেম
    c. তৃণভূমি ইকোসিস্টেম
38. বায়োগ্যাসদ্বারা গঠিত
    a. শুধুমাত্র মিথেন
    b. মিথেন এবং হাইড্রোজেন
    c. মিথেন কার্বন ডাই অক্সাইড এবং অন্যান্য গ্যাস
39. কোন ভারতীয় সম্প্রদায় টেকসই জীবনধারা সম্পর্কিত 29টি নিয়ম অনুসরণ করে?
    a. Jaroas
    b. Bishnoi
    c. সাঁওতাল
40. নিকটতম মহাদেশ ছিল ..
    a. Laurasia
    b. প্যানগায়া
    c. গন্ডোয়ানাল্যান্ডের
41. পরাশ্রয়ী উদ্ভিদ্ এরউদাহরণ ..হয়
    a. জল বাদামী
    b. টলমল করা
    c. ক্যাকটাস
42. বই 'সাইলেন্ট স্প্রিং' দ্বারা ..লেখা হয়েছিল
    a. কারসনের
    b. চার্লস Darwi
    c. ইপি Odum
43. ভারতেরাজ্য নির্দিষ্ট জনসংখ্যার ঘনত্ব সর্বোচ্চ
    a. কেরল
    b. পাশ্চাত্যেবাংলার
    c. উত্তরপ্রদেশ
44. উটপাখি মধ্যে ..পাওয়া
    a. অস্ট্রেলিয়া
    b. দক্ষিণ আমেরিকা
    c. আফ্রিকা
45. Neritic জোনের সাথেই ..যুক্ত করা হয়
    a. নদী
    b. হ্রদ
    c. মহাসাগর
46. অর্কিডযায়..একটি টাইপহয়
    a. পরাশ্রয়ী উদ্ভিদ্
    b. Xerophyte
    c. Halophyte
47. দ্য পাখি দোদোরযা 1681 সাল থেকে বিলুপ্ত হয়েছে অধ্যুষিত ..
    a. ফিলিপাইন
    b. মরিশাস
    c. ওয়েস্ট ইন্ডিজ
48. Minamataরোগ ..দূষণের কারণে
    a. ক্যাডমিয়াম
    b. লিড

c. বুধ

49. Selva সালে ..একটি ট্রপিকাল রেনফরেস্ট এসে গেছে
    a. দক্ষিন আমেরিকা
    b. মেক্সিকো
    c. মায়ানমার
50. লাইফ পৃথিবীতে সম্ভূত..
    a. 2.5 বিলিয়ন বছর আগে
    b. 3.5 বিলিয়ন বছর আগে
    c. 4.5 বিলিয়ন বছরআগে
51. নিচের কোনটিএকটি মাইক্রোনিউট্রিয়েন্ট এসে গেছে ..
    a. বোরন
    b. কার্বন
    c. মলিবডেনাম
52. ভারত পর্যায় II নিম্নলিখিতসাথে সম্পর্কিত
    a. কঠিন বর্জ্য ব্যবস্থাপনা
    b. অটোমোবাইল নির্গমন
    c. শব্দ দূষণ
53. শক্তিরউত্স
    a. কোনটিরঅপ্রচলিতনিউক্লিয়া r শক্তি
    b. বায়ু শক্তি
    c. জীবাশ্ম জ্বালানি
54. ভূমিকম্পের মাত্রা পরিমাপ করা স্কেল হল..
    a. কেলভিন স্কেল
    b. ফারেনহাইট স্কেল
    c. রিখটার স্কেল
55. জৈব পদার্থ দ্বারা পচে যায়..
    a. পাখি
    b. ব্যাকটেরিয়া
    c. মাছ
56. নিচের কোনটি একটি উৎপাদক..
    a. চড়ুই
    b. সিংহ
    c. ফাইটোপ্ল্যাঙ্কটন
57. বায়ুমণ্ডলে অক্সিজেনের উৎস কারণে ..হয়।
    a. শ্বসন
    b. সালোকসংশ্লেষ
    c. Chemosynthesis
58. ড সালিম আলী প্রখ্যাত ..গতি
    a. Herpetologist
    b. পক্ষীবিদ
    c. Entomologist
59. বাতাসের দ্বারা পরিমাপ করা হয়
    a. অ্যানিমোমিটার
    b. হাইগ্রোমিটার
    c. ব্যারোমিটার
60. ডায়নামো আবিষ্কার করেছিলেন...
    a. মাইকেল ফ্যারাডে
    b. জেমস ওয়াট

c. এলি হুইটনি

61. কালাপাক্কাম হল একটি...
    a. হাইডেল পাওয়ার স্টেশন
    b. পারমাণবিক বিদ্যুৎ কেন্দ্র
    c. তাপবিদ্যুৎ কেন্দ্র
62. মোহনা হল..
    a. অভ্যন্তরীণ জলাভূমি
    b. উজাড় এলাকা
    c. উপকূলীয় জলাভূমি
63. ভারত একটি মেগা বৈচিত্র্যের দেশ যেখানে..
    a. 4 পরিবেশগত হটস্পট
    b. 3 পরিবেশগত হটস্পট
    c. 2 পরিবেশগত হটস্পট
64. জলে আর্সেনিকের অনুমোদিত উচ্চ সীমা হল..
    a. প্রতি লিটারে **0.05** মিলিগ্রাম
    b. 0.005 মিলিগ্রাম প্রতি লিটার
    c. 0.0005 মিলিগ্রাম প্রতি লিটার
65. বায়ুমণ্ডলে নাইট্রোজেনের উপাদান কী।.
    a. 90%
    b. **80%**
    c. 70%
66. বায়ুমণ্ডলের সর্বনিম্ন স্তরের নাম কী?
    a. স্ট্রাটোস্ফিয়ার
    b. আয়নোস্ফিয়ার
    c. ট্রপোস্ফিয়ার
67. খনিজ পদার্থ কোন ধরনের সম্পদ?
    a. অ পুনর্নবীকরণযোগ্য সম্পদ
    b. নবায়নযোগ্য সম্পদ
    c. ক্রমাগত সম্পদ
68. কোন ধরনের শক্তি অটোট্রফিক জীব দ্বারা স্থির করা হয়?
    a. যান্ত্রিক শক্তি
    b. রাসায়নিক শক্তি
    c. হালকা শক্তি

12083CH14

ECOSYSTEM

14.1 *Ecosystem–Structure and Function*

14.2. *Productivity*

14.3 *Decomposition*

14.4 *Energy Flow*

14.5 *Ecological Pyramids*

14.6 *Ecological Succession*

14.7 *Nutrient Cycling*

14.8 *Ecosystem Services*

An ecosystem can be visualised as a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment. Ecosystem varies greatly in size from a small pond to a large forest or a sea. Many ecologists regard the entire biosphere as a global ecosystem, as a composite of all local ecosystems on Earth. Since this system is too much big and complex to be studied at one time, it is convenient to divide it into two basic categories, namely the **terrestrial** and the **aquatic**. Forest, grassland and desert are some examples of terrestrial ecosystems; pond, lake, wetland, river and estuary are some examples of aquatic ecosystems. Crop fields and an aquarium may also be considered as man-made ecosystems.

We will first look at the structure of the ecosystem, in order to appreciate the input (productivity), transfer of energy (food chain/web, nutrient cycling) and the output (degradation and energy loss). We will also look at the relationships – cycles, chains, webs – that are created as a result of these energy flows within the system and their inter- relationship.

14.1 Ecosystem – Structure and Function

In chapter 13, you have looked at the various components of the environment- abiotic and biotic. You studied how the individual biotic and abiotic factors affected each other and their surrounding. Let us look at these components in a more integrated manner and see how the flow of energy takes place within these components of the ecosystem.

Interaction of biotic and abiotic components result in a physical structure that is characteristic for each type of ecosystem. Identification and enumeration of plant and animal species of an ecosystem gives its species composition. Vertical distribution of different species occupying different levels is called **stratification**. For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layers.

The components of the ecosystem are seen to function as a unit when you consider the following aspects:

(i) Productivity;
(ii) Decomposition;
(iii) Energy flow; and
(iv) Nutrient cycling.

To understand the ethos of an aquatic ecosystem let us take a small pond as an example. This is fairly a self-sustainable unit and rather simple example that explain even the complex interactions that exist in an aquatic ecosystem. A pond is a shallow water body in which all the above mentioned four basic components of an ecosystem are well exhibited. The abiotic component is the water with all the dissolved inorganic and organic substances and the rich soil deposit at the bottom of the pond. The solar input, the cycle of temperature, day-length and other climatic conditions regulate the rate of function of the entire pond. The autotrophic components include the phytoplankton, some algae and the floating, submerged and marginal plants found at the edges. The consumers are represented by the zooplankton, the free swimming and bottom dwelling forms. The decomposers are the fungi, bacteria and flagellates especially abundant in the bottom of the pond. This system performs all the functions of any ecosystem and of the biosphere as a whole, i.e., conversion of inorganic into organic material with the help of the radiant energy of the sun by the autotrophs; consumption of the autotrophs by heterotrophs; decomposition and mineralisation of the dead matter to release them back for reuse by the autotrophs, these event are repeated over and over again. There is unidirectional movement of energy towards the higher trophic levels and its dissipation and loss as heat to the environment.

14.2. Productivity

A constant input of solar energy is the basic requirement for any ecosystem to function and sustain. **Primary production** is defined as the amount of

biomass or organic matter produced per unit area over a time period by plants during photosynthesis. It is expressed in terms of weight ($g\,m^{-2}$) or energy ($kcal\,m^{-2}$). The rate of biomass production is called **productivity**. It is expressed in terms of $g\,m^{-2}\,yr^{-1}$ or ($kcal\,m^{-2}$) yr^{-1} to compare the productivity of different ecosystems. It can be divided into gross primary productivity (GPP) and net primary productivity (NPP). **Gross primary productivity** of an ecosystem is the rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilised by plants in respiration. Gross primary productivity minus respiration losses (R), is the **net primary productivity** (NPP).

$$GPP - R = NPP$$

Net primary productivity is the available biomass for the consumption to heterotrophs (herbiviores and decomposers). **Secondary productivity** is defined as the rate of formation of new organic matter by consumers.

Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, availability of nutrients and photosynthetic capacity of plants. Therefore, it varies in different types of ecosystems. The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter. Of this, despite occupying about 70 per cent of the surface, the productivity of the oceans are only 55 billion tons. Rest of course, is on land. *Discuss the main reason for the low productivity of ocean with your teacher.*

14.3 Decomposition

You may have heard of the earthworm being referred to as the farmer's 'friend'. This is so because they help in the breakdown of complex organic matter as well as in loosening of the soil. Similarly, decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients and the process is called **decomposition**. Dead plant remains such as leaves, bark, flowers and dead remains of animals, including fecal matter, constitute **detritus**, which is the raw material for decomposition. The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation.

Detritivores (e.g., earthworm) break down detritus into smaller particles. This process is called **fragmentation.** By the process of **leaching,** water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts. Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as **catabolism**.

It is important to note that all the above steps in decomposition operate simultaneously on the detritus (Figure 14.1). Humification and mineralisation occur during decomposition in the soil. **Humification** leads

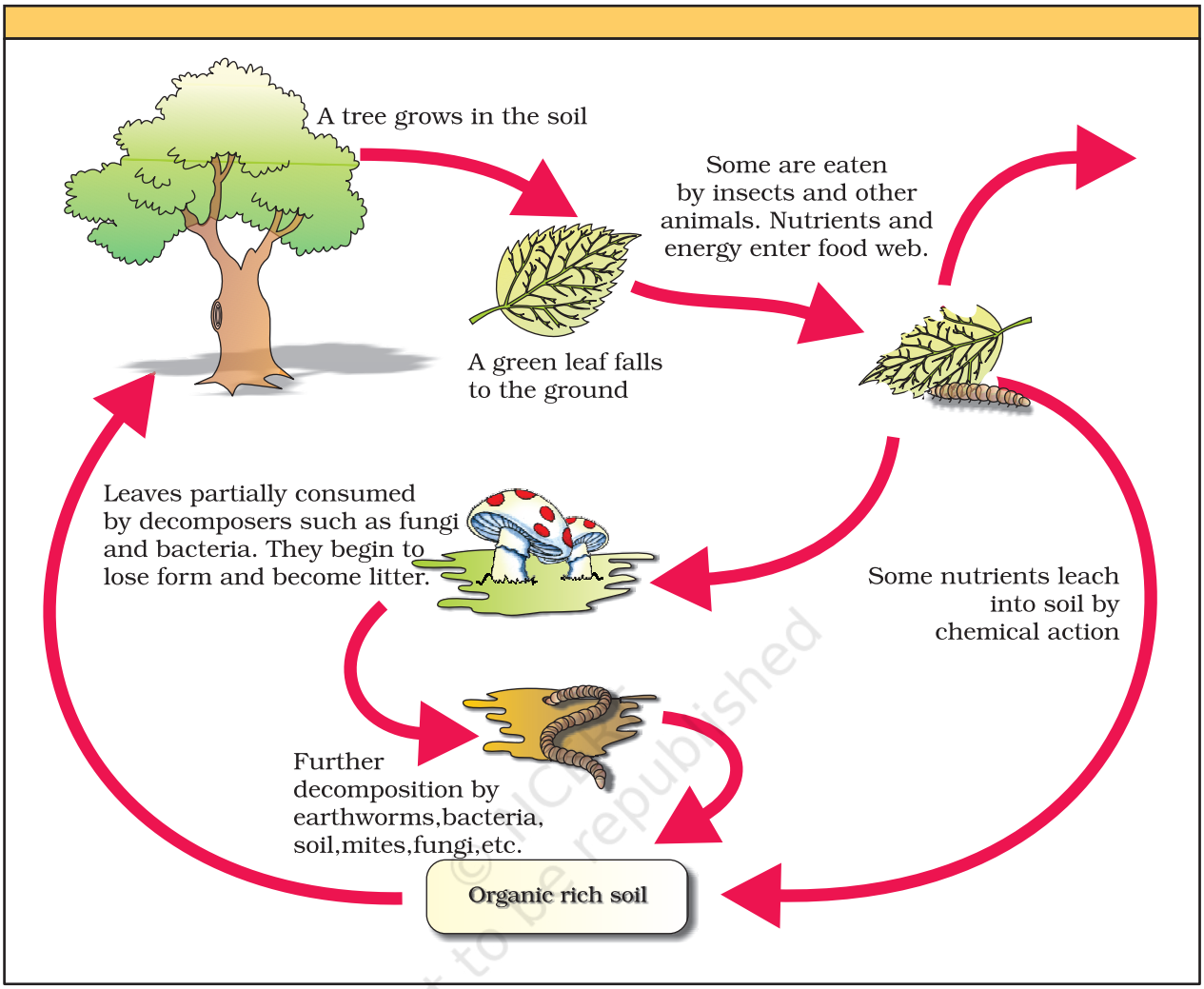


Figure 14.1 Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

to accumulation of a dark coloured amorphous substance called **humus** that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. Being colloidal in nature it serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as **mineralisation**.

Decomposition is largely an oxygen-requiring process. The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition, decomposition rate is slower if detritus is rich in lignin and chitin, and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars. Temperature and soil moisture are the most important climatic factors that regulate decomposition through their effects on the activities of soil microbes. Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in build up of organic materials.

14.4 Energy Flow

Except for the deep sea hydro-thermal ecosystem, sun is the only source of energy for all ecosystems on Earth. Of the incident solar radiation less than 50 per cent of it is **photosynthetically active radiation** (PAR). We know that plants and photosynthetic bacteria (autotrophs), fix Sun's radiant energy to make food from simple inorganic materials. Plants capture only 2-10 per cent of the PAR and this small amount of energy sustains the entire living world. So, it is very important to know how the solar energy captured by plants flows through different organisms of an ecosystem. All organisms are dependent for their food on producers, either directly or indirectly. So you find unidirectional flow of energy from the sun to producers and then to consumers. *Is this in keeping with the first law of thermodynamics?*

Further, ecosystems are not exempt from the Second Law of thermodynamics. They need a constant supply of energy to synthesise the molecules they require, to counteract the universal tendency toward increasing disorderliness.

The green plant in the ecosystem are called **producers**. In a terrestrial ecosystem, major producers are herbaceous and woody plants. Likewise, producers in an aquatic ecosystem are various species like phytoplankton, algae and higher plants.

You have read about the food chains and webs that exist in nature. Starting from the plants (or producers) food chains or rather webs are formed such that an animal feeds on a plant or on another animal and in turn is food for another. The chain or web is formed because of this interdependency. No energy that is trapped into an organism remains in it for ever. The energy trapped by the producer, hence, is either passed on to a consumer or the organism dies. Death of organism is the beginning of the detritus food chain/web.

All animals depend on plants (directly or indirectly) for their food needs. They are hence called **consumers** and also heterotrophs. If they feed on the producers, the plants, they are called primary consumers, and if the animals eat other animals which in turn eat the plants (or their produce) they are called secondary consumers. Likewise, you could have tertiary consumers too. Obviously the primary consumers will be **herbivores**. Some common herbivores are insects, birds and mammals in terrestrial ecosystem and molluscs in aquatic ecosystem.

The consumers that feed on these herbivores are carnivores, or more correctly **primary carnivores** (though secondary consumers). Those animals that depend on the primary carnivores for food are labelled **secondary carnivores.** A simple grazing food chain (GFC) is depicted below:

Grass ⟶ Goat ⟶ Man ⟶

(Producer) (Primary Consumer) (Secondary consumer)

The **detritus food chain** (DFC) begins with dead organic matter. It is made up of **decomposers** which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organic matter or detritus. These are also known as **saprotrophs** (*sapro:* to decompose). Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.

In an aquatic ecosystem, GFC is the major conduit for energy flow. As against this, in a terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the GFC. Detritus food chain may be connected with the grazing food chain at some levels: some of the organisms of DFC are prey to the GFC animals, and in a natural ecosystem, some animals like cockroaches, crows, etc., are omnivores. These natural interconnection of food chains make it a **food web**. *How would you classify human beings!*

Organisms occupy a place in the natural surroundings or in a community according to their feeding relationship with other organisms. Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as their **trophic level**. Producers belong to the first trophic level, herbivores (primary consumer) to the second and carnivores (secondary consumer) to the third (Figure 14.2).

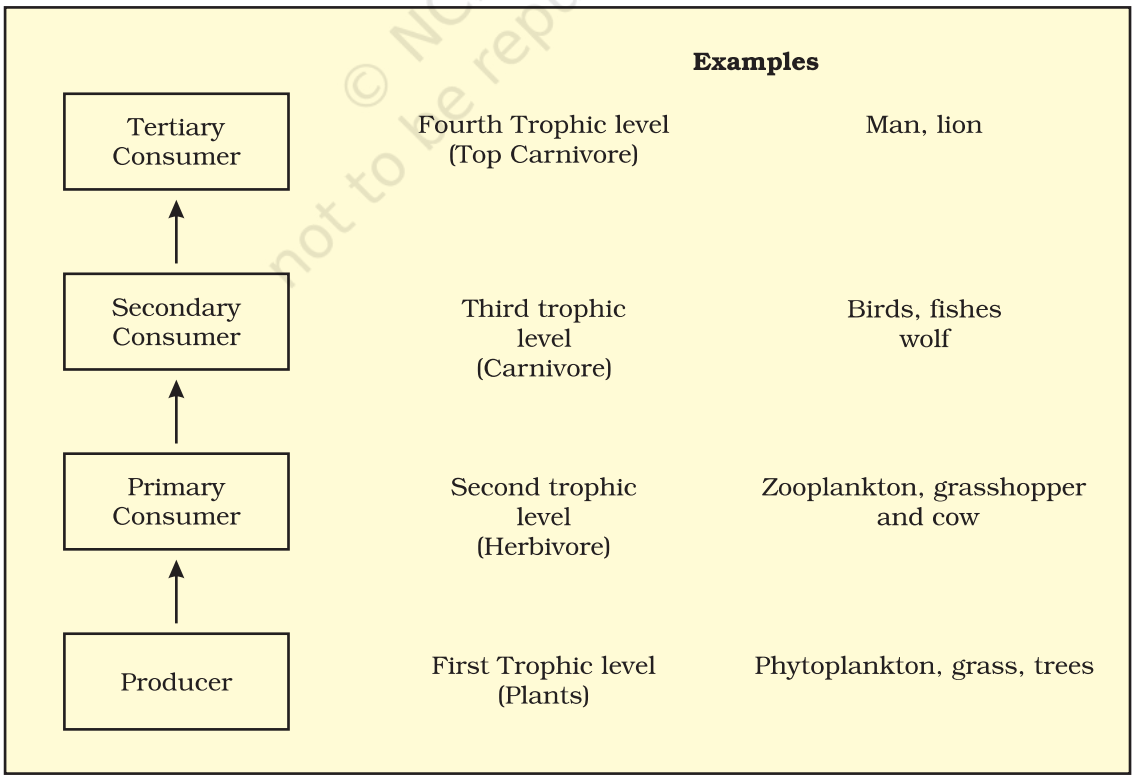


Figure 14.2 Diagrammatic representation of trophic levels in an ecosystem

The important point to note is that the amount of energy decreases at successive trophic levels. When any organism dies it is converted to detritus or dead biomass that serves as an energy source for decomposers. Organisms at each trophic level depend on those at the lower trophic level for their energy demands.

Each trophic level has a certain mass of living material at a particular time called as the **standing crop**. The standing crop is measured as the mass of living organisms (**biomass)** or the number in a unit area. The biomass of a species is expressed in terms of fresh or dry weight. Measurement of biomass in terms of dry weight is more accurate. *Why?*

The number of trophic levels in the grazing food chain is restricted as the transfer of energy follows 10 per cent law – only 10 per cent of the energy is transferred to each trophic level from the lower trophic level. In nature, it is possible to have so many levels – producer, herbivore, primary carnivore, secondary carnivore in the grazing food chain (Figure 14.3) . *Do you think there is any such limitation in a detritus food chain?*

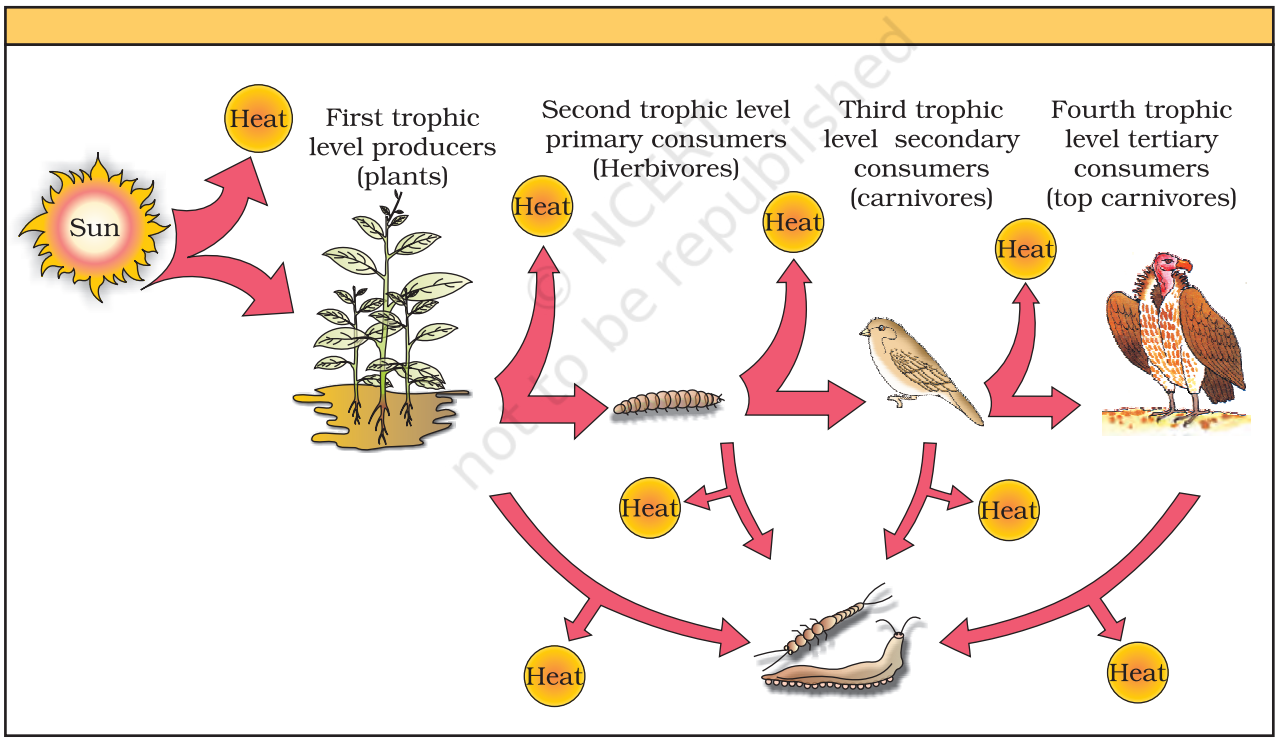


Figure 14.3 Energy flow through different trophic levels

14.5 Ecological Pyramids

You must be familiar with the shape of a pyramid. The base of a pyramid is broad and it narrows towards the apex. One gets a similar shape, whether you express the food or energy relationship between organisms

at different trophic levels. This, relationship is expressed in terms of number, biomass or energy. The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top level consumer. The three types of ecological pyramids that are usually studied are (a) pyramid of number; (b) pyramid of biomass and (c) pyramid of energy. For detail (see Figure 14.4 a, b, c and d).

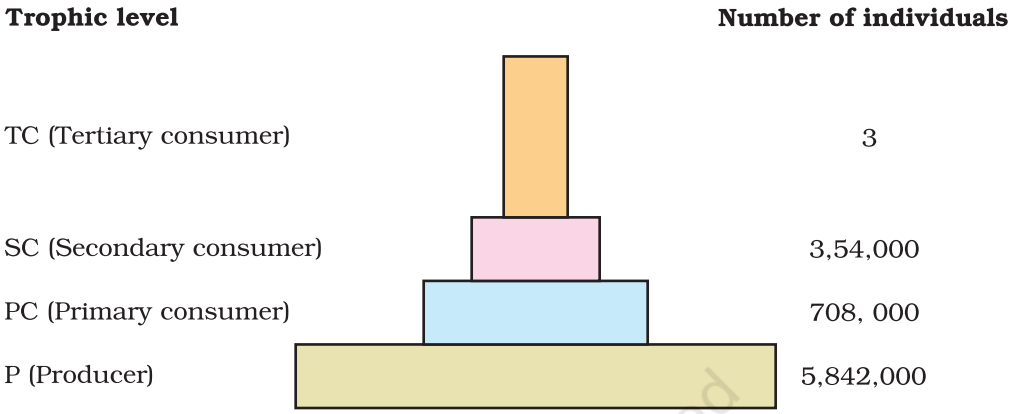


Figure 14.4 (a) Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants

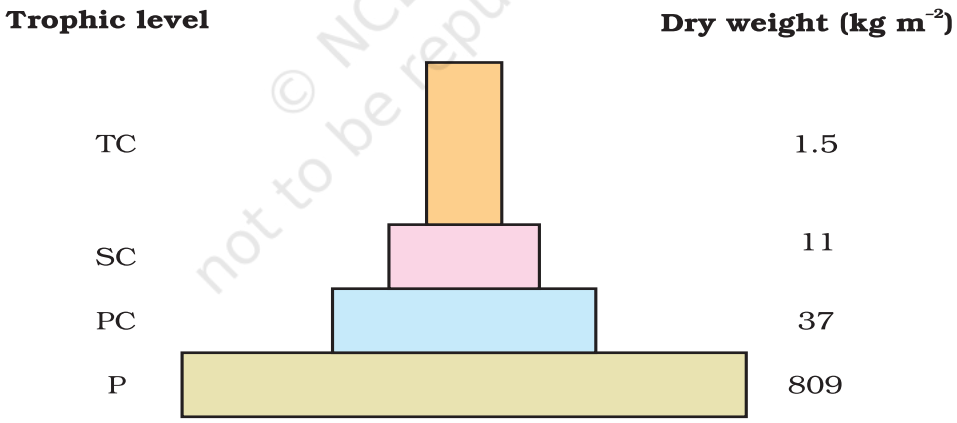


Figure 14.4 (b) Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels

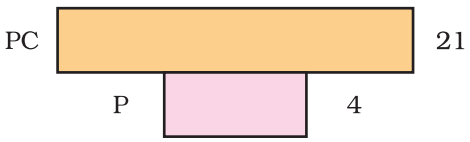


Figure 14.4 (c) Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton

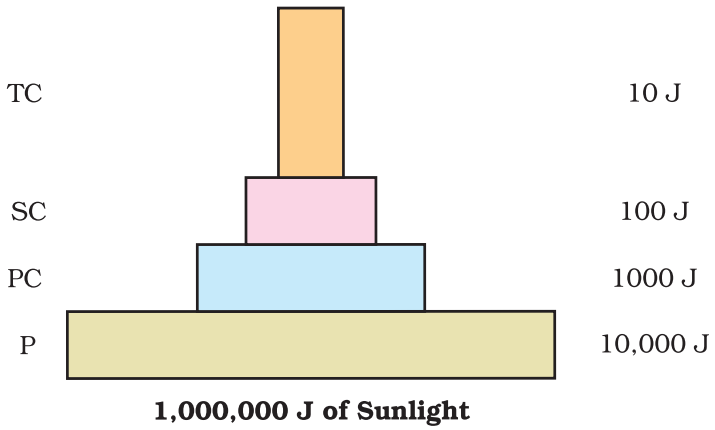


Figure 14.4 (d) An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP

Any calculations of energy content, biomass or numbers, has to include all organisms at that trophic level. No generalisations we make will be true if we take only a few individuals at any trophic level into account. Also a given organism may occupy more than one trophic level simultaneously. One must remember that the trophic level represents a functional level, not a species as such. A given species may occupy more than one trophic level in the same ecosystem at the same time; for example, a sparrow is a primary consumer when it eats seeds, fruits, peas, and a secondary consumer when it eats insects and worms. *Can you work out how many trophic levels human beings function at in a food chain?*

In most ecosystems, all the pyramids, of number, of energy and biomass are upright, i.e., producers are more in number and biomass than the herbivores, and herbivores are more in number and biomass than the carnivores. Also energy at a lower trophic level is always more than at a higher level.

There are exceptions to this generalisation: If you were to count the number of insects feeding on a big tree what kind of pyramid would you get? Now add an estimate of the number of small birds depending on the insects, as also the number of larger birds eating the smaller. Draw the shape you would get.

The pyramid of biomass in sea is generally inverted because the biomass of fishes far exceeds that of phytoplankton. *Isn't that a paradox? How would you explain this?*

Pyramid of energy is always upright, can never be inverted, because when energy flows from a particular trophic level to the next trophic level, some energy is always lost as heat at each step. Each bar in the energy pyramid indicates the amount of energy present at each trophic level in a given time or annually per unit area.

However, there are certain limitations of ecological pyramids such as it does not take into account the same species belonging to two or more trophic levels. It assumes a simple food chain, something that almost never exists in nature; it does not accommodate a food web. Moreover, saprophytes are not given any place in ecological pyramids even though they play a vital role in the ecosystem.

14.6 Ecological Succession

You have learnt in Chapter 13, the characteristics of population and community and also their response to environment and how such responses vary from an individual response. Let us examine another aspect of community response to environment over time.

An important characteristic of all communities is that their composition and structure constantly change in response to the changing environmental conditions. This change is orderly and sequential, parallel with the changes in the physical environment. These changes lead finally to a community that is in near equilibrium with the environment and that is called a **climax community**. The gradual and fairly predictable change in the species composition of a given area is called **ecological succession**. During succession some species colonise an area and their population become more numerous whereas populations of other species decline and even disappear.

The entire sequence of communities that successively change in a given area are called **sere(s)**. The individual transitional communities are termed seral stages or seral communities. In the successive seral stages there is a change in the diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass.

The present day communities in the world have come to be because of succession that has occurred over millions of years since life started on earth. Actually succession and evolution would have been parallel processes at that time.

Succession is hence a process that starts in an area where no living organisms are there – these could be areas where no living organisms ever existed, say bare rock; or in areas that somehow, lost all the living organisms that existed there. The former is called primary succession, while the latter is termed secondary succession.

Examples of areas where primary succession occurs are newly cooled lava, bare rock, newly created pond or reservoir. The establishment of a new biotic community is generally slow. Before a biotic community of diverse organisms can become established, there must be soil. Depending mostly on the climate, it takes natural processes several hundred to several thousand years to produce fertile soil on bare rock.

Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farm lands, burned or cut forests, lands that have been flooded. Since some soil or sediment is present, succession is faster than primary succession.

Description of ecological succession usually focuses on changes in vegetation. However, these vegetational changes in turn affect food and shelter for various types of animals. Thus, as succession proceeds, the numbers and types of animals and decomposers also change.

At any time during primary or secondary succession, natural or human induced disturbances (fire, deforestation, etc.), can convert a particular seral stage of succession to an earlier stage. Also such disturbances create new conditions that encourage some species and discourage or eliminate other species.

14.6.1 Succession of Plants

Based on the nature of the habitat – whether it is water (or very wet areas) or it is on very dry areas – succession of plants is called hydrarch or xerarch, respectively. **Hydrarch succession** takes place in wet areas and the successional series progress from hydric to the mesic conditions. As against this, **xerarch succession** takes place in dry areas and the series progress from xeric to mesic conditions. Hence, both hydrarch and xerarch successions lead to medium water conditions (mesic) – neither too dry (xeric) nor too wet (hydric).

The species that invade a bare area are called **pioneer species**. In primary succession on rocks these are usually lichens which are able to secrete acids to dissolve rock, helping in weathering and soil formation. These later pave way to some very small plants like bryophytes, which are able to take hold in the small amount of soil. They are, with time, succeeded by higher plants, and after several more stages, ultimately a stable climax forest community is formed. The climax community remains stable as long as the environment remains unchanged. With time the xerophytic habitat gets converted into a mesophytic one.

In primary succession in water, the pioneers are the small phytoplanktons, which are replaced with time by rooted-submerged plants, rooted-floating angiosperms followed by free-floating plants, then reed-swamp, marsh-meadow, scrub and finally the trees. The climax again would be a forest. With time the water body is converted into land (Figure 14.5).

In secondary succession the species that invade depend on the condition of the soil, availability of water, the environment as also the seeds or other propagules present. Since soil is already there, the rate of succession is much faster and hence, climax is also reached more quickly.

What is important to understand is that succession, particularly primary succession, is a very slow process, taking maybe thousands of

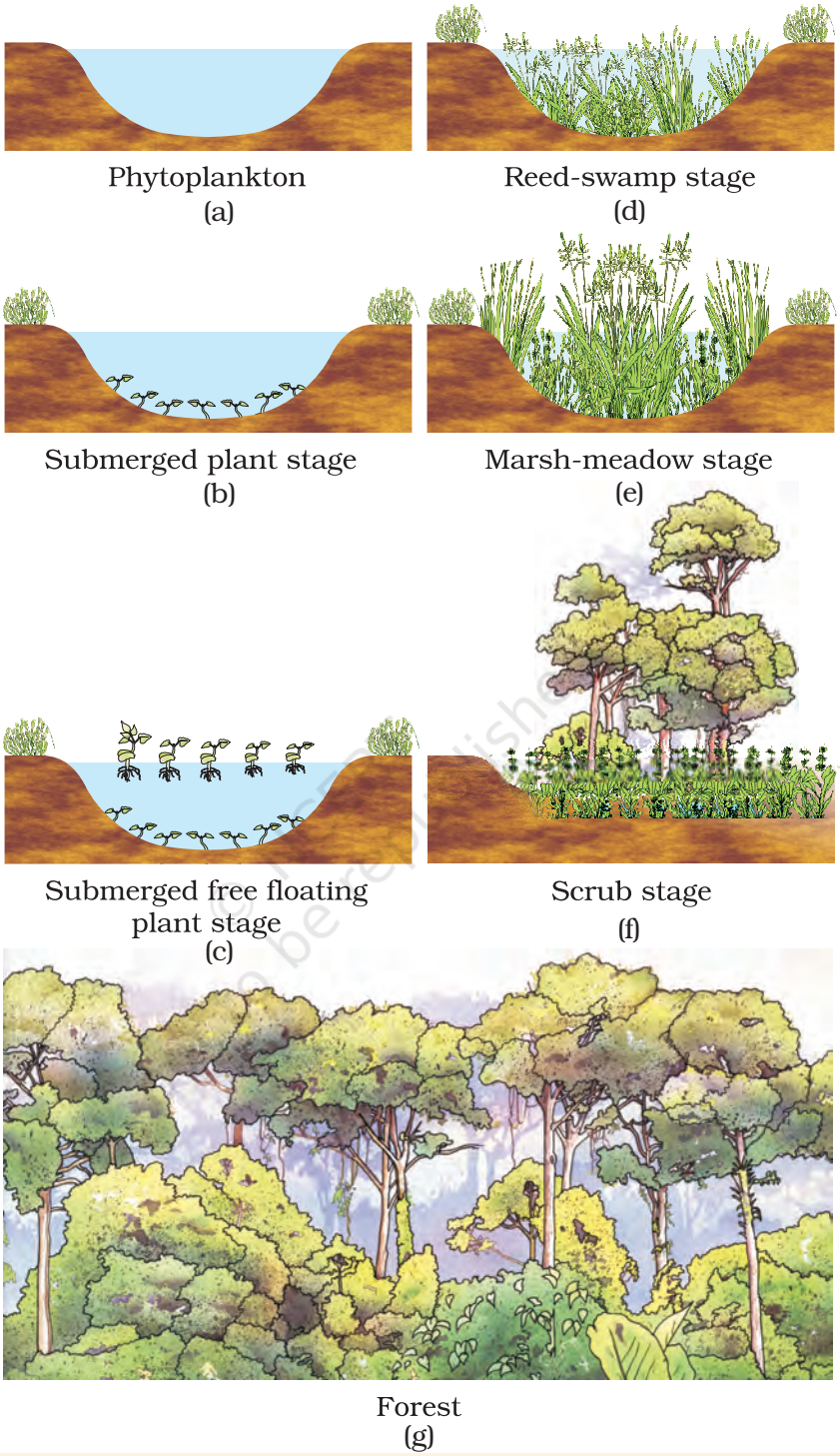


Figure 14.5 Diagrammatic representation of primary succession

years for the climax to be reached. Another important fact is to understand that all succession whether taking place in water or on land, proceeds to a similar climax community – the mesic.

14.7 Nutrient Cycling

You have studied in Class XI that organisms need a constant supply of nutrients to grow, reproduce and regulate various body functions. The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc., present in the soil at any given time, is referred to as the **standing state**. It varies in different kinds of ecosystems and also on a seasonal basis.

What is important is to appreciate that nutrients which are never lost from the ecosystems, rather they are recycled time and again indefinitely. The movement of nutrient elements through the various components of an ecosystem is called **nutrient cycling**. Another name of nutrient cycling is **biogeochemical** cycles (bio: living organism, geo: rocks, air, water). Nutrient cycles are of two types: (a) **gaseous** and (b) **sedimentary.** The

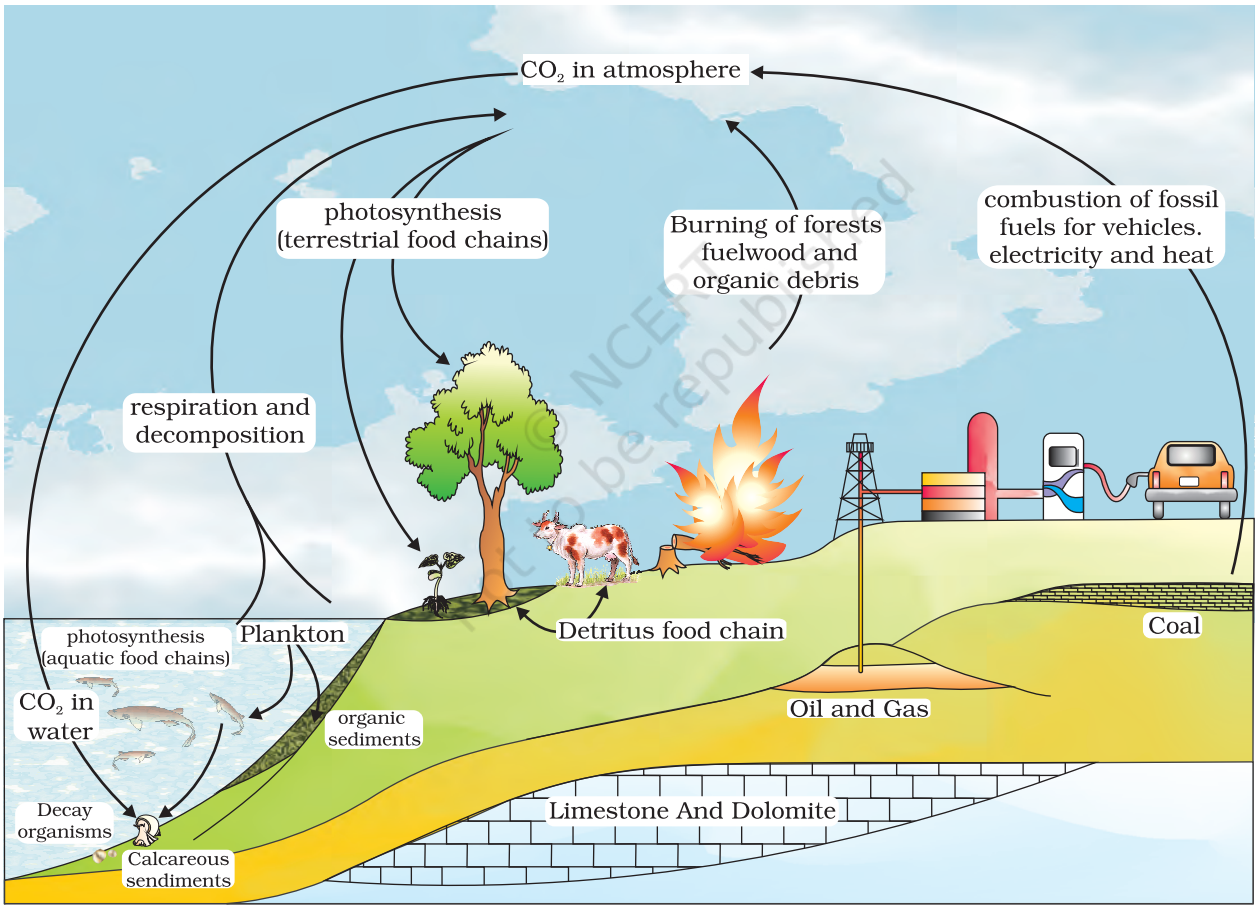


Figure 14.6 Simplified model of carbon cycle in the biosphere

reservoir for gaseous type of nutrient cycle (e.g., nitrogen, carbon cycle) exists in the atmosphere and for the sedimentary cycle (e.g., sulphur and phosphorus cycle), the reservoir is located in Earth's crust. Environmental factors, e.g., soil, moisture, pH, temperature, etc., regulate the rate of release of nutrients into the atmosphere. The function of the reservoir is

to meet with the deficit which occurs due to imbalance in the rate of influx and efflux.

You have made a detailed study of nitrogen cycle in class XI. Here we discuss carbon and phosphorus cycles.

14.7.1 Ecosystem – Carbon Cycle

When you study the composition of living organisms, carbon constitutes 49 per cent of dry weight of organisms and is next only to water. If we look at the total quantity of global carbon, we find that 71 per cent carbon is found dissolved in oceans. This oceanic reservoir regulates the amount of carbon dioxide in the atmosphere (Figure 14.6). *Do you know that the atmosphere only contains about 1per cent of total global carbon?*

Fossil fuel also represent a reservoir of carbon. Carbon cycling occurs through atmosphere, ocean and through living and dead organisms. According to one estimate 4×10^{13} kg of carbon is fixed annually in the biosphere through photosynthesis. A considerable amount of carbon returns to the atmosphere as CO_2 through respiratory activities of the producers and consumers. Decomposers also contribute substantially to CO_2 pool by their processing of waste materials and dead organic matter of land or oceans. Some amount of the fixed carbon is lost to sediments and removed from circulation. Burning of wood, forest fire and combustion of organic matter, fossil fuel, volcanic activity are additional sources for releasing CO_2 in the atmosphere.

Human activities have significantly influenced the carbon cycle. Rapid deforestation and massive burning of fossil fuel for energy and transport have significantly increased the rate of release of carbon dioxide into the atmosphere (see greenhouse effect in Chapter 16).

14.7.2 Ecosystem – Phosphorus Cycle

Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems. Many animals also need large quantities of this element to make shells, bones and teeth. The natural reservoir of phosphorus is rock, which contains phosphorus in the form of phosphates. When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the roots of the plants (Figure 14.7). Herbivores and other animals obtain this element from plants. The waste products and the dead organisms are decomposed by phosphate-solubilising bacteria releasing phosphorus. Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere. *Can you differentiate between the carbon and the phosphorus cycle?*

The other two major and important differences between carbon and phosphorus cycle are firstly, atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs, and, secondly, gaseous

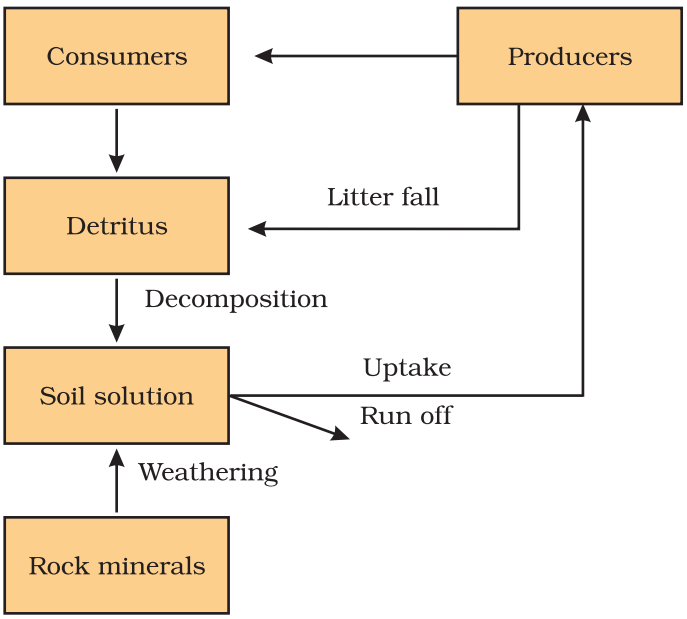


Figure 14.7 A simplified model of phosphorus cycling in a terrestrial ecosystem

exchanges of phosphorus between organism and environment are negligible.

14.8 Ecosystem Services

Healthy ecosystems are the base for a wide range of economic, environmental and aesthetic goods and services. The products of ecosystem processes are named as **ecosystem services**, for example, healthy forest ecosystems purify air and water, mitigate droughts and floods, cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values. Though value of such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a hefty price tag.

Robert Constanza and his colleagues have very recently tried to put price tags on nature's life-support services. Researchers have put an average price tag of US $ 33 trillion a year on these fundamental ecosystems services, which are largely taken for granted because they are free. This is nearly twice the value of the global gross national product GNP which is (US $ 18 trillion).

Out of the total cost of various ecosystem services, the soil formation accounts for about 50 per cent, and contributions of other services like recreation and nutrient cycling, are less than 10 per cent each. The cost of climate regulation and habitat for wildlife are about 6 per cent each.

SUMMARY

An ecosystem is a structural and functional unit of nature and it comprises abiotic and biotic components. Abiotic components are inorganic materials- air, water and soil, whereas biotic components are producers, consumers and decomposers. Each ecosystem has characteristic physical structure resulting from interaction amongst abiotic and biotic components. Species composition and stratification are the two main structural features of an ecosystem. Based on source of nutrition every organism occupies a place in an ecosystem.

Productivity, decomposition, energy flow, and nutrient cycling are the four important components of an ecosystem. Primary productivity is the rate of capture of solar energy or biomass production of the producers. It is divided into two types: gross primary productivity (GPP) and net primary productivity (NPP). Rate of capture of solar energy or total production of organic matter is called as GPP. NPP is the remaining biomass or the energy left after utilisation of producers. Secondary productivity is the rate of assimilation of food energy by the consumers. In decomposition, complex organic compounds of detritus are converted to carbon dioxide, water and inorganic nutrients by the decomposers. Decomposition involves three processes, namely fragmentation of detritus, leaching and catabolism.

Energy flow is unidirectional. First, plants capture solar energy and then, food is transferred from the producers to decomposers. Organisms of different trophic levels in nature are connected to each other for food or energy relationship forming a food chain. The storage and movement of nutrient elements through the various components of the ecosystem is called nutrient cycling; nutrients are repeatedly used through this process. Nutrient cycling is of two types—gaseous and sedimentary. Atmosphere or hydrosphere is the reservoir for the gaseous type of cycle (carbon), whereas Earth's crust is the reservoir for sedimentary type (phosphorus). Products of ecosystem processes are named as ecosystem services, e.g., purification of air and water by forests.

The biotic community is dynamic and undergoes changes with the passage of time. These changes are sequentially ordered and constitute ecological succession. Succession begins with invasion of a bare lifeless area by pioneers which later pave way for successors and ultimately a stable climax community is formed. The climax community remains stable as long as the environment remains unchanged.

EXERCISES

1. Fill in the blanks.
   (a) Plants are called as_____because they fix carbon dioxide.
   (b) In an ecosystem dominated by trees, the pyramid (of numbers) is_____type.
   (c) In aquatic ecosystems, the limiting factor for the productivity is_____.

(d) Common detritivores in our ecosystem are_____.
(e) The major reservoir of carbon on earth is_____.

2. Which one of the following has the largest population in a food chain?
   (a) Producers
   (b) Primary consumers
   (c) Secondary consumers
   (d) Decomposers
3. The second trophic level in a lake is
   (a) Phytoplankton
   (b) Zooplankton
   (c) Benthos
   (d) Fishes
4. Secondary producers are
   (a) Herbivores
   (b) Producers
   (c) Carnivores
   (d) None of the above
5. What is the percentage of photosynthetically active radiation (PAR) in the incident solar radiation?
   (a) 100%
   (b) 50 %
   (c) 1-5%
   (d) 2-10%
6. Distinguish between
   (a) Grazing food chain and detritus food chain
   (b) Production and decomposition
   (c) Upright and inverted pyramid
   (d) Food chain and Food web
   (e) Litter and detritus
   (f) Primary and secondary productivity
7. Describe the components of an ecosystem.
8. Define ecological pyramids and describe with examples, pyramids of number and biomass.
9. What is primary productivity? Give brief description of factors that affect primary productivity.
10. Define decomposition and describe the processes and products of decomposition.
11. Give an account of energy flow in an ecosystem.
12. Write important features of a sedimentary cycle in an ecosystem.
13. Outline salient features of carbon cycling in an ecosystem.

ECOSYTEM

Concept of an Ecosystem:

Living organisms cannot live isolated from their non-living environment be-cause the latter provides materials and energy for the survival of the former i.e. there is interaction between a biotic community and its environment to produce a stable system; a natural self-sufficient unit which is known as an ecosystem.Ecosystem are the parts of nature where living orgaisms interact among themselves and with their physical environment.

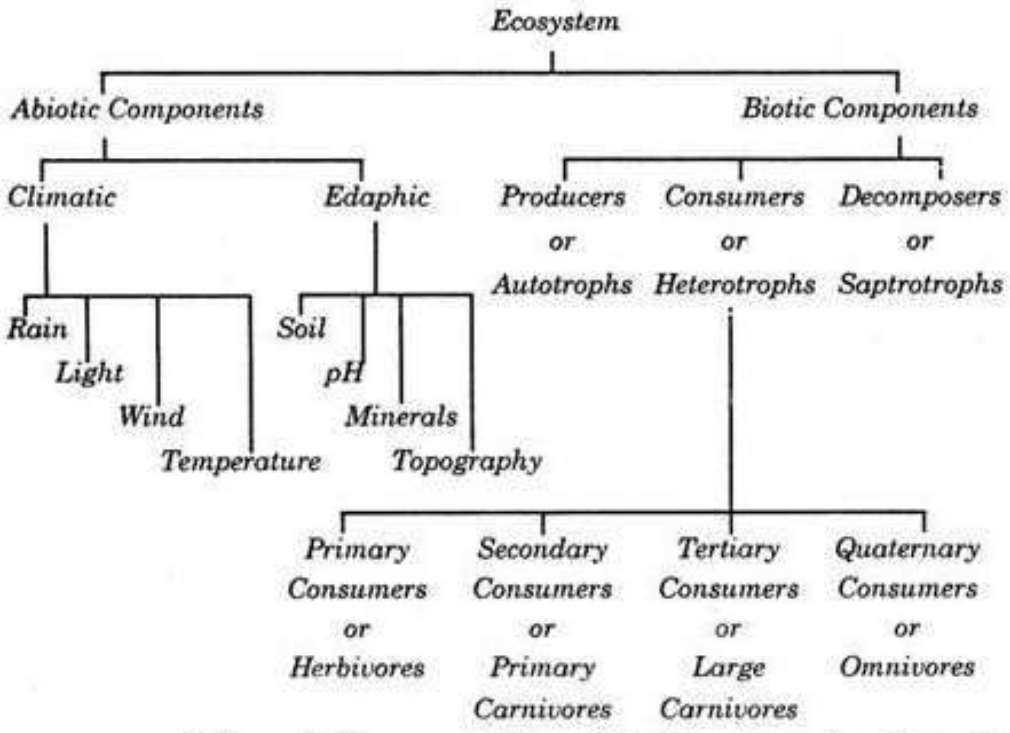
The term 'ecosystem' was coined by **A.G. Tansley**, an English botanist, in **1935**. ***An ecosystem is the structural and functional unit of ecology (nature) encompassing complex interaction between its biotic (living) and abiotic (non-living) components.***For example- a pond is a good example of ecosystem. A pond, lake, desert, grassland, meadow, forest etc. are common examples of ecosystems.

Structure and Function of an Ecosystem:

Each ecosystem has two main components:

(1) Abiotic

(2) Biotic



Schematic Representation of the Structure of an Ecosystem.

(1) Abiotic components (Nonliving): The abiotic component can be grouped into following categories:-

(a) Climatic Factors: Which include rain, temperature, light, wind, humidity etc.

(b) Edaphic Factors: Which include soil, pH, topography minerals etc.

The functions of important factors in abiotic components are given below:

Soils are much more complex than simple sediments. They contain a mixture of weathered rock fragments, highly altered soil mineral particles, organic mat-ter, and living organisms. Soils provide nutrients, water, a home, and a struc-tural growing medium for organisms. The vegetation found growing on top of a soil is closely linked to this component of an ecosystem through nutrient cycling.

The atmosphere provides organisms found within ecosystems with carbon di-oxide for photosynthesis and oxygen for respiration. The processes of evapora-tion, transpiration and precipitation cycle water between the atmosphere and the Earth's surface.

Solar radiation is used in ecosystems to heat the atmosphere and to evapo-rate and transpire water into the atmosphere. Sunlight is also necessary for photosynthesis. Photosynthesis provides the energy for plant growth and me-tabolism, and the organic food for other forms of life.

Most living tissue is composed of a very high percentage of water, up to and even exceeding 90%. The protoplasm of a very few cells can survive if their water content drops below 10%, and most are killed if it is less than 30-50%.

Water is the medium by which mineral nutrients enter and are trans-located in plants. It is also necessary for the maintenance of leaf turgidity and is required for photosynthetic chemical reactions. Plants and animals receive their water from the Earth's surface and soil. The original source of this water is precipita-tion from the atmosphere.

(2) Biotic components: The living organisms including plants, animals and micro-organisms (Bacteria and Fungi) that are present in an ecosystem form the biotic components.

(A) Producers:

The green plants have chlorophyll with the help of which they trap solar energy and change it into chemical energy of carbohydrates using simple inorganic compounds namely water and carbon dioxide. This process is known as photo-synthesis. As the green plants manufacture their own food they are known as **Autotrophs** (i.e. auto = self, trophos = feeder)

The chemical energy stored by the producers is utilised partly by the producers for their own growth and survival and the remaining is stored in the plant parts for their future use.

(B) Consumers:

The animals lack chlorophyll and are unable to synthesise their own food. There-fore, they depend on the producers for their food. They are known as **heterotrophs** (i.e. heteros = other, trophos = feeder)

The consumers are of four types, namely:

(a) Primary Consumers or First Order Consumers or Herbivores:

These are the animals which feed on plants or the producers. They are called her-bivores. Examples are rabbit, deer, goat, cattle etc.

(b) Secondary Consumers or Second Order Consumers or Primary Carnivores:

The animals which feed on the herbivores are called the pri-mary carnivores. Examples are cats, foxes, snakes etc.

(c) Tertiary Consumers or Third Order Consumers:

These are the large carnivores which feed on the secondary consumers. Example are Wolves.

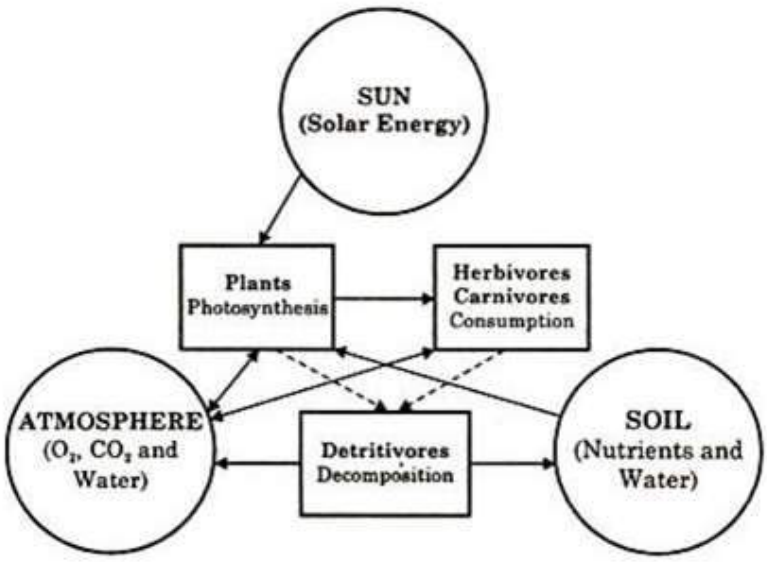
(d) Quaternary Consumers or Fourth Order Consumers or Omnivores:

These are the largest carnivores which feed on the tertiary consumers and are not eaten up by any other animal. Examples are lions and tigers.

(C) Decomposers or Reducers:

Bacteria and fungi belong to this category. They breakdown the dead organic materials of producers (plants) and consumers (animals) for their food and re-lease to the environment the simple inorganic and organic substances produced as by-products of their metabolisms.

These simple substances are reused by the producers resulting in a cyclic ex-change of materials between the biotic community and the abiotic environment of the ecosystem. The decomposers are known as **Saprotrophs** (i.e., sapros = rotten, trophos = feeder).



Relationship within an Ecosystem.

Functions of ecosystem

Ecosystems are complex dynamic system. They perform certain functions. These are:

Functions of Ecosystem:

(i)Productivity,

(ii) Decomposition,

(iii) Physical (energy flow),

(iv) Biological (food chains, food web, ecological succession),and

(v) Biogeochemical (nutrient cycling) processes

(I) PRODUCTIVITY

A constant input of solar energy is the basic requirement for any ecosystem to function and sustain. Primary production is defined as the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. It is expressed in terms of weight (g –2) or energy (kcal m–2). The rate of biomass production is called **productivity**. It is expressed in terms of g –2 yr –1 or (kcal m–2)yr –1 to compare the productivity of different ecosystems. It can be divided into **gross primary productivity (GPP**) and **net primary productivity (NPP)**. Gross primary productivity of an ecosystem is the rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilised by plants in respiration. Gross primary productivity minus respiration losses (R), is the net primary productivity (NPP). GPP – R = NPP Net primary productivity is the available biomass for the consumption to heterotrophs (herbiviores and decomposers). Secondary productivity is defined as the rate of formation of new organic matter by consumers. Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, availability of nutrients and photosynthetic capacity of plants. Therefore, it varies in different types of ecosystems. The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter. Of this, despite occupying about 70 per cent of the surface, the productivity of the oceans are only 55 billion tons. Rest of course, is on land.

(II) DECOMPOSITION

You may have heard of the earthworm being referred to as the farmer's 'friend'. This is so because they help in the breakdown of complex organic matter as well as in loosening of the soil. Similarly, decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition. Dead plant remains such as leaves, bark, flowers and dead remain of animals, including fecal matter, constitute detritus, which is the raw material for decomposition. **The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation.**

Detritivores (e.g., earthworm) break down detritus into smaller particles. This process is called fragmentation.

By the process of **leaching,**watersoluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.

Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as **catabolism**. It is important to note that all the above steps in decomposition operate simultaneously on the detritus.

Humification and mineralisation occur during decomposition in the soil. **Humification** leads to accumulation of a dark coloured amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. Being colloidal in nature it serves as a reservoir of nutrients.

The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as **mineralisation.**

Decomposition is largely an oxygen-requiring process. The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition, decomposition rate is slower if detritus is rich in lignin and chitin, and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars. Temperature and soil moisture are the most important climatic factors that regulate decomposition through their effects on the activities of soil microbes. Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in build up of organic materials.

(III) ENERGY FLOW

The chemical energy of food is the main source of energy required by all living organisms. This energy is transmitted to different trophic levels along the food chain. This energy flow is based on two different laws of thermodynamics:

First law of thermodynamics, that states that energy can neither be created nor destroyed, it can only change from one form to another.***Second law of thermodynamics,*** that states that as energy is transferred more and more of it is wasted.

The energy flow in the ecosystem is one of the major factors that support the survival of such a great number of organisms. For almost all organisms on earth, the primary source of energy is solar energy. It is amusing to find that we receive less than 50 per cent of the sun's effective radiation on earth. When we say effective radiation, we mean the radiation which can be used by plants to carry out photosynthesis.

Most of the sun's radiation that falls on the earth is usually reflected back into space by the earth's atmosphere. This effective radiation is termed as **the Photosynthetically Active Radiation (PAR)**.

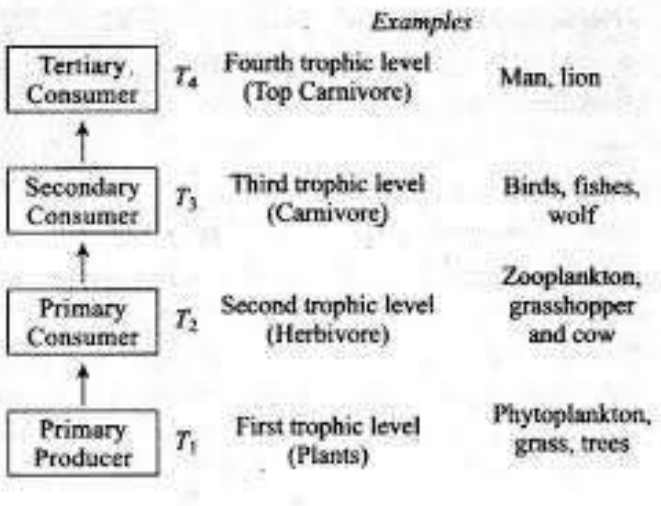
Overall we receive about 40 to 50 percent of the energy having Photosynthetically Active Radiation and only around 2-10 percent of it is used by plants for the process of photosynthesis. Thus, this percent of PAR supports the entire world as plants are the producers in the ecosystem and all the other organisms are either directly or indirectly dependent on them for their survival.

The energy flow takes place via food chain and food web. During the process of energy flow in the ecosystem, plants being the producers absorb sunlight with the help of the chloroplasts and a part of it is transformed into chemical energy n in the process of photosynthesis.

This energy is stored in various organic products in the plants and passed on to the primary consumers in the food chain when the herbivores consume (primary consumers) the plants as food and convert chemical energy accumulated in plant products into kinetic energy, degradation of energy will occur through its conversion into heat.

Then followed by the secondary consumers. When these herbivores are consumed by carnivores of the first order (secondary consumers) further degradation will occur. Finally, when tertiary consumers consume the carnivores, again energy will be degraded. Thus, the energy flow is unidirectional in nature.

Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as their **trophic level.** Producers belong to the first trophic level, herbivores (**primary consumer**) to the second and carnivores (**secondary consumer**) to the third.(Fig.)



The important point to note is that the amount of energy decreases at successive trophic levels. When any organism dies it is converted to detritus or dead biomass that serves as an energy source for decomposers. Organisms at each trophic level depend on those at the lower trophic level for their energy demands. Each trophic level has a certain mass of living material at a particular time called as the standing crop. **The standing crop is measured as the mass of living organisms (biomass) or the number in a unit area. The biomass of a species is expressed in terms of fresh or dry weight.**

Moreover, in a food chain, the energy flow follows the 10 percent law. According to this law, only 10 percent of energy is transferred from one trophic level to the other; rest is lost into the atmosphere.

(III) BIOLOGICAL

(A) Food Chain

The transfer of food energy from the producers, through a series of organisms (herbivores to carnivores to decomposers) with repeated eating and being eaten, is known as food chain.

In nature, basically two types of food chains are recognized – grazing food chain and detritus food chain.

Food chains and energy flow are the functional properties of ecosystems which make them dynamic. The biotic and abiotic components of an ecosystem are linked through them.

There are two types of food chains:

(i)Grazing food chains: which starts from the green plants that make food for herbivores and herbivores in turn for the carnivores. Ecosystems with such type of food chain are directly dependent on an influx of solar radiation.

This type of chain thus depends on autotrophic energy capture and the movement of this captured energy to herbivores. Most of the ecosystems in nature follow this type of food chain.

A simple grazing food chain (GFC) is depicted below:

The phytoplanktons →zooplanktons →Fish sequence

or

the grasses →rabbit →Fox sequences are the examples, of grazing food chain.

(ii) Detritus food chains: start from the dead organic matter to the detrivore organisms which in turn make food for protozoan to carnivores etc.

The detritus food chain (DFC) begins with dead organic matter. It is made up of decomposers which are heterotrophic organisms, mainly fungi and bacteria. They meet their energy and nutrient requirements by degrading dead organic matter or detritus. These are also known as saprotrophs (sapro: to decompose). *Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them.*

In an aquatic ecosystem, GFC is the major conduit for energy flow. As against this, in a terrestrial ecosystem, a much larger fraction of energy flows through the detritus food chain than through the GFC. Detritus food chain may be connected with the grazing food chain at some levels: some of the organisms of DFC are prey to the GFC animals, and in a natural ecosystem, some animals like cockroaches, crows, etc., are omnivores.

Parasitic food chain

Parasitic food chain is also a auxiliary food chain. It begins with the host and usually end in parasite.

(B) Food web

Simple food chains are very rare in nature because each organism may obtain food from more than oe trophic level. Thus, in an ecosystem, the various food chains are interconnected to each

other to form a network called food web. A food web illustrates all possible transfers of energy and nutrient among the organisms in an ecosystem, whereas food chain traces onle one pathway of food. Food webs are very important in maintaining the stability of an ecosystem.

Differences between food chain and food web

Food chain	Food Web
1. Food chain is defined as the phenomenon of transfer of energy through series of organisms falling on successive trophic levels.	1. Food web is an interconnection of food chains which shows relation between them.
2. In food chains, usually member of high trophic level feed upon a single type of organism of lower trophic level.	2. In food web members of higher trophic level feed upon many organisms of lower trophic level.
3. In food chains, separate and isolated food chains increase the instability of the ecosystem.	3. In food web, stability of the ecosystem increases by the presence of complex food webs.
4. It comprises of only one chain.	4. It comprises of many chains.
5. Removal of one group of organism disturbs the whole chain.	5. Removal of one group of organism not at all disturbs food web.

(III) ECOLOGICAL SUCCESSION

An important characteristic of all communities is that their composition and structure constantly change in response to the changing environmental conditions. This change is orderly and sequential, parallel with the changes in the physical environment. These changes lead finally to a community that is in near equilibrium with the environment and that is called a **climax community**. ***The gradual and fairly predictable change in the species composition of a given area is called ecological succession***. During succession some species colonise an area and their populations become more numerous, whereas populations of other species decline and even disappear. The entire sequence of communities that successively change in a given area are called **sere**(s). The individual transitional communities are termed **seral stages** or **seral communities**. In the successive seral stages, there is a change in the diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass. The present-day communities in the world have come to be because of succession that has occurred over millions of years since life started on earth. Actually, succession and evolution would have been parallel processes at that time. Succession is hence a process that starts where no living organisms are there – these could be areas where no living organisms ever existed, say bare rock; or in areas that somehow, lost all the living organisms that existed there. The former is called **primary succession,** while the latter is termed **secondary succession**.

primary succession: Primary succession is the series of community changes which occur on an entirely new habitat which has never been colonized before. For example, a newly quarried rock face or sand dunes. The establishment of a new biotic community is generally slow.

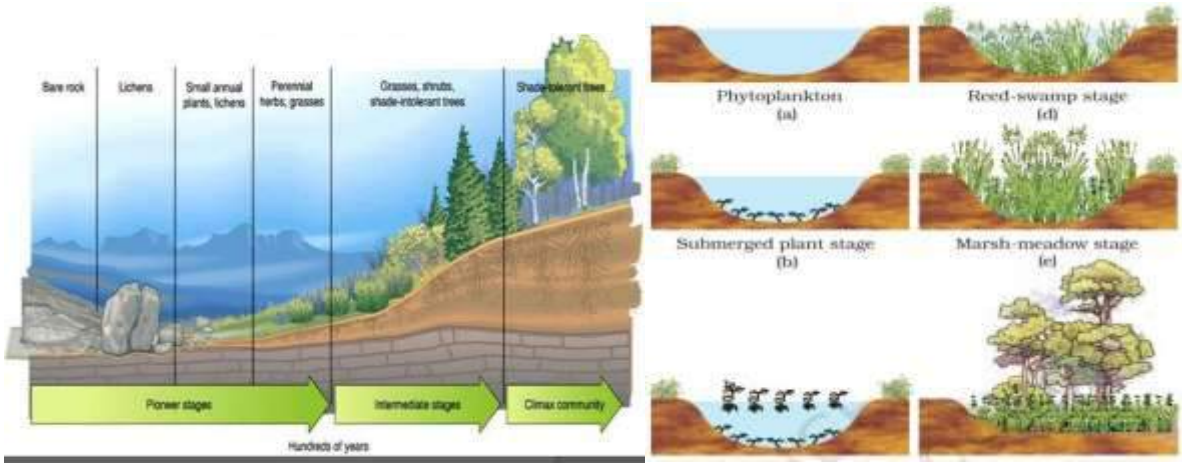
Secondary succession: Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farm lands, burned or cut forests, lands that have been flooded. Since some soil or sediment is present, succession is faster than primary succession.

Succession of Plants

Based on the nature of the habitat – whether it is water (or very wet areas) or it is on very dry areas – succession of plants is called hydrarch or xerarch, respectively. **Hydrarch succession** takes place in wetter areas and the successional series progress from hydric to the mesic conditions. As against this, **xerarch succession** takes place in dry areas and the series progress from xeric to mesic conditions. Hence, both hydrarch and xerarch successions lead to medium water conditions (mesic) – neither too dry (xeric) nor too wet (hydric). The species that invade a bare area are called **pioneer species**.

In *primary succession on rocks* these are usually **lichens** which are able to secrete acids to dissolve rock, helping in weathering and soil formation. These later pave way to some very small plants like bryophytes, which are able to take hold in the small amount of soil. They are, with time, succeeded by bigger plants, and after several more stages, ultimately a stable climax forest community is formed. *The climax community remains stable as long as the environment remains unchanged*.

In *primary succession in water*, the pioneers are the small **phytoplanktons**, they are replaced with time by rooted-submerged plants, rooted-floating angiosperms followed by free-floating plants, then reedswamp, marsh-meadow, scrub and finally the trees. The climax again would be a forest. With time the water body is converted into land (Figure 14.5).



In secondary succession the species that invade depend on the condition of the soil, availability of water, the environment as also the seeds or other propagules present. Since soil is already there, the rate of succession is much faster and hence, climax is also reached more quickly. What is important to understand is that succession, particularly primary succession, is a very

slow process, taking maybe thousands of years for the climax to be reached. Another important fact is to understand that all succession whether taking place in water or on land, proceeds to a similar climax community – the mesic.

(IV) BIOGIOCHEMICAL PROCESSES

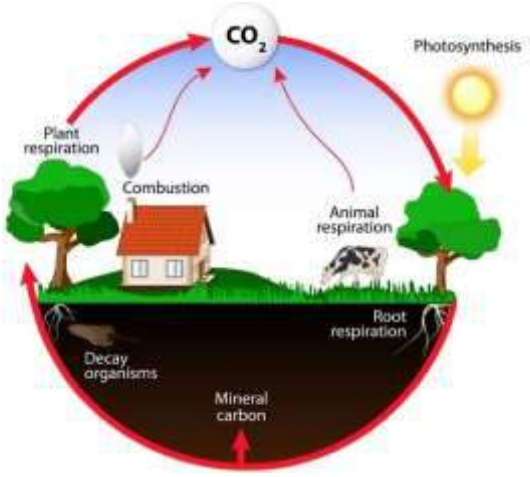
NUTRIENT CYCLING

All elements in the earth are recycled time and again. The major elements such as oxygen, carbon, nitrogen, phosphorous, and sulphur are essential ingredients that make up organisms. Biogeochemical cycles refer to the flow of such chemical elements and compounds between organisms and the physical environment. Chemicals taken in by organisms are passed through the food chain and come back to the soil, air, and water through mechanisms such as respiration, excretion, and decomposition.As an element moves through this cycle, it often forms compounds with other elements as a result of metabolic processes in living tissues and of natural reactions in the atmosphere, hydrosphere, or lithosphere. Such ***cyclic exchange of material between the living organisms and their non-living environment is called Biogeochemical Cycle.***

Nutrient cycles are of two types: (a) gaseous and (b) sedimentary. The reservoir for gaseous type of nutrient cycle (e.g., nitrogen, carbon cycle) exists in the atmosphere and for the sedimentary cycle (e.g., sulphur and phosphorus cycle), the reservoir is located in Earth's crust. Environmental factors, e.g., soil, moisture, pH, temperature, etc., regulate the rate of release of nutrients into the atmosphere. The function of the reservoir is to meet with the deficit which occurs due to imbalance in the rate of influx and efflux.

(1) Carbon Cycle

Carbon enters into the living world in the form of carbon dioxide through the process of photosynthesis as carbohydrates. These organic compounds (food) are then passed from the producers to the consumers (herbivores & carnivores). This carbon is finally returned to the surrounding medium by the process of respiration or decomposition of plants and animals by the decomposers. Carbon is also recycled during the burning of fossil fuels.



(2) Nitrogen cycle

Nitrogen is an essential component of protein and required by all living organisms including human beings. Our atmosphere contains nearly 79% of nitrogen but it can not be used directly

by the majority of living organisms. Broadly like corbondioxide, nitrogen also cycles from gaseous phase to solid phase then back to gaseous phase through the activity of a wide variety of organisms. Cycling of nitrogen is vitally important for all living organisms. There are five main processes which essential for nitrogen cycle are elaborated below

(a)Nitrogen fixation: This process involves conversion of gaseous nitrogen into Ammonia, a form in which it can be used by plants. Atmospheric nitrogen can be fixed by the following three methods: -

(i)Atmospheric fixation: Lightening, combustion and volcanic activity help in the fixation of nitrogen.

(ii) Industrial fixation: At high temperature (400^{o}C) and high pressure (200 atm.), molecular nitrogen is broken into atomic nitrogen which then combines with hydrogen to form ammonia.

(iii) Bacterial fixation: There are two types of bacteria- (i) Symbiotic bacteria e.g. Rhizobium in the root nodules of leguminous plants. (ii) Freeliving or symbiotic e.g. 1. Nostoc 2. Azobacter 3.

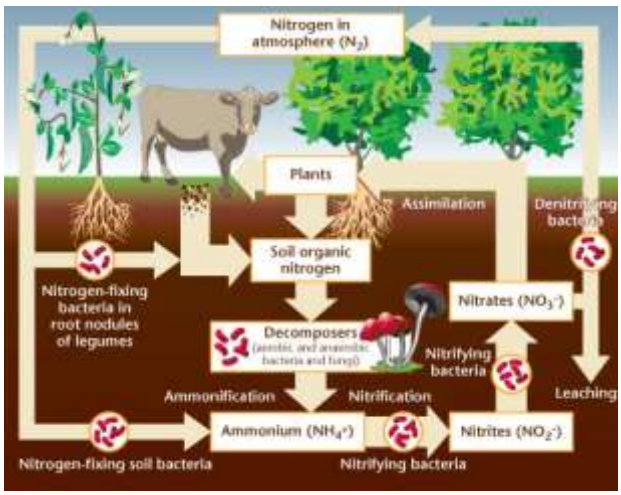
Cyanobacteria can combine atmospheric or dissolved nitrogen with hydrogen to form ammonia.

(**b) Nitrification**: It is a process by which ammonia is converted into nitrates or nitrites by Nitrosomonas and Nitrococcus bacteria respectively. Another soil bacteria Nitrobacter can covert nitrate into nitrite.

(c) Assimilation: In this process nitrogen fixed by plants is converted into organic molecules such as proteins, DNA, RNA etc. These molecules make the plant and animal tissue.

(d) Ammonification: Living organisms produce nitrogenous waste products such as urea and uric acid. These waste products as well as dead remains of organisms are converted back into inorganic ammonia by the bacteria This process is called ammonification. Ammonifying bacteria help in this process.

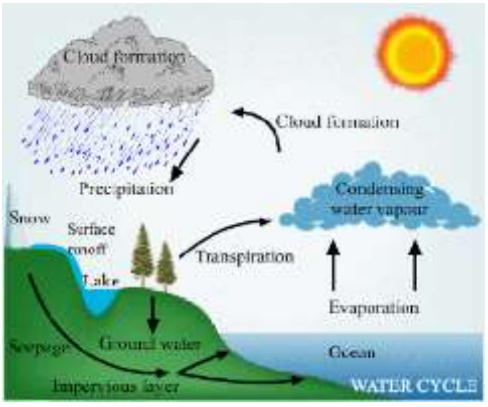
(e) Denitrification: Conversion of nitrates back into gaseous nitrogen is called denitrification. Denitrifying bacteria live deep in soil near the water table as they like to live in oxygen free medium. Denitrification is reverse of nitrogen fixation.



(3) **Water Cycle**

Water is essential for life. No organism can survive without water. Precipitation (rain, snow, slush dew etc.) is the only source of water on the earth. Water received from the atmosphere on the earth returns back to the atmosphere as water vapour resulting from direct evaporation and through evapotranspiration the continuous movement of water in the biosphere is called water cycle (hydrological cycle). Earth is a watery planet of thesolar system, about 2/3rd of earth surface is covered with water. However a very small fraction of this is available to animals and plants. Water is not evenly distributed throughout the surface of the earth. Almost 95 % of the total water on the earth is chemically bound to rocks and does not cycle. Out of the remaining 5%, nearly 97.3% is in the oceans and 2.1% exists as polar ice caps. Thus only 0.6% is present as fresh water in the form of atmospheric water vapours, ground and soil water. The driving forces for water cycle are 1) solar radiation 2) gravity. Evaporation and precipitation are two main processes involved in water cycle. These two processes alternate with each other Water from oceans, lakes, ponds, rivers and streams evaporates by sun's heat energy. Plants also transpire huge amounts of water. Water remains in the vapour state in air and forms clouds which drift with wind. Clouds meet with the cold air in the mountainous.

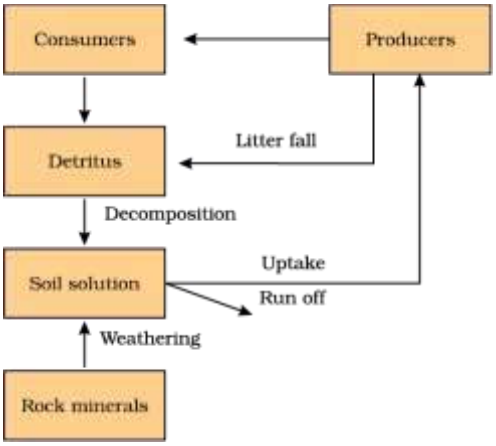
On an average 84% of the water is lost from the surface of the through oceans by evaporation. While 77% is gained by it from precipitation. Water run-off from lands through rivers to oceans makes up 7% which balances the evaporation deficit of the ocean. On land, evaporation is 16% and precipitation is 23%.



(4) Phosphorus Cycle

Phosphorus is a major constituent of biological membranes, nucleic acids and cellular energy transfer systems. Many animals also need large quantities of this element to make shells, bones and teeth. The natural reservoir of phosphorus is rock, which contains phosphorus in the form of phosphates. When rocks are weathered, minute amounts of these phosphates dissolve in soil solution and are absorbed by the roots of the plants (Fig.). Herbivores and other animals obtain this element from plants. The waste products and the dead organisms are decomposed by phosphate-solubilising bacteria releasing phosphorus. Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere. The other two major and important differences between carbon and phosphorus cycle are firstly, atmospheric inputs of phosphorus

through rainfall are much smaller than carbon inputs, and, secondly, gaseous exchanges of phosphorus between organism and environment are negligible.



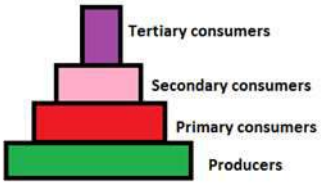
ECOLOGICAL PYRAMIDS

Ecological pyramids are the graphical representations of trophic levels in an ecosystem. The base of each pyramid represents the producers or the first trophic level while the apex represents tertiary or top level consumer. The three ecological pyramids that are usually studied are (a) pyramid of number; (b) pyramid of biomass and (c) pyramid of energy.

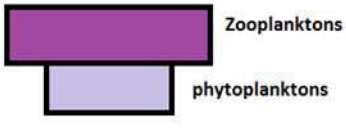
Pyramid of number: In this type of ecological pyramid, the number of organisms in each trophic level is considered as a level in the pyramid. The pyramid of numbers is usually upright except for some situations like that of the detritus food chain, where many organisms feed on one dead plant or animal.

(2) Pyramid of biomass: In this particular type of ecological pyramid, each level takes into account the amount of biomass produced by each trophic level. The pyramid of biomass is also upright except for that observed in oceans where large numbers of zooplanktons depend on a relatively smaller number of phytoplanktons.

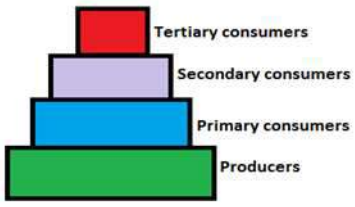
(3) Pyramid of energy: Pyramid of energy is the only type of ecological pyramid, which is **always upright as the energy flow in a food chain is always unidirectional**. Also, with every increasing trophic level, some energy is lost into the environment.



Pyramid of numbers



Pyramid of biomass in oceans



Pyramid of energy

Ecosystem homeostasis : Ecosystem homeostasis is equilibrium, or a balance of the organisms in an ecosystem. This means the populations of species in the ecosystem are relatively stable. Over time, these populations will change, but in the short term, they should move up and down in cycles around an average value**.**

TYPES OF ECOSYSTEM

An ecosystem consists of all the living and non-living things in a specific natural setting. Plants, animals, insects, microorganisms, rocks, soil, water and sunlight are major components of many ecosystems. All types of ecosystems fall into one of two categories: **terrestrial** or **aquatic**. Terrestrial ecosystems are land-based, while aquatic are water-based.The word "biome" may also be used to describe terrestrial ecosystems which extend across a large geographic area, such as tundra.

(1)Terrestrial Ecosystems

The ecosystem which is found only on landforms is known as the terrestrial ecosystem. The main factor which differentiates the terrestrial ecosystems from the aquatic ecosystems is the relative shortage of water in the terrestrial ecosystems and as a result the importance that water attains in these ecosystems due to its limited availability. Another factor is the better availability of light in these ecosystems as the environment is a lot cleaner in land than it is in water. The main types of terrestrial ecosystems are the forest ecosystems, the desert ecosystems, the grassland ecosystems and the mountain ecosystems. We are going to study all of these individually here in detail.

(a) Forest Ecosystems

These ecosystems have an abundance of flora or plants and hence in these ecosystems a large number of organisms live in a small space. This means that these ecosystems have a high density of living organisms. These ecosystems are classified according to their climate type as tropical, temperate or boreal i.e; tropical evergreen forest, tropical deciduous forest, temperate evergreen forest, temperate deciduous forest and taiga. In the tropics, rainforest ecosystems contain more diverse flora and fauna than ecosystems in any other region on earth. In these warm, moisture-laden environments, trees grow tall and foliage is lush and dense, with species inhabiting the forest floor all the way up to the canopy. In temperate zones, forest ecosystems may be deciduous, coniferous or oftentimes a mixture of both, in which some trees shed their leaves each fall, while others remain evergreen year-round. In the far north, just south of the Arctic, boreal forests – also known as taiga – feature abundant coniferous trees.

(b) Grassland Ecosystems

The grasslands are the areas which comprise mainly of the grasses with a little number of shrubs and trees. Grazing animals, insectivores and herbivores are the main types of organisms which are found in these regions. The three major types of grasslands are the prairies, savannas and

steppes. Grassland ecosystems are typically found in tropical or temperate regions, although they can exist in colder areas as well, as is the case with the well-known Siberian steppe. Grasslands share the common climactic characteristic of semi-aridity. Trees are sparse or non-existent, but flowers may be interspersed with the grasses. Grasslands provide an ideal environment for grazing animals.

Savanna are the tropical grasslands which are dry seasonally and have a large number of predators and grazers. Prairies are temperate grasslands which are totally devoid of large shrubs and trees. Prairies are of three different types, mixed grass, tall grass and short grass prairies.

(c) Desert Ecosystems

The common defining feature among desert ecosystems is low precipitation, generally less than 25 centimeters, or 10 inches, per year. Almost 17% of all the land on this planet is occupied by the desert ecosystems.The fauna and flora in these ecosystems is generally not much developed because of the high temperatures, intense sunlight and low availability of water. The main vegetation of such regions are the shrubs, bushes and a few grasses and trees. The stems and leaves of these plants are also developed in order to conserve as much water as possible. Camels, reptiles and some insects and birds are the living creatures which are found in such regions.

Not all deserts are hot – desert ecosystems can exist from the tropics to the arctic, but regardless of latitude, deserts are often windy. Some deserts contain sand dunes, while others feature mostly rock.

(d) Tundra Ecosystems

As with deserts, a harsh environment characterizes ecosystems in the tundra. In the snow-covered, windswept, treeless tundra, the soil may be frozen year-round, a condition known as permafrost. The mountain ecosystem is the most scattered and diverse in terms of the habitats that it provides. A large number of animals and plants are found in this ecosystem. Though the conditions at the very high altitudes can be very demanding allowing only the survival of the treeless alpine vegetation. Another important feature about these ecosystems is that the animals which live here have thick fur coats for protection against cold and generally have a long hibernation period in the winters. The slopes at lower altitudes are generally covered with coniferous forests.

During the brief spring and summer, snows melt, producing shallow ponds which attract migrating waterfowl. Lichens and small flowers may become visible during this time of year. The term “tundra” most commonly denotes polar areas, but at lower latitudes, tundra-like communities known as alpine tundra may be found at high elevations.

(2) Aquatic Ecosystem

An ecosystem which exists in a body of water is known as an aquatic ecosystem. The communities of living organisms which are dependent on each other and the aquatic surroundings of their environment for their survival exist in the aquatic ecosystems. The aquatic ecosystems are mainly of two types, the freshwater ecosystems and the marine ecosystems.

(a) Marine Ecosystem

Marine ecosystems are the biggest ecosystems. They cover around 71% of earth's surface and also contain almost around 97% of the total water present on earth. High amounts of minerals and salts are generally present in the water in the marine ecosystems and to better understand the amount and composition of the different minerals and salts in the water in different marine ecosystems. Marine ecosystems differ from freshwater ecosystems in that they contain saltwater, which usually supports different types of species than does freshwater. Marine ecosystems are the most abundant types of ecosystems in the word. They encompass not only the ocean floor and surface but also tidal zones, estuaries, salt marshes and saltwater swamps, mangroves and coral reefs.

(b) Freshwater Ecosystem

The freshwater ecosystems are very small in magnitude as compared to the marine ecosystems as these covers only 0.8% of the earth's surface and only account for 0.009% of the total water present on earth. There are three basic kinds of freshwater ecosystems and these are ***Lentic, Lotic, and Wetlands.*** The lentic ecosystems are slow-moving or still water like ponds or lakes. Lotic ecosystems are fast-moving water like rivers. The wetlands are those systems where soil remains saturated for a long period of time. Many different species of reptiles, amphibians, and around 41% of the world's fish species live in these ecosystems. The faster moving waters contain more dissolved oxygen than the slow moving waters and hence support greater biodiversity.

Pond Ecosystems – These are usually relatively small and contained. Most of the time they include various types of plants, amphibians and insects. Sometimes they include fish, but as these cannot move around as easily as amphibians and insects, it is less likely, and most of the time fish are artificially introduced to these environments by humans.

River Ecosystems – Because rivers always link to the sea, they are more likely to contain fish alongside the usual plants, amphibians and insects.

These sorts of ecosystems can also include birds because birds often hunt in and around water for small fish or insects.

As is clear from the title, freshwater ecosystems are those that are contained to freshwater environments. This includes, but is not limited to, ponds, rivers and other waterways that are not the sea (which is, of course, saltwater and cannot support freshwater creatures for very long). Freshwater ecosystems are actually the smallest of the three major classes of ecosystems, accounting for just 1.8% of the total of the Earth's surface. The ecosystems of freshwater systems include relatively small fish (bigger fish are usually found in the sea), amphibians (such as frogs, toads and newts), insects of various sorts and, of course, plants. The absolutely smallest living part of the food web of these sorts of ecosystems is plankton, a small organism that is often eaten by fish and other small creatures.

ECOSYSTEM SERVICES

Ecosystem services are the benefits that people obtain from ecosystems. They support, directly or indirectly, our survival and quality of life. Some ecosystem services are well known, such as those which are essential for life (e.g. food and clean air and water) or those which improve our quality of life (e.g. recreation and beautiful landscapes). Other services are often taken for granted, such as natural processes (e.g. pollination and flood regulation) (Fig 2). According to the Millennium Ecosystem Assessment (MA) that 60% of ecosystem services are being degraded or used unsustainably, often resulting in significant harm to human well-being. The MA categorised ecosystem services into four classes:

1. **Provisioning services,** which are the products obtained from ecosystems, such as food, water, fuel and materials for building. Agro-ecosystems provide food for human consumption and, together with the associated ecosystems supporting marine and freshwater fisheries, underpin global food security. Ecosystems play important roles in the global hydrological cycle, contributing to water provision, regulation and purification (Dudley and Stolton 2003; Bruijnzeel 2004; Brauman et al. 2007). The provision of fuels and fibres, medicinal and other biochemical resources such as metabolites, pharma-ceuticals, nutrients, crop protection chemicals, cosmetics and other natural products for industrial use and as a basis for biomimetics that may become increasingly important in nanotechnology applications (Ninan 2009). Biodiversity has also played an iconic, ornamental role throughout the development of human society. Uses of plant and animal parts, especially plumage of birds, have been important in conferring individual status, position and influence. Ornamental plants are typically grown for the display of their flowers but other common ornamental features include leaves, scent, fruit, stem and bark.

2. Regulating services, Ecosystems contribute to several of natural processes, like air quality regulation, climate regulation, water/flood regulation, disease and pest control, pollination and water purification, environmental regulation services of importance for human wellbeing, particularly in urban areas where vegetation reduce air and noise pollution, mitigate the “urban heat island effect” (Santomouris, 2001), and reduce impacts related to climate change (Bolund and Hunhammar, 1999). Numerous factors interact in the regulation of climate, including the reflection of solar radiation by clouds, dust and aerosols in the atmosphere. Vegetation cover also play a key factor in preventing soil erosion and vegetation cover combined with drought resulted in unprecedented wind erosion, destroying farmland and livelihoods.

3. Cultural services, which are the non-material benefits people, obtain from ecosystems and landscapes through spiritual enrichment, recreation and aesthetic enjoyment.

4. Supporting services, such as soil formation, photosynthesis and nutrient and water cycling which are necessary for the production of all other ecosystem services. In some estimates, over 75% of the world's crop plants, as well as many plants that are source species for pharmaceutical s , rely on pollination by animal vectors (Nabhan and Buchman, 1997). Klein et al. (2007) found that, for 87 out of 115 leading global crops (representing up to 35% of the global food supply), fruit or seed numbers or quality were increased through animal pollination. In many agricultural systems, pollination is actively managed through the establishment of populations of domesticated pollinators, particularly the honeybee.

Ecosystempreservation and conservation strategies

It has taken millions of years of evolution, to accumulate this rich diversity in nature, but we could lose all that wealth in less than two centuries if the present rates of species losses continue. Ecosystem and its conservation are now vital environmental issues of international concern as more and more people around the world begin to realise the critical importance of biodiversity for our survival and well- being on this planet. Ecosystem is a wealth to which no value can be put. In the final analysis, the very survival of the human race is dependent on conservation of ecosytem. It is evident that this invaluable heritage is being destroyed at an alarming rate due to several reasons. There are several strategies which are adapted for conservation of ecosytem. Some of these are

1. Legislation Formal policies and programmes for conservation and sustainable utilisation of ecosytem resources date back to several decades. The concept of environmental protection is enshrined in the Indian constitution in Articles 48a and 51a (g). Major central acts relevant to biodiversity include: Environment Protection Act, 1986; Fisheries Act, 1897; Forest Act, 1927; Forest (Conservation) Act, 1980; Wildlife (Protection) Act 1972 and Wildlife (Protection) Amendment Act 1991. Biological Diversity Act, 2002.

2. In -situ Conservation Conserving the animals and plants in their natural habitats is known as in situ conservation. The established natural habitats are: National parks and sanctuaries; Biosphere reserves; Nature reserves; Reserved and protected forests; Preservation plots ; Reserved forests. Biosphere Reserves are another category of protected areas. Under this, a large area is declared as a Biosphere Reserve where wildlife is protected, but local communities are allowed to continue to live and pursue traditional activities within the Reserve. A programme “Eco-development” for insitu conservation of biological diversity involving local communities was initiated. It integrates the ecological and economic parameters for sustained conservation of ecosystems by involving local communities with maintenance of earmarked regions surrounding protected areas.

3. Ex-situ Conservation Ex-situ conservation of plants and animals preserve/ or protect them away from their natural habitat. This could be in zoological parks and botanical gardens or through the forestry institutions and agricultural research centres. A lot of effort is under way to collect and preserve the genetic material of crops, animal, bird and fish species.

4. Community Participation in Biodiversity Conservation It is being recognized that no legal provisions can be effective unless local communities are involved in planning, management and monitoring conservation programmes. Successful conservation strategies will have to have the confidence and participation of the local communities.

5. Recording Indigenous Knowledge The lives of local communities are closely interwoven with their environment, and are dependent upon their immediate resources for meeting their needs. These communities have a vast knowledge about local flora and fauna which is very important for biodiversity conservation. Much of this knowledge is orally passed on from generation to generation.

6. International Conservation Strategies Conserving biodiversity is not an issue confined to any one country or community. It is a crucial global concern. Several international treaties and agreements are in place in the attempt to strengthen international participation and commitment towards conserving biodiversity. Some of these are:

- **The Convention on Biological Diversity:** This was signed during the Earth Summit in 1992. It focuses not only on conserving biodiversity but also on sustainable use of biological resources and equitable sharing of benefits arising from its use.
- **The Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES):** This is an international treaty which is designed to protect wild plants and animals affected by international trade. The treaty, in force since 1975, controls the export, import and re-export of endangered and threatened wildlife.
- **The Convention on Wetlands of International Importance:** This Convention, also known as the Ramsar Convention, was signed in Ramsar (Iran) in 1971 and came into force in December 1975. It provides a framework for international cooperation for the conservation of wetland habitats which have been designated to the 'List of Wetlands of International Importance' (Dilip Sarkar, Conserving Biodiversity in India).

ECOSYSTEM RESTORATION

Ecological restoration is the process of reclaiming habitat and ecosystem functions by restoring the lands and waters on which plants and animals depend.

Ecological restoration seeks to initiate or accelerate ecosystem recovery following damage, degradation, or destruction. It is a corrective step that involves eliminating or modifying causes of ecological degradation and re-establishing the natural processes — like natural fires, floods, or predator-prey relationships — that sustain and renew ecosystems over time.

Restoration practitioners do not carry out the actual work of ecosystem recovery. Rather, they create the conditions needed for recovery so the plants, animals, and microorganisms can carry out the work of recovery themselves. Assisting recovery can be as simple as removing an invasive species or reintroducing a lost species or a lost function (like fire); or as complex as altering landforms, planting vegetation, changing the hydrology, and reintroducing wildlife.

The goal of ecological restoration is to return a degraded ecosystem to its **historic trajectory**, not its historic condition. The ecosystem may not necessarily recover to its former state since contemporary ecological realities, including global climate change, may cause it to develop along an altered trajectory, just as these same realities may have changed the trajectory of nearby undisturbed ecosystems. History plays an important role in restoration, but contemporary conditions must also be taken into consideration.

Biome Notes

1. **Biome** – has similar climate and plant and animal life.
2. 6 major **terrestrial** (land) biomes – tundra, boreal forest, deciduous forest, tropical rainforest, grassland, desert
3. 2 major **aquatic** (water) biomes – marine and freshwater
4. **Adaptation** – change in an organism or its parts that makes it more fit for a specific environment

TROPICAL RAINFOREST (Jungle, Rainforest)

5. **Canopy** – tops of trees 30-50 meters above the ground
6. **Understory** – second layer of shorter trees and vines; about 20-30 meters above ground
7. Very humid climate because it rains almost every day. Plants have a lot of water and grow tall.
8. Very little plants and animals live on the forest floor because the canopy doesn't let much light through. Most plants and animals live in the canopy.
9. Has more varied plant life than any other biome and very poor soil for growing crops.
10. Highest levels of precipitation of all biomes – rains daily; temperatures stay warm (80°F) all year round – no seasons
11. Trees, ferns, vines, fungi, orchids, insects, birds, monkeys, jaguars, frogs, snakes, eagles, bats, snakes, spiders, ants, beetles, sloths, etc.
12. Adaptations for plants and animals to live here: **Animals** have arms, hands, and feet to climbing so they can live in the canopy, long strong tails to help climb and balance when living on tree branches; **Plants** grow quickly and reach the top of the canopy where there is sunlight, plants under the canopy have large leaves to collect sunlight and grow quickly, some plants get nutrients by eating insects instead of getting nutrients from the soil since there are very few nutrients in the soil.

DESERT

13. Extremely little rain yearly: more evaporation and transpiration (sun pulling water from leaves) than precipitation.
14. No seasons, temperatures change with night and day. Very dry and hot during day and cold at night
15. Sahara Desert is the largest desert in the world. It's bigger than the whole United States and it's still growing
16. Cacti, aloe plants, sagebrush, lizards, camels, snakes, spiders, scorpions, chameleons, birds, reptiles, armadillos
17. Adaptations for plants and animals to live here: **Animals** have sandy colored skin, fur, and scales for camouflage, reptiles have thick scaly skin to keep water inside their bodies, large ears and long legs to release heat during the day, able to go for long amounts of time without drinking water or can store up water; **Plants** have a large root system that soaks up water very quickly when it rains, waxy coating covers plants and protection with thorns to keep water inside them

GRASSLAND (Tropical – Savannah; Temperate – Prairie, Plains)

18. **Monsoon** – massive rain storm in tropical grassland where it rains for weeks straight
19. **Overgrazing** – farmers grazing animals in an area too much and killing all the grasses
20. Grasslands become deserts when farmer overplant or overgraze the land.
21. Two seasons – wet and dry. In the wet season it rains all the time and floods out the tropical grassland area. Temperate grassland get blizzards instead of monsoons. The dry season gets no rain

or snow at all.

22. Cold winters and warm summers. Tropical grasslands are hotter in the summer than temperate grasslands because they're closer to the equator.
23. Temperature grasslands have the best soil for growing crops. Called "bread basket" here in US since most of the wheat and grain for making bread is grown here.
24. Home to the largest land animals – mostly herbivores
25. Grasses, small trees and shrubs, antelope, zebra, giraffe, lions, elephants, ants, wild dogs, cheetahs, mice, rats, snakes, hawks, rabbits, eagles, vultures, hyenas, prairie dogs
26. Adaptations for plants and animals to live here: **Animals** are striped/patterned to blend in with grasses and shrubs, quick runners to catch fast prey or outrun predators, release heat during the day from large ears and long legs, large land herbivores live in packs/herds to keep themselves safe from predators; **Plants** have wide spread roots to catch water in dry season, grow fast, store water, some with thorns for protection

DECIDUOUS FOREST (Temperate-mild forest)

27. **Deciduous** – plants that drop their leaves in autumn (fall)
28. **Dormant** – when plants have lost their leaves and shut down for the winter due to less sunlight
29. Four equal seasons (spring, summer, winter, fall) with average amounts of precipitation all year
30. Summers are hot and winters cold.
31. Trees losing their leaves in the fall makes for very good growing soil. It's the second best.
32. Oak, maple, beech trees, ferns, wild flowers, fungi, squirrel, deer, owl, spiders, birds, snakes, snails, insects, worms, mice, raccoon, frogs, salamanders, rabbits, chipmunks, opossums
33. OUR BIOME – we live here
34. Adaptations for plants and animals to live here: **Animals** adapted for all four seasons by growing thick fur in the fall/winter and shedding their fur in the spring/summer, hibernation or migration; **Plants** lose their leaves and go dormant during the winter to keep from losing water through transpiration during the cold winter.

BOREAL FOREST (Coniferous forest, Evergreen forest, Taiga)

35. **Conifer** – triangular shaped tree that has needles for leaves, stays green all year long, and covers its seeds with cones
36. Summers are very short and warm with winters being cold and lasting almost half the year. Some precipitation, but not a lot and it falls mostly as snow in the winter.
37. The soil thaws completely in spring and parts of the forest become like a swamp; also known as a "swamp forest" which is what taiga means in Russian
38. Too cold more many decomposers so things tend to stay on the forest floor for a long time making the soil less fertile than the other forests; less sunlight due to tilt of Earth so plants can be small and die quickly if they don't grow fast
39. Spruce, pine, Douglas fir, moose, beavers, lynx, snowshoe hare (rabbits), weasels, squirrels, wolves, birds, elk, otter
40. Adaptations for plants and animals to live here: **Animals**: thick fur for warmth, white fur in the winter and brown fur in the summer for camouflage, hibernate during winter when plants go dormant and there is little food, hooves to dig through the snow pack and get to buried plants; **Plants** grow quickly because summer is very short, trees have needles to keep moisture inside them

and are cone shaped to let snow slide off them

TUNDRA

41. **Permafrost** – permanently frozen soil, covers the land – frozen soil stops trees from growing
42. Very cold, dry, and windy climate; like a cold desert. Gets only a little more precipitation a year than a desert does.
43. Yearly temperatures stay mostly below freezing except for the short spring/summer/fall season that lasts 3 months total. Some plants live their entire life span in this time.
44. Mostly in spring/summer/fall – flowers, grasses, lichen, ducks, geese, shore birds, weasels, arctic foxes, squirrels, caribou, mosquitoes, lemmings, mice, polar bears, penguins
45. Adaptations for plants and animals to live here: **Animals**: white fur for camouflage, thick fur for warmth, black skin under their white fur to help trap heat, short logs and small ears to keep heat from escaping their bodies, hooves to dig through the permafrost to find food; **Plants** have shallow roots because soil stays frozen, grow quickly because summer is very short

MARINE (Ocean)

46. **Streamlined** – sleek body shaped to move quickly through water – aerodynamic for the water
47. Covers 70% of Earth
48. Amount of sunlight and temperatures drop as you go deeper down. Water pressure increases the further down into the ocean an animal goes.
49. Plants grow near surface of ocean where they can capture sunlight
50. Currents and tides cause change in habitat at shore – where ocean meets land
51. Coral reefs have the second most diverse habitat on Earth
52. Algae, seaweed, phytoplankton, kelp, clams, crabs, lobsters, fish, sharks, dolphins, whales, sea birds, sea stars, sponges, coral, sea anemones, feather duster worms, sea cucumbers, sea urchins
53. Adaptations for plants and animals to live here: Plants and animals are able to live in salty water; **Animals** are streamlined so they can move quickly through the water, have gills for breathing, birds have waxy feathers to keep water off their bodies while they swim, webbed feet to push water large wings so they can glide using winds of the ocean using less energy; **Plants** float on top of the water to capture sunlight

FRESHWATER (examples: Pond, Stream, Lake, Creek, River)

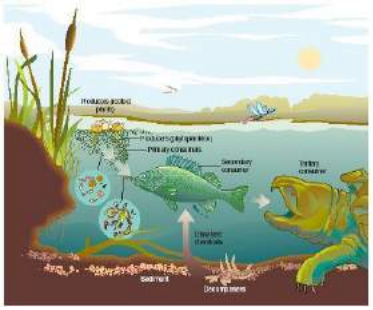
54. **Streamlined** – sleek body shaped to move quickly through water – aerodynamic for the water
55. Both still and running water that does not have salt
56. Factors that affect life are the temperature of the water, amount of sunlight and oxygen, food available, and the speed the water moves
57. Grasses, cattails, lily pads, algae, fish, frogs, birds, turtles, insects, hydra
58. Adaptations for plants and animals to live here: **Animals** are streamlined so they can move quickly through the water, have gills for breathing, birds have waxy feathers to keep water off their bodies while they swim, webbed feet to push water; **Plants** float on top of the water to capture sunlight

ESTUARY (examples: Swamp, bog, marsh, lagoon, mangrove swamp)

59. Boundary between freshwater and marine biomes like the Chesapeake Bay. THIS IS NOT A REAL BIOME BUT AN ECOSYSTEM.
60. **Brackish** - mixture of fresh and salt water – where the freshwater empties into the ocean

61. Usually shallow and sunlight reaches the bottom
62. Important “nurseries” for many young fish, sharks, and other animals before they head into the ocean. Many birds nest here as well.
63. Marsh grasses, mangrove trees, algae, fish, crabs, oysters, shrimp, birds, insects, frogs, spiders
64. Adaptations for plants and animals to live here: Plants and animals are able to live in brackish water; **Animals** are streamlined so they can move quickly through the water, have gills for breathing, birds have waxy feathers to keep water off their bodies while they swim, webbed feet to push water; **Plants** float on top of the water to capture sunlight

Label each picture with the name of the biome. List 3 things that make you think it is that biome.



MCQs in Ecosystems

Which statement most accurately describes how matter and energy are used in ecosystems?
A) Matter is cycled through ecosystems; energy is not.
B) Energy is cycled through ecosystems; matter is not.
C) Energy can be converted into matter; matter cannot be converted into energy.
D) Matter can be converted into energy; energy cannot be converted into matter.
E) Matter is used in ecosystems; energy is not.
Answer: A

Photosynthetic organisms are unique to most ecosystems because they
A) synthesize organic compounds they obtain from decaying heterotrophs.
B) synthesize inorganic compounds from organic compounds.
C) use light energy to synthesize organic compounds.
D) use chemical energy to synthesize organic compounds.
E) convert light energy into matter.
Answer: C

A cow's herbivorous diet indicates that it is a(n)
A) primary consumer.
B) secondary consumer.
C) decomposer.
D) autotroph.
E) producer.
Answer: A

To recycle nutrients, an ecosystem must have, at a minimum,
A) producers.
B) producers and decomposers.
C) producers, primary consumers, and decomposers.
D) producers, primary consumers, secondary consumers, and decomposers.
E) producers, primary consumers, secondary consumers, top carnivores, and decomposers.
Answer: B

If the sun were to suddenly stop providing energy to Earth, most ecosystems would vanish. Which of the following ecosystems would likely survive the longest after this hypothetical disaster?
A) tropical rain forest
B) tundra
C) benthic ocean
D) grassland
E) desert
Answer: C

Which of the following is true of detrivores?
A) They recycle chemical elements directly back to primary consumers.

B) They synthesize organic molecules that are used by primary producers.
C) They convert organic materials from all trophic levels to inorganic compounds usable by primary producers.
D) They secrete enzymes that convert the organic molecules of detritus into CO_2 and H_2O.
E) Some species are autotrophic, while others are heterotrophic.
Answer: C

The major role of detrivores in ecosystems is to
A) provide a nutritional resource for heterotrophs.
B) recycle chemical nutrients to a form capable of being used by autotrophs.
C) prevent the buildup of the organic remains of organisms, feces, and so on.
D) return energy lost to the ecosystem by other organisms.
Answer: B

Subtraction of which of the following will convert gross primary productivity into net primary productivity?
A) the energy contained in the standing crop
B) the energy used by heterotrophs in respiration
C) the energy used by autotrophs in respiration
D) the energy fixed by photosynthesis
E) all solar energy
Answer: C

Which of these ecosystems accounts for the largest amount of Earth's net primary productivity?
A) tundra
B) savanna
C) salt marsh
D) open ocean
E) tropical rain forest
Answer: D

Which of these ecosystems has the highest net primary productivity per square meter?
A) savanna
B) open ocean
C) boreal forest
D) tropical rain forest
E) temperate forest
Answer: D

The total biomass of photosynthetic autotrophs present in an ecosystem is known as
A) gross primary productivity.
B) standing crop.
C) net primary productivity.
D) secondary productivity.
E) trophic efficiency.
Answer: B

What is secondary production?
A) energy converted by secondary consumers from primary consumers
B) solar energy that is converted to chemical energy by photosynthesis
C) food that is converted to new biomass by consumers
D) energy that is not used by consumers for growth and reproduction
E) growth that takes place during the second year of life in consumers
Answer: C

Consider the food chain grass → grasshopper → mouse → snake → hawk. How much of the chemical energy fixed by photosynthesis of the grass (100%) is available to the hawk?
A) 0.01%
B) 0.1%
C) 1%
D) 10%
E) 60%
Answer: A

Nitrogen is available to plants only in the form of
A) N_2 in the atmosphere.
B) nitrite ions in the soil.
C) uric acid from animal excretions.
D) amino acids from decomposing plant and animal proteins.
E) nitrate ions in the soil.
Answer: E

In the nitrogen cycle, the bacteria that replenish the atmosphere with N_2 are
A) *Rhizobium* bacteria.
B) nitrifying bacteria.
C) denitrifying bacteria.
D) methanogenic protozoans.
E) nitrogen-fixing bacteria.
Answer: C

Unit 4: Biodiversity and Conservation

Introduction:

The word Biodiversity was first coined by Walter Rosen in 1986. The world is very rich in flora and fauna. It is a term used to describe the enormous variety of life forms on the surface of the Earth. It refers to the sum total of varieties of species-microbes, plants, insects, amphibians, reptiles, birds and mammals which are found in the biosphere and associated with ecosystem.

Definition:

Biodiversity itself is a combination of two words, Bio (life) and diversity (variety). In simple terms, biodiversity is the number and variety of organisms found within a specified geographic region. The presence of different kinds of living organisms, i.e., microorganisms, plants and animals, and their diverse ecological habits and the habitats in which they live are known as biodiversity.

In the Convention of Biological Diversity (1992), biodiversity has been defined as the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part.

Importance of Biodiversity:

1. Biodiversity is an imperative necessity for human race and society as we depend entirely on plants and animals for our basic necessities of life. We get our food, medicines, biochemicals, clothing's, shelter from the materials of our surrounding environment.
2. The energy which sustains human life is produced entirely by plants through photosynthesis. Energy is transferred from one trophic level to other at a diminishing rate.
3. Biodiversity is a pool of valuable genetic resource.
4. Many of the medicines come directly from different plants, fungi and bacteria.
5. As all species in a particular ecosystem live inter-dependently and loss of a particular species will disruptor break food chain or food web and disturb natural balance.
6. There is a close relationship between environmental pollution and community health. Due to air, water, and soil pollution in the environment, the community health will be disturbed.
   The conservation of biodiversity is the most important challenge of the present and immediate future for the benefit of the environmental and natural balance. Thus, conservation and wise management of biological diversity must get proper importance in our planning process and economic development must be based on ecological consideration.

Levels of Biodiversity:

It may range from the genetic level within a species to diversity found in different biomes, based on which three categories of biodiversity are recognized:

1. **Genetic Diversity**: When the genes within the same species show different versions due to new combinations, it is called genetic variability or diversity.
   It is the basic source of biodiversity. It provides specific characteristics and attributes to each individual making them different from each other. They are the basic unit of hereditary information transmitted from one generation to other. For example, there are 50,000 quantities of Oryza Sativa and 200 varieties of Mangifera Indica.
2. **Species Diversity:** This is the variability found within the population of a species or between different species of a community.

It represents broadly the species richness and their abundance in a community. There are two popular indices of measuring species diversity known as Shannon- Wiener index and Simpson index. Areas that are rich in species diversity are called 'hotspots' of diversity. India is among the world's 15 nations that are exceptionally rich in species biodiversity.

3. **Ecosystem Diversity**: This is the diversity of ecological complexity showing variations in physical characters, ecological niches, trophic structure, food-webs, nutrient cycling etc.
The ecosystem variations with respect to physical parameters include moisture, temperature, altitude, precipitation etc. Thus, there occurs tremendous diversity within the ecosystem, along these gradients. Each ecosystem has specific characteristics. For example, a forest ecosystem consists of predominantly trees, while grassland ecosystems have mainly grassed and shrubs.

Major Biogeographical Regions of India:

Biogeography comprising of phytogeography and zoogeography deals with region-wise distribution of plants and animals. India has a rich heritage of biological diversity and occupies the tenth position among the plant rich nations of the world.

Biogeographic Classification of India

India is known as a mega diversity country as it has diverse climate and landscape in different parts. Hence each region is characterised by different kinds of ecosystem, vegetation and animals. Based on these characteristics, biogeographers have classified India into ten biogeographic zones; each with particular climate, soil and biodiversity. These zones are as follows:

Sl. No.	Biogeographic zone	Province	% Of Country's landmass
1	Trans-Himalayas	Extension to the Tibetan plateau- cold desert in Ladakh (Jammu and Kashmir) and Lahaul Spiti (Himachal Pradesh)	5.70%
2	Himalayas	Kashmir in the North-West to Assam in the North-East	7.20%
3	Desert	The desert of Western Rajasthan- Thar	6.90%
		The desert of Gujarat- Kutch	
		Cold desert of Jammu & Kashmir - Ladakh	
4	Semi-Arid	Between the desert and the Deccan Plateau	15.60%
5	Western Ghats	Maharashtra, Goa, Karnataka and Kerala	5.80%
6	Deccan Plateau	Madhya Pradesh, Maharashtra, South Gujarat, West Bengal, Jharkhand,	4.30%
		Odisha, Chhattisgarh, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu	
7	Gangetic Plain	Upper Gangetic Plain, Lower Gangetic Plain	11.00%
8	North-East India	Brahmaputra valley, North- Eastern Hills	5.20%
9	Islands	Andaman and Nicobar Islands, Lakshadweep Islands	0.03%
10	Coasts	Coastline of India; West coast and East coast, mangroves of West Bengal	Rest of Landmass

Biodiversity Hotspots

Areas which exhibit high species richness as well as high species endemism are termed as hotspots of biodiversity.

A biodiversity hotspot is a biogeographic region with significant levels of biodiversity that is threatened with destruction. The concept of hotspot was introduced by Norman Myers in his articles "*The Environmentalists*" and "*Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions".*

Importance of Hotspots:

- Biodiversity supports all life on the Earth.
- Richest and important ecosystem.

Hotspots of India

1. **Eastern Himalayas**: It has nearly 163 globally threatened species including 45 mammals, 50 birds, 17 reptiles, 12 amphibians, 3 invertebrates and 36 plant species. The region is home for One horned Rhinoceros, the Wild Asian Water Buffalo and Himalayan Newt, etc.
2. **North – Eastern India**- This region is home to several primates such as monkeys, langurs and gibbons.
3. **Andaman and Nicobar Islands**- The biodiversity includes several species such as whales, dolphins, dugong, turtles, crocodiles, corals, sea shells, lobsters etc. The primary threat to this biodiversity comes from over exploitation of marine and forest resources.
4. **Western Ghats**- A major proportion of amphibians and reptile species, especially snakes are concentrated in the Western Ghats. There are 1,500 endemic plant species in the Western Ghats which makes the range of hills a globally important area for conserving plant life.

Major threats to biodiversity:

Some of the major causes and issues related to threats to biodiversity are:

1. **Loss of Habitat** – Destruction and loss of natural habitat is the single largest cause of biodiversity loss. Billions of hectares of forests and grasslands have been cleared over the past 10,000 years for conversion into agricultural lands, pastures, settlement areas or development projects. Marine diversity, wetlands and mangroves are under severe threat owing to destruction.
2. **Poaching**- Illegal trade of wildlife products by killing, prohibited endangered animals i.e., poaching is another threat to wildlife. Despite international ban on trade in products from endangered species, smuggling of wildlife items like furs, hides, horns, tusks, live specimens and herbal products worth millions of dollars per year continues.
3. **Human- wildlife conflict**- It refers to the interaction between wild animals and people which causes negative impact on people, resources, wild animals and their habitat. It occurs when growing human populations encroach and overlap with established wildlife territory. The resources gradually start reducing which leads to degradation of habitat which has its own consequences.

Species that have become endangered in India-

The International Union for Conservation of Nature and Natural Resources (IUCN) publishes the Red Data Book which includes the list of endangered species of plants and animals The red data symbolizes the warning signal for those species, which are endangered and if not protected are likely to become extinct in near future.

In India, nearly **450 plant species** have been identified in the categories of endangered, threatened or rare. Existence of about **150 mammals and 150 species of birds** is estimated to be threatened while an unknown number of species of insects are endangered. Few species of endangered reptiles, birds, mammals are given below:

a) **Reptiles : Gharial, green sea turtle, tortoise, python.**
b) **Birds : Great Indian Bustard, Peacock, Pelican, Great Indian Hornbill, Siberian White Crane.**
c) **Carnivorous Mammal's : Indian wolf, red fox, sloth bear, red panda, Indian lion, tiger, leopard, striped hyena, golden cat, desert cat, dugong.**
d) **Primates : lion tailed macaque, Nilgiri monkey, golden monkey, capped monkey.**
e) **Plants : A large number of species of orchids, rhododendrons, medicinal plants like Rauvolfia Serpentina, the sandal wood tree Santalum, Cycas beddonei, pitcher plant.**

Major Endemic Species of India.

India has three biodiversity hotspots and possesses a large number of endemic species. Out of about **47,000** species of plants in our country **7000** are endemic. Thus, Indian subcontinent has about **62% endemic flora**, restricted mainly to **eastern Himalayas, Khasi hills, Ganges-Brahmaputra lowlands and Western Ghats.**

A large number out of a total of **81,000** species of animals in our country is **endemic**. The Western Ghats are particularly rich in **amphibians (frogs, toads etc.) and reptiles (lizards, crocodiles etc.) About 62% amphibians and 50% lizards are endemic in Western Ghats**. Different species of monitor lizards, **reticulated python and Indian Salamander** and **Viviparous toad** are *Nectophhryne* are some of the endemic species of our country.

Biodiversity Conservation-

Biodiversity can be conserved by protecting or creating wilderness.

The enormous value of biodiversity due to their genetic, commercial, medical, aesthetic, ecological and optional importance emphasizes the need to conserve biodiversity. Gradually we are coming to realize that wildlife is not just 'a game to be hunted', rather it is a 'gift of nature' to be nurtured and enjoyed. A number of measures are now being taken the world over to conserve biodiversity including plants and wildlife.

There are two approaches of biodiversity conservation:

A) **In situ conservation (within habitat):** This is achieved by protection of wild flora and fauna in nature itself. E.g., Biosphere Reserves, National Parks, Sanctuaries, Reserve Forests, etc.
B) **Ex-situ conservation (outside habitat):** This is done by establishment of gene banks, seed banks, zoos, botanical gardens, culture collection etc.

A) **In situ Conservation**:

At present we have 18 notified Biosphere reserves, 103 National Parks and 536 wildlife sanctuaries in our country which are conserved and protected by law (**ENVIS centre on wildlife protected areas, 2016)**

A National Park is an area dedicated for the conservation of wildlife along with its environment. Grazing of domestic animals, all private rights and forestry activities are prohibited within a National Park. Each National Park usually aims at conservation specifically of some particular species of wildlife along with others. Some of the national parks in India are Kaziranga (Assam), Gir national park (Gujarat), Dachigam (Jammu and Kashmir), Bandipur (Karnataka), Periyar (Kerala), Jim Corbett (Uttarakhand),
Kanha (Madhya Pradesh), Ranthambor (Rajasthan), Sariska (Rajasthan), Gorumara (West Bengal).

Wildlife sanctuaries are also protected areas where killing, hunting, shooting or capturing of wildlife is prohibited except under the control of authority. Some important wildlife sanctuaries in India are Ghana Bird sanctuary (Rajasthan), Jaldapara sanctuary (West Bengal), Vedanthangal Bird Sanctuary (Tamil Nadu), Manas (Assam), Hazaribagh Sanctuary (Bihar).
Various projects related to conservation of certain animals have also been undertaken in our country to protect them like Project Tiger, Gir Lion project, Project Elephant etc.

B) **Ex Situ Conservation**-

This type of conservation is mainly done for conservation of crop varieties, the wild relatives crops and all the local varieties with the main objective of conserving the total genetic variability of the crop species for future improvement or afforestation programmes. In India, we have the following important gene bank/seed bank facilities.

- **National Bureau of Plant Genetic Resources (NBPGR**)- located in New Delhi. Here agricultural and horticultural crops are preserved by cryo-preservation of seeds, pollen etc. by using liquid nitrogen at temperature as low as -196-degree C.
- **National Bureau of Animal Genetic Resources (NBAGR**) is located at Karnal, Haryana. It preserves the semen of domesticated bovine animals.
- **National Facility for Plant Tissues Culture Repository (NFPTCR)** conserves the varieties of cop plants/ trees by tissue culture.

Botanical Gardens

They have collections of living plants for reference. A famous botanical garden of India is the **Indian Botanical Garden situated at Howrah (Kolkata**). **National Botanical Research Institute (NBRI) located at Lucknow (U.P.)** also has a large collection of plants. Botanical Survey of India (BSI) publishes the Green Book that enlists rare, endangered and endemic plant species growing in the

Biosphere and its importance:

Biosphere means the part of the earth where life is found. Within ecosystems, organisms interact with one another and with their physical environment in various ways through predations, competition, parasitism, mutualism and communalism. These relationships help organisms obtain the much-needed energy to keep themselves alive and to interact with their physical environment as they help circulate matter- such as water, oxygen, nitrogen, and carbon- through the ecosystem.

Even humans are part of the biosphere. However, many human activities like illegal dumping of wates into oceans and other bodies of water, the burning of fossil fuels and large-scale mining of minerals and other resources had a negative impact on the biosphere. It is now felt that we must conserve the biosphere's resources and coexist peacefully with other organisms in order to ensure the health and success of future generations.

Importance: The concept of biosphere reserves was evolved by the UNESCO under its Man and Biosphere (MAB) programme for achieving the following three objectives:

(i) To conserve for the present and future human use, the diversity and integrity of biotic communities within natural ecosystems and safeguard the genetic diversity of species on which their continuing evolution depends.

(ii) To provide areas for ecological and environmental research, including particular baseline studies, both within and adjacent to these reserves, such research being consistent with the above discussion.

(iii) Finally, to provide facilities for education, research and training.

Functions: The three functions of biosphere reserves are;

a) Conservation of biodiversity and ecosystems;
b) Development association of environment;
c) Logistics- International network for research and monitoring.

To qualify for designation as a biosphere reserve,

- an area should normally be representative of a major biogeographic region, contain landscape, ecosystems of animals and plant species of varieties which need to be conserved;
- provide an opportunity to explore and demonstrate approaches to "sustainable development" within larger regions where they are located;
- have an appropriate zoning system, with a legally constituted core area devoted to long term protection: a clearly identified buffer zone and an outer transition area.

The main functions of biosphere reserve are given below:

i) To preserve the various living including the species which need to be conserved and preserved non-living components of an ecosystem.
ii) Utmost attempt to conserve the various genetic diversities of life.
iii) Expansion of education about environment, ecosystem, conservation and uses.
iv) Extension of research-work and training.

v) Extension of local, national and international cooperation.

Biosphere reserve in India:

Sl. No.	Name of the biosphere	Year of Notification	Location
1	Nilgiri	1986	Tamil Nadu, Kerala and Karnataka
2	Nanda Devi	1988	Uttarakhand
3	Nokrek	1988	Meghalaya
4	Great Nicobar	1989	Andaman and Nicobar Islands
5	Gulf of Mannar	1989	Tamil Nadu
6	Manas	1989	Assam
7	Sundarbans	1989	West Bengal
8	Simlipal	1994	Odisha
9	Dibru- Saikhowa	1997	Assam
10	Dehang- Dibang	1998	Arunachal Pradesh
11	Panchmari	1999	Madhya Pradesh
12	Kangchendzonga	2000	Sikkim
13	Agasthyamalai	2001	Kerala
14	Achanakamar-Amarkantak	2005	Madhya Pradesh and Chhattisgarh
15	Kachchh	2008	Gujarat
16	Cold Desert	2009	Himachal Pradesh
17	Seshachalam Hills	2010	Andhra Pradesh
18	Panna	2011	Madhya Pradesh

OBJECTIVE TYPE QUESTIONS

A. SELECT THE APPROPRIATE ANSWER

1. Which of the following is *not* a biogeographic habitat of India as per classification

   (*a*) Himalayan
   (*b*) Western ghats
   (*c*) Sunderbans
   (*d*) Desert.

2. Vinblastin and Vincristine, two anticancer drugs have been obtained from

   (*a*) Periwinkle
   (*b*) Cinchona
   (*c*) Bacterium
   (*d*) Jelly fish.

3. Western ghats are very rich in endemic species of

   (*a*) Birds
   (*b*) Lions
   (*c*) Amphibians
   (*d*) Turtles.

4. Which of the following hot spots of biodiversity has the maximum number of plant and vertebrate species

   (*a*) Caribbean
   (*b*) Tropical Andes
   (*c*) Madagascar
   (*d*) Indo-Burma.

5. Which of the following is an extinct species ?

   (*a*) Dugong
   (*b*) Great Indian bustard
   (*c*) Dodo
   (*d*) Red panda.

6. Which of the following is an example of ex situ conservation ?

   (*a*) Biosphere reserve
   (*b*) Gene bank
   (*c*) Sanctuary
   (*d*) All of these.

7. Kaziranga National Park is famous for
   (*a*) One-horned rhino (*b*) Hangul
   (*c*) Tiger (*d*) Elephant.
8. There are only two sanctuaries in India dealing with preservation of plants. The plants are
   (*a*) Cinchona—Orchid (*b*) Citrus–Pitcher plant
   (*c*) Mango—Citrus (*d*) Mango—Pitcher plant.
9. Cryopreservation of plant seeds and pollen is done at a very low temperature of – 196°C by using
   (*a*) Ice (*b*) Carbon tetrachloride
   (*c*) Liquid nitrogen (*d*) Ammonia.
10. Which one of the following National Parks *do not* have tigers as their main wildlife ?
   (*a*) Gir (*b*) Corbett
   (*c*) Dudwa (*d*) Ranthambore.

B. FILL IN THE BLANKS

1. When variations occur within a species due to new combinations of genes, this is called ..... diversity.
2. Shannon-Wiener index gives a measure of ..... diversity.
3. Drugs, fuelwood and food derived from biodiversity represent ..... value of biodiversity.
4. Quinine is obtained from the bark of ..... tree.
5. In terms of plant richness, the rank of India in the world is ..... .
6. There are 34 biodiversity hot spots in the world, of which ..... exist in India.
7. Number of species found in a small homogeneous area is known as ..... richness.
8. Species restricted only to a particular area are called ..... .
9. Loss of habitat in instalments leading to small scattered patches is known as ..... .
10. Illegal killing of prohibited endangered animals is called ..... .
11. Red Data Book giving the list of endangered species of plants and animals is published by ..... .
12. Nanda Devi, Manas and Sunderbans are examples of ..... .

C. TRUE OR FALSE

1. Biodiversity not only includes the variability of all types of living organisms but also the variations within the ecosystems. (True/False)
2. The commercially usable value of biodiversity where the product is marketed and sold is called consumptive use value. (True/False)
3. When ecological surveys are carried out during a tour, it is known as ecotourism. (True/False)
4. Prevention of soil erosion and floods, cycling of nutrients, regulation of water cycle and reduction of global warming by the trees are examples of ecosystem service value. (True/False)
5. The commercial value of a tree timber is much more than its ecological services value. (True/False)
6. Maximum global biodiversity is found in tropical rain forests. (True/False)
7. Amongst the animals, highest number of known living species are that of mammals. (True/False)
8. Terrestrial diversity is much more than marine diversity. (True/False)
9. India has on record 47,000 species of plants and 81,000 species of animals. (True/False)
10. Highest number of known living species of plant kingdom in India belong to fungi. (True/False)
11. Though India is one of the 12 mega diversity countries in the world, yet it is not the centre of origin of any crop species. (True/False)
12. As we move across large landscape gradients the gamma richness increases. (True/False)
13. Human encroachment into forest areas is one of the main reasons for attack by wildlife on humans. (True/False)
14. Endangered animals cannot be prevented from becoming extinct by providing them special protection. (True/False)

ANSWERS TO OBJECTIVE TYPE QUESTIONS

A. SELECT THE APPROPRIATE ANSWER

1. (*c*)
2. (*a*)
3. (*c*)
4. (*b*)
5. (*c*)
6. (*b*)
7. (*a*)
8. (*b*)
9. (*c*)
10. (*a*)

B. FILL IN THE BLANKS

1. Genetic
2. Species
3. Consumptive use
4. Cinchona
5. 10th
6. Three
7. Alpha
8. Endemic
9. Habitat fragmentation
10. Poaching
11. IUCN
12. Biosphere reserves

C. TRUE OR FALSE

1. True
2. False
3. False
4. True
5. False
6. True
7. False
8. False
9. True
10. True
11. False
12. True
13. True
14. False.

human civilization. People should understand and be aware about the adverse
environmental problem, loss of biodiversity and the steps to counter these
Society should adapt and establish rules, acts and culture for protection of env
and biodiversity. The members of the society should be aware about the relati
man and nature.

An ideal state where everything is in equilibrium a balance of nature cannot
weather changes constantly, diversity of plants and animals fluctuate, mountain
lakes and rivers get silted. Still the supporters of this notion hold that ecosy
prevented to reach a state of balance due to exterior forces and are constantly
towards equilibrium. In a system in a state of near equilibrium when the
disturbance is removed the system recovers and attains the pre-disturbed status
the role of man and society would be to avoid the exterior forces i.e., the disturbe
are the barriers for a system to reach the equilibrium state.

People indirectly change biodiversity by burning fossil fuel and biomass by
altering hydrological patterns intentionally and accidentally introducing exotics wh
reduce interregional biodiversity, by destroying forest fringe, hedge rows and hab
that provides habitat for the plants and animals. People should be aware and s
about all these man-made activities and should take protection to conserve the n
biodiversity. Society should avoid man-made disasters, production of pollutan
water and soil.

Conservation and wise management of biological diversity must receive due im
in our planning process and economic development must be based on s
consideration. Natural balance or equilibrium, conservation does not mean stri
any utilisation of biological resources but their management for benefit of all life
humankind of the biosphere, so that it may yield sustainable benefits to the
generation while maintaining its potential to meet the needs of the future gene

M.C.Q.

1. **"Gaia hypothesis", which considers whole biosphere as f functional unit, is devloped by**
   (a) R. Carson (b) J. Lovelock (c) E. Haeckel
2. **Which of the following are features of mangrove—**
   (a) Thick stem (b) Pneumatophores (c) More than on
3. **In dry tropical forest dominant plant species is—**
   (a) Acacia (b) Kejuarina (c) Palm
4. **Forestry week is—**
   (a) 2-8th Oct. (b) 14-20th July (c) 21-27th Oct
5. **Wild life week is—**
   (a) 2-8th Oct. (b) 14-20th July (c) 21-27th Oct

6. **International Biodiversity day is observed on—**
(a) 1st Nov. (b) 29th Dec. (c) 18th Feb.
7. **One of the article on environmental protection in Indian Constitution—, dealing with fundamental duty is :—**
(a) Article 48A (b) Article 50A (c) Artide 230
8. **The process that separate is varieties into distinct units are known as–**
(a) Variation (b) Speciation (c) Specification
9. **Confinement of species in a particular area is described as**
(a) Endemic (b) Epidemic (c) Exotic
10. **Which one of the following is not found in India?**
(a) Lion (b) Leopard (c) Cheetah
11. **Jim Corbett National Park is situated in**
(a) Uttar Pradesh (b) Uttarakhand (c) Madhya Pradesh
12. **Joint Forest Management was initiated in India at**
(a) Chattisgarh (b) Uttaranchal (c) West Bengal
13. **Loktak lake, one of the most vulnerable wetlands in India is situated in**
(a) Manipur (b) Tripura (c) Meghalaya
14. **Biomes are recognized by their types of**
(a) Dominant Vegetation (b) Dominant Wild Life (c) Dominant Population
15. **Jaldapara National Park is in**
(a) Assam (b) West Bengal (c) Orissa
16. **Arundhati Roy is associated with**
(a) Chipko movement (b) Progressive Indian Film movement
(c) Narmada Bachao Andolan
17. **Aggregation of organisms of different populations refers to**
(a) Density (b) Diversity (c) Population
18. **Biodiversity means :**
(a) Various kinds of animals (b) Various kinds of plants
(c) Various kinds of biota
19. **What is the name of the supercontinent that broke into the present day continents?**
(a) Galapagos (b) Gandowanaland (c) Pangaea
20. **Genetic deversity is also referred to as**
(a) α diversity (b) β diversity (c) γ diversity
21. **Rachel Carson wrote the following book**
(a) Silent Spring (b) The fall of the Sparrow (c) Human Zoo
22. **Charles Darwin was**
(a) Mathematician (b) Linguist (c) Evolutionist
23. **'Ecosystem diversity' is also referred to as**
(a) α diversity (b) β diversity (c) γ diversity
24. **Jaldapara is famous for the conservation of**
(a) Tiger (b) Rhinoceros (c) Elephant

25. **Besides Sundarban, the other tiger project in West Bengal is loca**
(a) Buxa (b) Jaldapara (c) Garumara

26. **Collectively Sundarban is a—**
(a) Sanctuary (b) Biosphere reserve (c) Protected fore

27. **Who precisely defined ecology?**
(a) Aristotle (b) Darwin (c) Haeckel

28. **Lichen is an example of—**
(a) Neutralism (b) Mutualism (c) Commensalism

29. **Which of the following is a parasite–**
(a) Hook worm (b) Penicillin (c) Cockroach

30. **The production of such substances by organism, which are harm others is known as–**
(a) Antibiosis (b) Fungicide (c) Symbiosis

31. **Sunderlal Bahuguna is associated with which movement—**
(a) Chipko movement (b) Tehri Garhwal (c) All the above

32. **Green Bench in Calcutta started functioning from—**
(a) June 1996 (b) Dec. 1998 (c) March 1999

33. **Envis is related with—**
(a) Environment conservation (b) Environmental Information
(c) Environment pollution

34. **Three-mile island, the site of nuclear reactor accident in 197 situated in**
(a) USA (b) Russia (c) France

35. **In Western Himalayas the nature of forests are–**
(a) Tropical forest (b) Dry tropical forest (c) Temperate fore

36. **Which of the following is a biosphere reserve–**
(a) Nilgiri (b) Sundarbans (c) All

37. **Zooplanktons are regarded as**
(a) Producers (b) Consumers (c) Decomposers

38. **Solid wastes of Kolkata Municipal area deposited at–**
(a) Howrah (b) Dhapa (c) Baranagar

39. **Number of national parks in India is—**
(a) 66 (b) 32 (c) 102

40. **Number of sanctuaries in India is—**
(a) 400 (b) 387 (c) 66

41. **One of the 'Hot Spot' of India is—**
(a) Western Ghat (b) Sundarban (c) Manas

42. **Earth Day is observed on—**
(a) 11th July (b) 16th June (c) 22nd April

43. **Population Day is observed on—**
(a) 11th July (b) 31st May (c) 23rd March

44. Ecology Day is observed on—
(a) 31st May (b) 1st November (c) 18th February

45. Number of Hot spot in India —
(a) 3 (b) 2 (c) 1

46. Kanha of U.P. is a
(a) Reserve forest (b) National park (c) Sanctuary

47. Which of the following is an example of in-situ conservation—
(a) National Parks (b) Sanctuaries (c) All the above

48. Which of the following is Wetland Day—
(a) 11th July (b) 16th June (c) 5th June

49. Kaziranga of Assam is a—
(a) Sanctuary (b) National Park (c) Reserve Forest

ANSWERS

1.(b) J. Lovelock 2.(b) Pneumatophores 3.(a) Acacia 4.(b) 14-20th July 5.(a) 2-8th Oct. 6.(b) 29th Dec. 7.(a) Article 48A 8.(b) Speciation 9.(a) Endemic 10.(c) Cheetah 11.(b) Uttarakhand 12.(c) West Bengal 13.(a) Manipur 14.(a) Dominant Vegetation 15.(b) West Bengal 16.(c) Narmada Bachao Andolan 17.(b) Diversity 18.(c) Various kinds of biota 19.(c) Pangaea 20.(a) α diversity 21.(a) Silent Spring 22.(c) Evolutionist 23.(b) β diversity 24.(b) Rhinoceros 25.(a) Buxa 26.(b) Biosphere reserve 27.(c) Haeckel 28.(b) Mutualism 29.(a) Hook worm 30.(a) Antibiosis 31.(c) All the above 32.(a) June 1996 33.(b) Environmental Information 34.(a) USA 35.(c) Temperate forest 36.(c) All 37.(b) Consumers 38.(b) Dhapa 39.(a) 66 40.(b) 387 41.(a) Western Ghat 42.(c) 22nd April 43.(a) 11th July 44.(b) 1st November 45.(a) 3 46.(b) National Park 47.(c) All the above 48.(b) 16th June 49.(a) Sanctuary.

1. **আন্তঃক্ষেত্রীয় সংরক্ষণ বা ইন-সিটু সংরক্ষণ (In-situ Conservation) :** প্রাকৃতিক বাসভূমিতে অর্থাৎ জীবের নিজস্ব পরিবেশে সংরক্ষণের পদ্ধতিকেই আন্তঃক্ষেত্রীয় সংরক্ষণ বা ইন-সিটু সংরক্ষণ পদ্ধতি বলে। এক্ষেত্রে বাস্তুতন্ত্রে জীবের সংখ্যা যেমন বাড়ে তেমনি বাস্তুতন্ত্রের স্থিতিশীলতা বজায় থাকে। উদাহরণ—সুন্দরবনের রয়্যাল বেঙ্গল টাইগার-এর সংরক্ষণ। বিভিন্ন উপায় অবলম্বন করে ইন-সিটু পদ্ধতিতে জীবের সংরক্ষণ করা হয়। যথা—

(a) জাতীয় উদ্যান (National park),

(b) অভয়ারণ্য (Sanctuary),

(c) সংরক্ষিত বনভূমি (Reserve Forest),

(d) সুরক্ষিত বনভূমি (Protected Forest) এবং

(e) সংরক্ষিত জীবমণ্ডল (Biosphere Reserve) গঠন করে আন্তঃক্ষেত্রীয় সংরক্ষণ সম্ভব হয়েছে।

2. **বহিঃক্ষেত্রীয় সংরক্ষণ পদ্ধতি বা এক্স-সিটু সংরক্ষণ (Ex-situ Conservation) :** অধিক মাত্রায় বিপন্ন বা বিরল প্রজাতিকে তাদের নিজস্ব প্রাকৃতিক বাসভূমিতে সংরক্ষণ করা সম্ভব না হলে তাদের উদ্ধার করে ওই প্রাকৃতিক বাসভূমির বাইরে অন্যত্র কৃত্রিম পরিবেশে সংরক্ষণ করা হলে, তাকে **বহিঃক্ষেত্রীয় সংরক্ষণ বা এক্স-সিটু সংরক্ষণ** বলে। **উদাহরণ :** হিমালয়ের রেড পান্ডাকে চিড়িয়াখানায় সংরক্ষণ করা হয়েছে। প্রধানত চারটি উপায়ে এক্স-সিটু সংরক্ষণ করা হয়। যথা—

(a) চিড়িয়াখানা (Zoological Park),

(b) উদ্ভিদ উদ্যান (Botanical Garden),

(c) জিন ভাণ্ডার (Gene Bank) গঠন করে এবং

(d) জেনেটিক ইঞ্জিনিয়ারিং (Genetic Engineering)-এর মাধ্যমে বিপন্ন বা বিরল প্রজাতিকে সংরক্ষণ করা হয়।

প্রশ্নোত্তর পর্ব

▶ বহুবিকল্পভিত্তিক প্রশ্নোত্তর (MCQ) প্রশ্নমান 1

♦ সঠিক উত্তরটি নির্বাচন করো :

	প্রশ্ন	উত্তর
1.	জিনগত বৈচিত্র্য অনুযায়ী সারা বিশ্বে ধানের কত প্রকার বৈচিত্র্য বর্তমান— a. 10,000 b. 25,000 c. 50,000 d. 60,000	c. 50,000 প্রকার।

	প্রশ্ন	উত্তর
2.	বাস্তুতান্ত্রিক জীববৈচিত্র্যের সূচকের আবিষ্কর্তা হলেন— a. হুইটেকার b. ওডাম c. ম্যায়ার্স d. ব্যারোজ	a. হুইটেকার।
3.	একই জীবগোষ্ঠীর মধ্যে প্রজাতিগত বৈচিত্র্যকে বলা হয়— a. আলফা বৈচিত্র্য b. বিটা বৈচিত্র্য c. গামা বৈচিত্র্য d. হিটা বৈচিত্র্য	a. আলফা বৈচিত্র্য।
4.	সুন্দরবনের একটি দ্বীপে উদ্ভিদপ্রজাতির বৈচিত্র্য যে ধরনের জীববৈচিত্র্যে উদাহরণ তা হল— a. আলফা বৈচিত্র্য b. বিটা বৈচিত্র্য c. গামা বৈচিত্র্য d. থিটা বৈচিত্র্য	a. আলফা বৈচিত্র্য।
5.	সুন্দরবনের বিভিন্ন দ্বীপে উদ্ভিদপ্রজাতির বৈচিত্র্য যে ধরনের জীববৈচিত্র্যে উদাহরণ তা হল— a. আলফা বৈচিত্র্য b. বিটা বৈচিত্র্য c. গামা বৈচিত্র্য d. হিটা বৈচিত্র্য	b. বিটা বৈচিত্র্য।
6.	ক্রান্তীয় বৃষ্টি অরণ্যের জীববৈচিত্র্য যে ধরনের জীব বৈচিত্র্যে উদাহরণ তা হল— a. আলফা বৈচিত্র্য b. বিটা বৈচিত্র্য c. গামা বৈচিত্র্য d. থিটা বৈচিত্র্য	c. গামা বৈচিত্র্য।
7.	বিটা সূচকের সূত্রটি হল— a. $\beta = \frac{\gamma}{\alpha}$ b. $\beta = \alpha \times \gamma$ c. $\beta = \frac{\alpha}{\gamma}$ d. কোনোটিই নয়	a. $\beta = \frac{\gamma}{\alpha}$।
8.	গামা সূচকের সূত্রটি হল— a. $\gamma = \frac{\beta}{\alpha}$ b. $\gamma = \alpha \times \beta$ c. $\gamma = \frac{\alpha}{\beta}$ d. কোনোটিই নয়	b. $\gamma = \alpha \times \beta$
9.	জীববৈচিত্র্যের পরিমাণ বাড়তে থাকে— a. বিষুবরেখার দিকে b. বিষুবরেখা থেকে দূরত্ব বৃদ্ধিতে c. মেরুঅঞ্চলে d. সর্বত্র জীববৈচিত্র্য একই থাকে	a. বিষুবরেখার দিকে।

	প্রশ্ন	উত্তর
10.	প্রজাতির সংখ্যার সাথে বাসস্থানের ক্ষেত্রমানের মধ্যে পারস্পরিক সম্পর্ক সংক্রান্ত সূত্রটি হল— a. $S=\frac{C}{A^2}$ b. $S=\frac{A^2}{C}$ c. $S=CA^2$ d. $S=C-A^2$	c. $S=CA^2$।
11.	পরিবেশের উপাদানগুলির মধ্যে ভারসাম্য বজায় রেখে গড়ে তোলা পর্যটনশিল্পকে বলা হয়— a. ফ্যামিলি ট্যুরিজম্ b. ইকো-ট্যুরিজম্ c. এপি-ট্যুরিজম d. প্যালিও ট্যুরিজম্	b. ইকো -ট্যুরিজম।
12.	সিঙ্কোনা গাছের ছাল থেকে ম্যালেরিয়া প্রতিশেধক যে ঔষধটি তৈরি করা হয় তা হল — a. কুইনাইন b. রেসারপিন c. জিওলিন d. সককটিহ	a. কুইনাইন।
13.	সর্বাধিক জীববৈচিত্র্য দেখা যায় নিম্নলিখিত যে গোষ্ঠীভুক্ত প্রাণী সম্প্রদায়ের মধ্যে তা হল— a. সরীসৃপ b. পাখি c. স্তন্যপায়ী প্রাণী d. অমেরুদণ্ডী প্রাণী	d. অমেরুদণ্ডী প্রাণী।
14.	বর্তমানে ভারতকে যে-কটি জীব-ভৌগোলিক অঞ্চলে ভাগ করা হয় তা হল— a. 5 টি b. 10 টি c. 18 টি d. 25 টি	b. 10 টি।
15.	ভারতে যে কয়টি জীব-প্রদেশ রয়েছে তা হল— a. 25 টি b. 30 টি c. 35 টি d. 40 টি	a. 25 টি।
16.	ভারতে প্রাণীপ্রজাতির সংখ্যা— a. প্রায় 10,000 b. প্রায় 42,000 c. প্রায় 75,000 d. প্রায় 81,000	d. 81,000।
17.	পৃথিবীর 12 টি মেগা জীববৈচিত্র্য সম্পন্ন দেশসমূহের মধ্যে ভারতের সংখ্যা— a. পঞ্চম b. প্রথম c. দশম d. দ্বাদশ	c. দশম।

	প্রশ্ন	উত্তর
18.	পৃথিবীতে মোট কয়টি জীব-ভৌগোলিক অঞ্চল রয়েছে? a. 5 টি b. 8 টি c. 10 টি d. 12 টি	b. 8 টি।
19.	নিম্নলিখিত কোনটি জীববৈচিত্র্য ধ্বংসের কারণ নয় a. জলবায়ুর পরিবর্তন b. পরিবেশদূষণ c. চোরাশিকার d. বৃষ্টিপাত	d. বৃষ্টিপাত।
20.	জীববৈচিত্র্যের সংরক্ষণ বলতে বোঝায়— a. শুধুমাত্র বিপদগ্রস্ত প্রজাতির সংরক্ষণ b. কেবলমাত্র মানুষের প্রয়োজনীয় প্রজাতির সংরক্ষণ c. শুধুমাত্র জিনের সংরক্ষণ d. সমস্ত ধরনের জীবের সংরক্ষণ	a. শুধুমাত্র বিপদগ্রস্ত প্রজাতির সংরক্ষণ।
21.	Red Data Book রাষ্ট্রপুঞ্জের যে সংস্থা প্রকাশ করে তা হল— a. FAO b. WHO c. IUCN d. UNESCO	c. IUCN।
22.	সুন্দরবনের রয়্যাল টাইগার Red Data Book অনুযায়ী কোন গোষ্ঠীভুক্ত? a. বিপন্ন প্রজাতিভুক্ত b.বিপদগ্রস্ত প্রজাতিভুক্ত c. কম ঝুঁকিসম্পন্ন প্রজাতিভুক্ত d. বিলুপ্ত প্রজাতিভুক্ত	a. বিপন্ন প্রজাতিভুক্ত।
23.	মরিশাসের ডোডো পাখি Red Data Book অনুযায়ী কোন্ গোষ্ঠীভুক্ত— a. বিপন্ন প্রজাতিভুক্ত b. বিপদগ্রস্ত প্রজাতিভুক্ত c. কম ঝুঁকিসম্পন্ন প্রজাতিভুক্ত d. বিলুপ্ত প্রজাতিভুক্ত	d. বিলুপ্ত প্রজাতিভুক্ত।
24.	যে প্রজাতিকে বিপদগ্রস্ত প্রজাতি হিসাবে গণ্য করা হবে সেগুলি— a. 5 বছরের মধ্যে সম্পূর্ণ বিলুপ্ত হয়ে পড়বে। b. 10 বছরের মধ্যে 50% বিলুপ্ত হয়ে যাবে। c. 10 বছরের মধ্যে বিলুপ্ত 70% হয়ে যাবে। d. 10 বছরের মধ্যে সম্পূর্ণ বিলুপ্ত	b. 10 বছরের 50% মধ্যে বিলুপ্ত হয়ে যাবে।

	প্রশ্ন	উত্তর
25.	Red Data Book চালু হয়— a. 1992 সালে b. 1988 সালে c. 1948 সালে d. 2000 সালে	c. 1948 সালে।
26.	যে প্রজাতিকে বিপন্ন প্রজাতি হিসাবে গণ্য করা হবে সেগুলি— a. 5 বছরের মধ্যে সম্পূর্ণ বিলুপ্ত হয়ে পড়বে b. 10 বছরের মধ্যে 50% বিলুপ্ত হয়ে যাবে c. 10 বছরের মধ্যে 70% বিলুপ্ত হয়ে যাবে। d. 10 বছরের মধ্যে সম্পূর্ণ বিলুপ্ত হয়ে যাবে।	c. 10 বছরের মধ্যে 70% বিলুপ্ত হয়ে যাবে।
27.	উভচর প্রাণীর মধ্যে ভারতে ক-টি প্রজাতি চরম সঙ্কটপূর্ণ ভাবে বিপন্ন? a. 10 টি b. 19 টি c. 23 টি d. 35 টি	b. 19 টি।
28.	স্তন্যপায়ী প্রাণীর মধ্যে ভারতে ক-টি প্রজাতি বিপন্ন শ্রেণিভুক্ত? a. 44 টি b. 28 টি c. 75 টি d. 80 টি	a. 44 টি।
29.	পাখির মধ্যে ভারতে কয়টি প্রজাতি বিপদগ্রস্ত প্রাণীর তালিকাভুক্ত? a. 4 টি b. 6 টি c. 28 টি d. 3 টি	d. 3 টি।
30.	জীববৈচিত্র্য হটস্পট শব্দটি সর্বপ্রথম কে ব্যবহার করেন? a. ওয়াটার জি রোজেন b. নরম্যান মায়ারস c. বেঞ্জামিন ফ্রাঙ্কলিন d. আর্নেস্ট হেকেল	b. নরম্যান মায়ারস।
31.	জীববৈচিত্র্য হটস্পট শব্দটি কবে প্রথম প্রচলিত হয়? a. 1948 সালে b. 1962 সালে c. 1988 সালে d. 1992 সালে	c. 1988 সালে।
32.	সমগ্র পৃথিবীকে ক-টি জীববৈচিত্র্য হটস্পটে ভাগ করা হয়েছে? a. 5 টি b. 24 টি c. 34 টি d. 28 টি	c. 34 টি।

	প্রশ্ন	উত্তর
33.	কোন্ কোন্ বৈশিষ্ট্য উপস্থিত থাকলে কোনো এলাকাকে জীববৈচিত্র্য হটস্পট অ্যাখ্যা দেওয়া যায়? a. কম সংখ্যক প্রজাতি থাকলে b. প্রচুর পরিমাণে এনডেমিক প্রজাতি থাকলে c. অধিকাংশই বিপন্নপ্রজাতি থাকলে d. b ও c উভয়ই থাকলে	d. b ও c উভয়ই থাকলে।
34.	ভারতে মোট ক-টি জীববৈচিত্র্য হটস্পট রয়েছে? a. 8 টি b. 28 টি c. 4 টি d. 3 টি	c. 4 টি।
35.	ভারতে বাঘ সংরক্ষণের উদ্দেশ্য ব্যাঘ্র প্রকল্প কবে চালু হয়? a. 1982 সালের 22 জুন b. 1973 সালের 1 এপ্রিল c. 1985 সালের 2 1 সেপ্টেম্বর d. 1992 সালের 18 এপ্রিল	b. 1973 সালের 1 এপ্রিল।
36.	বর্তমানে ভারতে কটি বাঘ সংরক্ষণ কেন্দ্র রয়েছে? a. 18 টি b. 22 টি c. 50 টি d. 70 টি	c. 50 টি।
37.	কোন বছর ভারতে কুমির প্রকল্পে চালু হয়? a. 1972 সালে b. 1975 সালে c. 1982 সালে d. 1977 সালে	b. 1975 সালে।
38.	পশ্চিমবঙ্গের কোথায় কুমির সংরক্ষণ কেন্দ্র রয়েছে? a. বকখালিতে b. ঝাড়খালিতে c. বনখালিতে d. গোসাবাতে	a. বকখালিতে।
39.	কোন বছর ভারতে হাতি প্রকল্প চালু হয়? a. 1938 সালে b. 1948 সালে c. 1972 সালে d. 1992 সালে	d. 1992 সালে
40.	2016 সালের ব্যাঘ্র সুমারি অনুযায়ী ভারতে মোট বাঘের সংখ্যা হল— a. 2000 টি b. 320 টি c. 389 টি d. 428 টি	c. 389 টি।

	প্রশ্ন	উত্তর
41.	ভারতের প্রথম জাতীয় উদ্যান কোনটি? a. করবেট জাতীয় উদ্যান b. ডেজার্ট জাতীয় উদ্যান c. বান্ধে জাতীয় উদ্যান d. নন্দনকানন জাতীয় উদ্যান	a. করবেট জাতীয় উদ্যান।
42.	সর্বাধিক বাঘ সংরক্ষণ করা রয়েছে— a. উত্তরপ্রদেশে b. রাজস্থানে c. মধ্যপ্রদেশে d. কর্ণাটকে	c. মধ্যপ্রদেশে।
43.	ভারতে বন্যপ্রাণী (সংরক্ষণ) আইনটি জারি করা হয়— a. 1992 সালে b. 1962 সালে c. 1972 সালে d. 1974 সালে	c. 1972 সালে।
44.	ভারতে জীববৈচিত্র্য আইন পাশ হয়— a. 2002 সালে b. 2003 সালে c. 2001 সালে d. 2000 সালে	a. 2002 সালে।
45.	বাস্তুতান্ত্রিক জীববৈচিত্র্য মূলত— a. 3 প্রকার b. 5 প্রকার c. 4 প্রকার d. 8 প্রকার	a. 3 প্রকার।
46.	'বিশ্ববসতি দিবস' পালিত হয়— a. 12 জানুয়ারি b. 4 অক্টোবর c. 2 অক্টোবর d. 10 মে	c. 2 অক্টোবর।
47.	'আবাস স্থলের বৈচিত্র্য' কথাটির সমার্থক কথাটি হল— a. বাস্তুতান্ত্রিক বৈচিত্র্য b. জিনগত বৈচিত্র্য c. প্রজাতিগত বৈচিত্র্য d. সবগুলিই	a. বাস্তুতান্ত্রিক বৈচিত্র্য।
48.	'জীববৈচিত্র্য' শব্দটি সর্বপ্রথম ব্যবহার করেন— a. কোপেন b. নরম্যান ম্যায়ার্স c. ওয়াল্টার জি রোজেন d. ফার্মেন	c. ওয়াল্টার জি রোজেন।
49.	ওয়াল্টার জি রোজেন 'জীববৈচিত্র্য' শব্দটি ব্যবহার করেন— a. 1985 খ্রিস্টাব্দে b. 1886 খ্রিস্টাব্দে c. 1868 খ্রিস্টাব্দে d. 1968 খ্রিস্টাব্দে	a. 1985 খ্রিস্টাব্দে।
50.	ভারতে জীববৈচিত্র্য সম্পর্কিত আইনবিধি প্রণীত হয়— a. 2002 খ্রিস্টাব্দে b. 2001 খ্রিস্টাব্দে c. 2000 খ্রিস্টাব্দে d. 2004 খ্রিস্টাব্দে	a. 2002 খ্রিস্টাব্দে।

	প্রশ্ন	উত্তর
51.	ভারতের সর্ববৃহৎ উদ্ভিদ উদ্যানটি অবস্থিত— a. চেন্নাইতে b. কলকাতার নিকটে শিবপুরে c. দিল্লিতে d. বেঙ্গালুরুতে	d. কলকাতার নিকটে শিবপুরে।
52.	পৃথিবীতে মেগা জীববৈচিত্র্য দেখা যায়— a. নিরক্ষীয় ও ক্রান্তীয় অঞ্চলে b. সাভানা অঞ্চলে c. নাতিশীতোষ্ণ অঞ্চলে d. উপমেরু অঞ্চলে	a. নিরক্ষীয় ও ক্রান্তীয় অঞ্চলে।
53.	যে জলবায়ু অঞ্চলে জীববৈচিত্র্য সর্বাধিক লক্ষ করা যায় সেটি হল— a. তুন্দ্রা জলবায়ু অঞ্চল b. উষ্ণমরু জলবায়ু অঞ্চল c. নাতিশীতোষ্ণ তৃণভূমি জলবায়ু অঞ্চল d. নিরক্ষীয় বৃষ্টি অরণ্য জলবায়ু অঞ্চল	d. নিরক্ষীয় বৃষ্টি অরণ্য জলবায়ু অঞ্চল।
54.	যেকোনো বাস্তুতন্ত্রে শক্তির মূল উৎসব হল— a. উদ্ভিদ b. নক্ষত্র c. সূর্য d. জল	a. সূর্য।
55.	জীববৈচিত্র্য হ্রাস করার জন্য সবচেয়ে দায়ী— a. নগরায়ণ b. দূষণ c. জুম চাষ d. সবক-টি	d. সবক-টি।
56.	নল সরোবর পাখিরালয় অবস্থিত— a. কলকাতায় b. রাজস্থানে c. বিহারে d. গুজরাটে	d. গুজরাটে।
56.	পশ্চিমবঙ্গে ব্যাঘ্র সংরক্ষণ প্রকল্প কেন্দ্র গড়ে তোলা হয়েছে— a. বকখালিতে b. ঝাড়খালিতে c. দার্জিলিংএ d. বাঁকুড়ায়	b. ঝাড়খালিতে।
57.	পশ্চিমবঙ্গেজ কুমির প্রকল্প কেন্দ্র গড়ে তোলা হয়েছে— a. বকখালিতে b. ঝাড়খালিতে c. দার্জিলিংএ d. বাঁকুড়ায়	a. বকখালিতে।
58.	সিমলিপাল জাতীয় উদ্যান অবস্থিত— a. ওড়িশায় b. কেরলে c. অসমে d. পশ্চিমবঙ্গে	a. ওড়িশায়।

	প্রশ্ন	উত্তর
59.	মানস ব্যাঘ্র প্রকল্পটি অবস্থিত— a. কেরলে b. অন্ধ্রপ্রদেশে c. অসমে d. বিহারে	c. অসমে।
60.	ভারতে প্রথম বায়োস্ফিয়ার রিজার্ভ অঞ্চল হিসেবে চিহ্নিত করা হয়— a. পাঁচমারিকে b. সুন্দরবনকে c. নীলগিরিকে d. জিম করবেটকে	c. নীলগিরিকে।
61.	নন্দনকানন বন্যপ্রাণী অভয়ারণ্য অবস্থিত— a. ওড়িশায় b. পশ্চিমবঙ্গে c. অসমে d. কেরলে	a. ওড়িশায়।
62.	একশৃঙ্গবিশিষ্ট গন্ডার পশ্চিমবঙ্গের কোন অভয়ারণ্যে সংরক্ষণ করা হয়? a. জলদাপাড়া অভয় অরণ্যে b. গোরুমারা অভয়ারণ্যে c. বক্সা অভয়ারণ্যে d. সুন্দরবনে	a. জলদাপাড়া অভয় অরণ্যে।
63.	অসমের যে-জাতীয় উদ্যানটি একশৃঙ্গবিশিষ্ট গন্ডারের জন্য খ্যাত, তা হল— a. মানস জাতীয় উদ্যান b. কাজিরাঙা জাতীয় উদ্যান c. গির জাতীয় উদ্যান d. করবেট জাতীয় উদ্যান	B. কাজিরাঙা জাতীয় উদ্যান।
64.	দাজিপুর বাইসন অভয়ারণ্যটি অবস্থিত— a. গুজরাটে b. পশ্চিমবঙ্গে c. মহারাষ্ট্রে d. বিহারে	c. মহারাষ্ট্রে।
65.	ভারতের নবীনতম জীবমণ্ডল সংরক্ষণ অঞ্চলটি হল— a. পান্না b. মানস c. জিম করবেট d. নীলগিরি	a. পান্না।
66.	পেরিয়ার জাতীয় উদ্যানটি অবস্থিত— a. কেরলে b. মধ্যপ্রদেশে c. অসমে d. বিহারে	a. কেরলে।

MCQ

[25×1 = 25]

1. Which of the following agents is responsible for turning the Taj Mahal yellow?
   (a) Sulphur
   (b) Chloride
   (c) Sulphur di-oxide
   (d) Nitrogen di-oxide

2. Which one of the following is not a natural disaster?
   (a) Volcano eruption
   (b) Flood
   (c) Blow-out
   (d) Tsunami

3. Today the World's number one problem is:
   (a) Pollution
   (b) Population explosion
   (c) Nuclear proliferation
   (d) Natural calamities

4. Why is it difficult to recycle plastics?
   (a) It is very hard.
   (b) It comes in different sizes.
   (c) It is adhesive.

(d) It contains different types of polymer resins.

5. Which is the main source of nuclear radiation?
   (a) Nuclear Power Plant
   (b) Sunlight
   (c) Atmospheric air
   (d) Volcanoes.

6. Noise pollution is created if sound is in excess to
   (a) 70-75 dB
   (b) 50-60 dB
   (c) 80-99 dB
   (d) 40-65 dB

7. The major photochemical smog is _____.
   (a) Hydrogen peroxide
   (b) Chlorofluorocarbon
   (c) Peroxyacetyl nitrate
   (d) All of the above.

8. Which of the following is not a waterborne disease?
   (a) Measles
   (b) Typhoid
   (c) Cholera
   (d) Hepatitis

9. Which one of the following way is used to reduce the pollution load on marine water?
   (a) Manual cleaning of pollutants.
   (b) Damping the pollutants during winter.
   (c) Introducing sewage treatment plants.
   (d) Ban the license of industries which are near to the sea.

10. What is the main effect of thermal pollution to the oxygen solubility in water bodies?
   (a) They increase the solubility of oxygen in water bodies.
   (b) They maintain the solubility of oxygen in water bodies.
   (c) They reduce the solubility of oxygen in water bodies.
   (d) They don't cause any effect in solubility of oxygen to the water bodies.

11. Negative soil pollution is :
   (a) reduction in soil productivity due to erosion and overuse.
   (b) reduction in soil productivity due to addition of pesticides and industrial wastes.
   (c) converting fertile land into harden land by damping ash sludge and garbage.
   (d) None of the above.

12. Which of the following techniques is used to remove fluorides from the water?

(a) Osmosis
(b) Ion exchange
(c) Lime softening
(d) Both (b) & (c)

13. Noise pollution is measured in?

(a) Ohm
(b) Decibel
(c) Joul
(d) Ampere

14. Which one of the following can cause Thermal pollution?

(a) Residential houses
(b) Power Plants
(c) Death of marine organisms
(d) Oil spill

15. Greenhouse effect is related to:

(a) Green trees on house
(b) Global Warming
(c) Grass lands
(d) Greenery in Country

16. In which direction the wind of the tropical cyclone blows in the northern hemisphere?
   (a) Straight forward
   (b) Anti clockwise direction
   (c) Clockwise direction
   (d) In any direction

17. The atom bombs in World War II has been dropped on which of the following:
   (a) Hiroshima and Nagasaki in Japan.
   (b) Germany
   (c) Italy
   (d) Great Britain

18. Which of the following is not a 'green hous gas'?
   (a) Oxygen
   (b) Carbon di Oxide
   (c) Chlorofluorocarbons
   (d) Methane

19. Population Pyramids are useful to:
   (a) Express the population growth rates
   (b) Express the age-sex distribution
   (c) Indicate birth rates
   (d) Indicate the death rates

20. What is the main purpose of nuclear energy?
(a) To kill the enemy nation.
(b) To waste the excessive energy.
(c) To use it as an alternate source of energy.
(d) To cause mutation for people who are working.

21. Which of the following is not a solution of Global Warming?
(a) Reducing fossil fuel consumption.
(b) Planting more trees.
(c) Deforestation
(d) None of the above

22. Which is the Calm part of a tropical Cyclone?
(a) Eye
(b) Limb
(c) Periphery
(d) None

23. Which one of the medical condition caused by the high exposure of radiation?
(a) kidney stone
(b) AIDS
(c) Mutation
(d) Blood Pressure

24. Which of the following methods is better for the solid waste problem?

(a) Recycling
(b) Landfilling
(c) Both (a) and (b)
(d) None of the above.

25. Head Office of the National Institute of Disaster Management- is situated in India's City / State?

(a) Kolkata
(b) New Delhi
(c) Hyderabad
(d) Manipur

1. (c)
2. (c)
3. (b)
4. (d)
5. (a)
6. (c)
7. (b)
8. (a)
9. (c)
10. (c)
11. (a)
12. (d)
13. (b)
14. (b)
15. (b)
16. (c)
17. (a)
18. (a)
19. (b)
20. (c)
21. (c)
22. (a)
23. (c)
24. (a)
25. (b)

classmate

A) The build-up of _____ which is known as ‘GREENHOUSE EFFECT’ in the atmosphere is leading to current global warming

1. Chlorine
2. Sulphur dioxide
3. Fluorine
4. Carbon dioxide

B) The air quality index of the city is 190.it falls under which category

1. Very poor
2. Poor
3. Moderate
4. Good

C) Acid rain caused by oxides of _____

1. Phosphorus and Carbon
2. Sulphur and Phosphorus
3. Sulphur and Phosphorus
4. Nitrogen and Carbon

D) _____ is used to check water pollution caused by industrial affluents

(a) Water Hyacinth
(b) Parthenium
(c) Elephant Grass
(d) All of these

E) Which of the following is biodegradable pollutant

a) Sewage
(b) Plastic
(c) Polythene
(d) DDT

F) B.O.D. test or biological oxygen demand test is made for measuring

(a) Air pollution
(b)Water pollution
(c) Noise pollution
(d) Soil pollution

G) The chemicals released due to unsustainable agricultural practises and cause Soil Pollution are -

a. Pathogens
b. Chemical fertilizers
c. Strontium-90
d. Weedicides

G) In a coal fired power plant Electrostatic precipitators are installed to control the emission of

a. SO2
b. NO2
c. SPM
d. CO

H) Benzene and Methylbenzene the major Soil Pollutants mostly from the Petroleum Industries are -

a. Heavy organic pollutants
b. Inorganic pollutants
c. Carcinogenic pollutants
d. None of the above

I) Which of these pollutants is a Herbicide?

a. PHPs
b. Amides
c. Chlorinated hydrocarbons
d. Copper Sulphate

J) . Why is area treatment important for Soil?

(a) To reduces the impact of raindrops on the soil
(b) To maximize surface run-off
(c) Not treating the upper catchment and proceeds towards an outlet
(d) Not storing surplus rainwater

K) Oil tankers are now built with double hulls instead of one to avoid

a. oil spill
b. exposure of air
c. high cost
d. long distance

l) Oil tankers are now built with double hulls instead of one to avoid

A. oil spill
B. exposure of air
C. high cost
D. long distance

M) Plastic decomposes after
A. 10 years
B. 100 years
C. 1000 years
D. 1 year

N) In which unit sound is measured?
a) Kilometer
b) Pascal
c) Kilogram
d) Decibel

O) Which pollution cause hearing loss in organisms?
a) Air pollution
b) Noise pollution
c) Water pollution
d) Soil pollution

P) What is the dB of a threshold of hearing?
a) 0
b) 10
c) 50
d) 100

Q) What is the dB of a threshold of pain?
a) 100
b) 110
c) 120
d) 146

R) What is the permissible noise limit of 120 db?
a) 30 minutes
b) 2 minutes
c) 1 minute
d) 30 seconds

S) Thermal pollution due to excessive heat & temperature in the working place causes_____?
A. Reduction in working efficiency of manpower
B. Fatigue
C. High breathing rate
D. All A., B. & C.

T) The main pollutant in waste water discharged from a petroleum refinery is oil (both in free and emulsified form). Free oil is removed by_____?

A. Biological oxygen pond
B. Aerated lagoons
C. Trickling filters
D. Gravity separator having oil skimming devices

U) Presence of ____ in water stream are deleterious to aquatic life?

A. Soluble and toxic organics
B. Suspended solids
C. Heavy metals and cyanides
D. All of the above

V) BOD of raw municipal sewage may be in the range of about _____ mg/litre?

A. 1-2
B. 5-10
C. 150-300
D. 2000-3000

Unsustainable to sustainable development

What is Unsustainable development?

Our ancestors have left a lot of resources for us. They used their resources sensibly and not for their greed. But we are exploiting limited resources. Instead of using it for our needs, we are exploiting it for our greed.

Development means growth in different sectors. It is a positive change that leads to a better world and easier life. Development is different for different people. It can happen that a thing which development for one person might not be the growth for another. It is possible that one's development can be another's regression. Development is not always materialistic in nature. It can be of two types: Sustainable development and Unsustainable development.

Unsustainable development is one in which we forget our responsibility towards the environment. In unsustainable development, we degrade the available resources. Not thinking about the needs of future generations is unsustainable development. Unsystematic planning can lead to damage to natural as well as human-made resources. It can cause extreme degradation of the environment as well as the living organism.

Causes of unsustainable development

We as a human society do a lot of things that are unsustainable. Our activities can cause huge damage to the environment. By our irresponsible activities, we have ruined the natural balance of the environment. Humans have built so many buildings, roads, and dams for a luxurious lifestyle and our comfort. While building these apartments we neglected the needs of animals. We gave our best to destroy their habitats. Not only animals, but we have also done great harm to the flora of our environment. There are few root causes which has led to unsustainable development. There is no order of organizing

the most harmful one. These all causes are equally responsible for the degradation of the environment.

- We extract a lot of material from the Lithosphere

The lithosphere is the outermost layer of the earth's surface. We extract a lot of things from this such as oil and natural gas. It would be okay if we would have used it for our basic needs. But we focused more on extracting much more than what we need. We extract heavy metals, things that are rare in the biosphere and that we found in less quantity. This over-extraction has reduced the presence of resources in the environment.

- We create a substance that accumulates in nature

Due to the increase of industrialization, we create a lot of chemical compounds. These take a lot of years to break down in the environment. But we also create substances that already exist in nature like, carbon-di-oxide. We create it in such a quantity that it accumulates and becomes problematic.

- We physically damage nature's ability to run natural cycle

By chopping trees at a faster rate than they can grow, we are ruining the environment's capacity to heal itself. For making houses, buildings, roads, and dams a lot of trees we cut a lot of trees in a year. This also impacts the natural cycle and leads to global warming. Global warming means the increase of greenhouse gases in the environment.

- We indirectly become the reason for increased pollution

If we are purchasing polythene bags and using them we are indirectly contributing to the growth of pollution. Industries are still producing polythene bags because it is in demand. If we stop using them companies will no longer produce them.

- Increase in population

With the increase in population demand for people also increases. To meet these demands people extract resources from the environment. Thus, the resources decrease.

What is sustainable development?

Living a good life and taking care of future generations is sustainable development. It requires systematic planning and empathy towards nature. It does not say to live a very basic life without satisfying your

needs. It means to live a quality life within the capacity of the ecosystem. It is a dynamic process. A responsible citizen always takes care of future generations and their needs.

Pillars of Sustainable Development

Economic development

Economic development means poverty eradication from society. According to 2015 data, the proportion of the world's population with the income is $1/day. Government should provide at least basic health services to all the people. Health is directly proportional to poverty. With the increase in health problems poverty increases. Many people don't get at least two meals a day. Government should also provide at least basic food availability to the poor people. The problem of clean drinking water is also rising. Enhancing industrial productivity is also very important for economic development.

Social Development

Every person of the nation needs to get an education for the growth of society. Women should actively take part in social development. Education for all and good governance is equally important for sustainable growth.

Environmental Protection

We should try to prevent environmental degradation at the regional, national and global levels. We should keep a check on the human activities which are damaging the environment. We should control deforestation and over-extraction of resources. Only a healthy environment can be the wealthy ones.

Conclusion

God has given us a place to live, plants for meeting our medication, and food needs. Animals make our environment beautiful. Minerals and energy resources help us to live a comfortable life. If we will keep on overusing the resources we might not enjoy the privilege of taking

birth on earth. Earth might change into a barren moon in the next few decades.

Essay on Urban Problems Related to Energy

Essay on Urban Problems Related to Energy!

Urban center use enormous quantities of energy. In the past, urban housing required relatively smaller amounts of energy than we use at present. Traditional housing in India required very little temperature adjustments as the material used, such as wood and bricks, handled temperature changes better than the current concrete, glass and steel of ultra-modern building.

Cities are the main centres of economic growth, trade, education, innovations and employment. Until recently a big majority of human population lived in rural areas and their economic activities cantered on agriculture, cattle, rearing, fishing, hunting or some cottage industry.

It was some two hundred years ago with the dawn of industrial era the cities showed rapid development. Now about 50% of the world population lives in urban areas and- there is increasing movement of rural folk to cities in search of employment.

The urban growth is so fast that it is becoming difficult to accommodate all the industrial, commercial and residential facilities within a limited municipal boundary. As a result there is spreading of the cities into the sub-urban or rural areas too, this phenomenon is known as “urban sprawl”.

In developing countries too urban growth is very fast and in most of the cases it is uncontrollable and unplanned growth. In contrast to the rural set up, the urban set up is densely populated, consumes a lot of energy and materials and generates a lot of waste.

Energy use is closely related to development in industry, transport, communication, commercial, household and agricultural activities. The energy

requirement of urban population is much higher than that of rural ones. This is because urban people have a higher standard of life and their lifestyle demands more energy inputs in every sphere of life.

In urban areas the need of energy is increasing by leaps and bounds. Moreover, countries use energy in an uneven manner in the world. In developed countries the amount of energy used is much more compared to developing countries.

Industrialised developed countries use energy for these purposes:

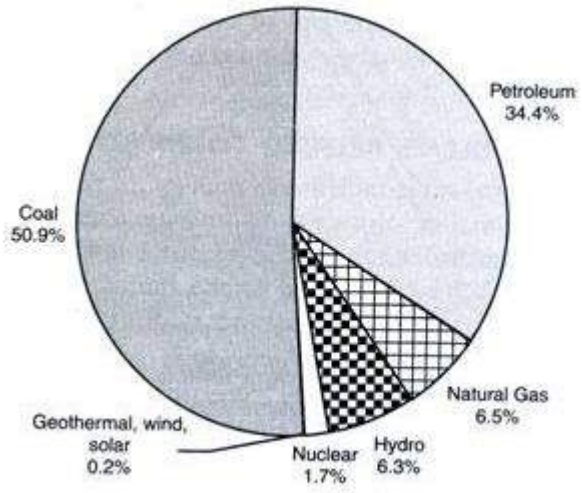
(i) Residential and commercial

(ii) Industrial

(iii) Transportation.

The two sources of energy are renewable and non-renewable energy sources. Optimal usage shall be the ideal mode for energy conservation. For an integrated management system we should have renewable energy as well as non-renewable energy sources.

At local level, biomass energy tapping, use of solar cooker, solar water heaters and solar photovoltaic cells must be encouraged. This shall be utilised besides the conventional energy from fossil fuels, hydel, thermal and nuclear power resources.



India's fuel share of energy consumption, 2001 (Btu)

Due to high population density and high energy demanding activities, the urban problems related to energy are much more magnified as compared to rural population.

There are several hurdles that play havoc in energy conservation. They are:

(i) Lack of awareness

(ii) Attitude

(iii) Lack of technical knowledge

(iv) Market distortion

(v) Capital shortages.

Regardless of the level of economic development, it is essential to realize sustainable growth of the economies in order to maintain a world order, and restrictions on energy supply which may hinder a sustainable economic development should be avoided at all costs. At the same time, however, inefficient final energy consumption which may result in aggravation of the global environmental problems should not be allowed.

Water Conservation : Rainwater Harvesting

As the world faces an increasingly critical need to address climate change, the impact that water conservation has on a sustainable environment is undeniable. Groundwater is the primary source of freshwater that caters to the demand of ever-growing domestic, agrarian and industrial sectors of the country. Over the years, it has been observed that the necessity for the exploitation of groundwater resources for various everyday needs, like toileting, bathing, cleaning, agriculture, drinking water, industrial and ever-changing lifestyles with modernization is leading towards tremendous water wastage.

Though many technological devices are being developed to minimize the water wastage, the impact will be greater if every individual contributes to

water conservation by minimizing or optimizing groundwater usage for daily activities. Today, water conservation at individual level has become very critical.

Our water resources are depleting each year. Additionally, we cannot generate artificial water and must depend on water sources available on our planet earth. Due to population boom and excessive need of water to suit our ever-expanding modern lifestyle, water scarcity is felt all over the world. This has given rise to major concerns over water conservation.

In this context, adopting rainwater harvesting and recharging groundwater is one of the simplest and best measures in conserving water globally. This practice can efficiently be implemented in lieu of traditional water supplies that are currently on the verge of tapping out.

RAINWATER HARVESTING

Rainwater harvesting is a simple strategy by which rainfall is gathered and stored for future usage. The process involves collection and storage of rainwater with help of artificially designed systems, that runs off natural or man-made catchment areas e.g. rooftop, compounds, rocky surface, hill slopes or artificially repaired impervious/semi-pervious land surface. The collected rainwater from surfaces on which rain falls may be filtered, stored and utilized in different ways or directly used for recharge purposes. Rainwater Harvesting is unrestricted from any kind of impurity, with relatively less storage cost and no maintenance cost involved except for periodical cleaning.

With depleting groundwater levels and fluctuating climate conditions, this measure can go a long way to help mitigate the adverse effects rising water scarcity. Reserving rainwater can help recharge local aquifers, reduce urban flooding and most notably, ensure water availability in water-scarce zones.

(Source: www.facebook.com/manjunath.reddy)

Advantages of implementing rain-water harvesting:

Reduced Water Bills

Rainwater harvesting systems are cost-effective, provide high-quality water, lessens dependence on wells and are considerably easy to maintain since they are not utilized for drinking, cooking or other sensitive uses. The all-around expenditures used in setting up harvesting methods are much cheaper compared to other purifying or pumping means. The cost of recharge to the subsurface reservoir is also lower than the surface reservoirs.

Ecological benefit

Storing water underground is environment-friendly. The ecological benefits of rainwater harvesting are immense. It minimizes the impacts of flooding by funneling the off water into large tanks for recycling and helps reduce the load placed upon drainage systems. No land is wasted for storage purpose and no population displacement is implicated therefore, groundwater is not directly exposed to evaporation and pollution. Additionally, it helps minimize the possibility of rivers drying up.

Reduces erosion and flooding around buildings

It reduces soil erosion and flood hazards by collecting rainwater and reducing the flow of stormwater to prevent urban flooding. Most buildings that utilize rainwater harvesting systems have a built-in catchment area on

top of the roof, which has a capacity of collecting large volumes of water in case of rainstorms.

An adequate means for Irrigation purpose

Harvesting rainwater allows the collection of large amounts of water and mitigates the effects of drought. Most rooftops provide the necessary platform for collecting water. Rainwater is mostly free from harmful chemicals, which makes it suitable for irrigation purposes.

Reduces demand on Ground Water

Another vital benefit is that it increases the productivity of aquifer resulting in the rise of groundwater levels and reduces the need for potable water. It is extremely essential, particularly in areas with low water levels.

There are two major techniques of rainwater harvesting.

1. Surface runoff harvesting

In this method, rainwater flows away as surface runoff and can be stored for future use. Surface water can be stored by diverting the flow of small creeks and streams into reservoirs on the surface or underground. It can provide water for farming, for cattle and also for general domestic use. Surface runoff harvesting is most suitable in urban areas.

Rooftop rainwater/storm runoff can be harvested in urban areas through:

- Recharge Pit
- Recharge Trench
- Tubewell
- Recharge Well

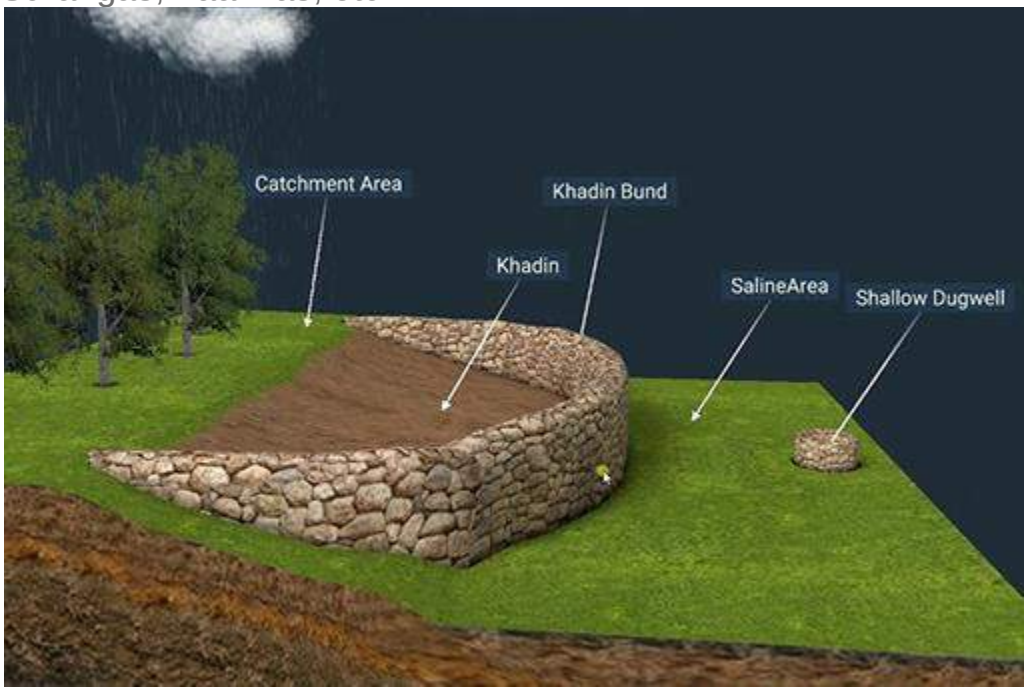
2. Groundwater recharge

Groundwater recharge is a hydrologic process where water moves downward from surface water to groundwater. Recharge is the primary method through which water enters an aquifer. The aquifer also serves as a distribution system. The surplus rainwater can then be used to recharge groundwater aquifer through artificial recharge techniques.

Rainwater in rural areas can be harvested through:

- Gully Plug
- Contour Bund
- Dugwell Recharge
- Percolation Tank
- Check Dam/Cement Plug/Nala Bund
- Recharge Shaft

Although rainwater harvesting measure is deemed to be a desirable concept since the last few years, it is rarely being implemented in rural India. Different regions of the country practiced a variety of rainwater harvesting and artificial recharge methods. Some ancient rainwater harvesting methods followed in India which includes Madakas, Ahar Pynes, Surangas, Taankas, etc.



(Source: www.youtube.com/labinapp)

Examples of Traditional water harvesting system in India

Trans-Himalayan Region

Zing -Tanks for collecting water from melted ice in Ladakh.

Western Himalayas

Kul -Water channels in mountain areas of Jammu, Himachal Pradesh.

Naula -Small ponds in Uttaranchal.

Eastern Himalayas

Northeastern Hill Ranges

Apatani system -Terraced plots connected by inlet and outlet channels in Arunachal Pradesh.

Zabo -Impounding runoff in Nagaland

Bamboo drip irrigation – Water from streams in the hills is brought to the plains via bamboo pipes for drip irrigation in Meghalaya

Brahmaputra Valley

Dongs – Ponds in Assam

Dungs or Jampois – small irrigation channels linking rice fields to streams in the Jalpaiguri district of West Bengal

Indo-Gangetic Plain

Dighis -Small square or circular reservoir fed by canals from rivers in Delhi
Baolis – secular structured stepwells from which everyone could draw water and use for washing and bathing.

Thar Desert

Baoris / Bers -Community wells in Rajasthan
Tankas -Underground tank Bikaner in Rajasthan
Kund – a circular underground well; having a saucer-shaped catchment area that gently slopes towards the center where the well is situated.

Central Highlands

Johads -Earthen check dams in Alwar district, Rajasthan
For further insight on **traditional water harvesting system** in India please visit http://mahenvis.nic.in/Pdf/Report/report_nrmc_water%20harvesting.pdf

Rainwater Harvesting In Arunachal

Arunachal Pradesh water resources department has executed demonstrative projects on rooftop rainwater harvesting and artificial recharge to groundwater under the cent percent central sector scheme **"Groundwater management and regulation"** during the 11th Five Year Plan, covering 235 projects in 11 districts. The districts included Tawang, West and East Kameng, Papum Pare, Kurung Kumey, Lower and Upper Subansiri, East and West Siang, Lower Dibang Valley, Anjaw, Miao (Changlang), Tirap and Longding. Out of the above, 100 projects were implemented in government schools, hospitals, primary health centers, office buildings, Circuit houses, and inspection bungalows. These projects were successfully executed and handed over to the user agencies for operation, maintenance and its utilization for various water needs. The first successful projects carried out by the Arunachal Pradesh water resources department was in Ruksin in East Siang district during 2002-03.

(Source: www.cpreecenvis.nic.in)

The Apatani's System – a wet rice cultivation cum fish farming system practiced in elevated regions of about 1600 m and gently sloping valleys. This system harvests both ground and surface water for irrigation. It is practiced by Apatani tribes of Ziro in the Lower Subansiri district of Arunachal Pradesh.

In the Apatani's system, valleys are terraced into plots divided by 0.6 meters high earthen dams which are then supported by bamboo frames. All plots have an inlet and outlet on opposite sides. The inlet of low lying plot functions as an outlet of the high lying plot. Deeper channels connect the inlet point to the outlet point. The terraced plot can be flooded or drained off with water by opening and blocking the inlets and outlets as and when required. The stream water is tapped by constructing a wall of 2-4 m high and 1 m thick near forested hill slopes. This is conveyed to agricultural fields through a channel network.

Conclusion

Harvesting and collection of rainwater is an adequate strategy that can be used to address the problem of water crisis globally. The use of a rainwater harvesting system provides excellent merits for every community. This simple water conservation method can be a boost to an incredible solution in areas where there is enough rainfall but not enough supply of groundwater. It will not only provide the most sustainable and efficient

means of water management but also unlock the vista of several other economic activities leading to the Empowerment of people at the grass-root level.
For this, the Government should come out with an appropriate incentive structure and logistic assistance to make it a real success. Rainwater harvesting is something that thousands of families across the world should participate in rather than pinning hopes on the administration to fight water crisis. This water conservation method is a simple and effective process with numerous benefits that can be easily practiced in individual homes, apartments, parks and across the world. As we all know that charity begins at home, likewise, a contribution to society's welfare has to be initiated from one's home.

Watershed Management - Overview

What is a Watershed?

Every body of water (e.g., rivers, lakes, ponds, streams, and estuaries) has a watershed. The watershed is the area of land that drains or sheds water into a specific receiving waterbody, such as a lake or a river. As rainwater or melted snow runs downhill in the watershed, it collects and transports sediment and other materials and deposits them into the receiving waterbody.

What is Watershed Management?

Watershed management is a term used to describe the process of implementing land use practices and water management practices to protect and improve the quality of the water and other natural resources within a watershed by managing the use of those land and water resources in a comprehensive manner.

What is Watershed Management Planning?

Watershed management planning is a process that results in a plan or a blueprint of how to best protect and improve the water quality and other natural resources in a watershed. Very often, watershed boundaries extend over political boundaries into adjacent municipalities and/or states. That is why a comprehensive planning process that involves all affected

municipalities located in the watershed is essential to successful watershed management.

Why is watershed management important?

Runoff from rainwater or snowmelt can contribute significant amounts of pollution into the lake or river. Watershed management helps to control pollution of the water and other natural resources in the watershed by identifying the different kinds of pollution present in the watershed and how those pollutants are transported, and recommending ways to reduce or eliminate those pollution sources.

All activities that occur within a watershed will somehow affect that watershed's natural resources and water quality. New land development, runoff from already-developed areas, agricultural activities, and household activities such as gardening/lawn care, septic system use/maintenance, water diversion and car maintenance all can affect the quality of the resources within a watershed. Watershed management planning comprehensively identifies those activities that affect the health of the watershed and makes recommendations to properly address them so that adverse impacts from pollution are reduced.

Watershed management is also important because the planning process results in a partnership among all affected parties in the watershed. That partnership is essential to the successful management of the land and water resources in the watershed since all partners have a stake in the health of the watershed. It is also an efficient way to prioritize the implementation of watershed management plans in times when resources may be limited.

Because watershed boundaries do not coincide with political boundaries, the actions of adjacent municipalities upstream can have as much of an impact on the downstream municipality's land and water resources as those actions carried out locally. Impacts from upstream sources can sometimes undermine the efforts of downstream municipalities to control pollution. Comprehensive planning for the resources within the entire watershed, with participation and commitment from all municipalities in the watershed, is critical to protecting the health of the watershed's resources.

What are some key steps in watershed management?

Familiarize Yourself with Your Watershed

Comprehensive watershed plans should first identify the characteristics of the watershed and inventory the watershed's natural resources. It is

important to establish a baseline of the overall nature and quality of the watershed in order to plan properly for the improvement of the resources in the watershed and to actually measure those improvements.

The first steps in watershed management planning are to:

- Delineate and map the watershed’s boundaries and the smaller drainage basins within the watershed;
- Inventory and map the resources in the watershed;
- Inventory and map the natural and manmade drainage systems in the watershed;
- Inventory and map land use and land cover;
- Inventory and map soils;
- Identify areas of erosion, including stream banks and construction sites;
- Identify the quality of water resources in the watershed as a baseline; and
- Inventory and map pollution sources, both point sources (such as industrial discharge pipes) and nonpoint sources (such as municipal stormwater systems, failing septic systems, illicit discharges).

Much of this information may already be compiled and available through the DEP, the Natural Resources Conservation Service of the U.S. Department of Agriculture, and municipal offices such as planning and zoning, inland wetlands, and public works. Additional information specific to the watershed can be gathered during volunteer stream walks which allow for on the ground study of the general conditions of the receiving waters and the adjacent watershed areas.

Build Local Partnerships

Watershed planning should also identify and include the partners, or "stakeholders," in the watershed. Development of local partnerships can also lead to greater awareness and support from the general public. Once individuals become aware of and interested in their watershed, they often become more involved in decision-making as well as hands-on protection and restoration efforts. Through such involvement, watershed management builds a sense of community, helps reduce conflicts, increases commitment to the actions necessary to meet environmental goals, and ultimately, improves the likelihood of success for the watershed management plan.

Local partnerships can include:

- Residents;
- Landowners;
- Federal, state, and municipal government officials;
- Watershed associations and other environmental and civic groups;
- Local business and industry leaders;
- Agricultural users;
- Developers;
- Teachers; and
- Recreational users.

Determine Priorities for Action

Watershed management planning should also determine what the opportunities are to reduce pollution or address other pressing environmental issues, prioritize those opportunities, and identify a time frame for accomplishing pollution reduction and resource and habitat improvements. Those issues that pose the greatest risk to human health or particular resources, or to desired uses of resources (i.e., swimming beaches), might be given highest priority for control and reduction. Watershed plans should establish clear goals, visions, and actions to be taken.

Examples of opportunities to reduce pollution and address other wide-ranging environmental issues include:

- Infrastructure improvements. More frequent maintenance of municipal stormwater systems or improving or replacing inadequate stormwater treatment systems, identifying and eliminating illicit (i.e., non-stormwater) connections to municipal stormwater systems;
- Reducing paved areas and other impervious cover, especially adjacent to waterbodies and wetlands. Zoning and subdivision regulations can be revised to address issues such as reducing lot coverage/impervious cover, reducing roadway widths, encouraging cluster and low impact development, limiting land disturbance such as grading and clearing, and increasing development setbacks from resources;
- Identifying appropriate areas for open space acquisition, greenways planning, and the establishment of vegetated buffers along waterbodies and wetland areas;
- Establishing sewer avoidance areas to limit development;

- Increasing inspections and maintenance of existing septic system and encouraging repairs to failing systems;
- Identifying other appropriate housekeeping practices for homeowners and landowners (encouraging the use of vegetated buffers adjacent to waterbodies and wetlands, reducing lawn areas and the amount of fertilizers and chemicals applied to them, recommending washing cars over lawns instead of driveways so rinse water can drain into the lawn and not run-off into storm drains, etc.);
- Identifying resource and wildlife habitat restoration priorities;
- Increasing and promoting public access and greenways and identifying areas where it is appropriate to do so; and
- Identifying and evaluating opportunities for nonstructural flood protection efforts;
- Improving waste management, pollution prevention, and recycling efforts at municipal facilities and businesses within the watershed.

Conduct Educational Programs

The degree of public education and participation in the planning process can greatly influence the success of watershed management. There are many ways to involve and educate the public in watershed management. The formation of citizen review groups and advisory committees can gain public support from the watershed and are an essential component to a successful, community-based, and locally led effort. These community-based groups and committees can also provide the means to keep the project going once the plan has been finalized to make sure that recommended actions are taken. It might also be helpful to identify a watershed coordinator to help in this effort.

- Outreach and education efforts can include:
- Periodic informational meetings;
- Stream walk assessments;
- Organized storm drain stenciling projects;
- Watershed clean-up days and riparian planting/habitat restoration days;
- Coordination with school systems within the watershed;
- Information kiosks and websites;
- Videos; and
- Newsletters and other printed materials to provide status and progress reports.

Ensure Implementation and Follow-up

It is important to establish a schedule with milestones and some sort of committee to ensure that projects proceed in a timely manner. A monitoring program should also be established to measure success through data gathering. It is also important to identify ways in which landowners can be assisted with undertaking necessary improvements, such as low interest loans or technical outreach information. Finally, it is important to ensure that the recommendations contained in the watershed plan, especially design standards, are integrated into municipal land use regulations (zoning, subdivision, inland wetlands).

Resettlement and Rehabilitation of People: Problems and Concerns | Disaster Management

Resettlement and Rehabilitation of People: Problems and Concerns!

It is a well-known fact that both natural and human made disasters force people to move out of their land. For example. Tsunami in South Asia in December 2004, Latur and Gujarat earthquake, the Orissa super-cyclone and scores of floods and droughts in other parts of our country have rendered thousands of people homeless and jobless. Disasters, like the Bhopal gas tragedy in Union carbide factory, derailment of trains, are examples of human made disaster.

Strategies for rehabilitation of thus displaced people are in the first place by way of preventive action. For instance, care is taken to build earthquake proof houses, gather advance information about cyclones and arrange for timely evacuation, build appropriate bunds in flood prone areas, maintain bridges that take regular up and down passing of trains/ road transport vehicles on them in order to avert likely disasters.

Secondly, advance preparation on the part of administration and local communities are made to face the consequences of sudden calamities. For both these remedial steps, the primary necessity is that of building awareness among the people in general and among administrative personnel in particular.

The scope for advance planning in the cases of natural and human made calamities is however quite limited and in comparison we can certainly plan better in the cases of development projects which are planned in advance.

Development projects come into existence after a fairly long period of planning and awareness of displacement caused by such projects already exists among those who initiate the projects. The tragedy is that despite this prior knowledge of the extent of displacement, those in-charge of development projects pay little attention to the processes of resettlement and rehabilitation of displaced people.

Development projects instead focus on economic efficiency and not on those who stand to lose all that they have, their land, means of livelihood and stable patterns of social and cultural life. Those who give up substantial portions of their assets for the sake of development projects need to be recognized as stakeholders in development projects. They too need to be a part of development.

The strategies formulated for resettlement and rehabilitation of those displaced by development projects can of course be equally applied to those displaced by natural and human made calamities. As far as our country's preparation for coping with the impact of natural and human made calamities is concerned, we have begun to feel a little aware of negative impacts of such events because they are now occurring at frequent intervals.

As a result there are some institutional measure have been taken by the government by way of constituting committees at various levels. They exist on paper and their immediate response to the actual events is yet to come in any significant manner.

But we can say that a beginning has been made and we need to further consolidate the initiatives already taken so that such measure can bring some relief to disaster victims by way of their resettlement and rehabilitation. At present, we find

that ad hoc relief measures are adopted to cope with the gravity of problems caused by such disasters.

Environmental Ethics

What responsibilities do we have to wild species and ecosystems — and to present and future generations of humans dependent on critical ecological services? How does the recognition of rapid, global environmental change challenge our traditional understandings of these obligations? What does it mean to be "sustainable" and why do many believe that achieving sustainability is an ethical imperative for science and society in this century?
These questions, and others like them, are explored in this series. Environmental ethics is a branch of applied philosophy that studies the conceptual foundations of environmental values as well as more concrete issues surrounding societal attitudes, actions, and policies to protect and sustain biodiversity and ecological systems. As we will see, there are many different environmental ethics one could hold, running the gamut from human-centered (or "anthropocentric") views to more nature-centered (or "non-anthropocentric") perspectives. Non-anthropocentrists argue for the promotion of nature's intrinsic, rather than instrumental or use value to humans. For some ethicists and scientists, this attitude of respecting species and ecosystems for their own sakes is a consequence of embracing an ecological worldview; it flows out of an understanding of the structure and function of ecological and evolutionary systems and processes. We will consider how newer scientific fields devoted to environmental protection such as conservation biology and sustainability science are thus often described as "normative" sciences that carry a commitment to the protection of species and ecosystems; again, either because of their intrinsic value or for their contribution to human wellbeing over the long run.

The relationship between environmental ethics and the environmental sciences, however, is a complex and often contested one. For example, debates over whether ecologists and conservation biologists should also be advocates for environmental protection — a role that goes beyond the traditional profile of the "objective" scientist — have received much

attention in these fields. Likewise, we will see that issues such as the place of animal welfare concerns in wildlife management, the valuation and control of non-native species, and the adoption of a more interventionist approach to conservation and ecological protection (including proposals to relocate wild species and to geoengineer earth systems to avoid the worst effects of global climate change) frequently divide environmental scientists and conservationists. This split often has as much to do with different ethical convictions and values regarding our responsibility to species and ecosystems as it does with scientific disagreements over the interpretation of data or the predicted outcomes of societal actions and policies.

The essays in this series illustrate the diversity of environmental ethics, both as a field of study and as a broader, value-based perspective on a complex web of issues at the junction of science and society. To gain a fuller understanding of the concepts and arguments of environmental ethics, begin with this introductory overview. From here you can explore a range of topics and questions that highlight the intersection of environmental ethics, ecology, and conservation science.

Summary

People flocked to the beach for respite one evening during Melbourne's record breaking four-day heatwave in January 2014, under a sky made hazy by smoke from a scrub fire.

Earth's climate has changed over the past century. The atmosphere and oceans have warmed, sea levels have risen, and glaciers and ice sheets have decreased

in size. The best available evidence indicates that greenhouse gas emissions from human activities are the main cause. Continuing increases in greenhouse gases will produce further warming and other changes in Earth's physical environment and ecosystems.
The science behind these statements is supported by extensive studies based on four main lines of evidence:

- Physical principles established more than a century ago tell us that certain trace gases in the atmosphere, such as carbon dioxide (CO_2) and water vapour, restrict the radiant flow of heat from Earth to space. This mechanism, known as the 'greenhouse effect', keeps Earth's surface and lower atmosphere considerably warmer than they would otherwise be. The gases involved are called 'greenhouse gases'. An increase in greenhouse gas concentrations raises the temperature of the surface.
- The record of the distant past(millions of years) tells us that climate has varied greatly through Earth's history. It has, for example, gone through ten major ice age cycles over approximately the past million years. Over the last few thousand years of this period, during which civilisations developed, climate was unusually stable. Evidence from the past confirms that climate can be sensitive to small persistent changes, such as variations in Earth's orbit.
- Measurements from the recent past (the last 150 years) tell us that Earth's surface has warmed as atmospheric concentrations of greenhouse gases increased through human activities, and that this warming has led to other environmental changes. Although climate varies from decade to decade, the overall upward trend of average global surface temperature over the last century is clear.
- Climate models allow us to understand the causes of past climate changes, and to project climate change into the future. Together with physical principles and knowledge of past variations, models provide compelling evidence that recent changes are due to increased greenhouse gas concentrations in the atmosphere. They tell us that, unless greenhouse gas emissions are reduced greatly and greenhouse gas concentrations are stabilised, greenhouse warming will continue to increase.

This document aims to summarise and clarify the current scientific understanding of climate change by answering nine key questions.

1 What is climate change?

The term 'climate', in its broadest sense, refers to a statistical description of weather and of the related conditions of oceans, land surfaces and ice sheets.

This includes consideration of averages, variability and extremes. Climate change is an alteration in the pattern of climate over a long period of time, and may be due to a combination of natural and humaninduced causes.

2 How has climate changed?

Global climate has varied greatly throughout Earth's history. In the final decades of the 20th century, the world experienced a rate of warming that is unprecedented for thousands of years, as far as we can tell from the available evidence. Global average temperature rise has been accompanied by ongoing rises in ocean temperatures, ocean heat storage, sea levels and atmospheric water vapour. There has also been shrinkage in the size of ice sheets and most glaciers. The recent slowdown in the rate of surface warming is mainly due to climate variability that has redistributed heat in the ocean, causing warming at depth and cooling of surface waters. Australia's climate has warmed along with the global average warming.

3 Are human activities causing climate change?

Human activities are increasing greenhouse gas concentrations in the atmosphere. This increase is extremely likely to have caused most of the recent observed global warming, with CO_2<sub<2< sub="" style="box-sizing: border-box; margin: 0px; padding: 0px;"> being the largest contributor. Some observed changes in Australia's climate, including warming throughout the continent and drying trends in the southwest, have been linked to rising greenhouse gas concentrations.</sub<2<>

4 How do we expect climate to evolve in the future?

If greenhouse gas emissions continue to grow rapidly, it is expected that, by 2100, the global average air temperature over the Earth's surface will warm by around 4°C above mid-19th century temperatures. There are many likely ramifications of this warming. However, if emissions are reduced sufficiently rapidly, there is a chance that global average warming will not exceed 2°C and other impacts will be limited.

5 How are extreme events changing?

Since the mid-20th century, climate change has resulted in increases in the frequency and intensity of very hot days and decreases in very cold days. These

trends will continue with further global warming. Heavy rainfall events have intensified over most land areas and will likely continue to do so, but changes are expected to vary by region.

6 How are sea levels changing?

Sea levels have risen during the 20th century. The two major contributing factors are the expansion of sea water as it warms, and the loss of ice from glaciers. Sea levels are very likely to rise more quickly during the 21st century than the 20th century, and will continue to rise for many centuries.

7 What are the impacts of climate change?

Climate change has impacts on ecosystems, coastal systems, fire regimes, food and water security, health, infrastructure and human security. Impacts on ecosystems and societies are already occurring around the world, including in Australia. The impacts will vary from one region to another and, in the short term, can be both positive and negative. In the future, the impacts of climate change will intensify and interact with other stresses. If greenhouse gas emissions continue to be high, it is likely that the human-induced component of climate change will exceed the capacity of some countries to adapt.

8 What are the uncertainties and their implications?

There is near-unanimous agreement among climate scientists that human-caused global warming is real. However, future climate change and its effects are hard to predict accurately or in detail, especially at regional and local levels. Many factors prevent more accurate predictions, and some uncertainty is likely to remain for considerable time. Uncertainty in climate science is no greater than in other areas where policy decisions are routinely taken to minimise risk. Also, the uncertainty means that the magnitude of future climate change could be either greater or less than present-day best estimates.

9 What does science say about options to address climate change?

Societies, including Australia, face choices about how to respond to the consequences of future climate change. Available strategies include reducing emissions, capturing CO_2, adaptation and ‘geoengineering’. These strategies, which can be combined to some extent, carry different levels of environmental risk and different societal consequences. The role of climate science is to inform

decisions by providing the best possible knowledge of climate outcomes and the consequences of alternative courses of action.

Wasteland Reclamation: 8 Ways of Wasteland Reclamation

Wasteland Reclamation: 8 Ways of Wasteland Reclamation !

Reclamation of waste land means re-claiming it or to use it for productive purposes.

1. Afforestation:

It means growing the forest over culturable wasteland.

Image Courtesy :

images2.wikia.nocookie.net/__cb20110309003623/fallout/images/a/a0/WastelandPicture.jpg

2. Reforestation:

Growing the forest again over the lands where they were existing and was destroyed due to fires, overgrazing, and excessive cutting. Reforestation checks water logging, floods, soil erosion and increase productivity of land.

3. Providing surface cover:

The easiest way to protect the land surface from soil erosion is of leave crop residue on the land after harvesting.

4. Mulching:

Here also protective cover of organic matter and plants like stalks, cotton stalks, tobacco stalks etc. are used which reduce evaporation, help in retaining soil moisture and reduce soil erosion.

5. Changing Ground Topography on Downhill's:

Running water erodes the hill soil and carries the soil along with it. This can be minimized by following alternation in ground topography:

(a) Strip farming:

Different kinds of crops are planted in alternate strip along the contour.

(b) Terracing:

In this arrangement, the earth is shaped in the form of levelled terraces to hold soil and water. The terrace edges are planted with such plant species which anchor the soil.

(c) Contour ploughing:

In this arrangement, the ploughing of land is done across the hill and not in up and down style.

6. Leaching:

In salt affected land, the salinity can be minimized by leaching them with more water.

7. Changing agricultural practices:

Like mixed cropping, crop rotation and cropping of plants are adopted to improve soil fertility.

8. Ecological Succession:

This refers to the natural development or redevelopment of an ecosystem which help in reclaiming the minerally deficient soil of wasteland.

Consumerism and waste products
• Consumerism is related to the constant purchasing of new goods, with little attention to their true need, durability, product origin, or the environmental consequences of their manufacture and disposal. • Consumerism interferes with the sustainable use of resources in a society by replacing the normal common sense desire for an adequate supply of life's necessities, with and insatiable quest for things that are purchased by larger and larger incomes to buy them. • Especially in developed countries, landfills are being rapidly filled with cheap discarded products that fail to work within

short time and cannot be repaired.

- In many cases, consumer products are made psychologically obsolete by advertising industry long before they actually wear out.
- The inordinate amount of waste that is generated by consumer-oriented societies around the world is now a serious environmental issue.
- Most human activities are related to production and consumption cycle which produce excessive amounts of waste in the form of solid, liquid and gaseous waste products.
- With the advent of and industrial civilization, the highly complex technological processes for production of goods have rapidly increased problems due to inadequate waste disposal.
- With the rapid increase in population, the amount of waste in terms of quantity and quality has increased waste management pressure many-fold in recent years.
- Our health will be affected by dangerous industrial effluents, and be will be smothered by clouds of smoke and unhealthy gases. Therefore, the reuse of goods and waste utilization should become a part of the production-consumption cycle.
- For example, it is estimated that the per capita production of domestic waste is many times higher in a developed country hence compared to a developing country.
- Large quantities of solid, liquid and gaseous waste is produced by urban industrial communities in the form of plastic, paper, leather, tin cans, bottles, mineral refuse, and pathological waste from hospitals.
- Dead animals, agricultural wastes, fertilizer and pesticide overuse, and human and animal excreta are essentially rural concerns.
- This attitude towards waste has led to disastrous effects on the environment besides the overexploitation of natural resources.

Three Issues Involved in Enforcement of Environmental Legislation in India

Some of the important issues involved in enforcement of environmental legislation in India are as follows: 1. The precautionary principle, 2. The polluter-pays principle, 3. Freedom of information!

The environmental issue in India looks gloomy despite so many Legislations and Acts. The rivers and lakes continue to be choked with industrial waste and sewage. The air in many cities of India is heavily polluted. Deforestation takes place quite normally. The protection of wildlife is not carried out in its true spirit, despite the enforcement of Acts.

The people must be guided and helped to establish the trend of acceptance of preventing the environment as a whole, our health and Earth's resources, The presence of legislation to protect the air, water, soil etc., doesn't necessarily mean the problem is addressed.

Once the legislation is made at the global, national or state level, it has to be implemented. For environmental

legislation to be successfully implemented there has to be an effective agency to collect relevant data, process it and pass it on to a law enforcement agency. If the law or rule is broken by an individual or institution, this has to be punished through the legal process.

The Government of India constituted a Central Board for prevention and control of water pollution after the Water Act, 1974 was passed. Subsequently Air (Prevention and Control of Pollution) Act 1986 was passed. The Central Board for prevention and control of water pollution was entrusted to manage the affairs enumerated in Air Act, 1986 and Environment Act, 1986.

Several other acts and rules were enacted. All the state governments also constituted pollution central boards in their respective states and accepted the central legislation in their respective legislative assemblies. Some of the pollution monitoring is carried out by other agencies, e.g., vehicular pollution is monitored by transport department. This is a real drawback because several agencies cannot control pollution.

Environmental litigation is more expensive than other types of disputes, as it involves expert testimony and technical

evidence central and state boards must be able to afford the expertise and the administrative backing.

So, efforts are made to share the costs of anti-pollution measures taken by the industry to avoid state sponsored expensive and lengthy legal battles. The laws enacted by the government should be made very stringent and harsh so that every citizen may not dare to play with the environment and instead he/she should protect it.

Three issues that are especially important for environmental legislation are:

1. The precautionary principle:

This principle has evolved to deal with risks and uncertainties faced by environmental management. The principle implies that an ounce of prevention is worth a pound of cure it does not prevent problems but may reduce their occurrence and helps ensure contingency plans are made.

The application of this principle requires either cautious progress until a development can be judged 'innocent', or avoiding development until research indicates exactly what the risks are, and then proceeding to minimize them.

Once a threat is identified, action should be taken to prevent or control damage even if there is uncertainly,

about whether the threat is real. Some environmental problems become impossible or costly to solve if there is delay, therefore waiting for research and legal proof is not costless.

2. The polluter-pays principle:

In addition to, the obvious the polluter pays for the damaged caused by a development this principle also implies that a polluter pays for monitoring and policing. A problem with this approach is that fines may bankrupt small businesses, yet be low enough for a large company to write them off as an occasional overhead, which does little for pollution control.

There is, thus, debate as to whether the principle should be retrospective. Developing nations are seeking to have developed countries pay more for carbon dioxide and other emissions controls, arguing that they polluted the global environment during the Industrial Revolution, yet enjoy the fruits of invention from the era.

This principle, in fact, is more a way of allocating costs to the polluter than a legal principle. This principle was adopted by OECD member countries in 1972, at least in theory.

3. Freedom of information:

Environmental planning and management is hindered if the public, NGOs or even official bodies are unable to get information. Many countries have now begun to release more information, the USA has a Freedom of Information Act, and the European Union is moving in this direction.

But still many governors and multinational corporations fear that industrial secrets will leak to competitors if there is too much disclosure, and there are situations where authorities declare strategic needs and suspend disclosure.

Environmental Awareness

Environmental awareness is to understand the fragility of our environment and the importance of its protection. Promoting environmental awareness is an easy way to become an environmental steward and participate in creating a brighter future for our children.

Photo courtesy of Jake Matthews.

What is Environmental Awareness?

To define environmental awareness we must first understand the environmentalist movement. Environmentalism is an ideology that evokes the necessity and responsibility of humans to respect, protect, and preserve the natural world from its anthropogenic (caused by humans) afflictions.

Environmental awareness is an integral part of the movement's success. By teaching our friends and family that the physical environment is fragile and indispensable, we can begin fixing the problems that threaten it.

How to Promote Environmental Awareness

Before you can begin promoting environmental awareness in your community, you must first make sure that you have a thorough understanding of environmental issues. Stay up to date on environmental news, read books and other resources, and learn about the issues affecting your own community. It's much easier to talk to others about the environment if you've already taken the time to educate yourself.

Numerous resources are available to promote environmental awareness and education: group learning (inside or outside of the classroom),

informational and inspirational seminars, online courses, books, articles, videos, and brochures are just a few of the tools that can get you involved in promoting the environment.

A good course of action that ensures your continued participation is to pick an environmental issue that strikes you as the most urgent. The amount of environmental issues seems limitless, and while they are all important, it's easy to get overwhelmed. Try choosing one issue to focus on at a time. You will soon see that all environmental issues are intertwined and will find your niche of interest.

Examples of Environmental Issues

Here are several cause-and-effect problems that harm our environment:

- **Oil Drilling-** This issue is one that causes a great deal of environmental destruction. Our dependence on fossil fuel is a global addiction that affects every aspect of the world. Oil spills and offshore drilling poison marine life, oil drilling (on land) suffocates the earth, and the combustion of fossil fuels add to the increased atmospheric CO_2, which in turns causes the progression of global warming and ocean acidification. This is a multifaceted issue and is a good cause to get involved with because it covers such a broad spectrum of issues.

- **Deforestation-** Millions of acres of forest are cut down for industrial benefit, such as large scale farming, oil mining, and the production of paper goods. Deforestation causes wildlife and biodiversity extinction because the loss of habitat threatens many species' existence. The International Union for Conservation of Nature (IUCN) has a Red List of environmentally threatened species with up-to-date information.
- **Production of Plastic Goods-** Currently our society creates a great deal of waste and much of that waste consists of plastic. According to the Environmental Protection Agency (EPA) in 2010 alone 31 million tons of plastic waste was created. This waste ends up all over the globe in both land and water, a good example is the Great Pacific Garbage Patch. Not only is plastic waste an issue, but the production of plastic is also dependent on fossil fuel combustion. According to the U.S. Energy Information Administration (EIA) in 2010 191 million barrels of liquid petroleum gases(LPG) and natural gas liquids (NGL) were used in the U.S. alone to produce plastic goods.

Share Your Knowledge

After you've chosen an issue and educated yourself, engage your community, family, and friends in a conversation about the issue's urgency and importance.

By engaging your community in the conversation, you are not only promoting environmental awareness, but you may also find opportunities to participate in communal projects or to get involved in other related causes.

Make a Difference

Once you're well versed in environmental issues, you can use that knowledge to start beneficial projects in your home and/or in your community.

Possible Project Ideas

- Instead of driving to work or school, take the bus, carpool, walk, or ride your bike to cut down on greenhouse gas emissions. According to the EPA transportation adds to 33% of the total atmospheric CO_2.
- Consider investing in appropriate technology like clean power (solar or wind), if not for your home then maybe for a community center. This supports a transition to clean and renewable energy.
- Buy reusable products such as glass bottles, reusable bags and reusable cups. Avoid buying disposable goods such as paper towels, plastic bottles, and plastic bags.
- Start composting and recycling, which will help cut down our waste production.
- Support local businesses and farmers, and buy organic and pesticide-free food when you can. Or, start your own community garden.

Once you have chosen your cause and have started a personal or community project, share it with the world! Get your coworkers, neighbors, friends, family, or even your local government involved. It's much easier and more effective to spread environmental awareness and start a local project if you collaborate with others in your community.

Promoting environmental awareness is a crucial part of being an environmental steward. Start participating in the change and teach your community what is needed to create a sustainable future.

THE ACTS

The Environment (Protection) Act, 1986 :-

https://www.indiacode.nic.in/bitstream/123456789/4316/1/ep_act_1986.pdf

The Air (Prevention and Control of Pollution) Act, 1981 :-

https://legislative.gov.in/sites/default/files/A1981-14.pdf

The Water (Prevention and Control of Pollution) Act, 1974 :-

https://www.indiacode.nic.in/bitstream/123456789/15429/1/the_water_%28prevention_and_control_of_pollution%29_act%2C_1974.pdf

The Wild Life (Protection) Act, 1972 :-

https://legislative.gov.in/sites/default/files/A1972-53_0.pdf

The Forest (Conservation) Act, 1980 :-

https://legislative.gov.in/sites/default/files/A1980-69_0.pdf

Sample MCQS

The Environment (Protection) Act was passed in the year

i) 1972
ii) 1974
iii) 1980
iv) 1986

The Air (Prevention and Control of Pollution) Act was passed in the year

i) 1981
ii) 1980
iii) 1972
iv) 1974

The Water (Prevention and Control of Pollution) Act was passed in the year

i) 1972
ii) 1973
iii) 1974
iv) 1975

The Wild Life (Protection) Act was passed in the year

i) 1971
ii) 1972
iii) 1973
iv) 1974

The Forest (Conservation) Act was passed in the year

i) 1972
ii) 1980
iii) 1974
iv) 1981

M.C.Q.

1. **The growth rate of population in India is—**
   (a) 3·6% (b) 5·6% (c) 2·1% (d) 3·9%
2. **The human population is growing—**
   (a) Geometrically (b) Arithmatically (c) Slowly (d) Moderately
3. **In which country population growth rate is high?**
   (a) India (b) Mexico (c) Canada (d) Brazil
4. **Which type of deseases are found maximum in human body?**
   (a) Water-borne (b) Air-borne (c) Food-borne (d) Soil-borne
5. **The virus responsible for AIDS—**
   (a) HIV (b) Polyomyletic (c) TMV (d) BMV
6. **Universal declaration of Human Rights draft resolution was accepted in the year—**
   (a) 1978 (b) 1948 (c) 1940 (d) 1944
7. **In India Women's Commission was set up in the year—**
   (a) 1978 (b) 1992 (c) 1998 (d) 2002
8. **In the Indian Constitution, the Human Rights have specific mention in clauses—**
   (a) 47 & 48A (b) 20 & 21B (c) 347A (d) 350A
9. **United Nations Conventions in respect of the right of child was made in—**
   (a) 1992 (b) 1968 (c) 2002 (d) 2006
10. **'Hepatitis' A is a _____ disease.**
    (a) Protozoan (b) Viral (c) Bacterial (d) Fungus
11. **'Salmonella' is responsible for—**
    (a) Cholera (b) Dyssentry (c) Typhoid (d) Pox
12. **Infant mortality in developed countries—**
    (a) 50 – 100/1000 infants (b) 30–40/1000 infants
    (c) 5 – 25/1000 infants (d) 69–75/1000 infants
13. **'Demography' is related to—**
    (a) Human population (b) Human health
    (c) Human Geography (d) Human ecology
14. **Carrying capacity is directly related to—**
    (a) Starvation (b) Population (c) Malnutrition (d) Economy
15. **'Aspergillosis' is a — disease**
    (a) Bacterial (b) Viral (c) Fungal (d) Myxoviral
16. **'ENVIS' is related to—**
    (a) Water pollution (b) Air pollution (c) Soil polution
    (d) Environmental Information System

17. **UNEP stands for—**
(a) United Nations Economic Programme (b) United Nations Economic Plan
(c) United Nations Economic Progress (d) United Nations Economic Pattern

18. **Vienna Declaration on Human Rights was made in—**
(a) 1990 (b) 1993 (c) 1994 (d) 1995

19. **In developing countries daily food intake in calory per person is—**
(a) 1500 – 2700 (b) 3100 – 3500 (c) 4000 – 4500 (d) 1000 – 1200

20. **At present in India the number of women per 1000 men—**
(a) 212 (b) 887 (c) 927 (d) 721

21. **Minamata disease was found in**
(a) Japan (b) Russia (c) China (d) Korea.

22. **5th June is**
(a) World Forest Day (b) World Red Cross Day
(c) World Environment Day (d) World Food Day.

23. **Melanin protects us from**
(a) X-rays (b) Infra-red rays (c) Visible rays (d) UV rays.

24. **Which is most ionising**
(a) X-rays (b) γ-rays (c) β-rays (d) α-rays.

25. **Thermal pollution results in**
(a) Depletion of oxygen (b) Increase in temperature of water bodies
(c) Death of aquatic animals (d) All the above.

26. **Which can be used for cleaning water body**
(a) Chlorella (b) Eichhomia (c) Cyanobacteria (d) Chlamydomonas

27. **Pollutant emitted by paddy fields is**
(a) CO_2 (b) CH_4 (c) CO (d) H_2O_2

28. **Methyl isocyanate of Bhopal gas tragedy was**
(a) Carbamate (b) Organophosphate
(c) Organochlorine (d) None of the above.

29. **World Environment Day is celebrated on**
(a) 25th Dec (b) 20th September (c) 5th June (d) 9th July.

30. **SO_2 pollution affects**
(a) Mitochondria (b) Chloroplasts (c) Golgi bodies (d) Vacuoles.

31. **Primary constituents of photochemical smog are**
(a) SO_2 and CO (b) CO_2 and NO_2
(c) NO_2 and hydrocarbons (d) Hydrocarbons and CFCs.

32. **BOD is a measure of**
(a) Industrial waste being poured in body
(b) Extent of pollution with organic compounds
(c) CO combined with haemoglobin (d) O_2 required by green plants during night.

33. Drinking mineral water/aerated drink with low levels (~ 0·02 ppm) of pesticide for long period would
(a) Cause cancer of intestine (b) Pesticide accumulation in the body
(c) Cause leukaemia (d) Produce immunity against mosquito.

34. In Indian metropolitan cities like Delhi major air pollutant is
(a) SPM (b) SO_x (c) NO_x (d) CO and CO_2.

35. Photochemical smog consists of
(a) O_3, SO_x, and hydrocarbons (b) O_3, PAN and NO_x
(c) SO_2, CO_2 and hydrocarbons (d) SO_2, PAN and smoke.

36. Given below are assertion and reason. Point out if (a) both are true with the reason being the correct explanation (b) both are true but the reason is not the correct explanation (c) the assertion is true but the reason is wrong (d) both are wrong.
Assertion. Inhabitants close to busy airports are likely to experience health hazards.
Reason. Sound levels of jet aeroplane usually exceed 160 dB
(a) (b) (c) (d)

37. Fluoride pollution mainly affects
(a) Brain (b) Heart (c) Teeth (d) Kidney.

38. Acid rain is caused by
(a) SO_2 (b) NO_2 (c) CO (d) Both a and b.

39. Entry of sewage in water caused a spurt in the growth of algae but killed fish due to
(a) Decrease in nutrients (b) Reduction in light
(c) Depletion of oxygen (d) All the above.

40. Chlorofluorocarbons are not being used in refrigerators because they
(a) Increase temperature (b) Cause allergic reactions
(c) Deplete ozone (d) Both a and b.

41. Third generation pesticides are
(a) Pheromones (b) Juvenile hormone analogus
(c) Insect repellents (d) Pathogens.

42. Ozone hole causes
(a) Global warming (b) Reduction in the rate of photosynthesis
(c) More ultraviolet rays come to earth (d) All the above.

43. Role of CFC present in atmosphere is to
(a) Reduction in ozone (b) Ozone formation
(c) Formation of haemoglobin (d) Enhance chlorophyll formation.

44. Concentration of DDT from lower to higher trophic level
(a) Increases (b) Decreases (c) Increases or decreases
(d) Remains constant.

45. **Noise becomes uncomfortable above**
(a) 180 dB (b) 140 dB (c) 100 dB (d) 80 dB.

46. **DDT is**
(a) Organophosphate (b) Organochlorine (c) Carbamate (d) Triazine.

47. **Which pesticide is a herbicide**
(a) Malathion (b) Lindane (c) BHC (d) 2, 4—D.

48. **Allethrin is**
(a) Fertilizer (b) Herbicide (c) Growth hormone (d) Insecticide.

49. **The process of conversion of harmful industrial wastes into less toxic or nontoxic form by micro-organisms is**
(a) Bioconversion (b) Precipitation
(c) Bioremediation (d) Complement fixation.

50. **70 — 90 dB sound is**
(a) Quiet (b) Very loud (c) Uncomfortable (d) Painful.

51. **Occurrence of water blooms in a lake indicates**
(a) Excessive nutrient availablity (b) Nutrient deficiency
(c) Oxygen deficiency (d) Absence of herbivores.

52. **The first biosphere reserve to be established in India was**
(a) Nanda Devi (b) Nilgiri (c) Great Nicobar (d) Thar.

53. **Soil pollutants affecting food-chains and food-webs by killing micro-organisms are**
(a) Chemical fertilizers (b) Agriculture wastes (c) Pesticides (d) Pathogens

54. **NEERI is at**
(a) New Delhi (b) Nagpur (c) Kolkata (d) Chennai.

55. **Minimata disease is caused by**
(a) Chromium (b) Cadmium (c) Methyl mercury (d) Radioactive elements.

56. **In acid rain, SO_2, sulphuric acid accounts for**
(a) 100 % (b) 30 % (c) 50 % (d) 70 %

57. **Maximum permissible noise as per Noise Pollution Rules 2000 is**
(a) 75 dB (b) 65 dB (c) 55 dB (d) 45 dB.

58. **Chlorofluorocarbons are responsible for**
(a) Acid rain (b) Ozone layer depletion
(c) Global warming (d) Thermal inversion.

59. **Chernobyl nuclear tragedy occurred in**
(a) April 1986 (b) August 6, 1945
(c) August 9, 1945 (d) December 3, 1984.

60. **Insecticides usually act upon**
(a) Muscular system (b) Digestive system
(c) Nervous system (d) Circulatory system.

61. Which one is correct

(a) Herbicides kill plants by blocking PS II

(b) Insecticides kill insects through impairment of nerve conduction and sometimes respiratory arrest

(c) Both a and b (d) None of the above.

62. An air pollutant which can cause acid rain and which is injurious to respiratory tissue is

(a) Nitric acid (b) Sulphur dioxide (c) Lead nitrate (d) Carbon dioxide.

63. Use of pesticides is problematic as

(a) Their residues persist in water and environment

(b) Mosquitoes have become resistant to DDT

(c) Kill silkworms (d) Deform gills of some fishes.

64. A hyper metal accumulator is

(a) *Daucos carota* (b) *Nicotiana tabacum*

(c) *Arabidopsis* (d) *Tlilaspi goesingensis.*

65. Rain is called acid rain when its pH is below

(a) 7 (b) 6·5 (c) 6 (d) 5·6

66. Bhopal tragedy occurred in

(a) 1982 (b) 1984 (c) 1986 (d) 1988.

67. Bhopal gas tragedy of 1984 took place because methyl isocyanate reacted with

(a) DDT (b) Ammonia (c) CO_2 (d) Water.

68. Lead concentration of blood is considered alarming at

(a) 4 – 6 μg/100 ml (b) 10 μg/100 ml (c) 20 μg/100 ml (d) 30μg/100 ml.

69. Biomagnification refers to

(a) Rapid growth due to excessive intake of nutrients

(b) Increase in population size (c) Decrease in population size

(d) Increase in concentration of nondegradable pollutants as they pass through food-chain.

70. Nitrogen oxides formed during emission from automobiles and power plants are a source of fine air particles which lead to

(a) Dry acid deposition (b) Photochemical smog

(c) Wet acid deposition (d) Industrial smog.

71. A lake receiving domestic sewage shows

(a) Drying up due to algal bloom

(b) Increased fish production due to higher nutrient availability

(c) Death of fish due to oxygen depletion

(d) Increased food-web organisation.

Given below are assertions and reasons. Point out if (a) both are true with reason being true explanation (b), both are true but reason is not correct explanation (c), assertion is true but reason is wrong (d), and both are wrong.

72. **Assertion** : Agriculture output increased several times after the introduction of DDT, Reason. DDT was the first insecticide used on a wide scale.
(a) (b) (c) (d)

73. **Assertion** : Methane component of green house gases contributing to global warming is about 20%.
Reason. Introduction of multipoint fuel injection engines in automobiles has decreased methane content in exhausts
(a) (b) (c) (d)

74. **Assertion** : Suspended particulate matter (SPM) is an important pollutant released by diesel vehicles.
Reason : Catalytic converters greatly reduce pollution caused by automobiles.
(a) (b) (c) (d)

75. **Assertion** : Presently the global atmosphere is warming up
Reason : The depletion of stratospheric ozone layer has resulted in increase in ultra-violet radiations reaching earth.
(a) (b) (c) (d).

76. **Environmental Protection Act was passed in**
(a)1986 (b)1981 (c) 1974 (d) 1968.

77. **Black lungs disease is common in**
(a) Farmers (b) Workers of petrochemical industry
(c) Coal mines (d) Refinery workers.

78. **CO_2, CH_4, N_2O, CFCs are called green house gases because they can absorb**
(a) Ultra-violet radiations (b) Long wave infra-red radiations
(c) Visible light radiation (d) X-ray radiation

79. **Which is correctly matched?**
1. Arsenic poisoning-Black foot disease. 2. Secondary Effluent treatment —Biological process. 3. Pyrolysis — Solid soil waste disposal. 4. Tubifex—Water pollution indicator. 5. Biomagnification —Degradable pollutants.
(a) 1, 2, 3, 5 (b) 1, 3, 4, 5 (c) 2, 3, 4, 5 (d) 1, 2, 3, 4

80. **Green house effect is the cumulative result of the influences of certain gases. Indentify the gas which is not involved in this influence.**
(a) Methane (b) Carbon dioxide (c) Chlorofluorocarbons
(d) Nitrogen.

81. Match the columns and find out the correct combination

I		II	
a	DDT	i	CO, CO_2
b	PAN	ii	Smog
c	Acid rain	iii	Biological magnification
d	Global warming	iv	SO_2

(a) a — iv, b — iii, c—ii, d—i
(b) a—i, b — iii, c-ii, d—iv
(c) a — ii, b — iiii, c—iv, d—i
(d) a —iii, b — ii, c — iv, d—i

82. Which one of the following is mismatched?
(a) Fossil-fuel burning—Release of CO_2 (b) Nuclear power—Radioactive wastes
(c) Solar energy —Green house effect (d) Biomass burning—Release of CO_2.

83. Identify the correctly matched pair
(a) Basal Convention — Biodiversity Conservation
(b) Kyoto Protocol — Climate change
(c) Montreal Protocol —Global warming
(d) Ramsar Convention —Groundwater pollution.

84. Which one of the following is not used for disinfection of drinking water?
(a) Chlorine (b) Ozone (c) Chloramine (d) Phenyl.

85. Which one of the following statements pertaining to pollutant is correct?
(a) DDT is a nonbiodegradable pollutant
(b) Excess fluoride in drinking water causes osteoporosis
(c) Excess cadmium in drinking water may cause black foot disease
(d) Methyl mercury in water may cause "itai itai" disease.

86. Formation of nonfunctional methaemoglobin causes Blue-baby syndrome. This is due to
(a) Excess of arsenic in drinking water (b) Excess of nitrate in drinking water
(c) Deficiency of iron in food
(d) Increased methane content in atmosphere.

87. A mutagenic pollutant is
(a) Organophosphates (b) Resins (c) Hydrocarbons (d) Nitrogen oxides.

88. Excess atmospheric CO_2 increases green house effect as CO_2
(a) Is opaque to infra-red rays (b) Is not opaque to infra-red rays
(c) Precipitates dust in the atmosphere (d) Reduces atmospheric pressure.

89. Limit of BOD prescribed by Central Pollution Control Board for discharge of industrial and municipal waste waters into natural surface waters is
(a) < 3·0 ppm (b) < 10 ppm (c) < 30 ppm (d) < 100 ppm.

90. **Montreal Protocol which calls for appropriate action to protect the ozone layer from human activities was passed in the year**
(a) 1985 (b) 1986 (c) 1987 (d) 1988.

91. **Blue-baby syndrome results from**
(a) Excess of TDS (b) Excess of chlorides
(c) Excess of dissolved oxygen (d) Methaemoglobin.

92. **Photochemical smog does not contain**
(a) PAN (b) Ozone (c) Nitrogen dioxide (d) CO_2

93. **A nonbiodegradable pollutant is**
(a) Newsprint (b) Green leaves (c) DDT (d) Cowdung.

Given below are assertions and reasons. Point out if (a) both are true with reason being correct explanation (b), both true but reason is not correct explanation (c), assertion true but reason is wrong (d), both are wrong.

94. **Assertion. Deforestation is one of the main factors contributing to global warming**
Reason. Besides CO_2, two other gases, methane and CFCs, are also included under green house gases.
(a) (b) (c) (d)

95. **Assertion. UV radiation causes photodissociation of ozone into O_2 and O thus causing damage to stratospheric ozone layer.**
Reason. Ozone hole is resulting in global warming and climatic change.
(a) (b) (c) (d).

96. **Assertion. Concentration of methane in the atmosphere has more than doubled in the last 250 years.**
Reason. Wetlands and rice fields are the major source of methane
(a) (b) (c) (d)

97. **Which one of the following is an environment-related disorder with correct main cause**
(a) Black lungs disease is found mainly in workers of stone quarries and crushers
(b) Blue-baby disease is due to heavy use of nitrogenous fertilizers
(c) Non-Hodgkin's lymphoma is found mainly in workers involved in manufacture of neem-based pesticides
(d) Skin cancer occurs mainly in people exposed to benzene and methane.

98. **Montreal Protocol refers to**
(a) Substances that deplete ozone layer (b) Persistent organic pollutants
(c) Global warming and climate change
(d) Biosafety of genetically modified organisms.

99. Match the columns

I	II
a Arsenic	i. Minamata disease
b Nitrate	ii Itai-itai
c Mercury	iii Blue-baby syndrome
d Cadmium	iv Skeletal fluorosis
e Fluoride	v Black foot disease

(a) (a) – (5), (b) – (3), (c) – (1), (d)– (2), (e) – (4)
(b) (a)-(2), (b)-(3), (c)-(5), (d) (1), (e) (4)
(c) (a)-(3), (b)-(4), (c)-(5), (d)-(1), (e)-(2)
(d) (a)-(5), (b)-(4), (c)-(3), (d)-(2), (e)-(1)
(e) (a)-(2) (b)-(5), (c)-(4), (d)-(3), (e)-(1)

100. Which one of the following will not control particulate pollutants
(a) Incinerator (b) Arrester (c) Scrubber (d) Filter
(d) Electrostatic Precipitator.

101. Which is not the proper strategy to reduce global warming
(a) Developing substitutes of chlorofluorocarbons
(b) Increasing use of air conditioners, refrigeration units and production of plastic foams and propellants in aerosol spray-cans
(c) Minimising use of nitrogen fertilizers in agriculture for reducing nitrogen oxide emission
(d) Increase vegetation cover, particularly forest, for photosynthetic utilisation of CO_2
(e) Reducing green house gas emission by limiting use of fossil-fuels.

102. Act formulated in 1986
(a) The Insecticide Act (b) The Environmental (Protection) Act
(c) The Water (Prevention and Control of Pollution) Act
(d) The Air (Prevention and Control of Pollution) Act
(e) The Noise (Prevention and Control of Pollution) Act.

103. Increase in concentration of pollutants at higher trophic levels is called
(a) Recycling (b) Eutrophication (c) Biodegradation (d) Biomagnification.

104. High amount of *Esherichia coli* in water is an indicator of
(a) Hardness of water (b) Industrial pollution
(c) Sewage pollution (d) Presence of chlorine in water.

105. Find out the incorrect statement in relation to pollution
(a) Plastic is a nondegradable pollutant
(b) Water vapours, smoke fumes and dust mixture form smog
(c) PAN affects photosynthesis
(d) Ozone layer forms protective shield to ionosphere.

106. **Eutrophication of water bodies leading to killing of fishes is mainly due to**
(a) Nonavailability of oxygen (b) Nonavailability of Light
(c) Nonavailability of food (d) Nonavailability of essential minerals.

107. **Process by which insecticides like DDT reach man is**
(a) Bioaccumulation (b) Biomagnification (c) Bioremediation
(d) Eutrophication.

108. **Effect of pollution is observed first on**
(A) Food crops (b) Green vegetation (c) Micro-organisms (d) Herbivores.

ANSWER

1. (c) 2. (a) 3. (b) 4. (a) 5. (a) 6. (b) 7. (b) 8. (a) 9. (a) 10. (b) 11. (c) 12. (c) 13. (a) 14. (b) 15. (c) 16. (d) 17. (a) 18. (b) 19. (a) 20. (c) 21. (a) 22. (c) 23. (d) 24. (d) 25. (d) 26. (b) 27. (b) 28. (a) 29. (c) 30. (b) 31. (c) 32. (b) 33. (b) 34. (a) 35. (b) 36. (c) 37. (c) 38. (d) 39. (c) 40. (c) 41. (b) 42. (c) 43. (a) 44. (a) 45. (d) 46. (b) 47. (d) 48. (d) 49. (c) 50. (b) 51. (a) 52. (b) 53. (c) 54. (b) 55. (c) 56. (d) 57. (a) 58. (b) 59. (a) 60. (c) 61. (c) 62. (b) 63. (a) 64. (c) 65. (c) 66. (b) 67. (d) 68. (d) 69. (d) 70. (b) 71. (c) 72. (a) 73. (b) 74. (b) 75. (b) 76. (d) 77. (a) 78. (c) 79. (b) 80. (d) 81. (d) 82. (d) 83. (c) 84. (b) 85. (d) 86. (a) 87. (b) 88. (c) 89. (a) 90. (c) 91. (c) 92. (d) 93. (d) 94. (c) 95. (b) 96. (d) 97. (b) 98. (b) 99. (a) 100. (a) 101. (a) 102. (b) 103. (b) 104. (d) 105. (c) 106. (d) 107. (a) 108. (b) 109. (c)

Read the following passages and darken the circle/circles corresponding to the correct statement.

Passage 1

Women and female children do much of the gathering and fetching from forests. Women also have fewer earning opportunities, enjoy lesser job search mobility and typically receive lower pay for the same and similar work.

Women's unequal access to knowledge systems and decision-making authority at all levels lower them to a great extent.

As a result, it has adverse effect on time, income, nutrition, health, social support networks and indigenous knowledge. In many regions, peasant women are responsible for indigenous seed-selection and preservation. With the large scale shift to hybrid seed varieties, control has passed unto the national and international laboratories. While traditional knowledge system is being devalued, the women, who possess this knowledge and depend on it, have little access to the institutions which create what is considered as scientific knowledge and modern technology.

In this sense, what we see today is not a crisis for sustenance of the poor and for women, it is also the loss of knowledge which is critical for generating a sustainable livelihood system.

PDF Created Using

Camera Scanner

Easily Scan documents & Generate PDF

https://play.google.com/store/apps/details?id=photo.pdf.maker

প্রশ্নোত্তর পর্ব

▸ বহুবিকল্পভিত্তিক প্রশ্নোত্তর (MCQ) প্রশ্নমান 1

♦ সঠিক উত্তরটি নির্বাচন করো :

	প্রশ্ন	উত্তর
1.	কাম্য জনসংখ্যা তত্ত্বটির উদ্ভাবক হলেন— a. ক্যানন b. কাস্ত্রো c. থম্পসন d. ওয়ারনার	a. ক্যানন।
2.	কাম্য জনসংখ্যা বলতে বোঝায়— a. আদর্শ জীবনযাত্রার মান b. আদর্শ অর্থনীতি c. আদর্শ জনগণ d. আদর্শ মানুষ ও জমির অনুপাত	d. আদর্শ মানুষ ও জমির অনুপাত।
3.	'S' আকৃতির কার্ভকে কী ধরনের কার্ভ বলে ? a. এক্সপোনেনসিয়াল কার্ভ b. সিগময়েড কার্ভ c. লগারিদ্‌মিক কার্ভ d. সরলরৈখিক কার্ভ	b. সিগময়েড কার্ভ।
4.	ভারতে পরিবার পরিকল্পনা কর্মসূচি কবে শুরু হয় ? a. 1948 সালে b. 1951 সালে c. 1962 সালে d. 1978 সালে	b. 1951 সালে।
5.	ভারতের পরিবার পরিকল্পনা কর্মসূচিতে কতজন সন্তানের নীতি সুগৃহীত হয় ? a. 1 জন b. 2 জন c. 3 জন d. 4 জন	b. 2 জন।
6.	জাতীয় জনসংখ্যা নীতি কোন বছর চালু করা হয় ? a. 2000 সালে b. 2005 সালে c. 2010 সালে d. 2015 সালে	a. 2000 সালে।
7.	নিম্নলিখিত কোন রোগটি সংক্রামক নয় ? a. হাম b. কলেরা c. ডায়বিটিস d. ম্যালেরিয়া	c. ডায়বিটিস।
8.	নিম্নলিখিত কোন রোগটি পরজীবী ঘটিত সংক্রামক নয় ? a. আমাশয় b. কালাজ্বর c. ম্যালেরিয়া d. কলেরা	d. কলেরা।

	প্রশ্ন	উত্তর
9.	নিম্নলিখিত কোন রোগটি বায়ুবাহিত রোগ ? a. যক্ষ্মা b. টাইফয়েড c. হেপাটাইটিস d. b ও c	a. যক্ষ্মা।
10.	কলেরা সৃষ্টিকারী ব্যাকটেরিয়ার নাম কী ? a. লেভিস কলেরি b. সালসোনেল্লা কলেরি c. ভিবরো কলেরি d. কোনোটিই নয়	c. ভিবরো কলেরি।
11.	জলবসন্ত কী ধরনের রোগ ? a. ভাইরাস ঘটিত b. ব্যাকটেরিয়া ঘটিত c. ছত্রাকঘটিত d. প্রোটোজোয়া ঘটিত	a. ভাইরাস ঘটিত।
12.	হেপাটাইটিস কী ধরনের রোগ a. ভাইরাসঘটিত b. ব্যাকটেরিয়া ঘটিত c. ছত্রাকঘটিত d. প্রোটোজোয়া ঘটিত	a. ভাইরাস ঘটিত ?
13.	প্লেগ কোন ধরনের রোগের উদাহরণ— a. ভাইরাসঘটিত b. ব্যাকটেরিয়া ঘটিত c. ছত্রাকঘটিত d. প্রোটোজোয়া ঘটিত	b. ব্যাকটেরিয়া ঘটিত।
14.	প্লেগ সৃষ্টিকারী ব্যাকটেরিয়ার নাম হল— a. মাইকোব্যাকটেরিয়াম পেস্টিস b. সালসোনেল্লা পেস্টিস c. ইয়ারসিনিয়া পেস্টিস d. ইয়ারসিনিয়া পারটুসিস	c. ইয়ারসিনিয়া পেস্টিস।
15.	নিউমোনিয়া সৃষ্টিকারী ব্যাকটেরিয়ার নাম হল— a. ডিপ্লোকক্কাস নিউমোনি b. পারকক্কাস নিউমোনি c. নিউমোনি ব্যাসিলাস d. সালমোনেল্লা নিউমোনি	a. ডিপ্লোকক্কাস নিউমোনি।

	প্রশ্ন	উত্তর
6.	টাইফয়েড সৃষ্টিকারী ব্যাকটেরিয়ার নাম হল— a. পরিকল্পাস টাইফি b. মাইকোব্যাকটেরিয়াম টাইফি c. সালমোনেল্লা টাইফি d. ইয়ারসিনিয়া টাইফি	c. সালমোনেল্লা টাইফি।
7.	নিম্নলিখিত কোন রোগটি বাহক দ্বারা সংক্রমিত হয় না? a. ডায়বেটিস b. প্লেগ c. ডেঙ্গু d. ম্যালেরিয়া	a. ডায়বেটিস।
8.	প্লেগের বাহক হল— a. ইঁদুর b. মাছি c. মশা d. শুধুমাত্র a ও b	d. শুধুমাত্র a ও b।
19.	সারা বিশ্বে প্রায় কত জন মানুষ আমাশয় মারা যায়? a. 1·1 বিলিয়ন b. 2·2 বিলিয়ন c. 4·9 বিলিয়ন d. 8·2 বিলিয়ন	b. 2·2 বিলিয়ন।
20.	নিম্নলিখিত কোন রোগটি জলবাহিত নয়? a. কলেরা b. টাইফয়েড c. হেপাটাইটিস d. যক্ষ্মা	d. যক্ষ্মা।
21.	যক্ষ্মা রোগ সৃষ্টিকারী ব্যাকটেরিয়ার নাম— a. মাইকোব্যাকটেরিয়াম টিউবার কিউলোসিস b. সায়ানো ব্যাকটর টিউবারকিউলোসিস c. সালমোনেল্লা টিউবারকিউলোসিস d. কোনোটিই নয়	a. মাইকো-ব্যাকটেরিয়াম টিউবার-কিউলোসিস।
22.	ম্যালেরিয়ায় জীবাণুবহনকারী মশা হল— a. কিউলেক্স b. অ্যানোফিলিস c. এডিস d. সবকটি	b. অ্যানোফিলিস।
23.	ডেঙ্গুর জীবাণুর বাহক মশা হল— [কল্যাণি-2014] a. কিউলেস b. অ্যানোফিলিস c. এডিস d. সবকটি	c. এডিস।
24.	গলায় ক্যানসারের প্রধান কারণ হল— a. অতিরিক্ত মাদক সেবন b. মদ্যপান c. খাদ্যে ভেজাল d. সবকটি	a. অতিরিক্ত মাদক সেবন।

	প্রশ্ন	উত্তর
25.	WHO-এর রিপোর্ট অনুযায়ী ভারতে প্রতি বছর ক্যানসারে মারা যায়— a. 10 লক্ষ মানুষ b. 50 লক্ষ মানুষ c. 3 লক্ষ মানুষ d. 8 লক্ষ মানুষ	c. 3 লক্ষ মানুষ।
26.	AID সৃষ্টিকারী ভাইরাসটির নাম হল— a. হিউম্যান ইমিউনো পাওয়ার b. হিউম্যান ডেফিসিয়েন্সি পাওয়ার c. হিউম্যান ইমিউনো ডেফিসিয়েন্সি d. কোনোটিই নয়	c. হিউম্যান ইমিউনো ডেফিসিয়েন্সি।
27.	টীকাকরণ প্রক্রিয়ার আবিষ্কর্তা কে? a. লুইপাস্তুর b. ক্যানন c. এডওয়ার্ড জেনার d. উইলিয়াম থম্পসন	c. এডওয়ার্ড জেনার।
28.	নিম্নলিখিত কোন বিষয়টি মানবাধিকারের মধ্যে পড়ে না? a. সাম্যের অধিকার b. স্বাধীনতার অধিকার c. সামাজিক সুরক্ষার অধিকার d. সম্পত্তির অধিকার	d. সম্পত্তির অধিকার
29.	ভারতীয় সংবিধানে মানবাধিকারের উৎস কী? a. Bill of Rights b. Bill of Administration c. Bill of Power d. Bill of Rituals	a. Bill of Rights.
30.	ভারতীয় সংবিধানের কোন Part-এ মৌলিক অধিকারগুলি লিপিবদ্ধ রয়েছে? a. I b. III c. IV d. III ও IV	d. III ও IV।
31.	ভারতে মানবাধিকার সুরক্ষার আইন কবে প্রতিষ্ঠিত হয়? a. 1947 সালে b. 1980 সালে c. 1993 সালে d. 2000 সালে	c. 1993 সালে।
32.	রাষ্ট্রপুঞ্জ কোন বছর মানবাধিকার কমিশন গঠন করে? a. 1947 সালে b. 1957 সালে c. 1982 সালে d. 1999 সালে	a. 1947 সালে।

	প্রশ্ন	উত্তর
33.	রাষ্ট্রপুঞ্জ নির্মিত মানবাধিকার কমিশনের প্রথম সভানেত্রী কে ছিলেন? a. সরোজিনি নাইডু b. ফ্রাঙ্কলিন রুজভেল্ট c. মার্গারেট নোবেল d. উপরের কেউই নয়	b. ফ্রাঙ্কলিন রুজভেল্ট।
34.	মানবাধিকার সংক্রান্ত বিষয়ে 1993 সালে রাষ্ট্রপুঞ্জে অনুষ্ঠিত সম্মেলনটি কোথায় হয়েছিল? a. ব্রাজিলের রিও-ডি-জেনিরো-তে b. সুইজারল্যান্ডের জেনিভায় c. ভারতের নতুন দিল্লিতে d. অস্ট্রিয়ার ভিয়েনাতে	d. অস্ট্রিয়ার ভিয়েনাতে।
35.	নারী কুশলতা বলতে বোঝায়— a. সমাজে নারীদের বৈষম্য দূরীকরণ b. নারীশিক্ষার সুযোগ তৈরি করা c. নারীসুরক্ষার বন্দোবস্ত করা d. উপরের সবকটিই	d. উপরের সবকটিই।
36.	'ইকোফেমিনিজম্' শব্দটির প্রবক্তা কে? a. ইউবোন b. ওডাম c. কাস্ত্রো d. ক্যানন	d. ইউবোন।
37.	বাল্যবিবাহ নিয়ন্ত্রণ আইন কোন বছর চালু হয়? a. 1927 সালে b. 1929 সালে c. 1938 সালে d. 1953 সালে	b. 1929 সালে।
38.	ভারত সরকার গঠিত মহিলাদের স্বনির্ভরগোষ্ঠীর নাম হল— a. মাতঙ্গিনী b. প্রীতিলতা c. প্রিয়দর্শিনী d. সত্যপ্রিয়া	c. প্রিয়দর্শিনী।
39.	গর্ভবতী মহিলাদের উদ্দেশ্যে গঠিত ইন্দিরা গান্ধি মাতৃত্ব সহযোগী যোজনা কোন বছর চালু হয়? a. 2000 সালে b. 1983 সালে c. 2008 সালে d. 2010 সালে	d. 2010 সালে।
40.	রাষ্ট্রপুঞ্জ অনুযায়ী মহিলাদের কোন বয়সের নীচে বিবাহ করাকে বাল্যবিবাহ বলা হবে? a. 10 বছর b. 14 বছর c. 18 বছর d. 21 বছর	c. 18 বছর।

	প্রশ্ন	উত্তর
41.	পুনর্বাসন বলতে বোঝায়— a. নতুন এলাকায় বাসস্থান নির্মাণ b. পুরাতন এলাকায় নতুন করে বাসস্থান নির্মাণ c. আর্থিক ক্ষতিপূরণ দেওয়া d. উপরের সবকটি	a. নতুন এলাকায় বাসস্থান নির্মাণ।
42.	শিশুশ্রম বন্ধের উদ্দেশ্যে ভারত সরকার কোন বছর Child Labour Act প্রণয়ন করে? a. 1967 সালে b. 1986 সালে c. 1992 সালে d. 2001 সালে	b. 1986 সালে।
43.	ভারতীয় সংবিধানের কত নং ধারায় 14 বছরের কম বয়সী শিশুকে কাজে নিযুক্ত করা দণ্ডনীয় অপরাধ হিসাবে গণ্য করা হয়েছে? a. 11 নং ধারায় b. 253 নং ধারায় c. 525 নং ধারায় d. 374 নং ধারায়	d. 374 নং ধারায়।
44.	পরিবেশ নৈতিকতা ধারণাটি কে প্রথম উপস্থাপনা করেন? a. রিচেল কারসন b. ডি স্মিথ c. ইঞ্জিন ওডাম d. কেউই নয়	a. রিচেল কারসন।
45.	পরিবেশ নৈতিকতার মানবকেন্দ্রিক দৃষ্টিভঙ্গিকে বলা হয়— a. Shallow Ecology b. Deep Ecology c. Population Ecology d. Community Ecology	a. Shallow Ecology।
46.	সর্দার সরোবর বাঁধ কোন নদীর ওপর নির্মাণ করা হয়েছে? a. নর্মদা নদীর ওপর b. তাপ্তি নদীর ওপর c. গোদাবরী নদীর ওপর d. শতদ্রু নদীর ওপর	a. নর্মদা নদীর ওপর।
47.	জলবাহিত প্রোটোজোয়া ঘটিত রোগটি হল— [বর্ধমান-2016] a. জিয়ার্ডিয়াসিস b. পোলিও c. টাইফয়েড d. কলেরা	a. জিয়ার্ডিয়াসিস।

	প্রশ্ন	উত্তর
48.	ম্যালেরিয়ার জন্য দায়ী— a. প্লাসমোডিয়াম b. প্যারাপ্লাসমোডিয়াম c. পেরিপ্লাসমোডিয়াম d. সিউডোপ্লাসমোডিয়াম	a. প্লাসমোডিয়াম।
49.	টাইফয়েড রোগটি হল— [বর্ধমান-2016] a. জলবাহিত রোগ b. বায়ুবাহিত রোগ c. ভেক্টর বাহিত রোগ d. মৃত্তিকাজনিত রোগ	a. জলবাহিত রোগ।
50.	নীচের কোনটি ত্বকের ক্যানসারের সম্ভাব্য কারণ হতে পারে? [কল্যাণী-2016] a. পার্থিব উষ্ণায়ন b. অতিবেগুনি রশ্মি c. অম্লবৃষ্টি d. কোনোটিই নয়	b. অতিবেগুনি রশ্মি।
51.	ম্যালেরিয়ার জন্য দায়ী— [গৌড়বঙ্গ-2017] a. ব্যাকটেরিয়া b. প্রোটোজোয়া c. ভাইরাস d. মাইকোপ্লাজম	b. প্রোটোজোয়া।
52.	পরিবেশের ওপর জনবিস্ফোরণের প্রভাব হল— [বর্ধমান-2016] a. বিশ্ব উষ্ণায়ন b. জীববৈচিত্র্যের ধ্বংস c. বৃক্ষচ্ছেদন d. উপরের সবকটি	d. উপরের সবকটি।
53.	ভারতে পরিবার কল্যাণ কর্মসূচির মূল লক্ষ্য হল— [বর্ধমান-2016] a. রোগপ্রতিরোধ b. জনসংখ্যা বৃদ্ধির হার নিয়ন্ত্রণ c. চাকরির ব্যবস্থা d. উপরের কোনোটিই নয়	b. জনসংখ্যা বৃদ্ধির হার নিয়ন্ত্রণ।
54.	2011 সালের হিসাব অনুযায়ী তৃতীয় বিশ্বে বসবাসকারী জনগণের মোট সংখ্যা হল— a. প্রায় 200 কোটি b. প্রায় 300 কোটি c. প্রায় 400 কোটি d. প্রায় 500 কোটি	c. প্রায় 400 কোটি।

	প্রশ্ন	উত্তর
55.	বিষণই আন্দোলনের সঙ্গে যুক্ত ছিলেন— a. সুন্দরলাল বহুগুনা b. অমৃতাদেবী c. চণ্ডীপ্রসাদ ভট্ট d. মেধা পাটেকর	b. অমৃতাদেবী।
56.	বিষণই আন্দোলন কোথায় সংঘটিত হয়? a. রাজস্থানের মেজারলি গ্রামে b. মহারাষ্ট্রের সাতারা গ্রামে c. গুজরাটের গান্ধিনগরে d. উত্তরপ্রদেশের গাড়োয়ালের মণ্ডলগ্রামে	a. রাজস্থানের মেজারলি গ্রামে।
57.	চিপকোর আন্দোলনের সূত্রপাত কোথায় ঘটে? a. উত্তরপ্রদেশের চামালির গোপেশ্বর গ্রামে b. উত্তরপ্রদেশের গাড়োয়ালের মণ্ডলগ্রামে c. রাজস্থানের খেজারেলি গ্রামে d. গুজরাটের সবরমতীতে	a. উত্তরপ্রদেশের চামালির গোপেশ্বর গ্রামে।
58.	গাড়োয়ালের পাহিড়ি এলাকায় যে কোম্পানীটি গাছকাটার ছাড়পত্র পেয়েছিল তার নাম হল— a. সিমন b. সাইমন্ড c. কেদার d. পুষ্পক	a. সিমন।
59.	গোপেশ্বর গ্রামে কার নেতৃত্বে চিপকো আন্দোলন গড়ে উঠেছিল? a. অমৃতাদেবীর b. গৌরিদেবীর c. সুন্দরলাল বহুগুনার d. কোনোটিই নয়	b. গৌরিদেবীর।
60.	কন্নড় ভাষায় 'এপিক্ক' শব্দের অর্থ হল— a. আন্দোলন করা b. এগিয়ে চলা c. আলিঙ্গান করা d. কোনোটিই নয়	c. আলিঙ্গান করা।
61.	এপিক্কো আন্দোলনে নেতৃত্ব দেন— a. সুন্দরলাল বহুগুনা b. পান্ডুরাম হেগড়ে c. মেধা পাটেকর d. সকলেই	b. পান্ডুরাম হেগড়ে।
62.	সাইলেন্ট ভ্যালি কোন নদীটির সংলগ্ন? a. কুন্তী নদীর b. কোশি নদীর c. গঙ্গা নদীর d. গোদাবরী নদীর	a. কুন্তী নদীর।

	প্রশ্ন	উত্তর
63.	নিম্নলিখিত কোন বিরল প্রজাতির জন্য সাইলেন্ট ভ্যালি গুরুত্বপূর্ণ? a. এশিয়ান চিতা b. সোনালি হনুমান c. অলিভ রিডাল কচ্ছপ d. সিংহের ন্যায় ল্যাজ বিশিষ্ট বানর	d. সিংহের ন্যায় ল্যাজ বিশিষ্ট বানর।
64.	সাইলেন্ট ভ্যালি অঞ্চলটি কোন খ্রিস্টাব্দে জাতীয় উদ্যান হিসাবে ঘোষিত হয়? a. 1967 খ্রিস্টাব্দে b. 1985 খ্রিস্টাব্দে c. 1991 খ্রিস্টাব্দে d. 1999 খ্রিস্টাব্দে	b. 1985 খ্রিস্টাব্দে।
65.	নিম্নলিখিত কোন ব্যক্তি নর্মদা বাঁচাও আন্দোলনের সঙ্গে যুক্ত নয়? a. মেধা পাটেকর b. বাবা আমতে c. অরুন্ধতী রায় d. চণ্ডীপ্রসাদ ভট্ট	d. চণ্ডীপ্রসাদ ভট্ট।
66.	তেহেরী বাঁধ কোন নদীর ওপর নির্মাণ করা হয়? a. অলকানন্দা b. ভাগিরথী c. পেন গঙ্গা d. ভিল গঙ্গা	b. ভাগিরথী।
67.	নিম্নলিখিত কোন ব্যক্তি তেহেরী বাঁধ বিতর্কের সঙ্গে যুক্ত? a. সুন্দরলাল বহুগুনা b. অমৃতাদেবী c. মেধা পাটেকর d. চণ্ডীপ্রসাদ ভট্ট	a. সুন্দরলাল বহুগুনা।
68.	ভারতে চিপকো আন্দোলনের সক্রিয়তা লক্ষ করা যায়— a. 1974 সালে b. 1973 সালে c. 1972 সালে d. 1971 সালে	a. 1974 সালে।
69.	ভারতে চিপকো আন্দোলনে নেতৃত্ব প্রদান করেন— a. সুন্দরলাল বহুগুনা b. রামদেব মিশ্র c. মেধা পাটেকার d. রাজীব গান্ধি	a. সুন্দরলাল বহুগুনা।
70.	চিপকো আন্দোলনকে Right Livelihood Award দ্বারা সম্মানিত করা হয়— a. 1987 সালে b. 1986 সালে c. 1988 সালে d. 1989 সালে	a. 1987 সালে।

	প্রশ্ন	উত্তর
71.	আমাদের দেশে পরিবেশদূষণ দমনের উদ্দেশ্যে গঠিত হয়— a. কোঠারি কমিশন b. ব্রুবেঞ্চ c. রাধাকৃষ্ণন কমিশন d. গ্রিনবেঞ্চ	d. গ্রিনবেঞ্চ।
72.	কাঠ বা কয়লাকে জ্বালানি হিসেবে ব্যবহার না-করে ব্যবহার করা উচিত— a. মাইক্রোওভেন ও ইনডাকশান ওভেন b. পেট্রোলিয়াম c. কেরোসিন d. প্লাস্টিক	a. মাইক্রোওভেন ও ইনডাকশান ওভেন।
73.	বিশ্ব পরিবেশ দিবস পালন করা হয়— a. 10 অক্টোবর b. 5 জুলাই c. 5 জুন d. 10 ডিসেম্বর	c. 5 জুন।
74.	চিপকো আন্দোলন গড়ে ওঠে ভারতের— a. পূর্ব হিমালয়ে b. গাড়োয়াল হিমালয়ে c. পশ্চিমঘাট পর্বতে d. আরাবল্লিতে	b. গাড়োয়াল হিমালয়ে।
75.	'Ramon Magsaysay Award -টি পান— a. গান্ধীজি b. সুভাষ চক্রবর্তী c. চণ্ডীপ্রসাদ ভট্ট d. মেধা পাটেকর	c. চণ্ডীপ্রসাদ ভট্ট।
76.	ভারতের দাসোলী গ্রামে যাঁর নেতৃত্বে স্বরাজ্যমণ্ডল আন্দোলনের সূত্রপাত হয়, তিনি হলেন— a. রামদেব মিশ্র b. চণ্ডীপ্রসাদ ভট্ট c. সুন্দরলাল বহুগুনা d. রাজীব গান্ধী	b. চণ্ডীপ্রসাদ ভট্ট।
77.	'Right Livelihood Award' 1987 সালে দেওয়া হয়— a. বন সংরক্ষণ আন্দোলনের জন্য b. জলাভূমি সংরক্ষণের জন্য c. পতিত জমি সংরক্ষণের জন্য d. কৃষিজমি সংরক্ষণের জন্য	a. বন সংরক্ষণ আন্দোলনের জন্য।

	প্রশ্ন	উত্তর
78.	2009 সালে 'Padma Vibhushan Award' পান— a. চন্ডীপ্রসাদ ভট্ট b. গোবিন্দ সিংরাওয়াত c. সুন্দরলাল বহুগুনা d. হীরালাল	c. সুন্দরলাল বহুগুনা।
79.	চন্ডীপ্রসাদ ভট্ট পদ্মভূষণ পান— a. 2005 সালে b. 2008 সালে c. 2009 সালে d. 2011 সালে	a. 2005 সালে।
80.	কোনো দেশের অর্থনৈতিক উন্নতির জন্য সর্বাপেক্ষা গুরুত্বপূর্ণ অবস্থা হল— a. মানুষ-জমি অনুপাত b. জনঘনত্ব c. জন অভিক্ষেপ d. কাম্য জনসংখ্যা	d. কাম্য জনসংখ্যা।
81.	বর্তমানে পৃথিবীর জনসংখ্যা বৃদ্ধির হার— a. 1·3 শতাংশ b. 2·0 শতাংশ c. 1·8 শতাংশ d. 2·4 শতাংশ	a. 1·3 শতাংশ।
82.	কোন্ মহাদেশে জনসংখ্যা বৃদ্ধির হার সবচেয়ে বেশি? a. এশিয়া b. আফ্রিকা c. উত্তর আমেরিকা d. ইউরোপ	b. আফ্রিকা।
83.	বিশ্বের কোন দেশে সর্বাধিক জনঘনত্ব লক্ষ করা যায়? a. সুইডেনে b. বাংলাদেশে c. ভারতে d. চিনে	b. বাংলাদেশে।
84.	গত 500 বছরে পৃথিবীর জনসংখ্যা কত গুণ বৃদ্ধি পেয়েছে? a. প্রায় 15 গুণ b. প্রায় 10 গুণ c. প্রায় 20 গুণ d. প্রায় 5 গুণ	b. প্রায় 10 গুণ।
85.	10,000 খ্রিস্টপূর্বাব্দে পৃথিবীর জনসংখ্যা ছিল প্রায়— a. 52·3 লক্ষ b. 53·2 লক্ষ c. 58·3 লক্ষ d. 55·2 লক্ষ	b. 53·2 লক্ষ।
86.	পৃথিবীর জনসংখ্যার নিরিখে প্রতি কত জন লোকের মধ্যে একজন ভারতীয়? a. 5 জন b. 4 জন c. 6 জন d. 10 জন	c. 6 জন।

	প্রশ্ন	উত্তর
87.	পৃথিবীর গড় জনঘনত্ব প্রতি বর্গকিমিতে— a. 41 জন b. 50 জন c. 55 জন d. 24 জন	a. 41 জন।
88.	ইউরোপ মহাদেশের গড় জনঘনত্ব প্রতি বর্গকিমিতে— a. 114 জন b. 90 জন c. 104 জন d. 120 জন	c. 104 জন।
89.	কোনো দেশ বা অঞ্চলের মোট জনসংখ্যা ও মোট জমির পরিমাণ বা ক্ষেত্রফলের অনুপাতকে কী বলে? a. কার্যকরী জমি b. মানুষ-জমির অনুপাত c. জনসংখ্যার ঘনত্ব d. কাম্য জনসংখ্যা	b. মানুষ-জমির অনুপাত।
90.	সুইডেনের বয়স-লিঙ্গ পিরামিডের আকৃতি হল— a. ঘণ্টার মতো b. উত্তাল আকৃতির c. তীক্ষ্ণ শীর্ষবিশিষ্ট d. ন্যাসপাতির মতো	d. ন্যাসপাতির মতো।
91.	বর্তমানে (2011) ভারতে প্রতি বর্গকিমিতে জনঘনত্ব হল— a. 500 জন b. 400 জন c. 382 জন d. 450 জন	c. 382 জন।
92.	কোন বিজ্ঞানী জনবিবর্তন মডেল প্রকাশ করেন? a. জিমারম্যান b. ম্যালথাস c. মার্কস d. থম্পসন	d. থম্পসন।
93.	ভূপ্রকৃতির বন্ধুরতা ও জনসংখ্যার বণ্টন কীভাবে সম্পর্কযুক্ত? a. ধনাত্মক ভাবে b. ঋণাত্মক ভাবে c. ব্যাস্তানুপাতে d. সম্পর্কহীন	a. ঋণাত্মক ভ
94.	নীচের কোন দেশে বর্তমানে অধিক জনসংখ্যা লক্ষ করা হয়? a. সুইডেনে b. পাকিস্তানে c. নরওয়েতে d. নিউজিল্যান্ডে	b. পাকিস্তানে
95.	নীচের কোন দেশের জনসংখ্যা কাম্য জনসংখ্যার পর্যায়ে রয়েছে? a. নেদারল্যান্ডস্-এর b. মিশর-এর c. শ্রীলঙ্কার d. থাইল্যান্ড-এর	a. নেদারল্যা

	প্রশ্ন	উত্তর
96.	জনবিবর্তন মডেলের কোন পর্যায়ে জন্মহার ও মৃত্যুহার উভয়ই অত্যন্ত বেশি? a. দ্বিতীয় পর্যায়ে b. তৃতীয় পর্যায়ে c. প্রথম পর্যায়ে d. চতুর্থ পর্যায়ে	c. প্রথম পর্যায়ে।
97.	জনসংখ্যার বিবর্তন তত্ত্ব অনুযায়ী জনসংখ্যা বিবর্তনের কটি পর্যায় লক্ষ করা যায়? a. তিনটি b. চারটি c. পাঁচটি d. আটটি	c. পাঁচটি।
98.	জনসংখ্যার বিবর্তন তত্ত্ব অনুযায়ী কোন দুটি পর্যায়ে জনসংখ্যার বৃদ্ধি বিশেষভাবে লক্ষ করা যায়? a. প্রথম ও দ্বিতীয় পর্যায়ে b. দ্বিতীয় ও তৃতীয় পর্যায়ে c. তৃতীয় ও চতুর্থ পর্যায়ে d. চতুর্থ ও পঞ্চম পর্যায়ে	b. দ্বিতীয় ও তৃতীয় পর্যায়ে।
99.	কোনো দেশের জন্মহার ও মৃত্যুহার প্রায় সমান হলে তাকে বলে— a. কাম্য জনসংখ্যা b. শূন্য জনসংখ্যা বৃদ্ধি c. জনস্বল্পতা d. জনাকীর্ণতা	b. শূন্য জনসংখ্যা বৃদ্ধি।
100.	কোনটি কাম্য-জনসংখ্যার সঙ্গে সম্পর্কিত তথ্য নয়? a. এটি দেশের অর্থনৈতিক উন্নয়ন সুদৃঢ় করে b. এই ক্ষেত্রে মানুষ-জমি অনুপাত সবচেয়ে কম হয় c. এর ফলে সাংস্কৃতিক পরিবেশের দূষণ ঘটে d. এটি একটি গতিশীল ধারণা	c. এর ফলে সাংস্কৃতিক পরিবেশের দূষণ ঘটে।
101.	স্থিতিশীল জনসংখ্যা পাওয়া যায়— a. চিলিতে b. ভারতে c. সুইডেনে d. উগান্ডায়	c. সুইডেনে।
102.	জনবিবর্তন মডেলের যে পর্যায়ে জনসংখ্যা বৃদ্ধির হার সর্বাধিক— a. প্রথম পর্যায়ে b. দ্বিতীয় পর্যায়ে c. তৃতীয় পর্যায়ে d. চতুর্থ পর্যায়ে	b. দ্বিতীয় পর্যায়ে।

	প্রশ্ন	উত্তর
103.	জনবিবর্তন মডেলের চতুর্থ পর্বে অবস্থানকারী দেশটি হল— a. উগান্ডা b. ব্রাজিল c. ডেনমার্ক d. সৌদি আরব	c. ডেনমার্ক।
104.	নীচের কোন দেশ জনসংখ্যা বিবর্তন তত্ত্বের প্রথম পর্বের অন্তর্ভুক্ত নয়? a. গ্যাবন b. জাম্বিয়া c. সিয়েরালিওন d. ইটালি	d. ইটালি।
105.	জনসংখ্যা বিবর্তনের পঞ্চম পর্যায়ে— a. জন্মহার ও মৃত্যুহার দুটিই বেশি ও অনিয়ন্ত্রিত b. জন্মহার বাড়তে থাকে এবং মৃত্যুহার ক্রমশ হ্রাস পায় c. জন্মহার মৃত্যুহারের তুলনায় কম হয় d. জন্মহার ও মৃত্যুহার একই থাকে	c. জন্মহার মৃত্যুহারের তুলনায় কম হয়।
106.	জনবিবর্তন মডেলের কোন পর্যায়ে জনবিস্ফোরণ ঘটতে পারে? a. প্রথম পর্যায়ে b. দ্বিতীয় পর্যায়ে c. তৃতীয় পর্যায়ে d. চতুর্থ পর্যায়ে	b. দ্বিতীয় পর্যায়ে।
107.	কোনো দেশের আগামী বছরগুলির জনসংখ্যা বৃদ্ধির পূর্বাভাসকে কী বলে? a. কাম্য জনসংখ্যা b. স্থিতিশীল জনসংখ্যা c. জনসংখ্যা অভিক্ষেপ d. জনবিস্ফোরণ	c. জনসংখ্যা অভিক্ষেপ।
108.	ভারতে জনসংখ্যা বৃদ্ধির হার সবচেয়ে বেশি— a. বিহারে b. রাজস্থানে c. পশ্চিমবঙ্গে d. উত্তরপ্রদেশে	a. বিহারে।
109.	কোনো দেশে সম্পদের তুলনায় জনসংখ্যা কম হলে তাকে বলে— a. কাম্য জনসংখ্যা b. স্থিতিশীল জনসংখ্যা c. জনস্বল্পতা d. জনাকীর্ণতা	c. জনস্বল্পতা।

	প্রশ্ন	উত্তর
110.	ভারতে জনসংখ্যা বৃদ্ধির হার সবচেয়ে কম— a. কেরলে b. গোয়ায় c. অরুণাচল প্রদেশে d. পশ্চিমবঙ্গে	a. কেরলে।
111.	কোনো দেশের নির্দিষ্ট সময়ে জন্মহার ও মৃত্যুহারের পার্থক্যকে কী বলে? a. জনসংখ্যার প্রকৃত বৃদ্ধি b. স্থিতিশীল জনসংখ্যা c. জনসংখ্যার স্বাভাবিক বৃদ্ধি d. জনাকীর্ণতা	c. জনসংখ্যার স্বাভাবিক বৃদ্ধি।
112.	কোনো দেশের সম্পদের তুলনায় জনসংখ্যা বেশি হলে তাকে বলে— a. কাম্য জনসংখ্যা b. স্থিতিশীল জনসংখ্যা c. জনস্বল্পতা d. জনাকীর্ণতা	d. জনাকীর্ণতা।
113.	পৃথিবীর সর্বাপেক্ষা জনবহুল দেশ হল— a. ভারত b. রাশিয়া c. চিন d. ব্রাজিল	c. চিন।
114.	শরণার্থী আগমনের ফলে পশ্চিমবঙ্গ ছাড়াও কোন রাজ্যের জনঘনত্ব যথেষ্ট বৃদ্ধি পেয়েছে? a. গোয়া b. মহারাষ্ট্র c. হরিয়ানা d. পাঞ্জাব	d. পাঞ্জাব।
115.	কোনো অঞ্চলে মানুষের বণ্টনগত তারতম্যের সূচক হল— a. কাম্য জনসংখ্যা b. জনঘনত্ব c. জনাকীর্ণতা d. মানুষ-জমি অনুপাত	b. জনঘনত্ব।

	প্রশ্ন	উত্তর
116.	ভারতে (2011 সালের জনগণনা অনুযায়ী) সর্বাধিক জনঘনত্বযুক্ত রাজ্যটি হল— a. পশ্চিমবঙ্গ b. হরিয়ানা c. বিহার d. উত্তরপ্রদেশ	c. বিহার।
117.	কোন দেশের জনসংখ্যা পিরামিডের আকৃতি নাসপাতির মতো? a. আমেরিকা যুক্তরাষ্ট্র b. কঙ্গো c. জাপান d. ভারত	a. আমেরিকা যুক্তরাষ্ট্র।
118.	বিশ্বের কোথায় অতি-নিবিড় জনবসতি অঞ্চল গড়ে উঠেছে? a. উত্তর- পশ্চিম ইউরোপে b. ব্রাজিলের পূর্ব উপকূলে c. কঙ্গো নদী অববাহিকায় d. নীলনদের অববাহিকায়	b. ব্রাজিলের পূর্ব উপকূলে।
119.	জনসংখ্যা বৃদ্ধির প্রধান কারণ হল— a. শিক্ষা b. জীবিকা c. কাম্য জনসংখ্যা d. পরিব্রাজন	d. পরিব্রাজন।
120.	নীচের কোনটি মানব উন্নয়নের সূচক— a. কাম্য জনসংখ্যা b. চিকিৎসা ব্যবস্থার উন্নতি c. মাথাপিছু আয় d. পরিব্রাজন	c. মাথাপিছু আয়।
121.	জনাকীর্ণতার ফলে সৃষ্টি হয়— a. ছদ্ম বেকারত্ব b. কাম্য জনসংখ্যা c. জনবিস্ফোরণ d. আদর্শ মানুষ জমির অনুপাত	a. ছদ্ম বেকারত্ব।
122.	নিম্নলিখিতগুলির মধ্যে কোনটি জনসংখ্যা হ্রাস-বৃদ্ধির নিয়ন্ত্রক নয়? a. জন্মহার b. মৃত্যুহার c. পরিব্রাজন d. অর্থনৈতিক পরিবেশ	d. অর্থনৈতিক পরিবেশ।

	প্রশ্ন	উত্তর
123.	জনবিস্ফোরণ সৃষ্টি হয়— a. জনাকীর্ণতার ফলে b. মাথাপিছু আয় বাড়লে c. জনস্বল্পতার ফলে d. এদের কোনোটিই নয়	a. জনাকীর্ণতার ফলে।
124.	কাম্য জনসংখ্যা সম্পর্কে সর্বপ্রথম আলোচনা করেন— a. জিমারম্যান b. অ্যাডাম স্মিথ c. মার্কস d. বিজু গার্নিয়ার	a. জিমারম্যান।
125.	মানুষ-জমি অনুপাতের ভিত্তিতে যা নির্ণয় করা যায় না— a. পরিব্রাজনের পরিমাণ b. জনাকীর্ণতা c. জনবিরলতা d. কাম্য জনসংখ্যা	a. পরিব্রাজনের পরিমাণ।
126.	নিম্নলিখিত দেশগুলির মধ্যে কোথায় জনাকীর্ণতা দেখা যায়? a. আমেরিকা যুক্তরাষ্ট্রে b. জাপানে c. সুইডেন-এ d. পাকিস্তান-এ	d. পাকিস্তান-এ।
127.	নীচের কোনটি জনাকীর্ণতার ফলে সৃষ্টি হয়? a. দূষণমুক্ত পরিবেশ b. বেকারত্ব c. পরিকাঠামোর চাপ d. ঋণের বোঝা হ্রাস	b. বেকারত্ব।
128.	জনসংখ্যার ঋণাত্মক বৃদ্ধি দেখা যায়— a. ভারতে b. ব্রাজিলে c. জাপানে d. আমেরিকা যুক্তরাষ্ট্রে	c. জাপানে।
129.	শূন্য জনসংখ্যা বৃদ্ধির হার দেখা যায়— a. উগান্ডাতে b. মিশরে c. সুইটজারল্যান্ডে d. সুদানে	c. সুইটজারল্যান্ডে।
130.	উন্নত দেশের অর্থনীতিতে জনসংখ্যার বৃদ্ধির হার— a. স্থিতিশীল b. ক্রমবর্থমান c. ক্রমহ্রাসমান d. অস্থিতিশীল	a. স্থিতিশীল।

	প্রশ্ন	উত্তর
131.	জন অভিক্ষেপের মাধ্যমে জানা যায়— a. ভবিষ্যৎ জনসংখ্যার প্রকৃতি b. বর্তমান জনসংখ্যার প্রকৃতি c. জনাধিক্য d. জনাকীর্ণতা	a. ভবিষ্যৎ জনসংখ্যার প্রকৃতি।
132.	আঞ্চলিক জনাকীর্ণতার কারণ হল— a. কৃষিজমির অধিক পরিমাণ b. গ্রামীণ জনসংখ্যার দ্রুত স্বাভাবিক বৃদ্ধি c. কৃষিক্ষেত্রে উৎপাদনশক্তি বিনাশ d. শিল্পের ক্রমবিকাশ	b. গ্রামীণ জনসংখ্যার দ্রুত স্বাভাবিক বৃদ্ধি।
133.	বিশ্বের কোন দেশে জনবিরলতা দেখা যায়? a. ইথিওপিয়ায় b. জার্মানিতে c. উগান্ডায় d. অস্ট্রেলিয়ায়	d. অস্ট্রেলিয়ায়।
134.	বিশ্বের কোন দেশে কাম্য জনসংখ্যা দেখা যায়? a. ভারতে b. বেলজিয়াম-এ c. অস্ট্রেলিয়ায় d. জার্মানিতে	b. বেলজিয়াম-এ।
135.	জন্মহার বেশি এবং মৃত্যুহার কম কোন ধরনের জনসংখ্যা পিরামিডে দেখা যায়— a. প্রথম শ্রেণির পিরামিড b. দ্বিতীয় শ্রেণির পিরামিড c. তৃতীয় শ্রেণির পিরামিড d. চতুর্থ শ্রেণির পিরামিড	b. দ্বিতীয় শ্রেণির পিরামিড
136.	প্রথম শ্রেণির জনসংখ্যা পিরামিডের অন্তর্গত একটি দেশ হল— a. ইথিওপিয়া b. ভারত c. শ্রীলঙ্কা d. কানাডা	a. ইথিওপিয়া।
137.	জন্মহার ও মৃত্যুহার উভয় কম হলে যে-শ্রেণির জনসংখ্যা পিরামিডটি নির্দেশ করে তা হল— a. প্রথম শ্রেণির পিরামিড b. দ্বিতীয় শ্রেণির পিরামিড c. তৃতীয় শ্রেণির পিরামিড d. পঞ্চম শ্রেণির পিরামিড	c. তৃতীয় শ্রেণির পিরামিড।

PDF Created Using

Camera Scanner

Easily Scan documents & Generate PDF

https://play.google.com/store/apps/details?id=photo.pdf.maker