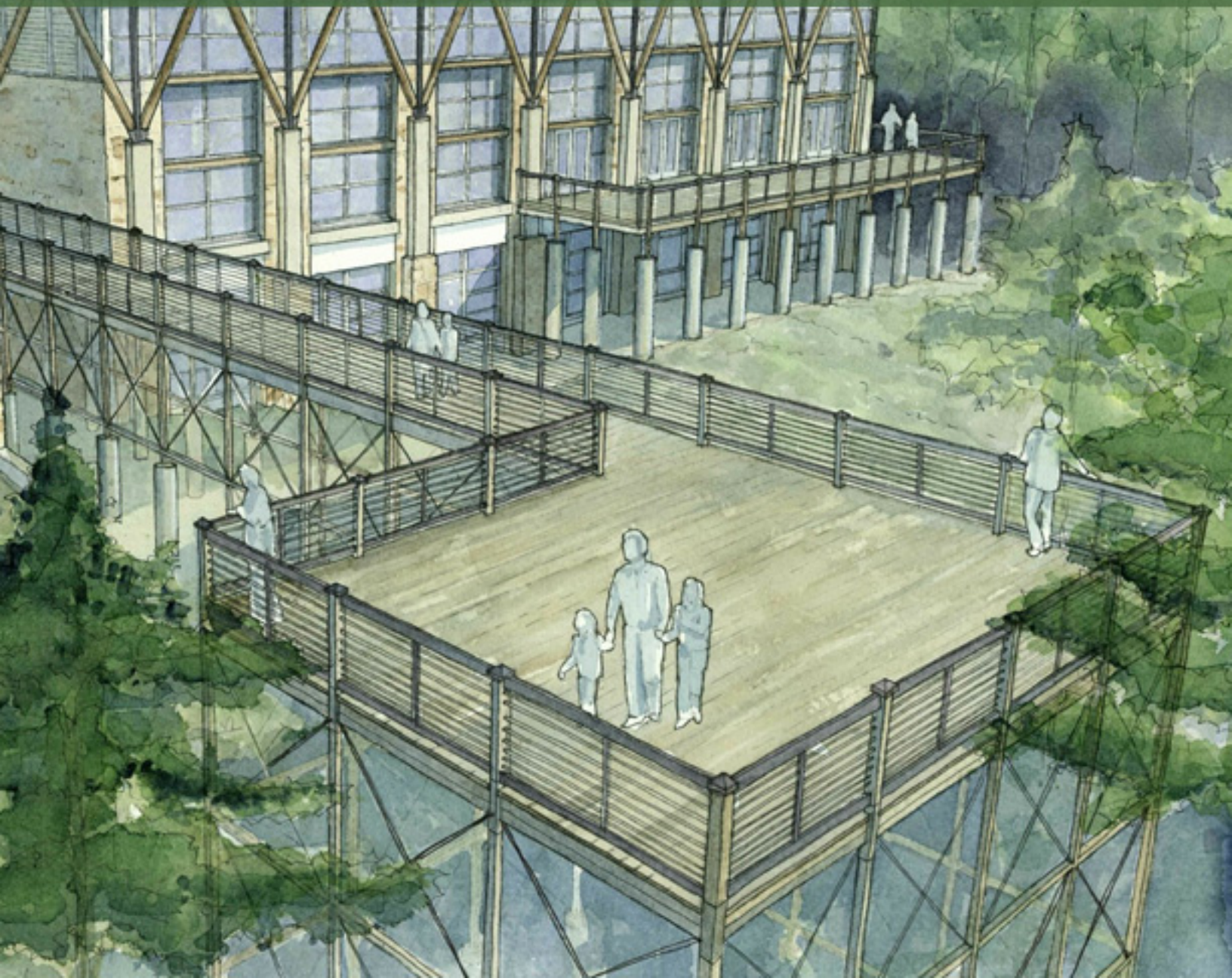


Environmental Science

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1

Basic System

The term ecosystem was introduced by A.G. Tansley in 1935. Before him, Mobins had used the term biocoenosis while Forbes coined the term Microcosm for the community of the organisms. Sukachev employed the term biogeocoenosis as synonym of ecosystem.

“Ecosystem is a segment of nature consisting of community of living beings and the physical environment, both interacting and exchanging material between them.”

According to Evans “the ecosystem involves the circulation, transformation and accumulation of energy and matter through the medium of living organisms and their activities.

According to Fitzpatrick a group of organisms interacting among themselves and with environment is known as ecosystem.

An ecosystem may be small like a drop of pond water (micro ecosystem) or may be as large as ocean. Each ecosystem has a distinct community with a distinct environment. Therefore, different ecosystems are identified by their bionics e.g., freshwater ecosystem, marine ecosystem, desert ecosystem, grassland ecosystem, tropical ecosystem. However, these ecosystems are not isolated. All the ecosystems of the world are inter-related and exchange materials amongst themselves. Therefore, some workers

consider the whole earth as ecosystem and call it biosphere or ecosphere.

The Significance

1. Ecosystem study gives information about the amount of available solar energy in an area.
2. It gives data about the availability of mineral elements, their utilisation and recycling.
3. Inter relationships between various types of organisms as well as between organisms and abiotic environment can be known.
4. Productivity of producers and consumers is known.
5. The maximum number of producers and consumers of various categories which can be supported in the ecosystem is known.

Main Features

- (i) The ecosystem is a unit of organisms connected to one another and to their environment within given space and time limit.
- (ii) Any system composed of physical, chemical and biological processes within a space and time unit.
- (iii) It is composed of three basic components-biotic (biome), abiotic (habitat) and energy components.
- (iv) It occupies certain well defined area on the earth-space and time unit.
- (v) Ecosystem of any given space-time-unit represents the sum of all living organisms and physical environment.
- (vi) It is an open system which is characterised by continuous input and output of matter and energy.
- (vii) There are complex sets of interactions between biotic and abiotic components including energy components on the one hand and among the organism on the other hand.
- (viii) It is powered by energy of various sorts but the solar energy is the most significant and tends to be relatively stable equilibrium. It has the natural resource system.

- (ix) It is well organised and structured system. The study of ecosystem development is helpful in the environmental planning from ecological point of view.

Different Varieties

Ecosystem can be natural or artificial, large or small, permanent or temporary, complete or incomplete.

Natural Ecosystem : It is an ecosystem developed under natural conditions without any major interference by man and based upon the particular kind of habitat, these are further divided into two sub categories.

- (a) Terrestrial ecosystem, e.g., forest, desert, grassland etc.
- (b) Aquatic ecosystem, e.g. freshwater lake, pond, river, sea.

Artificial Ecosystem (man-engineered) : It is an ecosystem which is created and maintained by human beings, e.g., garden, orchard, crop land, aquarium, dam, village, town, city, piggery, poultry etc. Agro ecosystem is the single largest man-made ecosystem which has large number of variations.

Macro Ecosystem : A large ecosystem such as ocean, forest etc.

Micro Ecosystem : A small specific part of a large eco-system with its own specialisation e.g., sub-alpine ecosystem, valley ecosystem.

Temporary Ecosystem : An ecosystem which persists for only a short duration like rain water pond.

Permanent Ecosystem : Which persists throughout e.g., forest or a lake.

Incomplete Ecosystem : Which lacks one or the other component e.g. cave, sea bottom, city (all lack producers), rain water pond with bloom of toxic algae (lack consumers).

Various Components : An ecosystem consists of two types of components - biotic and abiotic. Biotic components are living beings, the abiotic components are non-living that includes inorganic substances, organic substances and physical factors.

Biotic Component : The living organisms present in an ecosystem form the biotic components. They are classified into three categories—producers, consumers and reducer or decomposer.

Producers : They are autotrophic plants which synthesize organic food from inorganic raw materials using the energy of sun (exception - chemosynthetic bacteria). On land producers are usually large rooted green plants while in deep water ecosystems they are rootless algal floating or submerged in water. Autotrophs are sometimes called primary producers.

Consumers : They are mainly animals. They are unable to synthesize their food so depend upon other organisms or particulate organic matter (food) produced by producers. They are known as heterotrophs. They are of two main categories, herbivores and carnivores. The herbivores called primary consumers depend upon green plants for their food. Insects (aphides, bugs, ants), rodents and ruminants are the common herbivores in terrestrial habitats and small crustaceans and molluscs in aquatic habitats. Goat, Cow, deer, rabbit etc., are the common animals which are primary consumers.

The herbivores are used as food by primary carnivores (secondary consumers) (e.g., grasshopper, frog) which in turn are used as food by secondary carnivores (tertiary consumers) (e.g. snake that eats frog or birds which eat fish). In addition there may be top carnivores which are not further preyed upon (e.g., Falcon, Lion etc.)

Decomposers : (Osmotrophs = Saprotrophs = (Sapros = to decompose) (also called micro-consumers). They include fungi and bacteria which attack the dead bodies of producers and consumers and break down the complex compounds of dead protoplasm, absorb some of the decomposition products and release inorganic nutrients to the environment for reuse by the producers.

Thus there is a cyclic exchange of materials between living community and the abiotic environment of an ecosystem.

Abiotic Components

The non-living factors prevailing in an ecosystem form the abiotic components. These are further divided into following three parts:

- (i) Climatic: includes light, temperature, wind, water etc.
- (ii) Inorganic substances: nitrogen, calcium, sulphur, phosphorus etc.
- (iii) Organic compounds: protein, carbohydrates and lipids which are linked between abiotic and biotic components.

The various steps through which food energy passes into an ecosystem are called trophic levels. All green plants or producers belong to first trophic or T_1 -level. All the herbivores or primary consumers derive their energy from the producers belong to second trophic or T_2 -level, where as all the primary carnivores or secondary consumers belong to third trophic level or T_3 and the secondary carnivores or tertiary consumers belong to fourth trophic level or T_4 . Quaternary consumers (Top carnivores) generally belong to T_5 trophic level. Decomposers form the last or detritus trophic level (T_6).

Chain of Food

A food chain is a series of populations through which food energy moves in an ecosystem. A food chain is simple if it has only one trophic level besides the decomposers. A complex food chain has both producers and consumer trophic level. The idea of food chain was introduced by C. Elton. This idea describes the linear series of species, generally involving plants (autotrophs), herbivores and one or two successive sets of predators (a predator chain) or alternatively, the series of parasites and hyperparasites exploiting a host (a parasitic chain), saprophytic chains exploiting dead tissues are now known to be very important.

Web of Food

It is a network of food chains which become interconnected at various trophic levels so as to form a number of feeding connections amongst different organisms of a biotic community. An

organism can operate at more than one trophic level and obtains its requirement of food from different sources. Similarly an organism may be eaten by a number of different-organisms. Therefore, in nature linear and independent food chains are very rare. Instead several food chains are linked together. A food web opens several alternate pathways for the flow of food energy. It also allows an organism to obtain its food from two or more types of organisms of the lower trophic level. Thus a field mouse may be eaten by a wild cat, a snake or an owl. Similarly wild cats eat a number of herbivores like squirrel, birds, mice etc. A wolf or jackal can eat both rabbit and deer. The food web helps in maintaining the stability of the ecosystem by keeping the different species under check and maintain a state of equilibrium called homeostasis.

Flow of Energy

Biological activity needs utilization of energy. Solar energy is transformed from radiant to the chemical form in photosynthesis and from chemical to mechanical and heat form in cellular activities. Entrance of energy, its retention within the ecosystem and dissipation into space are governed by laws of thermo dynamics.

- (1) Energy can not be destroyed or created but is simply converted from one form to the other.
- (2) Processes involving energy transformation will not occur spontaneously unless there is degradation of energy from non random to a random form.

In an ecosystem all energy is provided by the sun of the sunlight energy only 1% is stored by plants in photosynthesis. This small amount of energy is sufficient to maintain all life on the surface of the globe. All of the energy stored by the autotrophs in the form of the food is available to the herbivores as food. Herbivores are primary consumers but they can store only 10% of this energy in their biomass and remaining 90% is used by them in life activities. In the same way herbivores are eaten by carnivores e.g. lion eats a deer. Thus only 10% of energy of lower trophic level can be captured by the organisms of next higher trophic level. This is known as Ten percent law.

Pyramid of Ecology

An ecological pyramid is graphic representation of a parameter like number, biomass or energy in a food chain at successive trophic levels with producers at the base, top carnivores at the top and other consumers forming intermediate tiers. The ecological pyramids are of the following types.

Number Pyramid

In this type of pyramid the number of individual organisms at each trophic level is shown. The pyramid may be upright or inverted. In grassland and crop ecosystems the pyramid may be upright where the producers are maximum in number and primary, secondary and tertiary consumers constitute the successive tiers, last tier makes the apex. In a tree ecosystem the pyramid is inverted i.e., one single tree which is primary producer has got large number of birds on it (Primary consumers) which have large number of insects outside their body (Secondary consumers).

Biomass Pyramid

The total fresh or dry weight of all living organisms in a certain unit area is called biomass. The amount of new biomass produced in a single growing season is called yield. The pyramid of biomass may be upright (terrestrial ecosystem) or inverted (aquatic ecosystem). In terrestrial ecosystem (Forest) the biomass of primary producers is maximum and biomass of top carnivores is minimum. In aquatic ecosystem the biomass of consumers is more than that of primary producers.

Energy Pyramid

The type of pyramid shows energy accumulation pattern at different trophic levels. Such a pyramid of all ecosystem is upright. Primary producers are characterised by maximum value and at each successive tiers of consumers the energy value per square meter per year is decreased by approximately 1/10. Thus there is noted a gradual decrease in the energy content at successive trophic level from producers to consumers.

Significant Ecosystems

In nature ecological grouping of plants and animals extends over large areas. Two major types of ecosystems are recognised in nature. These are:

1. Aquatic ecosystem: Further divided into
 - (a) Fresh water ecosystem
 - (b) Marine ecosystem
2. Terrestrial ecosystem. The major terrestrial ecosystem of the world are of four types
 - (a) deserts
 - (b) grasslands
 - (c) tundra
 - (d) forests

Pond of Fresh Water

It has a structure having the abiotic and biotic components. Location, size, depth and substrates of a pond influence the biology of pond ecosystem. A pond ecosystem is a self-sufficient, self-regulating system.

Abiotic Components

Temperature, light, pH of water and several basic inorganic and organic substances like H_2O , CO_2 , O_2 , N_2 , PO_4 , Ca, S and carbohydrates, proteins, lipids etc., make the abiotic components.

Biotic Components

Producers: This category includes green plants which may be submerged, free-floating or amphibious e.g., Hydrilla, Ceratophyllum, Utricularia, Vallisnaria, Jussiaea, Wolffia, Lemna, Eichornia, Azoll, Salvinia, Trapa: They are minute floating and suspended algal phytoplanktons like Ulothrix, Spirogyra, Oedogonium, Chlamydomonas, Volvox, Pandorina, Eudorina, Anabaena.

Consumers: These include

- (i) Primary Consumers: Herbivores

- (a) Zooplanktons: Some protozoans : Dileptus, Coleps, Euglena etc. rotifiers, Lecane, Asplanchna etc., Crustaceans, Cyclops, Stenocryptis etc., feeding upon phytoplanktons.
- (b) Benthos : Larvae of insects, beetles, fishes, mites, molluscs, crustaceans. Their biomass is determined.
- (ii) Secondary consumers : Insects, water beetles, frogs, fishes etc. feeding upon primary consumers are included under this group.
- (iii) Tertiary Consumers : Big fishes eating small fishes belong to this group.
- (c) Decomposers : Several bacteria, fungi and actinomycetes represent this group e.g., Aspergillus, Saprolegnia, Fusarium, Rhizopus.

Terrestrial Ecosystem : Forest Ecosystem is considered as an example here. Forests are natural plant communities with dominance of phanerogams. In India forests occupy approx. 1/10 of the land area. Forests can be divided into the 4 broad categories.

1. Tropical (wet evergreen, semi evergreen, moist deciduous and dry deciduous)
2. Sub-tropical
3. Temperate
4. Alpine

Abiotic Components

This includes inorganic and organic substances present in the atmosphere and soil. The climate (temperature, light, rain fall etc.) and soil (minerals) vary from forest to forest. In addition to minerals the occurrence of litter is the characteristic feature of majority of forests. Through litter decomposition approx. 90% energy trapped in the ecosystem by autotrophs dissipates into space as heat energy. The litter fall increases with decreasing latitudes.

Biotic Components

- (A) Producers: They are mainly represented by trees but shrubs

and ground flora are also found. Depending upon the kinds of the forests the flora varies.

(B) Consumers:

- (i) Primary Consumers are small animals feeding on tree leaves include ants, beetles, flies, bugs, spiders, leaf hoppers etc. neelgai, deer, elephants, moles, squirrels and fruit bats are large animals which feed upon shoots and/or fruits.
- (ii) Secondary consumers are different kind of birds snakes, lizards, feeding on primary consumers.
- (iii) Tertiary Consumers are tigers and lions are top carnivores.

(C) Decomposers : Streptomyces (Bacteria) and Fungi (Aspergillus, Alternaria, Fusarium) are helpful in decomposing the litter.

Evolution and Development

In our country Science is witnessed to be taught from very early days. If we look at the development of science in India, we find that very early in her civilisation India developed a great interest in mathematics and Ayurveda. During British Empire introduction of modern science in India was extremely slow, and the development of science in India was greatly accelerated after independence.

Culture and Tradition

Before the rise of modern science in Europe, around the 17th century, the level of advancement in sciences (astronomy, mathematics, medicine, biology, metaphysics, etc) achieved by ancient and medieval societies in the old world did not differ appreciably from one cultural area to another. In India the development of sciences is as old as her civilisation itself. Her peculiar geographical position enabled her to become the natural meeting ground of many nations and cultures and, in consequence, played an important role in the transmission and diffusion of ideas very early in her civilisation, India developed medical and alchemical practices of the Ayurveda. In mathematics, India developed a great interest and aptitude and made notable contributions to the number theory, the decimal place value, algorism, trigonometry and algebra.

Origin and Growth

In the beginning of the nineteenth century people with varying degrees of scientific background (medical men, naturalists and engineers) started coming to India from Europe, at first in search of services under local princes and chieftains and later on to man the scientific surveys and establishments set up by the government. These men framed in European institutions and laboratories, spent the best part of their lives in India and left an excellent record of their work in various branches of science.

Despite such long contacts, introduction of modern science in India was extremely slow. There were many causes of this delayed reaction. The European scientific world in India was limited to field sciences and not to basic sciences that depended on mathematics and laboratory work. Indian fauna and flora attracted the attention of European naturalists from the seventeenth century. Modern zoological researchers in India had their beginnings in random and scattered observations by the naturalists on elephants, fishes, serpents, molluscs, birds and mammals.

The Colonial Government adopted from the beginning a policy of secrecy and exclusion of Indians from Government scientific work. For technological jobs not considered of military importance, restrictions against the employment of Indians were relaxed as they could be employed very cheaply. As an example of the low salaries to trained and qualified Indians/ the order of the Governor-General dated 28th January 1835, establishing the Calcutta Medical College, regulated that "as inducement for pupils of a respectable class to enter the Institution, the pay of the Native Doctors, who shall have been educated at the College, and have received the certificates of qualifications, shall be Rs. 30.00 p.m. rising to Rs. 50.00 p.m. after 14 years of service, whereas an European Assistant to the Superintendent of the college shall draw a staff salary of Rs. 600.00 p.m. in addition to his registered pay and allowances." Calcutta Medical College established in 1835 under a number of capable teachers, became an important institution, for the study of anatomy, physiology and medicine (along with surgery), as well as of chemistry, botany and natural philosophy.

Indians asked for Western Education in Science from the Government. The Colonial power agreed to create facilities but with miserly financial provision just sufficient to train a few clerks able to operate in English in Government offices and European Commercial houses, and not to enable the native people to pick up treasures from European science. So the hard way of working for science began. Mahendra Lal Sircar (*born* in 1833), an M.D. of the Calcutta Medical College, clearly saw that science would never develop and strike deep roots in this country under foreign tutelage and that Indians themselves must come forward to raise funds and found institutions for the training of scientists and organisation of research.

In 1876 Dr. Sircar himself founded India's first research institution, "The Indian Association for the Cultivation of Science," completely under Indian Management and control with finances derived from private subscriptions. In the first half of the twentieth century the association developed into an important centre for research in the physical sciences - in optics, acoustics, scattering of light, X-rays and magnetism; and C.V. Raman performed his Nobel Prize Winning Experiments in its unassuming laboratories, *i.e.* western India. Jamshedji Tata a businessman, prepared plans for a similar institution for technical and scientific education and research which finally took the shape of "The Institute of Science" at Bangalore in the beginning of the twentieth century.

The Educational Despatch of 1854 paved the way for University education. In 1857 the three Universities of Calcutta, Bombay and Madras came into existence, but they came out just as examining bodies with powers to grant degrees. The actual teaching and academic work were left to the colleges. Fortified by the University Act of 1904, which empowered Universities to appoint professors and lecturers, to hold and manage educational endowments, and to erect, equip and maintain libraries, laboratories and museums, Asutosh Mookerji, Vice Chancellor of Calcutta University took the initiative in establishing the, first University College of Science. Undaunted by the Government's refusal to provide funds for the creation of professorships and other facilities, Asutosh obtained

princely endowments from Sir Tarak Nath Palit and Sir Rash Behary Ghosh, who had amassed enormous amounts of money and property in the legal profession, and established a number of chairs in Chemistry, Physics, Applied Mathematics and Botany.

According to the terms of the endowment, professorships could be filled only by Indians, a clause which further irritated the Government firmly entrenched in the view that only Europeans were suited for such high positions. This University College of Science, although starved financially all through, produced a group of physicists and chemists who received international recognition for their scientific developments and institutions staffed by high salaried Europeans and maintained and patronised by Government funds cut a sorry figure.

The development of science in India was greatly accelerated after independence (August 1947). In 1950 the Government of India appointed a Planning Commission for preparing a blueprint of all-round economic development. In 1954 the Indian Parliament accepted socialism as a political goal. Declaring these objectives, fullest emphasis was laid on the development of science and technology on all fronts. In 1957, the Government took one step further in adopting a National Science Policy Resolution that envisaged the cultivation of science and scientific research in all its aspects, assured an adequate supply, within the country, of research scientists of highest quality through an intensive programme of training, promised the availability of conditions and an atmosphere of academic freedom in which the creative talent of men and women would find full scope in scientific activity. The resolution thus reaffirmed the Government decision to encourage science and develop a healthy scientific community as a sound basis after a balanced economic development.

System of School Education

- In the beginning of twentieth century science was not a school subject in our country. The Report of the Secondary School Commission 1953, recommended the teaching of General Science as a compulsory subject in the high and higher secondary schools.

- The All India Seminar on the Teaching of Science in Secondary Schools (1956) dealt with almost all the problems facing the inclusion of General Science as a Core Subject for the Higher Secondary Classes—syllabus, apparatus, teaching aids, textbooks, science clubs, science museums, examination techniques etc. It suggested a uniform system of science teaching for the entire country, suited to its needs and resources.
- Indian Parliamentary and Scientific Committee (1962) studied the allied problems of science education in schools like
 - growth of school population,
 - shortage of qualified science teachers,
 - accelerated achievement in science,
 - demand for increase in technically trained manpower,
 - growing importance of science in the affairs of mankind, and
 - changes in the processes and goals of science.
- UNESCO Planning Commission (1963-64) worked on the problems of science education in India and suggested ways to improve it. As a follow up programme, Department of Science and Mathematics Education of the NCERT took up the pilot project of preparing new disciplinary science curricula at middle (VI-VIII) level -text books (Physics, Chemistry, Biology), teachers' guides, science kits, kit guides, teacher training films and evaluation material. This Disciplined Science Programme was changed to Integrated Science Programme in mid-eighties.
- In 1970 under UNICEF Assisted Science Education Programme (SEP) Primary "Science is Doing" Programme was developed by NCERT, which was used in primary schools throughout the country. This Programme was a package of classes I and II Science Syllabus, Class III-V Science Texts, Teachers Guides, Primary Science Kit, Kit Guide, and Teacher Training Films. This Programme was changed to EVS Programme in mid-eighties.

- Kothari Commission (1964-66) recommendations were implemented in 1975 when Science for All (SFA) was introduced as a part of general education during the first ten years of schooling. With this 10+2+3 education scheme started with an additional year of schooling, in the country. First Disciplined Science Course (Physics, Chemistry, Biology) was introduced at secondary level (IX-X). This was changed to Disciplined Science A-Course (Physics, Chemistry, Biology) and Integrated Science B-Course. Students had an option either to take Science A-Course or to take Science B-Course. This again changed to just one Integrated Science Course for all. At +2, Senior Secondary level (XI-XII) Disciplined Science Course (3 different science subjects - Physics, Chemistry, Biology) started from the very beginning of 10+2+3 education scheme.
- Then in 1986 the National Education Policy Document (NPE-1986) came out (Chapter 23). If some one asks, “What is new in this new education policy (NPE-1986), “Implementation” perhaps will be the right answer. Much emphasis has been given to quality pre-service and in-service teacher education in the policy document. For this District Institutes of Education (DIETs) and Institutes of Advance Studies in Education (LASEs) were established throughout the country for Elementary and Secondary Education respectively.

Recent Trends

India is now engaged in a broad spectrum of scientific research, both fundamental and applied, in Government, Universities and Private Research Establishments. In recent years there has been extraordinary success in developing new polymers, ceramics, composites, superconductors, nanomaterials, smart materials and biomaterials. Biotechnology, Genetic Engineering and Biomedical Research are some other fields in which India has started entering.

AIDS (Acquired Immuno Deficiency Syndrome) poses a threat to India as a large number of people are infected with HIV (Human

Immunodeficiency Virus). There are no drugs today for AIDS. The problem which has dogged anti HIV drugs is that resistant mutant forms of virus are formed within mere weeks. Lot of research work is to be done in search of a vaccine against HIV.

Per capita consumption of energy in India is very low compared to developed countries, and even that we are unable to afford. In the years to come when we have already entered twenty-first century, we will need much more energy. The major effort in next decade would have to be through an increase in the production of coal and a search of new reserves of oil. We should also give due emphasis to new technologies for solar energy and hydrogen energy.

India is also to expand its nuclear power programmes. Nuclear energy could play an important role in meeting our bulk energy requirement. Our expertise in the field of nuclear power technology as well as related research areas, is an asset for us.

For all this we need huge amounts of funds, as scientific research has become costly. If we compare the funds available for scientific research in India compared to some other developing countries, India has a very gloomy picture. South Korea had planned to increase its R&D spending to over 5 per cent of its GDP by year 2000. China had planned to increase its R&D investment from 0.5 per cent to 1.5 per cent of GDP by the year 2000. Unfortunately India's R&D expenditure has come down to 0.89 per cent of GDP from 1.1 per cent earlier. We need to realise that in order to be able to do competitive scientific research and development we have to bring our R&D expenditure to at least about 1.5 per cent of GDP and focus our efforts on a few selected programmes and projects.

Our scientists want people to support them and understand their needs, and they are to inform people about science, why science is needed, what they are doing and why. They (our scientists) are to build up partnership with public, industries, politicians and bureaucrats. They need informed friends of science at all places.

When changes which affect our future, are happening and will happen at such a rapid rate, and are based on science and technology, it is necessary that our scientists be more close to decision making.

In the existing state of scientific advancement and development of resources for research, the rate of scientific growth of developed countries is likely to continue to be faster than that of the developing countries like India. Science has become deeply involved with defence and big industry, with the result that big sciences like atomic energy, space, etc., has been and probably will remain concentrated in super powers,

In nuclear, space, computer and few other sciences, developing nations like India are already at the mercy of super powers. To be self-sufficient we are to change our science curriculum right from the school stage. We are not just to teach science but also scientific method. We are not just to teach science content but also science processes, the ways in which scientists advance their knowledge and solve problems. Science should be presented to students as a way in which they can conduct an inquiry into the nature of things as well as a body of information built up by other people.

The science processes are being neglected and the school science has been concerned almost exclusively with the content — the body of information. Science is not just content. Science is content plus science processes. If we want to advance in science like other developed countries, science processes should be given due importance like science content in school science curriculum, and students should be encouraged to become personally involved in solving problems and in discovering some science for themselves.

Fundamental Issues

Ecology is an interdisciplinary branch of biology which deals with the study of distribution structure, various aspects of life of organisms and their interaction with the environment.

The French Zoologist, Isidore Geoffrey St. Hilaire proposed the term ethology for “the study of the relations of the organisms within the family and society in the aggregate and in the community.” St. George Jackson Mivart coined the term hexicology, which he defined as “devoted to study of the relations which exist between the organisms and their environment as regard the nature of the locality the frequent, the temperatures and the amount of light which suit them, and their relations to other organisms as enemies, rivals or accidental and evolutionary benefactors.”

Meaning and Concept

The term ecology (Oekologie) was first used by Reiter in 1885 followed by Ernst Haeckel in 1886. It was coined by combining two Greek words oikos (meaning ‘house’ or ‘dwelling place’) and logos (meaning the study of) to denote such relationships between the organisms and their environment.

Thus, literally, ecology is the study of organisms ‘at home’. Misra has defined ecology as the study of interaction of form, function and factors. Krebs described ecology as “the scientific

study of interactions that determine the distribution and abundance of organisms.”

However, the recent development in study of ecology has been the recognition of the fact that the biotic (living) and abiotic (non-living) components of the nature are not only inter-related but both these components function in an orderly manner as a definite system, thus presently it is considered to be the structure and function of ecosystems. Ecology is a synthetic branch of science which obtains source materials from several other disciplines like climatology, geography, geology, limnology, mathematics, physics, chemistry, microbiology besides other branches of biology.

It is because ecology is to deal with the study of interactions of living beings among themselves as well as their physical environment. The physical environment consists of soil, water, air and energy. It provides both habitation and raw materials for the synthesis of organic food. Several other life processes are dependent upon the physical environment, viz., germination of seeds, pollination, respiration, hibernation etc. like components of living world, the various constituents of physical environment are inter-related. Some of their interactions are useful to living organisms e.g., ozone, nitrogen and carbon dioxide filter ultra-violet rays from incoming solar radiations while infra red rays are absorbed by the water vapours present in the atmosphere.

Ecology differs from other branches of biology firstly it comprehends physical environment alongwith organisms and secondly it deals with level of biological organisation. The various levels of biological organisation are called biological spectrum.

<i>Level of organisation</i>	<i>Basic division of biology</i>
Organic molecules	
Subcellular organelles	
Cells	Cell Biology
Tissues	Histogy
Organs	
Organ Systems Organisms	Anatomy, Physiology

Contd...

Level of organisation	Basic division of biology
Biochemistry	
Populations	
Communities	Ecosystems
Ecology	

Each level of organisation has properties peculiar to it that are not identifiable at the levels below. But studies at higher levels must take account of the lower levels. Ecology has three levels of organisation such as populations, communities and ecosystems. However, a strict demarcation between lower and ecological levels cannot be made since the latter also involve the study of effects on the constituents of lower levels of organisation.

Population : A population is a group of individual organisms of the same species (in breeding individuals) in a given area. It is also called local population. A local population adapted to its particular environment is called ecotype. A species may have several ecotypes. The different ecotypes have different genetic set-ups within the broad frame-works of the gene pool of the species. They are capable of interbreeding. Where two ecotypes meet, a continuous change from one type to another occurs due to interbreeding. It is called ecotone.

Community : A community is a group of population of different species in a given area. It may include all the populations in that area—all plants, all animals and micro-organisms or may be defined more narrowly as a particular group such as the fern community, or the seed-eating bi-community of that area. The different populations do not remain secluded but show interactions and inter-dependence.

Vegetation : A vegetation is a group of plants growing under the same climate over a wide range.

Ecosystem : An ecosystem is a segment of nature consisting of a community of living organisms and the physical environment,

both interacting with each other and exchanging materials between them. Ecosystem ecology emphasizes the movements of energy and nutrients among the biotic and abiotic components of the ecosystems. Because the ecosystem is the highest level of biological organisation, all ecological concepts can be set within its framework. The biotic components of any ecosystem are linked as foodchains. Food chains are interlinked to form complex food webs. Food webs are the basic units of ecosystem ecology. Thus ecology begins with populations and culminates in ecosystem.

Biosphere : The different ecosystems of the world are not independent rather exchange material among themselves. The biologically inhabited part of the earth consisting of all the ecosystems of the world is called biosphere.

The Characteristics

Like other sciences ecology too has its own principles and basic concepts. Earlier, stress was laid down on describing structural components and their relationships but later on emphasis was laid on the functional aspects of various components. There is also a trend to study historical or evolutionary causes of ecological phenomena.

Concept of Structure

1. The different types of organisms living in a particular environment are not only independent and mutually reactive but affecting each other in various ways. Animal population, Flora and vegetation are interdependent through the environment and are mutually reactive.
2. Environment, which is actually a complex of several interrelated and dynamic (variable) factors some of which become critical at critical stages of the life cycle of the species. It, therefore, works as a sieve selecting organisms that can flourish in it.
3. The species put each effort to maintain its uniformity in structure, function, reproduction, growth and development by preservation of its genetic pool. However species have

sufficient plasticity to modify themselves according to changing environment by virtue of somatic plasticity (ecads) or by recognition of their genes during sexual reproduction (ecotypes).

4. It is not only the environment which influences the life of organisms, but organisms too modify their environment to make it more congenial for their growth, development, reproduction and dispersal. The modified environment may become less suitable for the community already living in it. The dynamic environment and organisms make ways for the development of different kinds of organisms through a process known as succession. The process continues till the development of a community which is now more or less stable and is now able to keep itself adjusted in equilibrium with the environment. This final stage of community is called a climax.
5. According to Clements and Shelford (1939), under similar climatic conditions, there may develop more than one communities, some reaching to climax stage, others under different stages of succession. This complex of many communities growing in a particular area, sharing a common climate is called a biome.

Concept of Functionality

1. The basic structural and functional units of nature are ecosystems. An ecosystem is a segment of nature consists of community of living organisms and physical environment both interacting and exchanging materials between them.
2. Discrete biological unit consists of a number of populations each occupying a specific functional position with respect to other organisms with which it interacts. It is called ecological niche.
3. The degree of success of a particular population in an area is determined by the parameters of both abiotic factors as well as interaction with other types of populations. These interactions among organisms can be positive, negative or even neutral.

4. Also, there are involved energetics of ecosystem, as energy is the driving force of this system. The flow of energy in the ecosystem is unidirectional or non-cyclic. The radiant energy is trapped by the autotrophic organisms (producers) and is transferred as organic molecules to the heterotrophic organisms (consumers) and decomposers. Energy is lost during its transfer from one trophic level to the next. Organisms use the energy in respiration.
5. A number of inorganic nutrients are taken up by living organisms for their metabolism and body building and are called biogenetic nutrients. These chemical components keep on moving between biotic and abiotic components of an ecosystem in defined cycles called biogeochemical cycles.
6. Human beings have exploited the ecosphere to an extent that only economically important plants are allowed to grow in an ecosystem. This caused a reduction in species diversity and natural interaction amongst organisms and physical environment.
7. Under natural conditions, different populations undergo succession. Ecosystem undergo an orderly process of change with time, passing from a less complex to a more complex state. This process involves not only changes in species but also changes in physical environment of a community. The terminal or stabilised state is known as climax.

Concept of Evolution

1. Present day organisms are the product of evolution of the past organisms.
2. By knowing the evolutionary aspects of each ecological phenomena, we can predict the future shape of events under different sets of conditions.

Plant Ecology : Plant ecology is divided into four branches - autecology, synecology, system ecology and applied ecology. A perusal of the developmental history of ecology reveals that

ecological studies made from time to time are based upon three principles aspects - taxonomic affinities, habitat and level of organisation.

Autecology : This is also known as ecology of individuals where we study individual species or population in relation to its environment from the time of seed germination upto setting of fruits and seeds i.e., seedling growth, vegetative growth and reproductive growth. An applied branch of autecology is agronomy which studies the various aspects of crop plants.

Synecology : Under natural conditions, however, organisms-plants, animals, microbes etc., live together as natural group affecting each other's life in several ways. Thus, more complex situations exist where the unit of study, instead of single organisms are groups of organisms known as community. Synecology deals with the study of plant communities, including the composition, organisation and development in relation to environment. It is divided into several branches according to the aspect under study:

Habitat Specialisation (Habitat Ecology) : Organisms are influenced and modified by the habitat in which they live. Therefore, they can be studied in a group according to the habitat, e.g., freshwater ecology, marine ecology, grassland ecology, forest ecology, desert ecology etc.

Community Type (Community Ecology) : In ecology no organism can be studied in seclusion because of the interdependence and interaction amongst various members of a community. Therefore, community is studied as a single entity, e.g., forest ecology, grass land ecology.

Taxonomic Group : In early days of ecology, botanist and zoologists engaged themselves separately in the study of ecology of plants and animals respectively. This leads to the development of such sub-divisions as (i) Plant ecology, and (ii) Animal ecology. In each sub-division there are further specialised fields like ecology of pines, insect ecology, avian ecology, bacterial ecology and ecology of mosquitoes etc. However, modern ecologists feel that the principles in the study of plants and animals are not only much

similar, but these two great groups of organisms are inseparably inter-related with each other. Therefore, modern ecology studies inter-relations and inter-dependence of all organisms.

Levels of Organisation : Depending upon the level of organisation, synecology can be divided into many types:

- (i) Population Ecology. The study of growth, structure and regulation of population of organisms.
 - (ii) Community Ecology. Study of inter-dependence and interaction amongst various members of community.
 - (iii) Ecosystem Ecology. It deals with interactions of living and non-living parts of nature besides the flow of energy, biochemical cycling, trophic levels etc.
 - (iv) Biome Ecology. Study of different communities living in a particular climate or area.
 - (v) Genecology. It is the study of ecology in relation to genetics.
- There are some specialized branches of Ecology.

- (i) Geographic Ecology. The study of geographical distribution of plants and animals.
- (ii) Radiation Ecology. The study of effects of radiation on environment and organisms.
- (iii) Sociology. The study of ecology and ethology of mankind.
- (iv) Ethology. The interpretation of animal behaviour under natural surroundings.
- (v) Space Ecology. The effect of space on the growth, development, reproduction and behaviour of organisms and cycling of resources so as to sustain life for long periods in the space.

System Ecology : It deals the analysis and understanding of the structure and function of ecosystem. It employs mathematical models.

Applied Ecology : The study of the human needs and the applications of ecological concepts, e.g., agriculture, forestry, land use etc.

The Fundamentals

There are basic fundamental principles which govern the various aspects of organisms and components of environment. The following are the fundamental principles of ecology:

- (i) All living organisms and physical environment are mutually reactive. The organisms interact among themselves and affect each other and physical environment.
- (ii) The physical and biological processes follow the principles of uniformitarianism which states the same physical and biological processes, as the environment is influenced by human activity.
- (iii) Natural hazards affect adversely the biological communities in general and in particular. When biological processes are associated with physical events, yet severe hazards are created.
- (iv) Sustained life on earth is a characteristic of ecosystem, not of individual organisms or population.
- (v) Environmental principles of holistic nature of natural environment which largely affect the biological communities in a biospheric ecosystem.
- (vi) Ecosystem is a fundamental unit of ecological study because it comprises both biotic and abiotic components.
- (vii) Ecosystem functions through the input of energy mainly solar radiation which is trapped by green plants and is used to prepare food through the process of photosynthesis. The solar radiation is the main driving force of the ecosystem.
- (viii) The ecosystem productivity depends on:
 - (a) The availability of the amount of solar radiations to the primary producers.
 - (b) The efficiency of plants to convert solar energy into chemical energy.
- (ix) Ecosystem instability results when an ecosystem becomes unable to adjust with environmental changes.

- (x) Man being an active agent of environmental change, modifies the ecosystem through the exploitation of natural resources.

Methods and Implements

Ecology is an interdisciplinary approach for studying environment. It is considered both science and art. It concerns both the aspects doing and understanding. An ecologist has to work with living system and various environmental components. In ecology various types of tools and techniques are used. It employ scientific and non-scientific methods, tools and techniques. An ecologist has to begin with observations of living organisms and environmental components. The observations are quantified and statistical techniques are used to analyse the relationships and interdependence. The observation tool and correlation techniques an commonly used by ecologists the qualitative and quantitative method: and tools are employed in ecology.

<i>Qualitative Methods</i>	<i>Quantitative Methods</i>
(i) Observations	(i) Observation
(ii) Historical	(ii) Experimental
(iii) Longitudinal	(iii) Cross-sectional
(iv) Descriptive	(iv) Project method
(v) Sampling Technique	(v) Sampling technique

The qualitative is the subjective approach while qualitative is objective and scientific approach.

The Atmosphere

The term "Environment" which etymologically means surroundings, is considered as a composite term for the conditions in which organisms live and thus consists of air, water, food and sunlight which are the basic needs for all living beings and plant life, to carry on their life functions. The environment also includes other non-living things, temperature, wind, electricity etc. In other words, environment consists of both biotic and abiotic substances.

Environment creates favourable conditions for the existence and development of living organisms. Environment can be defined in number of ways:

- (1) "Environment is the sum of all social, economical, biological, physical or chemical factors which constitute the surroundings of man, who is both creator and moulder of his environment."
- (2) "Environment refers to the sum total of conditions which surround man at a given point in space and time."
- (3) "Environment is the representative of physical components of the earth where in man is the important factor influencing his environment."

"Environment" is assuming great importance in our dairy life. Though environment is a very broad term but in common parlance it is the 'limited surround' that affects the functioning of the world in which we live, thus in our daily life, what we are really concerned about is the "Biosphere". The part of the biosphere which can be affected by the present day technology, is called the Technosphere' and in the part of 'Ecosystem' that is badly affected.

It is very difficult to maintain ecological balance until and unless poverty elimination programmes are persued effectively. Our then Prime Minister in his speech on 6th July 1987 in the meeting of the World Commission on Environment and Development emphasized that there should be global commitment for mass poverty elimination. If we are able to improve the quality of life of the poor, we will be able to protect and regenerate the environment.

After the scientific and industrial revolution in the recent past, there has been immense impact of man on his environment. Man has failed to realise that any new factor upsets the balance of the ecosystem as a whole. All the devastating effects of man's effect to control nature have occurred because he has upset the balance relationship of the organisms that make up the environment. Huge industrial installations every year, introduction of faster mode of transport and sprouting up of large crowded cities (Urbanization) are the main outcomes of the modern civilization. These and a

large number of many others are contributing to what is called environmental pollution. Increasing industrialization is also causing much danger to man's life because it is also responsible for defouling or polluting of environment by man.

Mankind will perish if the protection of the environment does not become an integral part of all the development programmes because we cannot cheat the "Mother Nature".

Reliance on plant foods rather than animal foods is ecologically more viable and sustainable because of the tremendous loss of energy in the food chain of ecosystem. The conservation of natural resources especially forests and wild life got attention in both developed and developing countries. Late Sanjay Gandhi gave much attention to the preservation of trees and cultivating more of them.

The Government of India, along with other Governments participated in a United Nations sponsored conference on the human environment in June 1972 at Stockholm (Sweden). The conference concluded that the decline in environmental quality is due to increasing pollution, loss of vegetable cover and biological diversity and excessive concentration of harmful chemical in the environment.

In May, 1986 Government of India passed the Environment Protection Bill which afterward became an act. The act gave a wide meaning to the environment and concluded that the environment included water, air land and the living creatures such as plants, animals and human beings. To implement Environment Protection Act throughout India our Government launched National Environmental Awareness Campaign, organised All India Essay Competitions on environment for the school children, National Seminars on various aspects of the environment, established Environmental Education Centres (Ahmedabad).

The subject of environment got immense national priority. Its protection and promotion was made one of the twenty programmes of the Prime Minister. How the plant life and healthy environment affect our mental health is not even cleared to the well informed

people. There is an equal need for protection to oil and petroleum by minimizing its wastage.

It was categorically emphasized in an exhibition on “Our Environment and Our Future” held at International Trade Fair, New Delhi in 1989. We alongwith other developing countries, have to find alternative path to an alternative good. A goal which ultimately is the true goal of development—an environmentally sound and sustainable development. Time has reached when we are facing challenge to our intellect and wisdom for saving the humanity from extinction. It arises from our activities constricting the environment and depleting the biosphere, especially so in the name of development. We have to plan our actions ecologically for the sustenance of the environment and development. Perhaps the greatest challenge facing the present generation is need to balance apparently conflicting responsibilities of caring for the exploitation, preservation and conservation of environment around them.

Misra (1991) presented an excellent account of planning for environmental management. The four basic requirements of environmental management recognised by him are, (i) impact of human activities on the environment (ii) value system, (iii) Plan and design for sustainable development, and (iv) environmental education.

The conservation of natural resources especially forests and wild life, mineral, metals and oil got attention of the Govt. in both developed and developing countries. The problem is however, grave in over populated, poor and educationally backward society in which India is placed. Population, poverty and environment are interrelated. India has often been described a rich land with poor people. The nexus between poverty and environmental degradation can hardly be over-emphasized. The low level literacy, economic backwardness and over population are some of the important aspects of Third World States Culture.

A nation can be called super power largely due to its natural resources. All the branches of science should be involved in promoting the rational use of natural resources environmental protection, its improvement and welfare of human society.

The organisms live on different surroundings of the earth which include biotic (living) and abiotic components which form the environment. The individual pass through various stages in the life cycle i.e. from birth to death. They have capabilities to continue their race from generation to generation. With the death of old individual new one start their cycle of life.

For the existence of all living organisms on the earth, they need the system which sustains life. The important system is the environment which covers all living and non-living systems. So it is necessary for every layman and literate person to know the meaning of the environment.

Varied Components

Environment can be conveniently divided into two categories

- (1) Natural Environment
- (2) Man-made Environment

Natural Environment : It means the environment that comes into existence without interference of man. The natural environment system operates through self-regulating mechanism called homeostatic environment mechanism i.e. any change in the natural ecosystem brought about by natural process is counter balanced by changes in other component of the environment. Many components together coordinate to form a natural environment which helps in sustenance of life. The environment consists of mainly two components:

- A. Abiotic or Non-living components
- B. Biotic or Living Components.

Abiotic Components : They are those components which are not living but can support other living organisms. These are the basic components of Environment and when these components become unbalanced they will prove fatal for the living organisms. These are of three kinds:

1. Inorganic Substances. These include elements like Nitrogen, Calcium, phosphorous, water and gases like carbon dioxide and oxygen. These substances are required

for the synthesis of organic substances and are called inorganic nutrients or biogenetic substances.

2. Organic Substances. They are substances dispersed from dead bodies of organisms or are derived from their excretions. Organic substances together called organic detritus. It produces humus which is essential for maintaining proper soil aeration, hydration and fertility. Humus contains nucleic acids, amino acids, proteins, lipids, carbohydrates etc. These are again sent back to the environment after decomposition by decomposers.
3. Physical Factors. They include climatic, edaphic and topographic factors e.g. light, temperature, humidity, wind, rain, soil, topography and background etc.
 - (i) Light. It provides solar energy for photosynthesis. Maximum light energy is available at equator. It decreases towards poles. In a tree more energy is available to upper leaves than the lower leaves. Their rate of photosynthesis is accordingly higher.
 - (ii) Temperature. On the basis of temperature range, there are four life zones - tropical (hot throughout the year), subtropical (hot during summer and cool during winter), temperate (pleasant summer and cold winter with occasional snowy and arctic or alpine (Snowy throughout except for brief summer).
 - (iii) Rainfall. Amount and periodicity of rainfall determine type of vegetation.
 - (iv) Humidity. Transpiration is inversely related to humidity. Humid areas have abundant dense plant growth with numerous animals and epiphytes.
 - (v) Wind. It controls weather, transpiration, pollination and dissemination of propagules.
 - (vi) Soil. Its texture, pH and fertility determine the type of vegetation and animal community depends on it.

In addition to these, other abiotic components are:

- (a) Lithosphere. Outer most layer of the earth

- (b) Hydrosphere. Part of the earth having water resources
- (c) Atmosphere. It is a cover around the earth having a number of gases

Biotic Components : The living organisms form the biotic component of the environment. Every living organism in the Biosphere depends upon one another and these living organisms which exist in Biosphere forming the biotic community of the environment are as follows:

- (a) Producers or Autotrophs. They are autotrophic plants which synthesize organic compounds from inorganic raw materials in the presence of energy usually derived from the sun. Organic compounds serve two purposes—body building and liberation of energy during the process of respiration. All other organisms depend upon the producers for getting their food and energy contained in it.
- (b) Consumers or Heterotrophs. They are also called phagotrophs. Consumers are animals which ingest other organisms or their particulate organic matter. They are of two main categories—herbivores and carnivores. The herbivores or primary consumers directly feed on plant matter, e.g., rabbits, deer, cattle, goats, horses etc. Carnivores feed on the flesh of other animals. Secondary consumers or primary carnivores eat the herbivores e.g., frog, molluse, small birds etc. The secondary consumers, in turn are eaten by tertiary consumers and so on. The carnivores which are not further preyed upon are called top carnivores, e.g., Lion.
Since organic matter is resynthesized by consumers, they are also called secondary producers.
- (c) Decomposers. They include bacteria, actinomycetes and fungi. They decompose the complex compounds in the dead organic matter of plants and animals and again recycle the elements into the environment.

Man-made Environment : Man is the most powerful environmental agent, spearheaded by modern technologies capable

of modifying the environment according to his needs to a great extent without taking into account its consequences. Increase in the scientific technologies which are the product of human brain is now deteriorating the environment. Urbanisation, industrialisation and commercialisation all have led to more critical conditions. The condition of villages is worse as there is no proper sewerage and sanitation system. Increase production leads to spoilage of the environment and alter the composition of natural products.

Healthy Atmosphere

The development of any country depends on its geographical and environmental conditions. From the ancient time man is continuously exploiting and struggling with nature. Degradation of environment started with the development in the early man's life in the form of many inventions and discoveries. These resulted in the development of new tools and implements. He also made developments in other fields such as industry, nuclear and other technological developments which are causing degradation of environment.

Development : From the early time man is putting efforts for development such as agriculture, urbanisation, industrialisation, commercialisation etc. All these developments have put stress on the environment because these required large spaces which forests have to be cut without taking into account its consequences. Advancement in agriculture lead to use of more chemical fertilizers, pesticides, weedicides, insecticides without taking into consideration their ill effects. The urbanisation stresses on basic necessities like food, shelter clothing which directly influenced the forests. Industrialisation posed a serious threat to biotic and abiotic components of the environment. As more and more industries are being set up those are polluting the environment with their emission and discharge effluents.

Population Stress : As population is increasing day by day their basic demands are at the increase. The ecological balance of the earth is disturbing because the natural resources are limited

to meet their demands. This increase in population causing destruction of the environment. Therefore, it is necessary to save our environment by sustainable development. The increase in population should be at a rate that the resources should be exploited in a way that they not depleted.

Present Scenario : As we have already depleted lot of our natural resources it is the need of the day we should have a control on the unlimited use of our resources so that we could improve our environment. For this proper planning and management of resources as well as the environmental impact assessment should be done before establishing any developmental activity. Every person of the country should be aware of the consequences of changed environmental conditions. Non-governmental organisations also play important role in educating people and controlling environment. So it is important to safeguard our environment which in turn safeguards the living beings.

Problem of Pollution

Pollution of the environment is one of the most horrible ecological crisis to which we are subjected today. We know that three basic amenities for living organisms are air, land or soil and water. Some times in the past, these amenities were pure, virgin, undisturbed, uncontaminated and basically most hospitable for living organisms. But situation is just the reverse today, because progress in science and technology is also leading to pollution of environment and serious ecological imbalance which in the long run, may prove disastrous for mankind.

Environment pollution is the result of urban-industrial technological revolution and speedy exploitation of every bit of natural resources. The mad rat race among nations over the entire globe for development jeopardised the existence of man itself. The craze of progress in agriculture, industry, transportation and technology is taken as the general criterion of development of any nation. This craze resulted into unlimited exploitation of every bit of natural resources.

Such activities of man has created adverse effects on all living organisms in the biosphere. Rapid industrialization has left with us polluted rivers, contaminated soil, depleted wildlife and exhausted natural resources. Today the environment has become foul,

contaminated, undesirable, and therefore, harmful for the health of living organisms, including man. The splendid plentifulness of nature is a heritage that should never be spoiled. But the unlimited rapacious exploitation of nature by man has disturbed the delicate ecological balance existing between living and non-living components on the planet earth. The unfavourable conditions created by man himself threatened the survival not only of man himself but also other living organisms. The number of the species likely to become rare, threatened, endangered or near extinction in the Red Data Book of the IUCN is increasing with time.

Today India, which occupies 7th place among the industrialized developing countries of the world, is provided with a good industrial infrastructure in several industries like chemicals, power, nuclear energy, food, petroleum, pesticides, plastics etc. A rapid progress in atomic and nuclear energy has added a huge amount of radioactive substances in the atmosphere. A number of industrial effluents and emissions, especially toxic gases are spewed into the air daily. Thus the environment is deteriorated to such an extent that it has crossed the critical limit and has become lethal to all organisms, including man.

But what has come out of these developments? We find warnings every where as “Air unfit for breathing”, “Water unfit for drinking”, “Vegetables unfit for eating” and so on.

The environment pollution is thus necessary evil of all man made progress. It is not only the industrialized countries which are threatened with the environmental pollution, but the menace is growing in India too. The developed countries dump lot of effluents into the environment, polluting the whole globe.

Meaning and Definition

Pollution refers to any undesirable change in the physical, chemical or biological characteristics of our environment i.e. air, water and soil which adversely affect humans or other species of our biosphere directly or indirectly. The word pollution is derived from the Latin word *Pollutionem* (meaning to defile or make dirty).

Pollution can also be defined as an undesirable change in physical, chemical or biological characteristics of water, air and soil that may harmfully affect human, animal and the plant life, industrial progress, living conditions and cultural assets.

Pollution should not be confused with contamination which is the presence of harmful organisms or their products causing disease or discomfort.

Main Pollutants : Pollution is brought about by the addition of waste products of human activity to the environment. When the waste products are not efficiently assimilated, decomposed or otherwise removed by the natural, biological and physical processes of the biosphere, adverse effects may result as the pollutants accumulate or get converted into more toxic substances. Thus the materials which cause pollution of the environment are called pollutants.

Pollutant can also be defined as undesirable substances which are present in the wrong place, at the wrong time and in the wrong quantity.

Kind of Pollutants

- A. Pollutants are divided into two categories on the basis of their forms they exist in the environment after their release:
 1. **Primary Pollutants** : Those substances emitted directly from an identifiable source. These are present in the same form in which these are added by man e.g. sulphur dioxide, nitrogen oxide etc.
 2. **Secondary Pollutants** : These are substances derived from primary pollutants by chemical reactions so occur in different forms e.g., Primary pollutants such as hydrocarbons and nitrogen oxides, particularly in the environment react in the presence of sunlight to form a group of nitrous compounds like peroxyacetyl nitrate (PAN) as the secondary pollutant.
$$\text{Nitrogen peroxide} + \text{Hydrocarbons} \rightarrow \text{Ozone} + \text{peroxyacetyl nitrate}$$

- B. On the basis of their existence in nature, pollutants are divided into two categories:
1. *Quantitative Pollutants* : It is a normal component of the environment but becomes pollutant when its concentration crosses a threshold value e.g., carbon monoxide, carbon dioxide, nitrogen oxide.
 2. *Qualitative Pollutants* : A pollutant which is normally not a component of environment but is passed into environment through human action, e.g., pesticide, weedicide, fungicide.
- C. From ecosystem point of view, the pollutants may be classified as biodegradable and non-biodegradable pollutants.
1. *Biodegradable Pollutants* : These pollutants are easily degraded completely by micro organisms e.g., domestic sewage, heat etc. However, if these pollutants enter the environment in such large quantities that complete degradation of all cannot take place, then these become non-biodegradable pollutants and thus pollute the environment.
 2. *Non-biodegradable Pollutants* : These pollutants are not normally acted upon by microbes or are acted upon very slowly and thereby pollute the environment. Such pollutants are harmful even in low concentration. These pollutants not only accumulate, but are often biologically magnified as they move in biochemical cycles and along food chains. Non-biodegradable pollutants are further of two sub-types -
 - (i) Wastes e.g., glass, plastics, phenolics, aluminium cans
 - (ii) Poisons e.g., radio active substances, pesticides, smog gases, heavy metals like nickel, chromium, mercury, lead or cadmium.

In general pollutants are residues of substances made by us, used by us and even thrown away by us as waste products which pollute the environment in one way or the other.

On the basis of type of environment being polluted, we may recognise air pollution, water pollution, land (soil) pollution.

Pollution of Air : Air pollution is defined as the occurrence of foreign particles or gases in the atmosphere which are harmful to man vegetation, animals and buildings. Air pollutant is any solid, liquid or gaseous substance present in the atmosphere in such a concentration that it may or become harmful to human beings, other living creatures, human assets, natural resources and environment. Most of the air pollution is natural due to dust storms, marsh gas, respiration of organisms, decay and decomposition, forest fires, spores. Pollen grains etc. Only 0.05% of the air pollution is man made but its amount is enormous 5×10^8 tonnes.

Sources : The main sources of air pollution in India are:

Automobiles : The exhaust emitted by automobiles is a major source of air pollution. Automobiles release huge quantities of carbon monoxide (Co), hydrocarbons; and nitrous oxide in the air. Every gallon of petrol consumed by automobiles produces 3 lbs of CO and 15 Pbs nitrogen oxide which is sufficient to pollute 800,000 to 2,00,000 c.c. of air. The combustion of petroleum emits various particulate lead compounds. Mumbai residents have a lead content of 16-18 mg/100ml of blood while lead begins to show toxic effect beyond 20 mg/100ml. About 312 tonnes of lead is let out into Delhi's atmosphere every year. The larger lead particles settle down on the soil and pass into food chain. It is estimated that the highest intensity of CO in the atmosphere during peak traffic hours at some points in Kolkata is about 35 parts per million. In Delhi total calculated vehicular pollution has increased from 424 tonnes/day to 865 tonnes/day during 1980-81 to 1986-87.

There are more petrol driven vehicles in Delhi which collectively add about half a million tonnes of lead in the environment every year. This can endanger the people to dead lead poisoning.

Industrial Chimney Wastes : There are a number of industries which are sources of air pollution. The common air pollutants which

are discharged into air from industrial chimneys and power houses are CO, CO₂, SO₂, H₂S and hydrocarbons. These gases are produced due to burning of coal and petroleum and by combustion of lignite at thermal power stations. Many chemical industries release hydrochloric acid, chlorine, nitrogen oxide, zinc, lead, arsenic, oxides of copper in addition to SO₂, CO and H₂S. Petroleum refineries are the major source of gaseous pollutants. The chief gases are SO₂ and NO₂. Mathura based petroleum refinery is posing threat to Taj Mahal in Agra and other monuments at Fatehpur Sikri.

A study was made by central pollution control board which identified five major and 22,000 small industries polluting capital's atmosphere. One can imagine the kind of air inhaled by the residents of the localities surrounding these industrial units.

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 plants generate electricity by burning fossil fuels like coal and in some cases oils, release many pollutants such as flyash, SO₂ and other gases and hydrocarbons Table shows various gaseous pollutants from a 200 MW thermal power plant.

***Gaseous Pollutants from a 200MW Thermal Power Plant
(Coal Consumed $6.67 \times 200 = 1334$ i.e. 1400 Tonnes a day)***

<i>Components</i>	<i>Emission factor kg/tonne of coal</i>	<i>Emitted quantity (tonnes a day)</i>
Aldehydes	0.0025	0.0035
Carbon monoxide	0.25	0.35
Hydrocarbons	0.10	0.14
NO ₂	10.00	14.00
Oxides of Sulphur (0.5% S)	19(s)	13.30
Particulate matter (33% ash)	8(A)	369.60
Ash	2(A)	92.40

(A) - Ash content in coal in percent (S) - Sulphur content in coal in percent.

Burning of Fuels : Fossil fuels provide us energy for many domestic activities. Among fossil fuels coal and oils are major source of energy. Coal on combustion produces CO_2 . Incomplete combustion yields CO and a variety of hydrocarbons including methane. Burning of coal produces SO_2 and ash also.

Agriculture : About 60-65% of CO, is produced from burning of forests. About 40% of methane is produced from paddy fields, guts of livestock and burning of biomass. Crop spraying and dusting for pest and weed control are responsible for emitting organic phosphates, arsenic and lead into air.

Suspended Particulate Matter (SPM) : It is a major pollutant of air. Dust is generated from sources such as coal dust, cement dust, silica dust (Stone crushing). Cotton dust is main pollutant in Ahmedabad, Surat etc. In Delhi's atmosphere about 53,000 tonnes of SPM are added annually.

Major Impacts

Carbon Dioxide : It is released in the air through combustion of fuel in homes, factories etc. It is also produced during the process of respiration and volcanic eruptions. The amount of atmospheric carbon dioxide has been continuously rising over the years due to deforestation, burning of fuels without a corresponding increase in plant population. In 1987, alone earth produced 14,600 million metric tonnes of carbon dioxide. Out of this only 63% was absorbed by plants and oceans. The year added 5900 million tonnes of gas into the atmosphere. Consequently CO_2 concentration of atmosphere has been steadily rising. The global temperature is believed to have risen to 1°C during the last fifty years therefore, causing a warming effect (green house effect). Excess of carbon dioxide produces headache and nausea in human beings.

Carbon Monoxide : CO is a colourless, odourless, non-irritating but very poisonous gas. It is produced by incomplete combustion of fuels. It accounts for over 50% of the total air

pollutants. Automobiles produce 74% of all man made carbon monoxide. A good amount of CO is also produced naturally by plants and animals. It is estimated that plants alone give out 10^8 tonnes of carbon monoxide out of a total production of 2.54×10^9 tons from various sources. Carbon monoxide has 200 times stronger affinity for haemoglobin as compared to oxygen. It forms Carboxy-haemoglobin. Oxygen carrying capacity of blood is reduced. When in high concentration, causes headache, giddiness, laziness, reduced vision, nervous and cardiovascular disorders and even death. Carbon monoxide is the largest pollutant in Delhi's air and was measured at about 120,349 tonnes in 1991. In 1997, co-emission was about 132 times more than in 1987.

Sulphuric Dioxide : It is produced in large quantity by burning of fossil fuels (coal and oil) in industries, thermal plants, homes, fertilizer industries etc. and during smelting of metallic ores (e.g., iron, copper, lead, zinc, nickel etc.). It is also formed from hydrogen sulphide (H_2S) gas formed from natural sources. The gaseous SO , oxidises to SO_3 , which on combination with water forms sulphuric acid. Sulphur dioxide accounts about 18% of total air pollutants. Higher concentration of SO_2 causes chlorosis and necrosis of vegetation. Lichens are very sensitive to SO_2 and are completely destroyed. SO_2 also causes respiratory diseases in man (bronchitis, asthma, emphysema and lung fibrosis). It results in discolouration and deterioration of buildings, sculptures, painted surfaces, fabrics, paper, leather etc. The exhausts from Mathura refinery are a threat to the Taj at Agra.

Sulphur dioxide and sulphur trioxide react with water to form sulphurous acid (H_2SO_3) and sulphuric acid (H_2SO_4) respectively. These acids cause irritation of eyes, nose and throat. The highly corrosive H_2SO_4 attacks exposed metal surfaces such as steel rail tracks. The sulphurous and sulphuric acids may precipitate as rain or snow, producing acid rains or acid precipitation. The acid rains destroy crops and wild plants.

Aerosols : These are chemicals which are present in air in the form of vapours or fine mist. Aerosols are used as disinfectants.

They are emitted at high altitudes by jet and contain chlorofluorocarbons (CFCs). Chlorofluorocarbons are used as coolants (in refrigerators and air conditioners). CFCs have a long life. They cause green house effect and deplete ozone layer. Their use is being banned by all countries. CFCs are being replaced by hydro-fluorocarbons (HFC) and hydro-chlorofluorocarbons (HCFC). Related compounds are Polychlorinated biphenyls (PCB). They pass into food chain, act as poison and impair reproductive ability of the birds. In human beings PCM causes damage to liver, vision, central nervous system and change in pigmentation.

Fluorides : These are released during refinement of aluminium, rock phosphates etc. Gaseous fluorides cause necrosis, chlorosis and abscission of leaves etc.

Nitrogen Oxides : They are produced in the atmosphere electro-photo-chemically from nitrogen and oxygen. Biologically they are formed from nitrates and nitrites by denitrifying bacteria. These are also produced due to combustion process of fuel in industries, automobiles, nitrogen fertilizer plants etc. These include N_2O , NO , NO_2 , N_2O_4 and N_2O_5 . The nitrogen oxides form about 10% of air pollutants. Nitrogen oxide act on unsaturated hydrocarbon to form peroxyacyl nitrate (PAN). They are also responsible for forming photochemical smog. Alongwith SO_2 , nitrogen oxides cause acid rain. In the presence of moisture, nitrogen oxides have a corrosive effect on metals, marble and lime stone. The oxides possess mutagenic properties. They also cause eye irritation, respiratory troubles, blood congestion and dilation of arteries.

Hydrocarbons : These are produced naturally (e.g., marsh gas), evaporation from fuel dumps, incomplete combustion of fossil fuels, automobile exhausts, refineries, agricultural burning etc. Methane and ethylene are two common gaseous hydrocarbons. Methane is added by anaerobic decay of organic matter. It is the principle component of gobar gas. Approximately 57,232 tonnes of hydrocarbons are added in Delhi's air annually and from the survey it was found that motor cycles and scooters contribute the maximum amount of hydrocarbons. Benzene is a major constituent

of petrol and automobile exhaust. Ethylene aids in plant senescence, abscission and fruit ripening. Benzene and Benzpyrene are carcinogenic. Hydrocarbons generally cause bronchial constriction, asthma, irritation of eyes etc. At high levels in absence of oxygen methane may be narcotic on man.

Photo Chemical Oxidants : These are produced photochemically by reaction between nitrogen oxides and hydrocarbons producing secondary pollutants like ozone, peroxyacyl nitrates (PAN), aldehydes and phenols. The secondary pollutants formed due to the photo-chemical reactions are called photochemical oxidants.

NO_2	$h\nu$ (light)	$\text{No} + \text{O}$
nitrogen dioxide	→	nascent oxygen
$\text{O}_2 + \text{O}$ oxygen	→	O_3 ozone
$\text{H.C.} + \text{O}_3$ hydrocarbon	→	R. $\text{Co}_2 + \text{R. CHO}$ Aldehyde
$\text{RCO}_2 + \text{NO}$	→	$\text{RCO} + \text{NO}_2$
$\text{RCO} + \text{NO}_2 + \text{O}_2$	→	R. Co: O NO_2 peroxyacyl nitrate

The photochemical oxides badly affect the performance of human. They adversely affect respiratory system.

Ozone : The ozone is a clear, blue gas with a sharp smell. The ozone layer in the upper atmosphere (stratosphere) protects the living organisms from ultraviolet(UV) rays of the sun by absorbing nearly all of them. The ozone formed in the lower atmosphere by photochemical reaction as a result of human activity is harmful. At low concentration, it produces chest pain, coughing and often eye irritation. High concentration can kill both plants and animals. Ozone toxicity of plant is manifested by marking on leaves and leads to premature yellowing and fall of leaves. It leads to discolouration and damage to textiles at 1 ppm. Ozone injures mucous membrane. 16th September, 1996 was celebrated as "International Day for the Prevention of Ozone Layer." It was aimed

to create awareness about the danger of ozone depletion in the stratosphere.

Peroxyacyl Nitrates (PAN) : It causes irritation of eyes and throat, and produces respiratory troubles (asthma, bronchitis, lung cancer) in man. It affects the plant, particularly leafy vegetables such as spinach and lettuce.

Aldehyde : This produces irritation in gastrointestinal and respiratory tracts.

Phenols : They cause damage to liver, lungs etc.

Smog : Smog (Smoky fog) is a thick, dark or yellow fog over a town produced by combination of smoke and fog. It causes glazing, silvering and necrosis of crops. It also produces respiratory problems in humans and reduces visibility leading to accidents. Smog is of two types—Chemical smog (contains particulate matter and SO₂) and photochemical smog (contains pollutants like O₃, oxides of nitrogen, CO and hydrocarbons).

Benzpyrene : It is produced in tobacco smoke. Benzpyrene also results from coal and oil combustion. It occurs in automobile exhaust too. It causes lung cancer.

Ethylene : It is an unsaturated hydrocarbon produced from incomplete combustion of coal, wood, petrol, cigars etc. It causes premature senescence and abscission.

Indoor Pollution : It is caused by combustion of fuels and tobacco smoking. It is responsible for increased respiratory disorders and poor lung functioning.

Particulate Matter : They are added to air by industries and automobiles and by operations such as blasting, drilling, crushing, grinding, mixing etc. Some particulate matter is added to the air by living organisms. It comprises pollen, spores, cysts and bacteria. Particulate matter is of two types: Settable (large particles such as sand and water droplets which quickly settle down in still air) and suspended (very fine particles such as tobacco smoke do not settle at all). They are known as non-settleable particles. The later again classified into 3 categories:

Aerosols - less than 1 mm in diameter are solid or liquid.

Dust - Over 1 mm in diameter and are solid.

Mist- liquid more than 1mm in diameter.

10-15% of the air pollution is caused by particulate matter.

Impact on Livingbeings : The effect of particulate pollutants depends on the size of the particles. Particles larger than 2 mm are trapped in nasal hair and bronchial mucus, whence they are passed out. Smaller particles reach the lung alveoli with inhaled air. Here they may be engulfed by phagocytes or absorbed into the blood and prove harmful.

- (i) Air borne organic materials, such as spores, pollen, bacteria, fungi, fur, feathers produce allergic reactions, bronchial asthma, tuberculosis and lung cancer.
- (ii) Dust, smoke and smog cause bronchitis, asthma and lung diseases. Cotton dust causes lung fibrosis. Asbestos fibres cause lung cancer.
- (iii) The effect of gaseous pollutants depends upon their solubility in water, which allows their diffusion into the tissue.
 - (a) Sulphur dioxide causes drying of the mouth, sore throat and eye irritation. It may damage the tissue by forming sulphuric acid.
 - (b) Sulphur trioxide, nitrogen oxide and carbon monoxide combine with haemoglobin of the blood and reduce its oxygen carrying capacity leading to hypoxia in body tissues. It causes headache, muscular weakness, nausea, exhaustion. Nitrogen oxide impairs the working of lungs by causing accumulation of water in the air spaces. NO, inhalation causes eye irritation, lung oedema, blood congestion.
 - (c) Hydrocarbons are known to cause eye-irritation, coughing, sneezing, drowsiness etc. Benzene is a carcinogen causing leukemia.
 - (d) Lead affects central nervous system and distorts red blood corpuscles.

- (e) SPM penetrates deep into respiration system and cause bronchitis, asthma, cardiovascular problems.
- (f) Benzpyrena of tobacco smoke is arcinogenic.
- (g) Peroxyacyl nitrate causes irritation of eyes and throat and respiratory diseases.
- (h) Phenols damage spleen, kidneys, liver and lungs.
- (i) Chlorofluorocarbons (CFCs) undergo bio-magnification and may reach upto a level of 1400mg/kg of pectoral muscles in sea eagle and 3.5 mg/kg of fat in mother's milk. These impair reproductive activities of animals and damage the liver, CNS, vision etc. in human beings.
- (j) PCBs damage liver and CNS impair vision and change skin pigmentation.
- (k) Ozone damages the mucous membrane at a concentration of even less than 1 ppm.
- (l) Aldehydes cause irritation in gastro intestinal and respiratory tracts.
- (m) Smog cuses respirtory disorder like asthma, allergies etc.

Impact on Plants

- (i) SO₂ causes chlorosis, plasmolysis, membrane damage, metabolic inhibition and death. It does a great harm to forest tree.
- (ii) Fluorides and PAN damage leafy vegetables such as spinach and lettuce.
- (iii) Ozone and hydrocarbons cause premature yellowing and fall of leaves and flower buds and discolouration and curling of sepals.
- (iv) Nitrogen oxides reduce yield of crops.
- (v) Dust, Smoke and Smog reduce sunlight and form a thin layer on the leaves thereby retarding photosynthesis.
- (vi) Lichens are sensitive to air pollution. They are grown as pollution indicators.

Aesthetic Aspects

- (i) Dust and smoke in the air do not allow a clear view of nature's beauty.
- (ii) Foul odours emitted by industries, automobiles, dirty drains and garbage heaps in cities are a great nuisance.
- (iii) Gases like oxides of sulphur and nitrogen alongwith smoke make breathing difficult.
- (iv) The stone of Panthenon in Althens has deteriorated in the past 50 years from air pollution.
- (v) Similarly statue of liberty is corroded from SO_2 and NO_2 and Taj Mahal from SO_2 emitted by Mathura refineries.

Climatic Effect

Carbon dioxide content of the air is increasing due to deforestation and combustion in industries, automobiles and planes and is likely to become double by 2020. This increase is affecting the atmospheric composition and balance of gases, which are among the factors that controls earth climate. Increase of CO_2 may cause rise in atmospheric temperature producing what is called greenhouse effect. Aerosoles deplete the ozone layer in the stratosphere. Thinning of ozone layer would permit more of the harmful ultraviolet rays to reach the earth and may cuse extensive damage to plants as well as animals.

Green House Effect

Raising of temperature by allowing solar radiations to pass in but preventing long wave heat radiations to pass out is termed as green house effect. It was discovered by Joseph Fourier. In a glass house the glass panes, CO_2 and water vapors make the interior warm as compared to the outside. The gases involved in producing green house effect are CO_2 (57%), methane (12%), nitrogen oxide (6%) chlorofluorocarbons (20%) Ozone (near the ground level and water vapour (5%). These are called green house gases. These gases allow the solar radiations to reach earth and warm the same during day time. At night part of heat energy is passed out while the remaining is held back due to green house gases.

Carbon dioxide is added to atmosphere mainly by burning of fossil fuels, volcanic activities and respiration. It is estimated that more than 18×10^{12} tonnes of CO_2 is being produced annually from the fossil fuels only. Not only CO_2 , CFCs and oxides of nitrogen and methane also exert green house effect. CO_2 concentration has increased from 280 ppm in 1800 to 359 ppm in 1994 due to increasing use of fossil fuels and decreasing forest cover. More methane is being released from paddy fields due to intensive cultivation. Combustion of fossil fuels is also the causative agent for higher concentration of nitrogen oxides. The react with hydrocarbons to form ozone. Higher concentration of green house gases is slowly warming up the earth.

The Negative Effects

1. Global warming shall cause partial melting of polar and alpine ice caps that would result in raising sea level. Already the sea level has risen 15cm in the past century. If the trend continues, there is a danger of submersion of large areas e.g., Maldives and six other coral at all countries, several thousand islands.
2. Grain production will be reduced.
3. There will be a shift in rainfall and climatic zones.
4. Deserts are likely to increase.
5. Chances of hurricanes, cyclones and floods will be more.
6. The forests present in the middle latitudes will be wiped out.
7. Several lakes would dry up.

So, UNEP has chosen the slogan "Global warming: Global warming": and since 1989, 5th June is celebrated as World Environment Day. The cost of defense (reduction of gas emissions and research to identify the hardest hit regions and plan of coastal defence) would be enormous.

Depletion of Ozone Layer : Ozone layer is present in the stratosphere (15-50 km height). It is concentrated at a height of 20-25 km. Ozone is responsible for protecting the earth from high

energy Ultra-violet radiations by changing the same infra red rays. It forms a life saving screen as it checks the entry of lethal UV-rays. The depletion of this O₃ layer by human activities may have serious implications and this has become a subject of much concern over the last few years. The first horrifying report of alarming ozone depletion came from British Scientists who reported an Ozone hole in the Ozone layer over Antarctica in 1985.

This, Ozone hole, has grown in size over the years. In 1994 alone, it widened from 129-133 Dobson units. A similar but smaller hole has also appeared over North Pole. Size of the holes varies with the season. Damage has occurred to the ozone layer at other places e.g., it has thinned by 8% in the area over 30°-50°N latitude between 1979-1990.

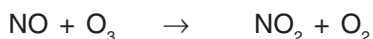
The temperature decreases with increasing altitude in the troposphere (8-16 km from earth surface), while it increases with increasing altitude in the stratosphere (above 16km upto 50 km). This rise in temperature in (Stratosphere is caused by the ozone layer. The ozone layer has two important and inter-related effects. Firstly, it absorbs UV light and thus protects all life on earth from harmful effects of radiations. Second, by absorbing the UV radiation the ozone layer heats the stratosphere, causing temperature inversion. The effect of this temperature inversion is very interesting. It limits the vertical mixing of pollutants, thereby causing the dispersal of the pollutants over large areas and near the earth's surface. That is why a dense cloud of pollutants usually hangs over the atmosphere in highly industrialized areas causing several unpleasant effects.

Thinning of hole in ozone layer allows harmful UV rays to reach parts of earth. It causes skin cancer e.g., in Australia over which ozone depletion has been recorded, 70% of the adults reaching the age of 70 suffer from skin cancer. Beside skin cancer there is a suppression of immune system, increased susceptibility to herpes, high incidence of cataract and dimming of eye sight. Large scale damage also occurs to green producers both in sea and over land. Food supply will, therefore reduce causing famine. A number of land animals are blinded.

Thinning of ozone layer or hole in ozone layer is caused by a number of pollutants. Major pollutants responsible for depletion are Chlorofluorocarbons (CFCs), nitrogen oxides (coming from fertilizers) carbon tetrachloride, halon and methyl chloroform. Chlorofluorocarbons (CCl_3F , CCl_2F_2) have maximum ozone depleting potential or DPD. CFCs are widely used as coolant in air conditioners and refrigerators, cleaning solvents, aerosol propellants and in foam insulation. CFC is also used in fire extinguishing equipments. They escape as aerosol in the stratosphere. In the stratosphere CFCs split up to release chlorine. Chlorine changes ozone to oxygen.



Chlorine seems to play dominating role in depleting ozone layer. A single chlorine atom is sufficient to convert 1 lakh molecules of ozone into oxygen. Chlorine is being emitted into troposphere and stratosphere by large number of rockets being fired into space. Nitric oxides released into stratosphere by jets also reacts with ozone to form oxygen.



World Support

The first global conference on the depletion of ozone layer was held in Vienna (Austria) in 1985 the year, scientists discovered hole in South Pole. This was followed by Montreal Protocol in 1987 which called for a 50% cut in the use of CFCs by 1998. Many countries including India did not sign the Protocol. The three day international "Saving the ozone layer" conference was organized jointly in London in March 1989 by the British Govt. and the UNEP which resulted 37 more countries to support for the Montreal Protocol which was initially signed by 31 countries.

In May 1989 another International Conference on Ozone was held at Helsinki. As many as 80 nations agreed to have a total ban on chemicals that cause ozone depletion by 2000 A.D. The

agreement for CFC elimination by 2000 A.D. is needed as a major step towards environmental protection.

Pollution Control

Air pollution is the big problem of present society. It is the need of the present day to make the social as well as legislative measures to protect the environment. Three types of steps can be taken to control air pollution. Separation of the pollutants from harmless gases, avoidance of pollutants, and conversion of pollutants to harmless materials.

Separation of the Pollutants : This can be done by the following steps.

- (i) Trees should be grown in all available places. The trees use CO_2 and release oxygen. This purifies the air for man and animals to breathe.
- (ii) Certain plants such as *Ficus variegata*, *Daucus carota*, *Phaseolus vulgaris* can fix carbon monoxide and some plants like *Pinus*, *Juniperus*, *Quercus*, *Pyrus* can metabolise nitrogen oxides. Plantation of such species should be encouraged to depollute the air.
- (iii) Sulphur free and lead free fuel should be used for motor vehicles. The exhaust gases from motor vehicles may be cleaned by use of catalytic converters.
- (iv) The current industrial processes may be suitably modified so as to reduce or check air pollution. Control equipments like gravity settling tanks or porous filters and electrostatic precipitators should be installed in factories to minimize the air pollution.
- (v) In factories chimneys should be tall to reduce pollution of air at ground level.
- (vi) Industrial smoke should be filtered before releasing it into the air to remove particulate matter.
- (vii) Use of generators in residential areas should be avoided.
- (viii) Poisonous gases should be removed by passing the fumes through water tower scrubber or spray collector.

- (ix) Reformulate gasoline to save ozone in the atmosphere.
- (x) Control equipment like Gravity Settling chambers, Porous filters cyclone collectors or electrostatic precipitators should be used in the factories to reduce air pollution.
 - (a) Gravity Settling Chambers. They are long chambers where slow moving gaseous stream deposits its heavier and larger particles (larger than 50 μm).
 - (b) Porous or Bag Filters. They are large sized porous bags of polyester, polypropylene, teflon through which dry exhaust emissions are passed under pressure to filter out particulate matter.
 - (c) Cyclone collectors. They contain a chamber in which gas stream with particulate matter is whorled round through tight circular spirals. The particulate matter get centrifuged, collected and removed.
 - (d) Electrostatic Precipitators (ESPs). They are devices where air stream with particulate matter is passed through regions having electrically charged plates so that they drift to an electrically grounded wall from where they can be removed easily.
 - (e) Wet Scrubbers. They separate gases by passing air stream through a fine spray of water.

Avoidance of Pollutants : This is done by following measures:

- (i) Use of automobiles should be minimized.
- (ii) Conventional fuels (Fire wood, coal, oil) should be replaced by electricity or natural gas. These will not emit SO_3
- (iii) Population should be brought under control.
- (iv) Industries should be away from residential areas.
- (v) Pollution free oils should be developed for automobiles.

Conversion of Pollutants : This is done by oxidation in the air or by chemical neutralization of acid and bases.

Recent steps taken to reduce air pollution are:

- (i) The supreme court directed about 168 industries of Delhi,

including big industrial houses such as Birla Textile Mills, DCM Silk Mills, Sri Ram Foods and Fertilizers etc. to shift to those areas by Nov. 1997 which are less hazardous.

- (ii) Since Sept., 1997, the Delhi Government has banned plying of those vehicles which are more than 15 years old.
- (iii) On Sept. 16, 1997 a Montreal Protocol was signed to identify and stop the use of ozone depleting substances. So Sept. 16 is celebrated by international community as Ozone Day.
- (iv) Indian Institute of Petroleum (IIP) has developed new ecofriendly multifuel low air pressure burners in Dec., 1997. These burners would save 10 to 20 percent of fuel over the conventional burners.
- (v) HFC-1340 is a country made ozone-friendly refrigerant chemical deployed by Indian Institute of Chemical Technology (HCT), Hyderabad. It will replace Freon-12 gas which causes depletion of ozone layer.
- (vi) Government of India has made it compulsory for all new cars to be fitted with catalytic converters and stated that unleaded petrol will be available throughout the country by 2000 A.D.

Pollution of Water : Water Pollution is the degradation of the quality of water due to addition of foreign substances (organic, inorganic, biological or radiological) to water or change in its physical property (temperature) so that it becomes a health hazard and unfit for use.

Water is one of the abundantly available substances in nature. It is an essential constituent of all animals and vegetable matter and forms about 75% of the matter of earth's crust. The earth has about 1.35 cubic kilometers of water of which about 97% is found in the oceans. The main source of land water is atmospheric rain. It is estimated that about 27% of rain water flows into oceans and about 73% is evaporated. A little percentage of water enters the soil whose some part reaches the deep zone due to force of gravity and called gravitational water. The upper layer of it called water

table. Surface water usually contains small amount of suspended particles (organic and inorganic) and a number of microorganisms such as bacteria, algae, viruses, protozoas etc. Water becomes polluted when concentration of these increases. Water pollution is a serious health hazard in India. About 50-60% Indian population suffers from water borne diseases and 30-40% all deaths are due to water pollution. Availability of fresh water has declined by 2/3rd in the past 50 years.

Main Reason

Man is the main cause of water pollution. Some pollution occurs naturally too. Soil particles enter water by its erosion; mineral dissolved in water from rocks and soil; animal wastes and dead fallen leaves fall into water sources, decaying of organic matter also pollutes water.

Different Kinds

Water sources (Ponds, tanks, lakes, streams and rivers) receive 6 main types of pollutants: organic wastes, pathogenic organisms, inorganic wastes (chemical and minerals), radioactive wastes, solid particles and heat.

Sources : Different sources which add the pollutants in water are broadly classified into following groups

- (a) Domestic effluents
- (b) Industrial effluents
- (c) Surface run off
- (d) Thermal pollution (waste heat)

Domestic Effluents : It consists of waste water which is discharged into sewerage system. It contains human and animal excreta, food residues, detergents, organic wastes from tanneries, slaughter houses and canning industries, a large number of bacteria and discharges, from other commercial establishments connected to public sewerage system. Municipal sewers contain many kinds of pollutants and a lot of industrial wastes. The sewage is passed into water courses, generally without treatment.

Beautiful Dal Lake of Kashmir has become polluted as raw sewage and other domestic effluents are passed into it from nearby localities, hotels and house boats. Hussainsagar lake (major source of drinking water for Hyderabad) receives some 30 million litres of waste water daily from domestic and industrial sources. Delhi produces 2000 million litres of sewage, half of which is passed untreated in Yamuna. A time will come when the water of Yamuna will become unfit for human use even after treatment. A special feature of this is Putrescibility i.e. decay and decomposition of organic matter present in it due to the presence of bacteria and other micro organisms. Most laundry detergent contain phosphate. People in remote areas often take bath, wash their clothes and animals in the same pond.

Such ponds become heavily polluted. Sewage pollution is due to the presence of coliforms, enterococci, eggs of intestinal worms and pathogens of typhoid, dysentery, diarrhoea, cholera, hepatitis, jaundice etc. Two-thirds of all illness and one-third of all deaths in India are due to water borne diseases caused by sewage contamination.

IWP are indices of water pollution and are calculated by the sensitivity of Daphnia and Trout to organic wastes in water, while faecal pollution is indicated by number of Escherichia coli in water (unit being mpn).

In water organic matter provides nutrition for decomposers, namely bacteria (Escherichia) and Fungi (Mucor, Leptomitus). They break down the organic matter using oxygen in the process. It results in decreased oxygen content. Water having dissolved oxygen (D.O.) below 8 ppm is polluted. It is heavily polluted below 4 ppm of D.O.

Biological Oxygen Demand : It is the amount of oxygen required in milligrams by decomposer micro organisms in five days to complete the decomposition of organic matter present in one litre of water at 20°C. B.O.D. indicates the quality of waste water i.e. degree of pollution pure drinking water should have a B.O.D. less than 1ppm. A weak organic waste has B.O.D. below 1500 mg/

litre, medium organic pollution has B.O.D. 1500-4000 mg/litre while high organic pollution has B.O.D. above 4000 mg/litre.

Industrial Effluents : They are industrial wastes which are allowed to pass into water bodies. The effluents contain heavy metal such as mercury, lead, copper, arsenic, cadmium, zinc and acids and alkalies. Acids and alkalies destroy micro organisms. Some organic pollutants present in effluent are phenol, naphtha, proteins, cellulose fibres and aromatic compounds. Some of the chemicals are carcinogens. Industrial effluents are most hazardous pollutants both on land and water. Main source of mercury is combustion of coal, smelting of metallic ores battery and paint industries cadmium is released from mines, metal, welding, electroplating and pesticide industries. Lead is added by smelters, chemical and pesticide industries.

Arsenic contamination of drinking water was reported in west Bengal in the beginning of 1980's Initially only seven villages were reported to be affected but this number has gone upto 840 by the end of 1997. About two million people are using arsenic contaminated water. The main cause is use of underground water through deep tube wells.

Surface Run Off : Run off is flow of extra water present on the surface into water reservoirs and water courses. Since croplands are provided with fertilizers and fields are sprayed with pesticides, the surface run off from these fields brings heavy loads of pollutants into natural water bodies. Pesticides such as DDT are non-degradable. India alone uses about 100,000 tonnes of pesticides annually. Fertilizers include, nitrates, phosphates and sulphates of potassium. They reach the ground water through leaching or carried to rivers, lakes and ponds. The nutrient enriched water show eutrophication.

Thermal Pollution : It is caused by the production of hot effluents, hot air and hot water. Rise in temperature of air and water to a harmful level due to heat from power plant industries and automobiles called thermal pollution. Hot water is released in all those industries which employ water as coolant. Industries

employing steam also give out a lot of hot water. Hot water kills both plant and animal life in the area of its discharge e.g., nuclear power station located in Kota draws cool water from Chambal river and discharges hot water into it.

Effects of Domestic Effluents and Organic Wastes

- (1) Water borne pathogens cause a number of diseases like jaundice, typhoid, cholera, dysentery etc. The usual method to find out their concentration is by calculating their most probable number (mpn.) According to Central Water Health Engineering Institute, 60 persons out of 100000 die every year due to typhoid, dysentery etc, which are caused by polluted water. Diarrhoea is mostly due to water contamination. It kills 4.6 million children every year.
- (2) Sewage stimulates the activity of decomposer micro organisms collectively called sewage fungus. It contains bacteria (e.g., *Beggiotoa*, *Eschrichia*), fungi (*Mucor*, *Fusarium*) and some algal (*chlamy domonas*, *cladophora* etc.)
- (3) Sewage makes the water turbid, brownish, oily and foul smelling and makes it unfit for human consumption.
- (4) Organic wastes form a scum and sludge in polluted water which becomes unfit for industrial use.
- (5) Detergents present in sewage water contain phosphates some minerals are also released during decomposition of organic matter which stimulates the algal blooming.

Effects of Industrial Wastes

- (1) Compounds like mercury, arsenic and lead are neurotoxic and cause number of nervous disorders.
- (2) Minimata diseases was first reported in Japan in 1952 which appear due to eating of mercury contaminated fishes from the bay Minamata. The victim develop numbness of lips and limbs, impairment of tactile sense, speech and hearing, narrowing of vision, diarrhoea, hemolysis leading to death.

- (3) Mercury inhibits chromosomal disjunction during gamete formation (Ramel, 1974). It therefore, brings about genetic changes.
- (4) Cadmium polluted water brings about nausea, vomiting, diarrhoea, cramps, renal damage. It also caused a disease itaiitai (ouch-ouch) in Japan(1947)
- (5) Lead contaminated water leads to loss of appetite, anaemia, irritability, damage to liver, kidney and brain.
- (6) Excess of nitrates in drinking water cause methaemoglobinemia. In this nitrite enters the blood, combines with haemoglobin and forms methaemoglobin. It reduces oxygen carrying capacity of blood.
- (7) Cobalt contamination causes low blood pressure, bone defects, paralysis, diarrhoea, lung irritation.
- (8) Excess use of fluorides leads to fluorosis. It is characterised by mottling of teeth, weak bones, boat shaped posture and knock knees. A high dose of fluoride (100-200 ppm) causes the retarded growth.

Effect of Surface Run-off

- (1) Excess of nitrates and phosphates from fertilizers are washed into water bodies. It leads to eutrophication.

Eutrophication is the phenomenon of nutrient enrichment of a water body that initially supports a dense growth of plant and animal life. The rapid increased growth of water plants especially algal is called bloom. Bloom generally occurs on the surface. They cut off light from submerged plants. As a result oxygen replenishment decreases inside the water. Night time respiration of animals and plants further decrease the dissolved oxygen. It causes death of a number of animal and submerged plants. Number of decomposers increases which release pollutants like methane, hydrogen sulphide and ammonia which combine to form scum and sludge killing the bloom forming plants. The water body gives foul smell, brown colouration, bad taste and becomes unfit for drinking.

- (2) Excess of pesticides, weedicides into water bodies cause Bio-magnification.

Bio-magnification or biological concentration or biological amplification in the phenomena of increase in concentration of persistent pesticides per unit weight of organisms with the rise in trophic level of a food chain.

Pesticides are the chemicals used to kill plant and animal pests. These include insecticides, fungicides, algicides, rodenticides and weedicides or herbicides. Most of them are broad spectrum and effect, all types of organisms so collectively called biocides. Most of the biocides are non-biodegradable and toxicants. The long range effects of such biocides are a threat to our ecological security. According to person (1985) pesticides related death in developing countries are estimated at 10,000 year and about 1.5-2 million persons suffer from acute pesticide poisoning.

Some of most toxic biocides are DDT (Dichloro-diphenyl trichloroethane), BHC (benzene hexachloride), Chlordane, heptachlor, methoxychlor, toxaphene, aldrin, endrin and PCPs (poly chlorinated biphenyls). Indiscriminate use of the biocides could make them an integral part of our biological geological and chemical cycle of the earth, e.g., if DDT enters a pond, lake, it is taken up by the plants of the pond, then reaches in 200 plankton feeding on plants, then to fish and finally in the body of the bird who eat the fish. DDT concentration continuously increases in successive trophic levels in a food chain. This is bio-magnification or biological amplification. This is the reason why our food grains as wheat and rice and vegetables and fruits today contain varying amount of pesticides which have become their integral part and cannot be removed by washing or other means.

Bio-magnification

- (1) In India, endemic familial arthritis (pain in joints, hips and inability to stand up) appeared in Malnad region of Karnataka due to eating of crabs picked from rice fields sprayed with pesticides.
- (2) DDT interferes the egg shell formation in many birds. The shell remain thin and break by bird's weight during incubation.

- (3) Persistent pesticides are often teratogens and carcinogens besides being poisonous. In higher concentration they cause softening of brain, cerebral haemorrhage, hypertension and malfunctioning of sex hormones.
- (4) Dieldrin is 5 times more toxic than DDT when ingested and 40 times more poisonous when absorbed. Endrin is the most toxic amongst chlorinated hydrocarbons. Endrin rich agricultural wastes killed 5 million fish in one case.
- (5) Excessive spray of hard biocides, sometimes causes an imbalance in prey predator population.

Thermal Pollution

- (1) Warmer water contains less oxygen (14 ppm at 0°C and 1 ppm at 20°C) so thermal pollution causes deoxygenation of water therefore, the rate of decay of organic matter falls down and kills the aquatic animal.
- (2) High temperature also denatures enzymes, increases respiration but lowers down the rate of photosynthesis. Hence there is decreased primary production.
- (3) Trout eggs fail to hatch and Salmon does not spawn at higher temperature.

Pollution of water can be checked or at least minimized by the following measures

- (1) Taking bath and washing clothes directly in ponds, tanks and other sources which supply drinking water should be prohibited.
- (2) Separate ponds should be reserved for the water supply to cattle and other animals.
- (3) Over use of fertilizer and pesticides should be avoided.
- (4) Solid wastes should be recycled where ever possible.
- (5) Hot water should be cooled before release from factories.
- (6) Reverse osmosis in which brackish water is demineralized by pumping it through a semi-permeable membrane under strong pressure.

- (7) Water hyacinth can purify water by taking up heavy metals, such as lead, mercury, cadmium and nickel and some toxic material from water.
- (8) Domestic and farm yard sewage and industrial waste should be suitably treated before reusing then into water. This process can reduce the harmful effect of the wastes. It is given below:-

Treatment of Waste Water

Waste water is the water which has been used for a purpose and cannot be employed again unless and until it has been removed of pollutants or impurities that have crept in during the previous use. Waste water carry a number of pollutants. The two common sources of water pollution are sewage and industrial effluents. All water courses of India are badly polluted due to passage of waste water into them from human settlements carrying untreated sewage and industrial effluent. Central Ganga Authority was established in 1985 to free Ganga from Sewage and effluent contamination. It is planned to install sewage treatment plants for 27 cities on the bank of Ganga to handle about 1,000 million litres of sewage daily before its discharge into river. Ganga Action plant (GAP) was launched in June 14,1986. Similar action plan has been started for cleaning the Yamuna and Gomti rivers in which river Yamuna covers 15 big cities and Gomti covers 3 cities.

Sewage Treatment: The sewage is taken to sewage treatment sites. The treatment occurs in three steps primary, secondary and tertiary.

Primary Treatment : It is also called physical treatment because in this method mechanical screening and sedimentation of undissolved solids in raw sewage (e.g. large lumps of organic matter, sand and silt) is done. It fails to remove any dissolved substances in water. It does not remove pathogens.

Secondary Treatment : It is mainly biological treatment because the organic matter is decomposed with the help of microbes the waste water is then sterilized through chlorination. Secondary treatment consists of two steps, decomposition and chlorination.

- (i) Decomposition of organic wastes. There are two methods for decomposing organic wastes.
 - (a) Trickling Filter Method. In this case, sewage after primary treatment is passed through a thick layer of gravel (small stones). Bacteria consume the organic matter during its filtration. The water that trickles out through the bottom of the gravel bed is much cleaner.
 - (b) Activated Sludge Method. The waste water is pumped into an aeration tank. Here it is mixed with air and sludge (consisting of bacteria and algae). The bacteria decompose most of the organic matter while algae provides oxygen for bacteria. The water which is now almost clear of organic matter still carries large amount of nitrates, phosphates, etc.
- (ii) Chlorination. After decomposition the water is sent by pipes into chambers where it is chlorinated. It kills micro organisms of sewage fungus as well as pathogen contaminants. The water is rich in phosphorus, nitrogen and minerals. It is directly supplied to the field as manured water.

Tertiary Treatment : It is undertaken when water is to be recycled. In this, nitrates and phosphates are removed by precipitation, filtration, aeration and purification methods. The treated water now can be used or released into natural waters.

Treatment of Industrial Effluents : It consists of neutralization of acids and alkalies, removal of toxic compounds by chemical oxidation coagulation of colloidal impurities, precipitation of metallic compounds and cooling of waste water.

Pollution of Soil

Soil supports plant life, which, in turn, supports animal life. Hence soil pollution affects all organisms. Soil pollution can be defined as alteration in soil by addition and removal of materials leading to decrease in soil fertility. Substances which reduce productivity of the soil are regarded soil pollutants.

Types of Soil Pollutants : Many materials adversely affect the physical, chemical and biological properties of the soil and reduce its productivity. These include:

Domestic Wastes : These are discarded materials or useless leftovers. They include waste foods, paper, clothes, leather, bottles, cans, plastics, ash etc.

Industrial Wastes : Both solid and liquid wastes of the industry are dumped over the soil. The waste contain scraps, flyash, dyes, plastics, toxic chemical like mercury, copper, zinc, lead, cadmium, cyanides, alkalies, organic solvents etc. These come from industries involved in manufacture of paper, chemicals, rubber, petroleum, products, cement, sugar, refineries etc.

Fertilizers and Manure : Fertilizers and manure are added to the soil for increasing crop yield. Excessive use of chemical fertilizers reduces soil's productivity by decreasing its bacterial population and increases its salt content.

Pesticides : These are sprayed on the crops to protect them from pests. These include insecticides (BHC, DDT, aldrin endrin), fungicides and herbicides some of the sprayed pesticides fall on the soil and penetrate inside.

Dumping of Human Excreta : and wastes from cow sheds and slaughter houses befouls the land. Human excreta also contains many pathogens which cause many soil borne diseases in plants and animals including man.

Ash : It is a solid or powdery mass left after burning of wood, dung and coal. It contains minerals, some of them in toxic concentrations. The ash, therefore, not only renders the nearby soil unfit for agriculture but also pass a number of heavy metals and other toxic chemicals in water and food chain.

Kinds of Soil Pollution : Soil pollution is of two main types. Positive and Negative.

Positive Soil Pollution : Reduction in productivity of the soil due to addition of some unwanted materials (industrial wastes, pesticides, discarded materials etc.) in the soil is called positive, soil pollution. It caused by:

- (1) Salination of soil. Increase in the concentration of soluble salts in the soil is called salination. It is thus, a positive soil pollution. It result from.
 - (i) Poor Drainage. The salts dissolved in irrigation and flood water accumulate on soil surface due to poor drainage.
 - (ii) Capillary Action. The salt present in deeper strata are drawn up by capillary action and deposited on the surface.
 - (iii) Saline Irrigation Water. The ground in arid regions is often saline. If used for irrigation, it adds salt to the soil.
 - (iv) Parent Rock. The soil formed by weathering of saline rocks is found to be saline.
- (2) Addition of pesticides (DDT, BHC, aldrin, endrin, melathion, pyrethrum) and weedicides in the soil.
- (3) Industrial wastes. These are dumped over the soil.
- (4) Mine dust. This is major source of pollution in mining areas.

Negative Soil Pollution : It is the loss of soil productivity by reduction in its some useful components or by destruction of its top layer.

- (1) Soil Erosion. It is the removal of top fertile soil by agencies like wind, water etc. converting the latter into desert.
- (2) Reduction in Mineral Contents. The mineral contents are reduced due to intensive agriculture, flowing water, faulty irrigation and overgrazing.

Effects of Soil Pollution

- (1) The chemical and pesticides after the basic composition of the soil. This may kill the essential soil organisms which contribute to structure and fertility of the soil.
- (2) The industrial pollutants increase the toxicity level of the soil which proved fatal. In Japan people died of disease itai-itai due to cadmium poisoning of the soil.

- (3) The use of inorganic fertilizers spoils the quality of the soil in the long run. They cause accumulation of nitrates in the soil which may cause cyanosis or blue baby syndrome.
- (4) Mine dust causes many types of deformities in animals and human beings.
- (5) The use of human and animal excreta as manure pollutes the soil besides promoting crop yield.
- (6) Excreta may contain pathogens that contaminate the soil and vegetable crops and affect the health of man and domestic animals.
- (7) Radioactive dust may find its way from the soil into crops, live stock and humans via food chains.
- (8) Excess of chemical fertilizers reduces natural bacterial population in the soil.
- (9) Nitrates of chemical fertilizers cause methaemoglobinaemia in man.
- (10) Soil pollution also causes a number of plant diseases.

Control of Soil Pollution

Control of soil pollution mainly involves the disposal of solid wastes to provide some benefit to society. The various methods are:

- (1) Solid wastes should be recycled. It is treatment of waste to regenerate a resource. Recycling of newsprint and other waste paper helps reduce pressure on forests. Similarly recycled glass, plastics, polythene, metals etc., save a lot of energy as well as original resources.
- (2) An efficient system of disposal should be developed to deal with domestic solid wastes.
- (3) Use of chemical fertilizers and pesticides should be highly judicious.
- (4) The use of bio fertilizer and manures can decrease the need for chemical fertilizers which will reduce soil pollution.
- (5) Proper legislation should be passed and strictly enforced. Stringent laws should be imposed on defaulters.

- (6) Improvement in mining techniques and transport of extracted material can reduce the spread of mine dust.
- (7) Reforestation and plantation can check soil erosion and the advancement of deserts.
- (8) In January 1998, Indian scientists have developed a novel method of decontaminating effluents from pulp and paper industry (e.g., chemical oxygen) using chemical wastes (like hyposludge, alum-sludge and bamboo dust carbon) from the same factory.
- (9) Proper cropping pattern can eliminate weeds and this can exclude the need for herbicide use.

Pollution of Noise

Sound is the main means of communication in many animals including humans. A low sound is pleasant and harmless. Noise pollution is the release of unwanted, irritating and often excessively higher level of sound. A loud unpleasant sound is called noise which produces unpleasant effects on the ears.

Frequency of sound is measured in Hertz or Hz. A frequency of 1HZ means one cycle per second. Human beings have a hearing range of 20Hz to 20000 Hz. The unit of loudness of sound intensity is called decibel or dB with zero as the limit of hearing. Moderate conversation has a noise value 60 dB. Sound becomes polluting noise at about 80 dB and becomes intolerable above 100 dB.

Sources

Noise pollution originates from a number of sources such as:

- (1) Domestic gadgets like mixer, pressure cookers, washing machines, desert coolers, air conditions, fans, vacuum cleaners generators (as high as 100dB)etc.
- (2) Loud speakers (a noise 60-80 dB in morning 80-100 dB in evening.)
- (3) Personal entertainment sources like transistor, radio, record player, T.V. etc.

- (4) Agricultural equipments such as harvesters, threshers, tractors, pump sets etc.
- (5) Utensils.
- (6) Transport vehicles like scooters, motor cycles, cars, buses, trucks, trains, aeroplanes, helicopters. Air ports produce the maximum noise during landing and take off of aeroplanes. Road transport is major of noise pollution in cities and towns.
- (7) Dynamiting of mountains, bulldozers, road roller.
- (8) Defence equipments like aircraft, rocket launching, tanks, artillery etc.
- (9) Commercial establishments such as music T.V., exhaust fans, air conditioners, coolers etc.
- (10) Crackers.

Cause and Effect : Noise pollution affects the power of hearing as well as general health of man. The various affects of noise pollution are:

- (1) Noise affects hearing ability. A continuous exposure of noise of 80 dB impairs hearing by 15 dB. The city noise is generally more than this loudness, therefore, city dwellers are prone to deafness with advancing age. A sudden loud noise may result in rupturing of ear drums.
- (2) Noise pollution may cause increased rate of heart beat, blood pressure by increasing level of cholesterol in the blood.
- (3) Persons affected by noise pollution suffer from gastric spasms, nausea, peptic ulcers.
- (4) Damage to heart, brain and liver has been reported in animals due to prolonged noise pollution.
- (5) Constant high level noise results in insomnia (sleeplessness) and headache.
- (6) Noise also affects the developing embryo mother's uterus and impair the development CNS of unborn babies.
- (7) Noise pollution causes dilation of eye pupil, defective eye sight and colour vision.

- (8) Noise also detracts attention and causes emotional disturbances.
- (9) Noise pollution causes dilation of blood vessels of brain results in headache.
- (10) Noise pollution interferes with our conversation, disturbs concentration and upsets our mood.

Control of Noise Pollution

Three types of measures can be adopted to control noise pollution:

- (a) Reduction of noise at sources
 - (b) Interruption of path of transmission of noise and
 - (c) Protecting the receiver. The following measures can control noise pollution.
- (1) Silence zones should be created around educational institutions, hospitals and residential areas.
 - (2) Noise producing machinery or their parts are covered by sound insulating material or kept in side sound proof-rooms.
 - (3) Noise producing industries, railway stations, aerodromes should be located away human settlements.
 - (4) Radios and transistors should be kept at low volume.
 - (5) All noise producing machines should be replaced by quieter machines.
 - (6) Proper laws should be enforced to check the misuse of loudspeakers and announcement systems.
 - (7) Use of pressure horns should not be allowed in towns and cities.
 - (8) The intense sound produced by jets and other objects should be deflected away from residential areas.
 - (9) Motor vehicle noise on roads can be reduced by planting many rows of trees.
 - (10) Proper lubrication, repair and maintenance of machinery reduce the noise.

Population on Rise

China is considered to be the most populous country in the world. As the population of India is increasing at a rapid rate the time is not very far off when India will become the most populous nation in the world. Increasing human population has created many environmental problem for us and has also caused extinction of several other population. This shows the need for the study of human population.

Population education has been introduced into the educational system of the country to make the students aware of:

- (i) The consequences of uncontrolled population growth.
- (ii) The advantage of small family norm.
- (iii) The growth, distribution and density of population.
- (iv) The relation of population to the standard of life.

The scientific study of human population is called demography at present, the world human population grows at a rate of about 2% a year and it becomes double every 35 years. World population presently is increasing by 2 persons per second, 2,00,000 people every day, 8 million every month and 70 million every year. Such a high growth rate of human population is called. "Pollution Explosion".

India is second most populous country in the world, next to china (1120 millions). According to 1981 census, Indian population was 684 millions while according to 1991 Census, India's population was 844 million, just 160 million short of one billion mark which reached by a turn of the century. The year 1921 is called the big divide because after 1921, India's population began to increase rapidly. Obviously, containing and unchecked growth of population is the most important and urgent problem before India. It has also been found that population growth is most rapid in countries having low per capita income. If we really want social and economic progress it is necessary to have check in population growth by reducing the birth rate.

Population explosion has caused multiple problems of basic fundamental nature. Increase in population not only pollute our natural resources but also exploiting it. In most developing countries the increase in population has caused low standard of living, lack of basic amenities like, food, cloth, shelter. Most of the major environment trends of present and of future e.g. ecological disturbances, environmental degradation which are the result of increase in population is causing serious problems, it is most for each nation to accept its responsibility to plan and manage its own development in a way so as to maintain sustainable balance between its resources and its population.

In Stockholm conference held on global environment in 1972, the then our Prime Minister late Smt. Indira said that increasing population invites poverty and it leads to population increase.

With the increase in population the number of consumers on the earth have increased but the resources are limited thus causing various fundamental problems it is not possible for proper management of land with increase in population. It is great hazard to our environment.

In India there is a great problems of population explosion, creating tension and various other problems. To study this increase from last 90 years, in villages as well as cities, the following birth rate and death rate Data in studies.

Birth and Death Rates in India

Period	Birth Rate	Death Rate	Growth Rate (%)
1891-1901	45.8	44.4	0.14
1901-1911	49.2	42.6	0.66
1911-1921	48.1	47.2	0.09
1921-1931	46.4	36.3	1.01
1931-1941	45.2	31.2	1.4
1941-1951	39.9	27.4	1.25
1951-1961	41.7	22.8	1.99
1961-1971	37.2	15.1	2.21
1971-1981	33.2	12.5	2.7

The above table shows that improvement in medical technology, and more provision and treatment lead to decrease in the death rate and increase in the birth rate. Due to this population is continuously increasing. Population can be controlled if a balance is maintained between birth rate and death rate.

If a comparison is made between the village population and city population (Table Below) with passage of time there is a decline in village population but increase in city population. It is due to migration of people from villages to nearby cities and caused population pressure in the cities and thus causing degradation of environment

Comparison between Village Population and City Population

Year	Village Population	City Population
1901	89.2	10.8
1911	89.7	10.2
1921	88.8	11.2
1931	88.0	12.0
1941	86.1	13.9

Contd...

Year	Village Population	City Population
1951	82.7	17.3
1961	82.0	18.0
1971	81.1	19.9
1981	79.0	21.0
1991	72.9	27.4

In cities the environment is hundred times more polluted due to wastage, garbage, excreta disposal etc.

Density of Population per Kilometer

Year	Population Density
1921	81
1931	80
1941	103
1951	117
1961	142
1971	177
1981	216
1991	267
2001	289

From the density table it is evident that there is increase in population density which indicates that increased population poses serious pressure on the earth.

The Reasons

The major causes that have contributed towards increase in human population is;

Decline in Death Rate : Birth and death rates are two major factors that determine the population growth of a country. The

excess of births over deaths in a year per 1000 in the population is called the growth rate.

Table shows that since the 1st census, a hundred years ago, the death rate has decreased considerably whereas the birth rate has not gone down considerably.

So it is decrease in death rate and not increase in birth rate that has led to the increase in population various factors contributing to the decrease in death rate are:

- (a) Control of diseases
- (b) Better sanitation and community health schemes
- (c) Decrease in infant mortality
- (d) Improvement in agriculture
- (e) Better means of transport
- (f) Better storage conditions
- (g) Protection from natural risks

Besides, there are other factors too, which are responsible for increase in population. These are:

- (i) Superstitions
- (ii) Variation in population measurements
- (iii) Child marriage
- (iv) Illiteracy
- (v) Polygamy
- (vi) Unemployment
- (vii) Lack of communication
- (viii) Low status to women

Consequences of Increase : Uncontrolled growth of population decreases the growth of any country and is also responsible for individual's family problems. Per capita income availability of natural resources and basic necessities of life are adversely affected. These necessities include space, food, employment, education, medical aid, sanitation and essential goods.

- (1) **Space.** To accommodate increasing population, new cities and towns are developed at the cost of agriculture, forests etc. which has caused new problems particularly soil erosion and floods.
- (2) **Food.** Due to increase in population but slower food increase, the people are not able to get adequate and balanced diet and suffer from malnutrition. So people become, anaemic, mentally retarded and less-fit members of the society.
- (3) **Unemployment.** Rise in population has resulted in large scale unemployment. New employment schemes introduced by Government have failed to absorb the fast growing numbers.
- (4) **Education.** Increase in population leads to rush in educational institutions which lowers educational standard, impairs teacher-taught relationship.
- (5) **Medical Aid.** Due to overpopulation it is becoming difficult to provide proper medical facilities to each person by the state Government.
- (6) **Sanitation.** Rise in population leads to increase in pollution of air, water and soil. This seriously affecting the human health.
- (7) **Price Rise.** Overpopulation causes deficiency of basic needs of life so causing hike in their prices.
- (8) **Energy Crisis.** Population explosion accompanied with rapid industrialisation and urbanisation has led to greater demand of already deficient energy sources such as fuel wood, fossil fuels etc.

Affecting Factors

By taking into consideration, the increase in population rate it is concluded that within 12 years about 100 crores of population increased. But in developing countries it is more than that of the developed countries as is evident by the following tables.

Increase in World Population

<i>Year</i>	<i>Populations in crores</i>	<i>Increase % every year</i>
1650	54.50	—
1700	62.30	0.29
1750	72.80	0.34
1800	90.60	0.49
1850	1,23.00	0.72
1900	1,60.80	0.61
1950	2,40.00	0.99
1970	3,63.20	2.57
1980	4,38.40	2.07
1990	5,48.00	2.28
2000	6,25.00	3.03

Increase in India's Population

<i>Year</i>	<i>Populations in crores</i>	<i>Increase % every year</i>
1901	23.08	0.80
1911	25.20	0.59
1921	25.10	-0.04
1931	27.80	1.08
1941	31.80	1.44
1951	36.10	1.35
1961	43.00	2.16
1971	54.80	2.48
1981	68.30	2.46
1991	84.39	2.14
2001	102.70	1.93

The above given data shows that though population of the world is increasing at rapid rate, the population increase in India is more rapid than the world.

Controlling Methods

Population pressure is a serious threat to whole of the earth. It has depleted all the natural resources and decreased the quality of the life. Even on the global level, many policies and programmes have been launched to control population explosion.

- (i) Education. People particularly those in the reproductive age group, should be educated about the advantages of a small family and ill effects of large families and overpopulation. In this line mass media and all educational institutions can play important role.
- (ii) Age of Marriage. The only practicable and direct method to control population is to reduce the birth rate. Demographers explain that postponement of marriage age from 16 years to 20 or 22 years would bring down the birth rate by 20 to 30 percent.
- (iii) Family Planning. Family planning is one of the most effective methods in controlling population at global level. India is the foremost country to launch this programme and in the year 1952 family planning programme had been launched. This could come down the birth rate in India only slightly later different measures were suggested to decrease the birth rate.
 - (i) Literacy rate should be increased.
 - (ii) Involving social organisation so as to make it a people's programme.
 - (iii) Providing more job facilities to the women.
 - (iv) Proper implementation of community health programme.
 - (v) Incentive to the people for sterilisation.
 - (vi) Providing facilities like contraceptives, IUD birth control pills, sterilization etc.

Effects of Environment

As mentioned earlier that environment is effected badly due to the pressure of the population. Increase in population stresses upon the natural resoruces for their fundamental needs. When the natural resources are exploited to unlimited extent, it leads to imbalance in nature. Various effects of population explosion are:

- (i) Non availability of food, shelter, clothes and other fundamental needs.
- (ii) Degradation of quality of natural resources such as air, water and vegetation.
- (iii) Increase in green house gases causing green house effect global warming.
- (iv) Increase in diseases.
- (v) Imbalance in the water, land and oceans.
- (vi) The environmental degradation has more serious consequences.

The Animals

Wild life refers to all naturally occurring plants, animals, micro organisms which are neither domesticated nor tamed. The term “wild life” is generally held to include large ferocious animals such as lions, tigers, leopards, wolves, jackals, elephants, deer, rhinoceroses, crocodiles, whales etc. However, it actually refers to all living organisms, living in nature without the control of man. The term ‘wild life’ was first used by Willian Hornaday in his book “Our Vanishing Wild Life”.

The Significance

Wild life has great importance to mankind due to its many uses:

Ecological Balance : All organisms are so closely interlinked through food chain, food webs, Bio-geochemical cycles that destruction of any link in a food chain may up set the ecological balance in nature e.g., destruction of snakes will increase population of rats, which will destroy crops or killing of carrivoves will increase the population of herbivores which will damage the forests.

Economic Importance : Wild life has following uses:

- (i) Plants form the basis of biotic system as they act as producers in the ecosystem.

- (ii) Plants produce a number of useful products like resin, gums, drugs, tannins, fibres, rubber, vegetable oils, wood, organic acids, dry fruits etc.
- (iii) Plants give oxygen during the process of photosynthesis which is used by aerobes during respiration.
- (iv) Plants decorate our landscapes and provide pleasing greenery.
- (v) They act as habitat for variety of animals.
- (vi) Animals present in the ecosystem act as consumers and help in homeostasis.
- (vii) CO₂ produced by animals in respiration is used by plants in the process of photosynthesis.
- (viii) Animals provide a number of useful products like food, fur, wool, silk, horn, honey etc.
- (ix) Some help in pollination and also in dispersal of fruit and seeds.
- (x) Many animals act as scavengers.
- (xi) Some animals are used for transport and agricultural operations.
- (xii) Some animals play important role in controlling pests.

Gene Bank : Wild life serves as gene bank for improving domesticated varieties used in agriculture, horticulture, animal husbandry and culture fisheries.

Experimental Animals : Monkey, Guinea Pig, Rat and Frog are used as experimental animals in medical research.

Aesthetic Importance : Due to their beauty many birds, variously colourful butterflies, mammals etc. have great aesthetic value to human beings.

Commercial Importance : Wild life is renewable source and is beneficial to mankind in many ways:

- (i) Fresh water and marine fishes are source of food.
- (ii) Ivory of elephants, horns of Rhino fetch large amount of money in foreign market.

- (iii) Fur, wool, leather, honey, lac obtained from animals are sources of trade.
- (iv) Many useful products such as timber, paper, gum, resins tea, coffee, drugs obtained from wild plants.

Reason for Extinction

Extinction refers to disappearance of a species from earth when its last surviving member dies. It is a natural but slow process due to unplanned activities of man. There are a number of causes which are known to cause extinction of wild life:

- (i) *Destruction of Habitats* : Destruction of natural habitats causes the most serious threat to the wild life. It is due to (a) Filling drainage of wet lands (b) Setting up of dams and reservoirs destroys habitats of wild life and prevent sprawling as well as migration of certain fishes (c) Mining, building of roads in ecologically fragile areas (d) deforestation caused by shifting cultivation, fire overgrazing (e) Pollution in water bodies and atmosphere.
- (ii) *Indiscriminate Hunting* : It is of three types: (i) Sport Hunting, Killing animals for recreation (ii) Subsistence Hunting, Killing animals for safety and food (iii) Commercial Hunting. Killing animals for profit through sale of their fur and other products e.g., Dodo (*Raphus cucullatus*), a unique bird of Mauritius, and Cheetah (*Acinomyx jubatus*) the fastest mammal of India have recently disappeared mainly due to extensive hunting. Many species offish, molluses, sea turtles, sea-cows and whales are facing extinction.
- (iii) *Introduction of Exotic Species* : Intentional or chance introduction of exotic species into new islands or countries by man adversely affects the native species. They cause ecological imbalance due to removal of biological control e.g. rabbits and goats introduced into Pacific and Indian Oceans are destroying the habitats of several plants, birds and reptiles. *Periplaneta americana* (American cockroach) is threatening the existence of native oriental cockroach, *Blatta orientalis*. The exotic fish trout (*Salmo*) and bass are

endangering many fish species in USA. Large scale killing of American chestnut tree by an exotic fungus, *Endothia parasitica* (chestnut blight) of China.

- (iv) *Over-exploitation of Natural Resources* : Over fishing, mechanical catching of animal species etc. is a serious threat to the wild life.
- (v) *Economic Consideration* : Highly priced articles or scarce commodities are always in demand and poachers take risk for obtaining the same, e.g., musk deer (*Moschus moschiferus*) and great one-horned rhinoceros (*Rhinoceros unicornis*) in India are being extensively killed for the medicinal importance of their musk and rhino-horn respectively.
- (vi) *Highways* : A number of wild animals are confused and get killed by heavy traffic on highways thus causing decrease in their number.
- (vii) *Lack of Education* : Majority of the people in our country are not aware of the importance of wild life and the consequences of its destruction. Proper education can greatly help in saving wild life.
- (viii) *Official Laxity* : It is the implementation of Wild Life (protection) Act.

Disappearing Species

They are those species which are liable to become extinct if proper measures are not taken to provide them protection, food and proper habitat, so as to realise their full biotic potential. It is estimated that about 25,000 plant species and 1,000 vertebrate species and many invertebrate species are threatened with extinction.

The international union of conservation of Nature and Natural Resources (IUCN, Hq. at Merges in Switzerland) is maintaining a red data book which contains a record of animals which are known to be in danger. A similar red data book has also been prepared for plants. IUCN has identified 3 categories of endangered species on the basis of following characteristics.

- (i) past and present distribution of the species.
- (ii) decline in the number of population of the species.
- (iii) availability and quality of natural habitat of the species.
- (iv) the biology and potential value of the species.

On the basis of degree of danger three categories are recognised:

- (i) *Endangered (E) Species* : These are those species whose number has decreased to an extent that they pose immediate danger of extinction. They are not likely to survive if the factors (small number, deterioration of habitat and abundance of predators) threatening their extinction continue. These include Great Indian bustard, pink headed duck, lion, tiger, leopard, musk deer, one horned rhinoceros etc.
- (ii) *Vulnerable (V) Species* : These are those species whose population is sufficient but the organism is threatened with depletion due to some factor, common vulnerable species in India are Golden Langur, Leopard cat etc.
- (iii) *Rare (R) Species* : These are those species which are very less in number confined to limited area or are thinly distributed over a more wide area. Though these are not endangered presently but may become endangered due to their less number e.g., Snow Loris, Wild Yak, Gharial etc.

Wild Life Preservation

It is the scientific management of the biosphere in such a way that maximum benefit yielded to the present generation while maintaining its potential to meet the requirement of the future generation.

A comprehensive world conservation strategy for judicious use of living resources has been formulated by the scientists from 100 different countries. Some of the steps to protect the wild life are given:

1. Protection of useful animals and plants especially the endangered species both in their natural habitat (in situ) and in zoological and botanical garden (ex situ)
2. Wild relatives of all the economically important plants and animals be identified and conserved in protected areas or reserves.
3. Preservation of critical habitats such as feeding, resting, breeding and nursing of both plants and animal species to promote their growth and multiplication.
4. Resting and feeding places of migratory animals should not be altered or polluted. 4th October of every year is celebrated as World Habitat Day.
5. Proper management of life supporting systems (air, water and land).
6. International trade in wild plants and animals and their products should be regulated by law.
7. Hunting should be regulated only licenced persons should be permitted to shoot animals. Hunting of young animals should not be allowed. Hunting during breeding season of the animals should be prohibited. Hunting of threatened species should be banned.
8. Introduction of Alien species must be controlled so that they are not able to disturb the local ecosystem.
9. Educating the people about the importance of wild life and its conservation.
10. Over-exploitation of useful products of wild life should be avoided.
11. National parks and sanctuaries should be set up to protect wild life and ensure its multiplication.

To prevent further deterioration and extinction of the wild life, conservation programmes are going on all over the world. The national conservation programmes should be coordinated with the international programmes, particularly those of UNESCO (United Nations Educational, Scientific and Cultural Organisation) and IUCN

(International Union for Conservation of Nature and Natural Resources).

Strategy for Protection

India is with various bio-geographical provinces ranging from the cold deserts of Ladakh and spiti to the hot deserts of Thar, from the temperate forests of Himalayas to the tropical rain forests of Kerala, and from the large inland fresh water lakes (wullar and Manasbal lakes in Kashmir, Chilka lake in Orissa, Kolleru lake in Andhra Pradesh) to the vast coastline and coral reefs of Deccan.

Because of diverse climates and physical conditions, India has rich flora and fauna. There are about 75,000 species of animals. To protect and preserve wild life a number of steps have been taken by Government of India.

1. The Indian Board for Wild Life (IBWL) was established in 1952 to look after the country's wild life.
2. Since 1955, wildlife week is observed every year in the first week of October to educate the people about the importance of wild life and need to protect it.
3. In 1972, Wild Life (Protection) Act was constituted which states that:
 - (a) Trade in rare and endangered species has been banned.
 - (b) National parks and sanctuaries should be set up for preservation of wild life by all the states except Jammu and Kashmir.
 - (c) Hunting and trade of the products of useful animals should be controlled.
4. The National Wild Life Action Plan was introduced in 1983-84 which requires rehabilitation of endangered species by captive breeding.
5. Creation of National parks and biosphere reserves started in 1986.
6. Botanical Survey of India (BSI) and Zoological Survey of India established to have wild life protection programmes.

7. Wild life study has been incorporated in the school and college curricula to acquaint the students with the need for preservation of wild life.

Areas of Protection

In situ conservation of wild life is a comprehensive system of protected areas. There are different categories of protected areas which are managed with different objectives for bringing benefits to the society. These include:

- (i) National Parks
- (ii) Sanctuaries
- (iii) Biosphere Reserves

National Parks : A national park in an area strictly reserved for the betterment of the wild life maintained by a national government and where activities such as plantation, cultivation, grazing are not allowed. There are at present 66 national parks in India covering an area of 33,988.14 square kilometers which is nearly 1% of India's total area. Some of the important national parks are given in the following Table:

Some National Parks in India

Name	Location	Important Animals Found
Corbett National Park	Uttar Pradesh	Tiger, elephant, panther, nilgai, deer, crocodile, python etc.
Kaziranga National Parks	Assam	Tiger, one-horned rhinoceros, wild buffalo, elephant, leopard, deer, Python, gibbon etc.
Kanha National Park	Madhya Pradesh	Tiger, panther, boar, deer, nilgai, peafowl, crocodile etc.
Gir National Park	Gujarat	Lion, panther, deer, nilgai, langur, python, crocodile etc.
Desert National	Rajasthan	Black buck, chiikara, great Indian bustard etc.
Bandipur National Park	Karnataka	Tiger, elephant, leopard, panther, deer, langur etc.
Hazaribagh National Park	Jharkhand	Tiger, leopard, boar, gaur, deer nilgai, peafowl etc.

Sanctuaries : A sanctuary is an area reserved for the conservation of animals only but human activities such as cultivation, procuring timber and private ownership right are allowed so long they do not interfere with the well beings of animals. There are some 421 sanctuaries in India covering about 3.2% of geographical areas. Some important sanctuaries of India are given in the following table.

Some Important Sanctuaries of India

<i>Name</i>	<i>Location</i>	<i>Important Animals Found</i>
Jaldapara Sanctuary	West Bengal	Elephants, rhinoceros, tiger, leopard, deer, gaur etc.
Bir Motibagh Sanctuary	Punjab	Nilgai, black buck, deer, jackal, peafowl etc.
Sultanpur Lake Bird Sanctuary	Haryana	Crane, sarus, duck, crocodile etc.
Shikari Devi Sanctuary	Himachal Pradesh	Black bear, snow leopard, flying fox, deer etc.
Dachigam Sanctuary	Jammu and Kashmir	Black and brown bear, Kashmir stag, snow leopard etc.
Nagaring Sagar Sanctuary	Andhra Pradesh	Tiger, panther, nilgai, deer, black buck, fox, jackal etc. ducks, cranes, sand pipers
Chilka Lake Bird Sanctuary	Orissa	Golden plovers etc.
Annamalai Sanctuary	Tamil Nadu	Tiger, elephant, panther, gaur, deer, langur etc.
Manas Wild Life Sanctuary	Assam	Tiger, Panther, rhinoceros, gaur, swamp deer, langur, wild dog etc.

Strategy for Tiger Protection

In our environment smaller micro-organisms to higher organisms are present and they maintain proper balance in food chain. Tiger regulates the food chain. In early 19th century the population of

tiger was 40,000 but today their number has reduced greatly because tiger skin is used for decoration. This made tiger an endangered species. To protect tiger from extinction, Govt. of India started "Project Tiger" on April 1, 1973. At present 21 national parks and sanctuaries are involved in 'Project Tiger'.

The project tiger enabled to raise the tiger population to 4,334 in 1989. In Sept. 1998, the number of tigers in the world is estimated to about 7000.

Biosphere Reserves: A biosphere reserve is a specified area in which multiple use of the land is permitted by dividing it into zones, each for a particular activity.

Zones of a Biosphere Reserve: A biosphere reserve is basically divided into three zones:

- (i) *Core Zone:* It lies in the centre where human activity is not.
- (ii) *Buffer Zone:* Limited human activity is permitted in this zone.
- (iii) *Manipulation Zone:* Several human activities can occur in this zone but ecology is not allowed to disturb.

Reserves of Biospheres

Fourteen biosphere reserves (Table) have been planned in India. The first biosphere reserve established in India was Nilgiri Biosphere Reserve (1986). While Nanda Devi Biosphere Reserve was established in 1988.

Biosphere Reserves of India

<i>Biosphere Reserves</i>	<i>Locations</i>
Nilgiri	Karnataka, Kerala and Tamil Nadu
Nanda Devi	Uttar Pradesh
Namdapha	Arunachal Pradesh
Kaziranga	Assam
Uttarakhand (Valley of Flowers)	Uttar Pradesh

Contd...

<i>Biosphere Reserves</i>	<i>Locations</i>
Sunderbans	West Bengal
Gulf of Mannar	Tamil Nadu
Thar Desert	Rajasthan
Nokrek	Meghalaya
Great Nicobar	Andaman and Nicobar
Little Rann of Kutch	Gujarat
Manas	Assam
North Islands of Andamans	Andaman and Nicobar
Kanha	Madhya Pradesh

Planet of Earth

Land is the solid, exposed surface of the earth distinct from oceans, lakes etc.

Land forms about one-fifth of the earth's surface. It measures about 13,939 million hectares. About 36.6% of the land area is covered by houses factories, roads, railways, deserts and dunes, glaciers, mountains and polar ice marshes, about 30% by forests, and about 22% by meadows and pastures. Only 11% of land area is fit for tilling.

The Surface

It is the top fertile layer of the earth capable of supporting plant growth. It is a dynamic layer in which many chemical, physical and biological activities are going on constantly. It covers about four-fifths of the land area.

“Soil is the most precious thing of nation, region or locality. It is the base on which the human civilization thrives. Among the boundaries of ‘NATURE’ none is more important for the survival of the human race than the soil.”

The scientific study of soil is called pedology. It deals with the origin, formation and geographic distribution of the soil. Soil consists of five components (i) mineral matter (ii) organic matter (iii) water

(iv) air and (v) living organisms. All these components are essential for proper plant growth.

Mineral Matter : Soil is an aggregation of mineral particles of different size and shapes. The assortment of these particles differ from one soil type to another. The mineral particles are derived from the under lying parent rock by its weathering or disintegration. Weathering of rocks involve physical and chemical break down. The former occurs to temperature variations, alternate drying and wetting, microbial activities, action of plant roots and burrowing animals while latter occurs due to oxidation, reduction, hydration, carbonation etc.

The mineral matter in the soil occur as particles of different size and shape. Depending upon size 5 types of mineral particles are recognised gravel (2-50mm²). coarse sand (2-0.2 mm), fine sand (0.2-0.02mm), silt (0.02-0.002 mm) and clay (less than 0.002mm). While gravel and sand particles are visible with naked eyes, the silt particles can be seen with the help of light microscope and the clay by an electron microscope. Gravel consists of stones. Sand and silt consists largely of quartz (silicon dioxide, SiO₂) and are chemically inert. Clay contains mineral salts is chemically active and has great water holding capacity. Soil texture spends upon the proportion in the which the various types of particles are mixed.

The best soil for the growth of the plants loamy soil. A good loamy soil contains 1 part clay, 2 parts silt and 2 parts sand. A clay soil is not good for plant growth because it is impermeable to water. The sand soil is also not good because it can not hold water.

Transported Mineral Particles

- (a) Soil transported by gravity are called alluvial and form mud flows and land slides etc. Most alluvial deposits on the western Himalayas on stabilisation bear chirpine community.
- (b) The soil transported by running water are called alluvial. These occur on out wash plains, flood plains, terraces etc.

The flood plain deposits in Himalayas bear chir, pine, deodar etc. In plains Acacia, Delbergia etc. present.

- (c) Wind blown deposits bear sand which gradually deposits in the form of an arc. It has salt binder plants like prosopis.

Organic Matter : It is formed in the soil by decay of dead plant parts, animal wastes and dead animals, which get decomposed by the action of bacteria and fungi present in the soil. The mineral matter alone called parent earth. They become soil when mixed with organic matter. Organic matter is thoroughly mixed with the mineral matter by burrowing animals like earthworms, centipedes, millipedes, insects etc. The organic matter gives brown colour to the soil. The organic matter of the soil form humus. It is brown in colour, spongy in texture. When present in clay soil it looses the soil particles and make it porous but in sand soil it acts as weak cement to hold the sand particles together so that water holding capacity is increased.

Water : The space between soil particles is filled with water or the source of water in the soil is rain water. After heavy rain most of the water drains away along the slopes called run away water. Some of the water enter in the soil and moves down due to force of gravity called gravitational water which finally reaches the underground water table. Some of the water retained by the soil particles against force of gravity called field capacity or water holding capacity of the soil. Some of the water forms field capacity remains tightly absorbed on the surface of soil particles and is not absorbed by the plants called hygroscopic water. Remaining water fills the interspaces of the soil particles called capillary water. It is the only water which is all the time available to the plants.

Air : The interspaces of the soil particles also contain air. It is inversely proportional to the amount of water. The best soil for the growth of plant is that which interspaces have water and air in equal proportion. Clayey soil is poorly aerated as it contains very tiny pore spaces. This makes it unsuitable for plant growth which require oxygen.

Living Organism : A variety of organisms live in the soil. These include flora (plant) as well as fauna (animals)

- (i) Microfauna. i.e, protozoans visible with microscope. These include Amoeba, Euglena, paramecium etc.
- (ii) Macrofauna. i.e., animals visible with naked eyes. These include earthworms, centipedes, millipedes, insects, termites, snails, rats etc.
- (iii) Microflora. comprising bacteria such as Rhizobium, Azobacter, Clostridium etc.
- (iv) Microflora. includes algae, moulds, mushrooms etc.

Profile of the Soil : Soil profile shows 4 distinct regions called horizons. Horizon A in the top soil. It is darker and of a looser texture than the underlying horizon B. Plant and animal matter collects at the surface of this horizon, forming the litter. Below the litter is the humus, i.e., organic matter undergoing decay by microbial-action. The rest of horizon is rich in organic and mineral contents.

The horizon B has soil particles smaller and usually more compacted than in the horizon A. Minerals brought by rain water from the upper horizon collect in this horizon. The horizon C consists of weathered materials derived from the intact parent rock that forms the horizon D.

Erosion of Soil : Soil is the major and only plant life sustaining resource on earth which continues the flow of energy on the earth. But over exploitation and improper use of this resource by man leads to its depletion. This degradation of soil is mainly due to two factors. Soil erosion and soil pollution.

The removal of top fertile soil from its resting place by various physical agencies like wind, water is called soil erosion.

Water Erosion : It is the soil erosion caused by the agency of water. Water erosion is maximum during melting of snow and heavy rainfall which can not be absorbed by soil. Soil cover and slope of the area determine the degree of erosion. Heavy rain fall directly bombard the soil and churn up the same.

The compaction caused by falling rain drops and water borne soil particles clog all the soil pores. There is no more absorption

of water and it collects on the surface of the soil which moves along with slopes. It is called run off which takes away suspended soil particles and causes soil erosion. Depending upon the form of the lost soil it may be:

Sheet Erosion : Here the removed soil is like a thin covering from large area. This sheet is lost more or less uniformly. It occurs on smooth and gentle slopes. Sheet erosion causes thinning of surface layers of the soil. It gives rise to areas of light colour or galled spots.

Rill Erosion : If sheet erosion occurs with full force, the run off water moves rapidly over the soil surface cutting well defined finger shaped groove like structures, appearing as thin channels or streams called rills. The rills functions as narrow water channel in which flowing water picks up more speed and higher cutting power.

Gully Erosion : This results due to the convergence of several rills (thin channels formed during rill erosion) towards the steep slope, which form together wider channels (grooves) of water, known as gullies. Gullies are either V or U shaped depending upon width they are designated as small and large.

Gullies not only cause the loss of land to the farmers but also cut the field into fragments which can not be ploughed or harvested together.

Wind Erosion : It is the removal of top fertile soil through the agency of wind. Soil erosion by wind is common in dry (arid) regions where soil is chiefly sandy and the vegetation is very poor or even absent. In our country wind erosion affects about 50 million hectares of land, most of which is in Rajasthan. As in water erosion, wind erosion also triggered by the destruction of natural vegetation cover of land by over-felling and overgrazing.

Once the top soil is laid bane to the fury of strong gales, it gets blown off in the form of dust storms and sand storm. Depending upon the whole mechanisms of the soil removal, this may be of the following types.

- (a) *Suspension* : The fine soil particles the size of less than 1mm., get suspended in wind. They are carried as dust. The dust storms contain these particles in large number. These particles are deposited several kilometres away when the wind velocity decreases.
- (b) *Sanitation* : In such arid regions where rainfall is low, drainage is poor, and high temperature prevails, water evaporates quickly leaving behind the salts. Salts are normally chlorides, sulphates, carbonates and nitrates of potassium, magnesium and sodium and chlorides and nitrates of calcium. The major portion of such salty soil is carried by wind in the form of small leaps which is caused by direct pressure of wind on small particles of soil.
- (c) *Surface Creep* : The heavier particles of soil (5-10 mm) that are not easily thrown up by wind are simply pushed along the ground by the striking of the smaller particles. Surface creep is therefore, an indirect movement.

Wind removes away the fine particles from the exposed soils. Only coarser particles of the size of sand remain behind. The process of wind erosion, therefore, makes the soil sandy. The sandy soil is neither chemically fertile nor capable of retaining water. It therefore, becomes highly unstable and liable to shift with the movements of wind. This gives rise to sand dunes which are even more unstable.

Removal of top soil exposes the root system of the plants growing in that soil. They get undergo desiccation and get killed. Many plants get buried inside sand dunes. On settling, wind borne sand particles damage irrigation channels, ponds, lakes and fertile soil. The deposition of sand particles on fertile soil makes the latter barren. This causes the spread of deserts in the direction of wind.

Effects of Soil Erosion

- (1) Soil erosion causes the removal of top fertile soil. The soil exposed after erosion is less fertile as a result vegetation cover of the soil is reduced.
- (2) Erosion on the hill slopes destroy the forest vegetation of the mountain and foot hills.

- (3) With the lost of forest vegetation due to soil erosion, the wild life of the area also gets destroyed.
- (4) Thinning of soil layer reduces the plant growth, minerals and water.
- (5) Crop production is also reduced.
- (6) Total rain fall of the area is reduced because of less vegetation due to soil erosion.
- (7) In the absence of vegetation as rain water is not readily absorbed, it rapidly passes along the slopes. It produces flash floods in plains.
- (8) Soil erosion cause disturbance in air, humidity balance.
- (9) Soil erosion leads to reduced productivity of the land, reduced water availability for irrigation and reduced hydroelectric power during dry period of the year. Hence famine overtakes the area.
- (10) Soil erosion causes the development of deserts.

Conservation of Soil : Soil conservation is the maintenance of soil fertility by preventing soil erosion, protection against fire, waste and misuse, planning judicious use and use of fertilizers. Due to lack of proper conservation methods the vast areas of fertile land have been converted into wastelands. There are several ways of conserving soil.

Biological Methods : They are meant for keeping the soil under cover for maximum period of time. Soil cover, especially, that of living plants, decreases water erosion. Erosion becomes negligible under continuous plant cover.

Biological methods are of three types—agronomic, dry farming and agrostological.

Agronomic Methods : Natural protection by growing vegetation in a manner that reduces soil loss. These are:

- (i) **Addition of Fertilizers :** Density of plant growth is dependent on the fertility, hydration and aeration of the soil. Soil fertility is maintained by the addition of manure and fertilizers. It improves both aeration and hydration. Presence of manure decreases run off.

- (ii) *Crop Rotation* : It is the practice of growing different crop plants in successive years on the some piece of land. It decreases soil loss and preserves the productivity of land. The same crop year after year depletes the soil minerals. This is overcome by culting legumes.
- (iii) *Mixed Cropping* : Two or more crops are grown simultaneously on the same piece of land e.g. Millet, Black gram and pigeonpea the method avoids the risk of crop failure, provides a better use of soil fertility and check soil erosion.
- (iv) *Mulching* : It is effective against wind as well as water erosion. Soil is allowed to remain untilled. It is covered with grasses, straw, leaves, crop, residue and other form of plant litter. Mulches (2-3" thick) reduce soil moisture by addition of organic matter to soil. The covered soil does not come in direct contact with the agencies of erosion.
- (v) *Contour Farming* : It is normally performed on slopes. The land is ploughed at right angles to the direction of slope. It produces alternate furrows and ridges around the slope. Ridges at the same level are known as 'contours' the water is caught and held in furrows and stored, which reduces run off and erosion.
- (vi) *Strip Cropping* : It involves the planting of crop in rows or strips to check flow of water. It may be contour strip cropping (strips planted along the contour at 90° to the direction of slope), field strip cropping (strip planted parallel to each others), or wind strip cropping (strip planted in straight paralleled rows at 90° to the direction of prevailing wind.)
- (vii) *Fallowing* : It is an old method to improve soil fertility and prevent soil erosion. After harvesting of a crop, the land is left untilled for one or more season. But the practice is not possible modern-day India when the pressure on the land is already severe.

Dry Farming : This practice is useful for croplands grown in low and moderate rainfall areas, where ordinary farming is at risk,

crop production, animal husbandry and growing grazing fields are the only possibilities of checking erosion. Method employed differ in different areas. Some of them are following the land, strip cropping, crop rotation, contour farming etc.

Agrostological Methods

- (i) *Retiring the Land* : The land is taken out of cultivation permanently in areas which are prone to heavy erosion, especially on the sloping mountains. The land is ploughed and sown with grasses. Grazing is not allowed in first year controlled grazing is permitted after soil erosion has stopped and the soil becomes stabilized. The grasses use to check soil erosion are cyanodon dactylon, and dactylis glomerata.
- (ii) *Lay Farming* : This aims at to grow grasses in rotation with field crops like Jowar and Gingelly (*Sesamum indicum*), which help in building up the structure of soil, preventing soil erosion and improving its fertility.
- (iii) *Controlled Grazing* : Excessive grazing makes a land barren and the soil particles exposed become dry. The underground roots become weak due to lack of foliage and the soil becomes dry and weak which is easily eroded by wind and water.
- (iv) *Afforestation and Reforestation* : Afforestation is the formation of forest where no forests existed previously. Reforestation is the replantation of forests which have been previously destroyed by felling, fire or over-grazing. In hilly areas deforestation results in reduced frequency of rain fall, increased melting of snow, formation of temporary rivulets in rainy season, occurrence of floods and damage to agriculture and property. Afforestation and Reforestation help to check soil erosion and therefore, the loss occurred through it.

Mechanical Methods : These methods are used as supplements to biological methods. These methods help in increasing water retentivity of the soil, decrease the velocity of run off and prevent soil erosion. These are:

- (i) *Basin Listing* : In this a number of small basin or furrows are constructed along the slopes or contour to retain water which also reduces its velocity.
- (ii) *Levelling* : Construction of small gullies, grooves and undulation in the path of the slop increase chances of erosion. These are filled up and soil is levelled so that water absorption increases and erosion is prevented.
- (iii) *Terraces* : It means the division of sloppy areas into series of small flat fields called terraces by mean of ridges. Because of their step like appearance they are called bench terraces. The terraces slow down the velocity of run off and check erosion.
- (iv) *Ridge Terracing* : These are constructed in those areas where terraces cannot be built. Here small ridges are constructed at a distance of 1-2m throughout the slope for retaining moisture and prevention of soil erosion.
- (v) *Gully and Ravine Control* : To check the formation of widening of gullies by constructing bunds, dams, drains or diversions through which excess run off water channelled. The check dams reduce the rapidity of water flow and are slowly filled up with the deposition of silt.
- (vi) *Construction of Dams* : Floods are the regular- feature of every year in the rivers. Floods are the major causes of soil erosion. This wide spread erosion can be checked by constructing dams. These dams provide water for irrigation and unfertile lands can be converted to fertile ones.

Unfortunately, so far very little effective work has been done in India to combat wind and water erosion. It is estimated that a programme for the control of wind erosion covering 50 million hectares would cost 3000 crores of rupees. This is assuming an average cost of not more than Rs. 600 per hectare to carry out necessary afforestation, grassing and protective measures.

So far roughly about Rs. 300 crores have been spent on soil conservation since the beginning of the plan more than 20 years ago.

Natural Resources

During early time man had to struggle for survival like animals, but now he has become the dominant species in the biosphere. He has achieved this position due to fine combination of some physical features and mental abilities. The special better character which man has developed are:

- (i) Large brain
- (ii) Skilled hands
- (iii) Power of abstract thinking
- (iv) Foresight
- (v) Strong memory

Man's need are diverse e.g, food, shelter, transport, economic welfare etc. Man is able to prepare tools and animals. He can domesticate the animals and can use their services at his will. He has devised a spoken and written language and this enables him to record and communicate his ideas and experiences to other in the form of books etc. Mental capabilities of man have enabled him to explore and understand natural phenomena, and to manipulate the environment to his advantage. Man is more than a mere biological creature as he has a strong desire for comfortable and secure life.

Therefore, he depends more on and draws more materials and energy from the environment than other organisms. He has created a socio-cultural environment which he constituted by skills, efforts, tools and other social bindings.

With the development of human civilization, man has created new artificial ecosystems cities where soil has been covered with concrete and steel. Man also shuts himself indoor, manufacturing weather year round to suit his needs. All this finally changed the biosphere into a human dominated environment called noosphere (noo-mind. sphere-domain). Man has affected the environment from the very beginning nomad to present day civilized i.e., hunting, fishing and food gathering stages. Man converted the self sufficient system of biosphere into a system of natural resources.

The Meaning

The word resource has been defined as:

Any means of attaining given ends or

Means of supplying a material generally held in reserve.

The natural resources are the materials necessary for life and available in the normal environment such as energy, air, water, land (soil), minerals, micro organisms, plants and animals. For man, resources are the substances required for his survival and comforts. These substances are obtained directly from the environment. Infact natural resources are the components of atmosphere, hydrosphere and lithosphere.

The Distinction

1. The natural resources are classified into three main types on the basis of their chemical nature:
 - (i) Inorganic resources viz. air, water and metallic minerals.
 - (ii) Organic resources viz. plants, animals, micro organisms and fossil fuels and
 - (iii) Mixed resources viz. soil which is an inorganic as well as organic resource.
2. The natural resources are of three types on the basis of their distribution:
 - (i) National i.e. confined to national boundaries e.g., mineral, lands.
 - (ii) Multinational i.e. shared by many countries e.g., some rivers, certain lakes, migratory animals.
 - (iii) International i.e. used by all the nations e.g., air, solar energy.
3. With regard to their abundance and availability the natural resources are of two types:
 - (i) Inexhaustible. These are present in plenty and are not likely to be exhausted by human use e.g., air, clay, sand, tidal energy and precipitation. Although air will never become limiting quantitatively but it may become a limiting factor qualitatively if its pollution is not checked.

- (ii) Exhaustible. These are likely to be finished by human use. They are further divided into:
 - (a) Renewable. These are the resources which are continuously consumed by man but renewed by nature. They include water, soil and living objects - crops, forests, domestic animals and wild life. Some of those materials are constantly renewed in nature. Other can be reclaimed or purified and used again and again. The renewable resources are, therefore, not likely to be exhausted. However, they too may be lost by excessive and unwise use.
 - (b) Non-renewable. They are not renewable after use and are not replenished by nature i.e. once used are lost for ever as they are not restored e.g. metallic minerals and non-metallic mineral fuels or fossil fuels—coal, natural gas and petroleum. All substances are regarded as renewable as matter can not be destroyed. However, coal or oil after burnt can not be used again though carbon present in air is picked up by plants. Similarly, iron of a can get rusted on a damp place in lost to us though it remains in the soil. The cycles of these substances are too long for any possible management. Therefore, such substances are said to be non-renewable. Man is making excessive use of minerals and fossil fuels is the industry and automobiles unmindful of the consequences. At current rates all the known global reserves of industrial metals may last for less than a century and those of petroleum and natural gas may exhaust in 15 to 20 years.

The Menace

Advancement in technology has led to increase in population, rise in standard of living and high expectation for better life. All these have created increased in demands on natural resources. A balance exists in nature in the relationship between organisms and their physical environment but due to increased demands and stress on natural resources man has disturbed the balance by

excessive use of natural resources. This led to an ecological crisis and has threatened its existence. The only way to save man kind is the conservation of natural resources.

Preservation of Energy

Conservation is defined as the most efficient and most beneficial utilization of natural resources man should take steps to ensure availability of natural resources for future generation.

- (a) He should use the resources sparingly and wisely to check their depletion.
- (b) He should recover the used resources for reuse as far as possible.
- (c) He should discover new resources to fulfil his requirements.
- (d) He should not pollute the natural resources to keep fit for use.

Roots of Energy

Energy is an important input for development. It aims at human welfare covering household, agriculture transport and industrial complexes. The major energy sources at present are fuel, wood and fossil fuels. Energy resources are renewable as well as non-renewable.

- (I) *Renewable (inexhaustible) Energy Resources*: These are normally bio-mass based and available in unlimited amount in nature since these can be renewed over relatively short period of time. These include fire wood (or fuel wood) animal dung, solar energy, wind energy, water energy etc.
- (II) *Non-renewable (exhaustible) Energy Resources*: These are present in limited amount and take lower period to develop again. If these used unlimited, they are likely to be exhausted one day. These energy resources are coal, natural gas, mineral oil and nuclear power. Since coal, petroleum and natural gas are organic in their origin so-called fossil fuels.

Conventional and Non-conventional Sources: The expansion of energy sources has been directly related with the pace of industrial and agriculture development.

- A. *Conventional Energy Sources:* As most of the fuel wood was used for domestic purposes especially in rural areas so very little of it was available to industrial sector. Coal, already in use in industries, became a highly priced source. It was supplemented by mineral oil. Similarly, in those areas where running water and needed technology was available hydro-electricity became dearer. After world war II nuclear power, another source of energy, was developed. All these sources are known as conventional sources of energy.
- B. *Non-conventional Energy Sources:* As the coal and oil deposits are going to exhaust one day and most of non-renewable energy resource cause environmental pollution so we must conserve the non-renewable conventional sources and replace them by non-polluting renewable sources called non-conventional sources of energy which include urban waste, agriculture waste, energy plantations, animals and human wastes, solar energy, wind energy, tidal energy, geothermal energy etc. these are pollution free, environmentally clean.

Consumption of Energy

The requirement of energy in India are met from both commercial and non-commercial sources. Most important sources of commercial energy are coal, lignite, oil, hydroelectricity and to some extent atomic energy. Non-commercial sources of energy are firewood, agricultural wastes and animal dung.

Coal is a major source of power and an industrial fuel. The estimated coal reserves of India are 123,000 million metric tonnes and four-fifth of them are confined to Jharkhand Bihar, Bengal coal belt out of the total coal produced 75% of it is used by railways, industries and thermal power plants. In 1950-51 crude oil production was 2.5 lakh tonnes while consumption was of 31 lakh tonnes. By

1987-88 production increased to 31 million tonnes and consumption raised to 40 million tonnes.

During hunting and food gathering stages of human civilization, the daily per capita need for energy was just 2,000-4,000 kilo calories. It was mainly derived from food and man used his own muscle power for work. During 19th century, the use of energy of fossil fuel started and the daily per capita energy increased to 70,000 kilocalories.

It is interesting to note that developed countries which share 30% of total population utilise 80% of total energy. India wastes 24% of natural gas due to inadequate facilities. Poor sections of the society use fire wood which results forming deforestation. Action of man gradually diminishing the world's forest resources.

Despite depleting reserves, the demand for fossil fuels is rising rapidly. With only a few years left for depletion of petroleum stringent conservation strategies have to be adopted.

Conservation of Energy : Conservation of energy is very important because there is no life without energy. Conservation is more important than generation of energy. It is necessary to understand the importance of energy so that people get used to conserve energy. With the increase in population, energy need has also increased. In our country, the yearly demand of energy is 12.80% but the production is 9.8%

Conservation of energy means the management, proper use and saving of energy resources. The following measures can be taken to conserve energy resources.

1. Methods should be developed to reduce wastage during extraction and maximise recovery of fuel e.g. shield mining system has improved coal extraction from 35% to 70%.
2. Prospecting should be carried out in new areas to find out the existence of more mines and wells.
3. Lot of fossil fuels occur in deep mines and wells. Techniques should be developed to recover the same.
4. Wastage of fuel incurred during transportation should be avoided through use of better containers.

5. Since oil wells and coal mines are prone to catch fires efforts should be made to prevent it.
6. Fuel use efficiency of equipment, devices and vehicles should be improved with maximisation of combustion.
7. Interfuel substitution is carried out through coal gasification for producing liquid fuel and compressed natural gas (CNG). Methanol can be mixed with petrol to reduce consumption of the latter.
8. Transport system can be made to run on solar energy (e.g., solar cars) and hydrogen fuel. This will save energy and will prevent pollution.
9. Use of oil should be minimised to save it for future use.
10. Over-consumption of oil in automobiles should be checked by keeping the engines in a good working order.
11. Search for new oil reserves, on shore as well as off shore should continue more earnestly and effectively.
12. Use of biogas plants should be encouraged.
13. More fuel, wood trees and shrubs should be grown as a mass campaign.
14. Population growth should be checked to control increase in energy requirement.
15. We should useless energy and avoid wastage of energy light and fans and other home gadget should be turned on only when needed.
16. Public should be educated and about the need and modes for sewing energy.
17. More stress should be laid on alternate resources of energy like hydroelectric, geothermal, Wave, tidal, solar and nuclear.

Other Substitutes

Energy crisis is an important environment problems of today. It is because the world's almost dependence on fossil fuel energy. There is a need to find out alternate energy resources which are renewable and non-polluting such as solar energy, hydroelectric

power, wind power, geothermal nuclear, tidal, dung, garage and wood energy.

Solar Energy : It is an inexhaustible non-conventional energy resources. The amount is quite high but diffuse. Some 200 watts/m²/hr. It has a good prospects especially in tropical countries such as India. Intense efforts have been made to for its large scale harnessing. Solar equipments for space heating, water heating, air conditioning, lighting and cooking have been developed.

The solar energy resources may be converted into other form of energy through thermal or photovoltaic conversion routes. The solar thermal route uses radiations in the form of heat that in turn may be converted to mechanical, electrical or chemical energy. Solar thermal devices like solar cookers, solar water/air heaters, solar dryers have been developed. Govt gives financial help to encourage preparing solar equipments.

By photovoltaic systems solar radiations can directly converted into electricity through silicon solar cells. India is going to set up its first solar power station near Delhi very soon. In Haryana, first solar water heater installed in 1982 at Haryana Breweries Ltd. Murthal. It is able to heat 15000 litres of water per day at a temp, of 65°C. Photovoltaic water pumps are also operating in India. Solar cars are a reality. The only defect in large area required for harnessing solar energy.

Wind Energy : It is an inexhaustible resource which has been used since ages for grinding grains, lifting water and propelling ships, the instruments used for harnessing wind power is called wind mill. A wind mill can be installed wherever a steady wind of more than 25km/hr is available. The force of the wind rotates the wheel which is connected to a generator or turbine for generation of electricity. Asia's largest wind mill complex is located at Lamba (Gujarat) with an installed capacity of 28 MW. The limitation of wind energy is that the wind always does not blow with required intensity all the year round and in all areas.

Hydroelectric Energy : It is virtually an inexhaustible resources. It is produced from the kinetic energy of water falling from a height/

using turbines. It is the most common, non-polluting, commercial source of energy. Many hydroelectric powerhouses have established on many rivers in hilly areas of our country. In large sized hydropower plants, water is impounded in large reservoirs called dams. Dams have been used in preventing floods, regular supply of canal water and development of agriculture.

Nuclear Energy : It is a heat energy released during fusion commission of the atoms of certain elements, such as uranium. Heat energy is converted into electricity. Atomic energy (nuclear energy) is non-renewable resource. A large amount of energy is released from a very small amount of the element (1 kg of Uranium liberates an energy equivalent to 35000 kg of coal). Energy liberation is carried out in nuclear reactors. The nuclear power houses have been set up in Tarapur (Mumbai), Kota (Rajasthan) and in Narora (U.P.) Besides generating electricity, nuclear energy is also used in running submarines, warships, spacecrafts etc.

Geothermal Energy : It is a non-conventional source of energy which is obtained from either hot rocks directly or from water trapped in hot rocks present in the interior of earth. The trapped water is changed into steam which comes out at certain places as hot springs. Steam and hot water coming out of the earth in same places can be used for heating buildings and water and for generating electricity. Already a 5 KW geothermal plant is operating at Manikaran (H.P.) However geothermal resources are limited.

Tidal Energy : It is a small but inexhaustible resource. Tidal waves of the sea can be used to generate electricity. Dual flow turbines can produce electricity both during rising and receding tide. In 1966, France constructed the first tidal electric plant. India has three good sites for tidal power plants - Gulf of Kutch, Gulf of Cambay and Sunderbans. A tidal power plant is established in Gulf of Kutch by the assistance of French.

OTEC : It is ocean thermal energy conversion. In tropical oceans there is a temperature difference of surface water (28°-30°c) and deep water (5°-7°c at a depth of 800-1000m). The

difference can be used to generate electricity. Already IMW plant is operating in area of Lakshadweep Island.

Wave Energy : It is small but inexhaustible resource. A platform with sloping ramp collection basins and low head turbines is required to convert wave power into electricity. A commercial wave powered plant is operating near Bergen, Norway.

Biomass Based Energy (Renewable Resource) : Biomass is the term used for all materials originating from photosynthesis. Over 3000 million tonnes of organic wastes are formed annually in India, out of them some 1650 million tonnes are animal dung, human night soil, slaughter house waste, cannery wastes etc. The rest are crop residue, forest residue, garbage and overgrowth of aquatic plants. Organic wastes are used to prepare manure, dried or directly burnt as fuel. Biogas plants yield both fuel gas and manure.

- (i) Dung cakes. A large quantity of animal dung in rural areas is converted into cakes and dried. The cakes are used for heating and cooking at homes in villages and small towns.
- (ii) Biogas (Gobar Gas). Biogas is methane rich fuel gas which is produced as a product of anaerobic breakdown and fermentation of biomass. Animal dung is used to produce biogas. India has a large population of domestic animals from which about 200 million tonnes of wet dung is available. It is mixed with other organic wastes. Water content is made 90% at which most methane bacteria are active. The organic wastes are dumped in pits connected with gas storage tank. Biogas is stored in storage tank from where it supplied for cooking, heating or other purposes. The residue left forms a good manure.

Wood Energy : It is a renewable resource. Fuel wood is the most common source of energy in villages of India use of wood as a fuel is fast depleting the country's tree and forest wealth. Deforestation is causing soil erosion and floods. Energy plantation is growing of fire wood trees on non-forest, non-agricultural parts of land.

Energy Cropping : It is renewable resource which consists in growing crops from which alcohol and other energy fuels can be obtained e.g., potato, sugarcane, maize, Tapioca. Alcohol can be used as such or mixed with petrol.

Petroplants : They are renewable energy resource. These are those plants having large amount of latex with long chain liquid hydrocarbons e.g. Jatropa, Euphorbia etc. Growing petro-plants is part of energy cropping.

Resources of Land : Land is solid exposed crust of earth which occurs in 27% of the area occupying 133.93 million hectares. In India agriculture occupies nearly 43% land, forest 23%, pastures 4% and human habitations 8%. A judicious land used is important, otherwise economic disaster and ecological crisis can overtake human population any time.

Land Use Planning and Management

1. A land classification and capability map be prepared with the help of scientific survey and remote sensing method.
2. Land should be classified into types for agriculture, pastures, forests, slopes, marshes, swamps, barren, rocky, sandy etc.
3. Projections be made for both short term and long term requirements of land for different purposes like agriculture, aquaculture, water reservoirs, forestry, grazing, human settlements, industries, road etc.
4. Legislation should be enacted to control land use. Fertile agriculture land should not be lost to non-agricultural purposes.
5. Erosion and landslides should be prevented in hills by taking appropriate afforestation measures and soil conservation techniques.
6. Forest land should not be encroached upon.
7. Only barren and waste land should be used for building industries, residential complexes, dams and roads.
8. Solid wastes of cities and towns should not be dumped on leave fertile soil.

Resources of Soil : Soil or upper fertile part of earth's crust supports life system on land. However it is prone to erosion and loss of fertility. There are several factors to cause loss of soil fertility and erosion of soil.

Reduction of Soil Fertility

- (i) Over cropping withdraws most of essential minerals from upper fertile layer of the soil.
- (ii) Non-rotation of crops causes efficiency of particular minerals.
- (iii) Leaching of minerals.
- (iv) Overgrazing.
- (v) Precipitation of minerals due to change in pH.
- (vi) Non-availability of organic wastes.

Restoration of Soil Fertility

- (i) Stoppage of over cropping.
- (ii) Rotation of crops.
- (iii) Leaving the soil uncultivated for 1 -2 years.
- (iv) Addition of manure and compost.
- (v) Green manuring.
- (vi) Addition of suitable fertilizers.
- (vii) Avoiding irrigation soils with brackish water.
- (viii) Reduction of soil salinity through leaching of salts.

Resources of Water : Earth is a water planet with 77% of its surface covered with water. Water is an inorganic and renewable resource which is an essential component of all living beings and habitat of several organisms. Water circulates between earth and its atmosphere. Water is of three types fresh brackish and marine.

Fresh Water Resources : Fresh water constitutes only 2.7% of total water content of the earth. Out of this 77.2% is stored in glaciers and ice caps. And 22.4% is ground water and solid moisture. Remaining 0.36% is found in lakes, rivers, streams and swamps etc. The ultimate source of freshwater in rainfall India receives about 2750 km³ of rainfall every year. About 600 km³ seeps into ground

while 900 km³ water evaporates. Ground water is major source of fresh water. It is neither used by plants nor exposed to evaporation. However it can be pumped out.

The Uses

1. Fresh water is used for drinking by human beings. It is also used in cooking, washing, bathing, disposal of sewage.
2. Maximum water is consumed in agriculture.
3. Industries use a large amount of water for cooling, heating and other purpose.
4. Impounding of water and generation of electricity.
5. Water ways are used for inland transport.
6. Construction of buildings.
7. Rearing offish and other aquatic organisms called aquaculture.

Fresh water resources facing a number of problems due to:

1. Unequal Distribution. Though 113 trillion m³ of rain water falls annually on earth but water availability is not same everywhere.
2. Increasing Water Use. Since 1950, per capita use of fresh water has trebled in India. ‘
3. Growing Cities. As all cities are growing very fast the demand of water is also increasing.
4. Depleting Ground Water. Due to excessive use of water table has lowered at number of places.
5. Agriculture. In India irrigation is assured in only 45% of the cropland. The remainder has to be provided with irrigation water.
6. Waste Water. A lot of waste water is produced by industries and domestic users which is passed into water bodies causing pollution.

Management and Conservation

- (i) Treatment of waste water. The waste water must be rid of its inorganic and organic ingredients through primary and secondary treatments.

- (ii) Use of treated waste water. The treated water should not be passed into rivers, lakes but should be used for irrigation.
- (iii) Drinking water. For a good management of fresh water resource, there should be proper arrangement for supply of drinking water.
- (iv) Afforestation and reforestation. Water availability-increases if hills, watersheds, catchment areas and slopes are covered by vegetation.
- (v) Impoundments. Dams and reservoirs built upstream or downstream can help reduce intensity of floods, make water available to rivers and canals.
- (vi) Reducing over consumption.
- (vii) Linking river systems. This can help send water from a region of surplus to the area of scarcity.

Resources of Oceans : Oceans are the largest reservoirs of water having over 97% of total free water and occupying 70% of earth's surface. Oceans produce more biomass than the land, function as heat bank and help maintain atmospheric balance of carbon dioxide by absorbing the extra one.

As the food and energy available on land is continuously decreasing, scientists attention has been diverted towards oceans which can be used in the following ways:-

- (i) As source of food and other edible animals mainly fishes.
- (ii) As a source of edible sea weeds such as many brown algal (kelps) etc.
- (iii) For the production of useful products like algin, agar, carrageenan, diatomitic etc.
- (iv) For generating power from tides.
- (v) For extraction of common salts.
- (vi) Planning floating cities on ocean surface is under way.
- (vii) To build shore terminals for ships etc.
- (viii) It is used for commercial navigation and shipping.
- (ix) Ocean floor contains polymetallic nodules commonly called manganese nodules.

Problems

- (i) *Silt* : Over 3000 million tonnes of silt enters the sea from land through rivers.
- (ii) *Wastes* : Towns, cities and industries situated on the sea coast pass their effluents, sewage and garbage in sea.
- (iii) *Toxic Wastes* : There is a tendency to dump toxic wastes in sealed containers deep in sea which soon leak and release the waste.
- (iv) *Eutrophication* : Due to pouring of wastes in sea, eutrophication, (bloom forming algae) occurs which are toxic and kill the animals.

Management and Conservation

- (i) *Treatment of Wastes* : Waste and waste water should neither be dumped directly in oceans nor in rivers. They must be treated.
- (ii) *Oil Slicks and Spills* : They should be immediately cleaned.
- (iii) *Fish Catch* : It should be regulated to prevent reduction in fish population.
- (iv) *Mariculture* : It should be undertaken on large scale but only for providing food but also marine products like pearls.

Mineral Resources : They are inorganic substances obtained or mined from earth's crust. Minerals were deposited only once during the cooling of earth's crust. Fresh deposits cannot occur except through volcanic eruption. An orebody is an area in the crust where the minerals occur in such a concentration that it can be economically exploited. The amount of minerals found in an ore is called resource. The various steps involved in minerals utilisation are:

- (i) The mineral extraction.
- (ii) Conversion of minerals into bulk metal, ceramics and chemicals.
- (iii) Manufacture of public utility goods such as medicines, metallic structures, household utensils and pesticides.
- (iv) Their return to environment as waste refuse.

Mineral Conservation

- (i) *Mining* : Wastage during mining should be minimised.
- (ii) *Poor Mines* : Techniques should be developed to extract mineral from mines of low quality.
- (iii) *Transport* : Wastage during ore transport should be prevented.
- (iv) *Purification* : It involves a lot of wastage which should be reduced to minimum.
- (v) *Effluents* : Areas of all minerals contain smaller quantities of other minerals. They should not be allowed to go waste but reclaimed.
- (vi) *Recycling* : It is recirculating a material recycling reduces pressure on mining. It is also cheaper because of lesser energy requirement.
- (vii) *Substitution* : It is replacement of a mineral with another in some of the uses.

The Forestry

Forests are self-sustained wooded tracts with biotic community dominated by trees forming a sort by canopy. India gave birth to Gautma Buddha, in a sacred grove of “SAL Tress” dedicated to the Goddess “LUMBINI.” He achieved salvation under a pipal tree forest in a peculiar organism of unlimited kindness and benevolences, that makes no demands for its sustenance and extend generosity through its products of life activity.

Area of Forest

India has a very rich Flora and Fauna much of which is present in forest area. The flora and Fauna of a forest are inter dependent on each other. The plant wealth of India’s forests are made up of about 45000 species of trees, shrubs, herbs, creepers and climbers which account for about 12% of global plant wealth. Indian forest contain 7500 species of animals and as many as 60,000 species of insect pests.

The forests are complete ecosystem consisting of two components abiotic and biotic i.e. both non-living and living components.

Abiotic Components : The non-living factors prevailing in an ecosystem from abiotic components,

1. Water - It is a complex mixture of many compounds and gases. Mainly it is formed of two molecules hydrogen and oxygen. It forms 71% of the earth's surface and represents the most extensive habitat for the organisms. It helps in growth of the plants.
2. Soil - It is uppermost crust of the earth which is rich in organic and inorganic matter. It sustains the life of the plants on the earth. Plants absorb essential nutrients from the soil-
3. Climate - It plays an important role as it influences the dense growth, high yield and stimulates the other micro organism to form the humus. Suitable climate of the region affects the forest canopy and increases forest products. It includes.
 - (i) Light - It provides solar energy to the ecosystem for heating and photosynthesis. Besides photosynthesis, light controls morphogenesis. Photoperiods influence leaf fall, appearance of new leaves and flowering in plants.
 - (ii) Temperature - Suitable temperature stimulates the rich growth of plants and transportation rate in which the plants give out excess water into atmosphere in the form of vapours. Most organisms survive a temperature range of 0° to 60° C less.
 - (iii) Precipitation - It is the process of condensation of water vapour which evaporate in the atmosphere through transpiration of forest trees. It helps in the formation of clouds, snow, hails etc.
 - (iv) Humidity - Transpiration is inversely related to humidity. Humid areas have abundant dense plant, growth with numerous animals and epiphytes. Humidity maintains the soil moisture which helps in improving the quality of forests.
 - (v) Wind - It controls weather, transpiration, pollination and dissemination of propagules.
 - (vi) Atmospheric gases - These include oxygen, nitrogen and carbon dioxide. The carbon dioxide is used in the

process of photosynthesis. Nitrogen increases the fertility of the soil and oxygen is used for respiration thus, play important role in maintaining forest ecosystem.

Biotic Components : The living organisms present in the forest form the biotic components. These include plants and animals. These are respectively called producers, consumers and decomposers.

- (i) Producers - They are the plants in the form of grasses, herbs, shrubs and trees. These synthesise their own food by the process of photosynthesis. The inorganic material required are obtained from the forest ecosystem.
- (ii) Consumers - These are mainly the animal which are unable to synthesise their food. Therefore, they take other organisms or parts of organisms. These are further divided into:
 - (a) Herbivores (Primary Consumers) These are the animals which feed on the green plants only e.g. deer, goat, rabbit.
 - (b) Carnivores (Secondary Consumers) These are animals which take herbivores e.g. frogs, snake, wolf.
 - (c) Top Carnivores (Tertiary Consumers) These are largest carnivores which feed on small carnivores e.g. Lion.
- (iv) Decomposers - These are mainly bacteria and fungi, which obtain their food from organic materials of dead producers and consumers.

The Significance

Forests are invaluable wealth of a country and a renewable natural resource. They are beneficial to man in several ways:

1. Forests are source of wood which is used as timber. Timber is the basic material for building houses making furniture, railways sleepers, sport goods, boats, ships etc.
2. The forest provide fuel in the form of wood for cooking and keeping warm. Over 1500 million people use wood as a

source of energy. Over 1000 million m³ of wood is used as fuel in the world. In S-E. Asia fuel wood provides 42% of the total energy requirements. It is 58% of the total in Africa.

3. The forest provide food to the tribes in the form of tubers, roots, leaves and fruits.
4. Forest provides a large number of important products such as essential oils, (Kas sandal wood), natural camphor (Laurel tree - *Lauru nobilis*), tannins, resins, gums, dyes drug, spices, bidi wrappers (tendi leaves), soap substitutes like ritha and sikakai, lac, honey, wax, silk etc Horns hides, musk and ivory are provided by forest animals.
5. Bamboos form the poor's man timber. They are used in carts ropes, roofing, flooring, scaffolding etc.
6. Forests keep the environment cool through increasing humidity of the atmosphere by transpiration which increases the chances of rainfall.
7. The fertility of the forest soil increases by dead fallen leaves which decay and form humns.
8. Forests maintain oxygen contents of the atmosphere.
9. Forests reduce atmospheric pollution by using carbon dioxide in the process of photosynthesis.
10. Forest trees provide shelter to a number of animals such as insects reptiles, birds, mammal.
11. Forest prevent soil erosion by:-
 - (i) The roots which firmly binds the soil,
 - (ii) Their fallen leaves which decrease the speed of water flow,
 - (iii) Their trees which decrease the velocity of wind to prevent dislodging of the soil particle.
12. Forests have aesthetic importance as they simulate art of literature and music.
13. The humus of the forests floor acts s a giant sponge which

absorbs large amount of water. This regulates the water flow in streams, springs, wells and rivers.

Covered Area : According to Brewbaker (1984) total forest area of the world in 1900 was nearly 1000 million hectares (mha). By 1975 it was reduced to 2890 Mha and if this continues like this by 2000 A.D. it would be merely 2370 Mha. In India, nearly 80% of the country was covered with forests around 3000 B.C. Waves of migrants came to India, many from treeless countries and changed the whole landscape.

There are no reliable statistics of forest cover in India. However according to Central Forestry Commission (1980), there are only 74.8 Mha of the land area under forest cover which forms about 22.7% of the total land mass of India. It has increased to 75.23 Mha (22.96%) in 1993.

In India there are 16 types of forests on the basis of geographical, climatic and edaphic conditions and their species composition. The most common in the tropical dry deciduous (38.7%) followed by tropical moist deciduous (30.9%) type . These two types of tropical deciduous forests contribute to the bulk (69.6) of the forest area in India.

As indicated earlier, according to CFC (1980) the forest cover in nearly 22.7%. However this is contrary to the general belief that effective forest cover is substantially low and that the forest wealth is deteriorating at rapid rate. Maximum damage is suffered by closed forests, which are more valuable from ecological and economic view points. We cannot afford depletion of these forests. The rapid decline of forests were:

- (a) Overpopulation
- (b) Deforestation

Problem of Deforestation

Deforestation is deterioration, reduction or removal of forest cover. It is the main cause of soil erosion in India. It is estimated that forest cover has declined from 7000 Mha in 1900 to 2890 Mha in 1985. It is expected that by 2000 A.D. forest cover will left only 2370 Mha. The reason for deforestation are given below.

Causes of Deforestation

1. Population Explosion - Population growth poses serious threat to the forest. The forests are the basis needs of everyday life as they provide us food, shelter and raw material for other essentialities but these forests deforested for fulfilling the increasing demands of over population like clearing of forests for agriculture, industries and urban area etc.
2. Fires - Fire is worst enemy of the forests. Forests fire destroys adult as well as young trees and even seeds and useful fauna of the forests. Animal like is also lost and there is a danger to human life too in a forest fire.
3. Pests - Certain pests cause much damage in the forest. These either eat their leaves or bore into their stem or spread diseases.
4. Industrial Development - Industrial development although increases the economy of the country, but the basic raw material for these are obtained by the forests and ultimately growing industries for fulfilling their requirements started over exploiting the forests.
5. Grazing and Growing Mammals - These animals trample the seedlings or young plants, then destroy the leaves on the lower branches of tall trees and finally damage their trunks and roots.
6. Agriculture Expansion - Agriculture expansion means to convert the forest land area which are more fertile into agricultural areas to fulfil the crop necessities of the people of the country. Shifting cultivation also leads to deforestation in which a patch of forest land is cleared through lopping and burning the remainder. The ash is mixed in the soil. The cleared land is cultivated for one year and next year that land is left bared and another forest area cleared. This type of cultivation is called Jhum in north-eastern region, Podu in Andhra Pradesh bewar or dahza in M.P. Every year about 5 lakh hectares of land are cleared for shifting cultivation.

7. Hydroelectric Projects - Dams, reservoirs and hydroelectric projects submerge large forest tracts, killing all plants and animals of the area.
8. Quarrying and Mining - In forested and hilly areas mining and quarrying are extremely harmful as they spoil vegetation over large areas.
9. Short Term Policies - Short term policies made by our Government i.e. five year plans also adversely affect the forest areas. It is easy to cut the forest areas in five years but not easy to grow in such a short tenure. Thus these policies play significant role in deforestation.

Effects of Deforestation

- (i) Increased chances of soil erosion.
- (ii) Floods and draughts become more frequent.
- (iii) Man deprived of benefits of trees and woodland animals.
- (iv) Increased chances of reduced rainfall but more dust storms.
- (v) Extinction of forest dwelling species.
- (vi) Economic life of forest dwelling people is adversely affected.
- (vii) Pattern of rain fall is changing.
- (viii) Scarcity of timber, fuel wood etc. Shortage of fuel wood forces people burn animal dung which otherwise have been used as manure. This reduces soil fertility.

The Preservation

It is the development and management of forests in such a way to improve climate and water flow, prevent soil erosion and to provide optimum sustainable yield both for the present and future generations. The following steps can help conserve the forest wealth.

- (i) Economically utilization of timber to prevent wastage.
- (ii) The wood fuel should be supplemented with alternative source of energy such as biogas.

- (iii) Afforestation and reforestation should be undertaken. It is the development of forest where they did not exist in past (afforestation) or where they had been destroyed previously (reforestation). Afforestation should be done in areas unfit for agriculture, along highways and rivers, around playgrounds and parks and in spacious grounds. A special function of tree plantation, Van Mahotsava, is held each year in our country. In afforestation, native species should be preferred. Exotic species should be grown only on selective basis. NAEB (National Afforestation and Eco-development Board) looks after afforestation, tree plantation, restoration and development of ecologically fragile area.
- (iv) Forest fires should be controlled through modern fire-fighting equipments.
- (v) Using chemical and biological methods pests and diseases of forest trees should be controlled.
- (vi) Grazing should be regulated and discouraged.
- (vii) States forest policy should be adopted within overall frame work of National Forest Policy of 1988 which states that one third of total geographical area of country should be under forest cover.
- (viii) Financial assistance to forestry sector should be increased as it was only 1.03% of total plan out lay in 7th five year plan and was further reduced to 0.94% in 8th five year plan.

Management of Forests

It involves the improvement of our forests to ensure regular supply of useful plant products. There is requirement for improving many forest plants genetically for better yield, quick growth, resistance to pests and pathogens. It involves the following measures.

- (i) Improvement Cutting - It involves cutting of all old dying trees, trees damaged by storms and animals, diseased trees and crooked trees.

- (ii) Selective Cutting - It is the cutting of timber trees when they are fully matured. It is better to remove the less vigorous trees for timber and allow the others a chance for normal growth.
- (iii) Forest floor should be quickly cleared off from fallen tree and broken branches.
- (iv) Overcrowding of trees in the forest should be avoided.
- (v) Afforestation Programmes.

Many afforestation programmes are undertaken by our government which are of three types.

Social Forestry Programme (1976) : It was started in India in 1976 by NCA (National Commission on Agriculture). It involves the afforestation on public and common land for fuel wood, fodder, agricultural implements and fruits for the benefit of rural community. The programme is aimed at reducing the demand on existing forests. The plants selected for social forestry vary from place to place. The important ones are Albizia, Moringa, Delbergia, Acacia, Casuarina, Tectona, Zizyphus, Morus etc.

Agro-forestry Programme : It is growing of multipurpose trees, shrubs, horticultural plants and forage plants alongwith crops. It is aimed at reviving the ancient practice of using the same land for fanning, forestry and animal husbandry.

Urban Forestry Programme : It is aimed at growing of fruit, flower and shade bearing shrubs and trees in urban areas along roads, in private compounds and in common parks. Forest conservation Act, 1980 was enforced to check indiscriminate deforestation.

Chipko Movement : Just as man has important organ for breathing same is the case with earth. To save important part of the mother earth some people became conscious and started opposing the selfish people who not only destroyed environment of the earth but also destroyed themselves as well as other organisms. Chipko Andolan is similar movement in which people opposed the cruelties of man on the forest or nature. This Chipko Andolan started in the year 1972 in the upper reaches of Uttar

Pradesh Himalayan region, Tehri Garhwal. Alaknanda valley faced unprecedented flood due to degradation of forests on the hills by the contractors. The menfolk opposed this large scale deforestation but never got success. The real movement started in March 1973 in Gopeshwar in Chamoli district when a sports goods factory of Allahabad was to cut ten Ash trees near the village Mandal. The local people prevented the same by hugging the marked trees (hence chipko). The same was repeated later in Rampur Phata in 1974, women led by Gaura Devi successfully prevented felling of forest trees near village Reni.

The movement spread slowly to all nearby areas and outside by Chandi Prasad Bhatt of Gopeshwar and Sunder Lal Bahuguna of Silyara in Tehri region. Sunder Lal Bahuguna who is now a world famous figure on eco-protection conducted a peace march of about 3000 km in this hilly region to protest against the felling of trees and to prevent the construction of hydroelectric project in the silent valley region in Kerala. Such movements will help to preserve forests for future India.

The Chipko movement succeeded and following are the results of this movement.

- (i) Contractor system abolished by the Government.
- (ii) Uttar Pradesh Forest Development Corporation department formed which works for the welfare of the hilly areas and the population residing there.
- (iii) It slows down the process of deforestation.
- (iv) It created awareness amongst the people of not only U.P. but of other states.
- (v) It enlightened people about the necessity of ecological balance in nature.

The Settlements

Habitation means the specific area or settlement in which the living organisms live e.g. land, water, forest etc. These provide habitat to various living organisms. The impact of urbanisation and development on the indoor environment is critical for living systems.

Habitation in Cities

Urbanisation is set to be quiet revolution in the Third World that has escaped the attention of most policy maker. With only 27% of India's population living in urban areas, it is often said that India lives in its villages. According to an estimate over 50% of India's population will be living in urban areas by the year 2015 and there will be more than 50 cities with population of one million and above.

Urbanization, no doubt, has a positive impact on income levels, employment and production economics, but it has brought a number of problems such as shortage of housing, inadequate water supply, sanitation and waste disposal facilities, congestion, traffic problems, air, water, noise, vehicular and industrial pollution and in general, an unsafe social environment.

The overall quality of urban environment is deteriorating day

by day with the largest cities reaching saturation points and unable to cope with the increasing pressure on their infrastructure. Cities are known as engines of economic growth because they contribute nearly 60% of the national income but they are also inherently unsustainable in terms of environment.

Under the situation the environment thinking of human society need a conscious, purposeful and planned interaction with it.

Urbanisation in India is age old as we find in our geological records. But due to the scientific and technological development in every field of present society and over-exploitation of present resources and increase in the demand of the developmental activities such as construction of buildings, roads, bridges, industrialization, agricultural development etc lead to the urbanisation. The urbanisation is having lasting effect on human beings as well as on the environment. The reasons for rapid increase in urbanisation are:

- (a) Increase in population
- (b) Standard of living
- (c) Migration of rural people to the urban areas for employment.

Urbanisation Effect : The growth in urbanisation has devastating effect on the environment and is changing the whole composition of the environment. The following are the effects of urbanisation on the environment.

1. With the development in the economy, cities and town grow. This leads to conversion of agricultural land to commercial area which causes reduction in fertility of the land.
2. The demand for water has been rising in the urban centres due to growth in population and also due to increase in economic activities. Under the increasing demand of water, the existing systems are crumbling. Under pressure to supply adequate water, cities are exploring sources which are 100 or more kilometres away. It is likely to upset the ecological balance in the region in the long run. Excessive

withdrawal of ground water for meeting growing demand creates its own set of problems.

3. The urbanisation means expansion of cities and migration of the people from rural areas. It leads to increase in the development of houses, religious places, social and educational institutions which put pressure on the inputs. Construction of these building exploit the materials like wood, concretes, cement, bricks, iron etc. Wood production leads to deforestation that causes soil erosion and pollution.
4. With the urbanisation there is a vast development in industrialisation. To meet the fundamental demands of increased population in the urban areas, these industries over exploit the natural resources. Such industries also have been causing severe air, water and land pollution. Further all such industries have grown unplanned and without any environmental control. Most water bodies in these areas are so contaminated with toxic chemicals that they are totally unfit even for irrigation purposes what to say of drinking water.

Most of the industries discharge waste water and their effluents containing toxic materials into rivers without adequate treatment. This results in that water bodies remain polluted affecting the health of the population living in the region. Industries are also source of land pollution as they dump solid wastes in open areas which leached into soil.

5. Relative poverty, a rapid growth of population, high cost of land, building and their construction lead to live a large number of urban residents in substandard houses and slums. About 40% of India's urban population lives below the poverty line and that living in slums which are devoid of adequate water supply, sewage and drainage facilities and water disposal services. As a result, unhealthy living conditions are created which become severe as well as acute during rainy seasons. These people live in total polluted environment.

6. The number of vehicles is increasing on Indian roads day by day. These have added considerably to the air pollution in urban areas. The pollutants emitted from vehicles are more hazardous as they are more closer to the public compared to pollutants released by industries.
7. The increasing noise level in cities is a new and recent phenomenon.
8. The deteriorating environmental conditions in urban areas are also related with rapid increase in population in cities.

Home Atmosphere

Indoor environment means the environment of the houses and habitat in which the organisms live or it is the place where man spends his maximum time. The increase in technologies and new domestic machineries in polluting the indoor environment.

Causes of Indoor Environmental Pollution

- (i) The indoor environment is very much affected by various construction materials like cement, sand, clay, wood, iron, lime etc. These material though used in construction are pollution causing.
- (ii) Mica, plywood, varnishes and other chemicals used are all harmful.
- (iii) Even kitchen play important role in polluting the indoor environment. All the fuel used for cooking purposes such as Kerosene oil, LPG pollute environment. The rural people still use cow-dung cakes, fuel wood which on combustion give out harmful gases and smoke add to the environment and cause pollution. Many gadgets used in kitchen like mixer grinder and juicer produce loud sound that produces noise pollution.
- (iv) The furniture used in house which is a symbol of standard is also harmful for the indoor environment because the varnishes and paints used are poisonous and give out harmful gases in the indoor environment.

- (v) Polythene and plastics used in houses pollute the air inside the house as well as soil.
- (vi) From different household activities like bathing, washing of clothes and utensils with detergents waste water is produced which also affects the indoor environment. Some kind of acts such as heating of chlorinated water causes the formation of chloroform that produces suffocation leads to death.
- (vii) With the increase in technology number of gadgets have been increased in houses. Some of which release chlorofluorocarbons which go in atmosphere and causes depletion of ozone layer.

From the above we can say that advancement in luxury items provide all facilities yet they adversely affect the health of the human being due to pollution of indoor environment.

Preventive Measures for Indoor Environment

House in the necessity of life to live. It is necessary to have clean indoor environment to keep ourselves healthy. For keeping indoor environment clean following measures are to be taken:

- (a) The house should be built in way that it should be airy and should have light.
- (b) Less use of polythene and plastics.
- (c) Only good quality of materials should be used for the purpose of construction.
- (d) Synthetic and non-biodegradable materials should be avoided.
- (e) Waste produced in the houses should be properly used.
- (f) Traditional fuels should be avoided. Only non-polluting fuels should be used.
- (g) There should be a proper system for disposal of excretory products.
- (h) All noise producing gadgets should not be used at high frequency.

- (i) Use of solar energy should be encouraged.
- (j) Deodorants and perfumes should be used in limit to avoid depletion of ozone.

Disposal of Waste : Wastes are the by-product of all the matter which is consumed by all living organism in the industries as well as in agriculture and other fields. With the increase in population there is increase in consumption of food and other resources with the result the waste has also increased. All the waste is thrown out in an open area outside cities which make the land unfit for use as well as cause environment pollution. Wastes are classified into two categories.

1. Rural waste
2. Urban waste.

Rural Waste : It is the waste results from agriculture and dairy farms. These wastes either reused by burning of agricultural waste or is used as manure by composting it. The manure is used to increase the fertility of the soil. The waste produced by the man and animal is used for production of fuel by Gobar gas plants and bio-gas plants.

Urban Waste : It is further classified into two categories: Solid waste and Liquid waste.

Solid Waste : The solid waste includes glass containers as bottles, crockeries, plastic containers polythene and other packing materials that are used and then thrown away as garbage.

Liquid Waste : It includes the water based waste produced by the activity of man. As the water is used in various activities of man thus waste water is produced which is directly thrown in the environment.

Sources of Waste

1. Waste is produced by different industries. Industrial waste can be solid and liquid produced by processing or during the production of different kind of materials. These waste contain harmful chemical and pollutants.

2. A large amount of waste is produced by various domestic activities. Domestic waste include, garbage, rubbish, sewerage, vegetable waste etc. All these waste contain a number of disease causing organisms and also various non-bio-degradable, combustible and non-combustible materials. These waste when thrown in open produce a number of harmful effects.
3. Agriculture is also producing a lot of waste. It includes the waste produced from the crops and livestock of cattle like rice husk, dungs etc. When these waste are exposed in open cause health problems to both man and animals.
4. Fly ash and soot from burning of coal in thermal power plants.
5. Hospital waste is most dangerous as it contains a number of pathogenic microorganisms which cause both communicable and non- communicable diseases.

Waste Management of Industrial and Urban Solid Waste :

In urban areas and industries, large amount of solid waste is produced and as the population is increasing the quantity of solid waste is increasing day by day. The waste include that of hospital waste, commercial waste and waste from building material, sludge, dead animal skeleton, heaps of crop residues etc.

These waste is thrown openly on the barren areas or nearby empty plots. The materials which can be recycled are collected from the waste by sweepers and rag pickers and rest is left over there which give harmful odour and cause air pollution. Soil and land as well as water pollution.

Solid wastes are causing much problem in developed effluent countries as U.S.A. and European countries. In India also, several million tons of solid waste is dumped along highways and other places. There is problem of disposal of these wastes especially in developed countries where labour is very expensive. In India most of junk is purchased by hawkers and resold after profit.

To solve these problem technologies have been developed

which give rise to some processes for the management of this solid waste. These are:

1. *Collection* : All the solid waste produced from different sources is collected by sweepers employed by the Municipal Committees and by other agencies in developing countries such as India. But in all developed countries the work of collection of waste is done by automatic machines.
2. *Transfer* : All the solid wastes collected from different parts of the city is transferred through vehicles to the places made by municipalities for the disposal.
3. *Disposal* : It is most important method of solid waste management. In this safety is taken for disposal of solid waste as it contains a number of harmful organisms. From the disposal site materials are selected for various other steps such as:
 - (i) *Incineration* : From the waste all combustible materials such as hospital wastes are taken out and burnt. It is called incineration. It should not be done in open as it produces a number of toxic gases that would pollute the environment. It is to be done in incinerator which are safe and protect the environment from pollution.
 - (ii) *Composting* : All putrescible refuse such kitchen' waste like fruits, vegetables, skin, milk products, leaves, human waste are separated from non putrescible one and are biologically degraded. This forms the manure which can be used in agricultural fields to increase the fertility of the soil.
 - (iii) *Controlled Tipping or Landfill* : It is method of confining the wastes to smallest area. Landfills are the areas in which non-combustible and non-biodegradable materials are dumped by digging the soil or trench. But these landfills have many problems and sometimes proves to be hazardous. Leaching of waste from land fills pollute the underground water as well as the soil.

Management of Liquid Waste from Urban Areas and Industries : Liquid waste is the sewage and chemical rich water coming out from houses and industries. Domestic sewage has all the waste water containing excretory products, chemical from soaps, detergents, waste from hotels, hospitals and other public places. Sewage is a blackish cloudy liquid having a number of pollutants and toxic chemicals. Therefore, it is necessary that the waste water should be properly managed before it is discharged into water bodies. Following are the methods by which the pollutants are reduced from waste water.

Primary Treatment : It is also called physical treatment because it separates coarse organic matter as well as grit. Primary treatment involves the following processes:

- (i) **Shredding :** The large pieces of sewage and other wastes are cut into small ones with the help of machines.
- (ii) **Churning :** After shredding, the waste water is churned vigorously. It mixes various wastes and causes floatation of lighter ingredients.
- (iii) **Sedimentation :** There churned waste water is passed into sedimentation chamber having a gentle slope of 2.5° - 7.5° sand and grit settle down.
- (iv) **Screening :** After removal of grit, the waste water is allowed to pass through a system of stationary or mechanically raked screens. It removes large objects as well as organic matter floating on water. The screened material forms sludge. It is removed by skimmers. The remaining water has very fine organic matter, pathogens and decomposer Micro-organisms. It is sent for secondary treatment.

Secondary Treatment : It is mainly biological treatment because the organic matter is degraded with the help of microbes. It involves following steps:

- (a) **Trickling Filter Method or Bio-filtration :** The waste water is allowed to trickle over a minimum 2 metre thick bed of gravel (small stones) having sewage fungus (containing

bacteria, fungi and algae.) Bacteria and fungi perform decomposition of organic matter. The algae provide oxygen to them. Therefore, while trickling through gravel, the organic matter of waste water is fully decomposed.

- (b) **Activated Sludge Method** : In this method the oxygen is supplied by mechanical agitator and collected for further treatment such as:
- (i) The sludge is first acted upon by anaerobic micro-organisms. It is then dried and heated which forms a humus like nutritive fertilizer.
 - (ii) Raw Material is passed into water stabilisation ponds having sewage fungus. Here it is broken down by algar and bacteria of sewage fungus.
 - (iii) Sewage is filled in aerated lagoons and oxygen is supplied through aerators.
 - (iv) The hard and solid wastes are burnt and water is taken out. The process called incineration.
 - (v) The water drawn out treated chemically and can be reused.

Land Pollution Control and Disposal of Solid Waste : It is judicious disposal of solid waste so as to prevent land pollution and provide some benefit to society. The various methods of waste disposal are:

Salvage (Resource Recovery) : All those articles of the waste which can be recycled are picked up e.g. metals, plastic, glass, paper, empty bottles, card board, polythene, rags etc. It generates employment as well as resource recovery.

Recycling : It is the treatment of waste to regenerate a resource. The two basic reasons for recycling are (i) conservation of resources and (ii) reduction in volume of refuse to be disposed. There are some materials suggested as recyleable. These are:

- (a) **Paper** : Waste paper of old books, newspapers, answer books, magazines etc. are available in plentiful supply. Recycling of paper would save our forests.

- (b) *Metals* : These can be easily recycled from industrial scrap, which is the largest source of secondary metals. Another important source of the waste material are wrecked automobiles and aluminium cans.
 - (c) *Glass* : It is the perfect product for recycling. However, it is about as expensive to make a new glass bottle as to recycle an old one.
 - (d) *Agricultural Wastes* : These are recycled to produce useful products e.g. paper and hardboard from coconut waste, jute waste, baggase of sugarcane, stem of rice etc.
 - (e) *Food Processing and Cannery Wastes* : These are fermented to produce organic acids with preservation important. The unpalatable wastes can be used as manure while the palatable waste is used as cattle fodder.
 - (f) *Gobar Gas Plants* : These plants use cowdung or other organic wastes of farm houses which provide gas for domestic use and manure for fields.
 - (g) Sludge burnt with coal to produce electricity.
 - (h) Several million tons of used tyres pile up every year. Disposal of these tyres is an environmental headache. These are recycled and used again.
3. *Utilisation* : Slag (Ore remains after extraction of metal), fly ash (from coal fired power station) can be used to make bricks, lightweight and foam light weight cement.
 4. *Hog Feeding* : This is a common method of disposing garbage. However it spreads diseases in pigs as well as humans.
 5. *Pyrolysis* : In this method the waste is heated at a high temperature (1650°) without providing air. It does not emit any pollutants in the air. Instead it yields industrial gas, alcohol and number of useful chemicals.
 6. *Burning* : Agricultural refuse, fallen leaves, rubbish and garbage are often burnt in open space. Though it reduces the bulk of waste, it produces offensive odours and air pollutants.

7. *Incineration* : It is controlled burning of waste in chambers where the temperature is kept at 850°C. Grit extractors remove dust particles from emissions. Incinerators are used to produce utilisable energy.

“Toxic colonialism” is a striking phrase coined by Jim Puckett of Greenpeace for the dumping of the industrial waste of the west on the territories of the third world. Lor Tom Strathelyde, Junior Environmental Minister says “we make a distinction between waste for disposal and waste for recovery. Our policy is that all developed countries should become self-sufficient in disposing off their own wastes.

The United Kingdom has the facilities to be able to dispose off all waste arising in this country. We are prepared to allow developing countries which do not have suitable facilities to continue to have access to U.K. facilities. This ensures that waste is managed in an environmentally sound manner.

Educational Aspects

Teacher's main job lies to teach. There is not a method or the methods of teaching science which could suit in all the situations. All teachers are different. No two children are alike. Teachers differ in personality. Children differ from family to family and from locality to locality — even in respect of their mental and physical development. Thus a teaching method is largely governed by these three factors — environment, teacher and pupil. It will be advisable to lay down a series of methods of science teaching, so that the teachers could select from them according to their need.

Fundamental Issues

There are some guiding principles for determining our teaching methods. They are as follows:

1. Every method we use should be based on an understanding of the pupils in our classroom, and not on an understanding of children we have read about.
2. Every method we use should be one which we thoroughly understand and believe will be successful with the pupils in our classroom and not merely one which we have heard is successful.
3. Every method we use should lead the pupils to a sense of achievement through interest and purpose.

4. Every method we use should stimulate the pupils to think and cooperate actively.
5. Every method we use should be based on the realisation that the word education derives from a Latin word 'educio' which means "I bring up" or "I nourish." Education is a "drawing out" and not a "putting in."

Mindful of the above points there are certain vital instincts which stimulate the child to learn and through which he acquires knowledge and skills. They are instincts of play, imitation, curiosity and competition. These are the instincts which are principally concerned with the educational development of the child and which we must consider when planning our methods of teaching science.

Beside these vital instincts from which the impulse to learn springs, there are some physical agents which enable a child to acquire skills and knowledge. They are as follows:

1. The hands — Learning by touching and doing.
2. The eyes — Learning by seeing.
3. The ears — Learning by hearing.
4. The mouth — Learning by saying.
5. The nose — Learning by smelling.
6. The tongue — Learning by tasting.

These senses should be utilised as much as possible in our method of science teaching for creating effective teaching learning situations.

Traditional Methods

1. Lecture Method (8 4)
2. (Improved) Lecture Method (8 5)
3. Demonstration Method (8 6)
4. Concrete to Abstract Approach (8 7)
5. Lecture Demonstration Method (8 8)
6. (Improved) Lecture Demonstration Method (8 9)
7. Laboratory Method (8 10)

Discovery Methods

8. Scientific Method (8 11)
9. Project Method (8 12)
10. Investigatory Project Method (8 13)
11. Problem Solving Method (8 14)
12. Heuristic Method (8 15)
13. Inquiry Approach (8 16)

Other Methods

14. Discussion or Interactive Approach (8 17)
15. Programmed Instruction Method (8 18)
16. Multimedia Package Approach (8 19)
17. Individualized Instruction Method (8 20)
18. Modular Approach (8 21)
19. Teacher Centred versus Child Centred Approach (8 22)
20. Activity Approach (8 23)
21. Process Approach (8 24)
22. Environmental Studies (EVS) Approach (8 25)

Method of Teaching

Lecture Method : This is one of the most popular methods of teaching in our schools. This is a teacher structured method, and the students are just passive listeners most of the time. Very few teachers allow questions during the lecture, though some of them give some time to their students to ask questions after the lecture. Many students forget their questions by the time the lecture is over. So their questions remain unanswered. Teachers talk most of the time without using any teaching aid though some of them use blackboard. For them the lecture method is talk and chalk method. Sometime the back benchers cannot even read what is written on the blackboard. Students take notes of the lecture, and slow writers miss many points.

Research studies have been made on what actually happens in classrooms where teacher is teaching by lecture method. ‘Step

into a classroom and what do you hear. The chances are better than 60 per cent you will hear someone talking. If someone is talking the chances are that it will be the teacher more than 70 per cent of the time. The teachers talk more than all the students combined.

The teacher is the main actor 85 per cent of the time. Pupils receive recognition, praise and encouragement only 1-2 per cent of the time." According to Flanders, N.A. "We want to encourage our pupils to learn to express themselves fluently, yet on average there are two speeches by each pupil each day in class, and the mean length of these is 8.4 words."

Students dislike lectures. In an adult education class those who had heard only 15 minutes of a radio talk could score 41 per cent on a factual recall test while those who listened to the 30 minutes of the lecture could score only 25 per cent on the same test. In other words, the second period of 15 minutes proved to be for less productive as it reduced the listener's ability to recall the first 15 minutes. It may be due to fatigue set in which students lost the concentration. The span of concentration seems to be less for the child than for the adult. Children switch their attention rapidly from one subject to another.

It implies that the teacher should not lecture continuously for more than a very limited time, say 15 minutes with an average secondary school class. After that a change of activity, to practical work, watching a film, writing or working in small groups, or discussion could be submitted.

Lecture method has some advantages and disadvantages.

Advantages

1. It is quick, and a lot of knowledge can be imparted in quite a lesser time.
2. It is highly efficient if teacher teaches in systematic and logical manner.
3. It is convenient and easy and a teacher is free to develop his own style of teaching.

Disadvantages

1. Students' involvement and participation is nil or quite less.
2. Students' previous knowledge or entry behaviours are usually not taken into consideration.
3. Developing scientific skills are neglected.
4. Teacher needs a lot prior knowledge to prepare a lecture.

It is wise to have notes (in points) available while lecturing for ensuring correct sequencing of ideas and figures, but word by word reading from notes should be avoided. Listening to your tape recorded lecture or comments of your colleagues on your lecture will enable you to find out the limitations of the lecture method as well as to enable you to improve your further lectures.

Lecture Method is perhaps as old as appointment of the first lecturer in our country, as lecturer is one who lectures, and uses Lecture Method in his class. But old is Gold. It is correct that in Lecture Method, no audio-visual aids are used, and we do not need audio-visual aids all the time. If our students have enough experience of what is to be talked about in we do not need to use audio-visual aids in the lesson, and the lecture can be improved (enriched) by adding Teacher-Learner Interaction (TLI) and Learner-Learner Interaction (LLI), into it. Involve your students into your Lecture with the two interactions — TLI and LLI. Adding these two interactions with the lecture, some of the disadvantage of the lecture (8.4) can be removed, and the lecture can be improved.

Encourage your students to ask questions (NPE 1986). You should also ask questions to all types of students (average, below average and slow learners) and not just the above average during your (improved) lecture. Sometimes ask some open question, for which first students had to have LLI, before answering.

Demonstration Method : Demonstration means 'to show. In lecture method, the teacher just talks but in demonstration method he also shows and illustrates certain phenomenon and applications of abstract principles through demonstration of experiments. Demonstrations provide concrete experiences to students.

Demonstrations may also include use of films, slides, overhead projector or the micro-projector.

While using the demonstration method the teacher can:

1. provide significant, rich and worthwhile experiences to students enhancing their power of observation.
2. illustrate abstract ideas in concrete form.
3. coordinate laboratory work with theory and highlight safety methods.
4. pose a problem to students and gather their hypotheses based on their experiences.
5. provide concrete experiences for the solution of a problem.
6. add additional demonstrations after its review, if considered necessary.
7. do those demonstrations which are dangerous for students to perform themselves.

Characteristics of a Good Demonstration

1. It should be clearly visible to all students, even to the back benches.
2. It should be pretested so that it may be convincing, striking and clear-cut.
3. Children should also be involved.
4. Results should not be known to students.
5. If there are more than one demonstration in a lesson they should be well-spread.
6. In a demonstration only one idea should be taken at a time. Too many ideas in one demonstration may confuse the children specially the young ones.

Points to be Noted

1. For large scale demonstration, the teacher must spend a good deal of time in thinking and devising experiments to make principles quite clear, and in showing various types

of experiments necessary to clarify the numerous difficult concepts of the science course.

2. The teacher should carry out the experiment in such away that the students should learn how to carry it out by themselves.
3. When carrying out demonstration experiments the teacher should make sure that everything is in order before the lesson begins. He should be certain that the demonstrations will prove his points. The table should be well illuminated either by day light or by electric lights. The background should preferably be white or black so that the apparatus and other materials are clearly visible.
4. The teacher should see the general order and tidiness of the demonstration table. Nothing looks worst than a demonstration table littered with books and other material not to be used. The demonstration table should have only apparatus and materials relevant to the lesson.
5. In this method students are placed in a passive role which may be frustrating or boring for them unless the teacher involves them in thinking behind the experiment and in the manipulation.

This problem can be minimised if the demonstration is assembled ready for action before the lesson and there is every expectation that it will work. Demonstrations need to be rehearsed. For effective demonstration the following questions should be kept in mind:

- (a) Is the apparatus clearly laid out from where the students view?
- (b) Do instruments have large enough dials to be read by all the students in the class?

Overhead projector has made it possible to modify some demonstrations so that they are more easily seen and students can take readings and plot graphs while demonstration is proceeding. Under such conditions the teacher can involve their students in making predictions, speculations about causes, and thinking of ways of testing ideas.

Advantages

1. There is a possibility of using more sophisticated apparatus.
2. More difficult experiments can be undertaken.
3. More hazardous experiments may be attempted.
4. Expenses may be minimised compared to laboratory method.
5. There is a possibility to demonstrate manipulative and allied practical skills.
6. There is possibility to draw the attention of all the pupils of the class simultaneously.
7. It takes less time compared to laboratory and other innovative methods.
8. This method is more efficient in a way compared to laboratory method as a teacher is more competent than students to handle apparatus.
9. All students can see the same operation and techniques simultaneously.
10. Teacher is in a position to explain each and every step and to ensure that all students see and interpret all the work in the same manner.

Disadvantages

1. All students do not experiment with their own hands. It is a substitute for laboratory work.
2. When the demonstration is complex or there are too many demonstrations in one lesson, students feel difficulty in understanding the basic concepts, principles and skills.
3. Various details of the apparatus, significant reactions and other essential steps undertaken by the teacher in drawing conclusions are not necessarily visible to all the students of the class equally well.
4. It deprives students of many of the advantages of laboratory method such as handling of the apparatus and other materials as well as making their own interpretations.

Whenever you plan a lesson, ask yourself whether you really need audio-visual aids, as sometimes you do not need audio-visual aids. If your answer is “yes” then ask yourself of what type of audio-visual aids. Edger Dale has arranged the various audio-visual aids, from more concrete in nature to comparatively more abstract (5.4)

1. Direct Purposeful Experiences (5.5)
2. Contrived Experiences (5.6)
3. Dramatic Participation (5.7)
4. Demonstrations (5.8)
5. Field Trips or Excursions (5.9)
6. Exhibits (5.10)
7. Motion Pictures and Television (5.11)
8. Radio Recording and Still Pictures (5.12)
9. Visual Symbols (5.13)
10. Verbal Symbols (5.14)

This will help you to select right type of audio-visual aids for your lessons. This arrangement should not be considered as rigid divisions or watertight compartments.

This is a method generally used by our science teachers. Students cannot learn science either by lecture or by demonstration used in isolation. Even most effective demonstration cannot guarantee learning in science. This may also be true for the lecture-demonstration method. It can succeed when lecture is based upon concrete experiences of the students’ environment and a demonstration focuses them into scientific phenomenon, while discussion between teacher and students goes on in a permissive atmosphere. Demonstration method when combined with a well directed discussion is a successful teaching technique. It can be modified by allowing limited students participation and by problem solving at times. It fits well into the regular method of uniform class procedure for all students but does not permit of very wide individualisation. If widely individualised and modified, it approaches to a method usually called the problem solving or project method.

Through contrived situations in this method students themselves form concepts. Therefore lecture-demonstration method should achieve the advantages of both lecture and demonstration methods, and minimise their disadvantages. Lecture-demonstration method though widely used in our science classes has a limited role in the teaching-learning process. This is because all students do not participate actively.

Advantages : Lecture-demonstration method, has all the advantages of a demonstration method plus one more that the teacher can also involve the students in discussion.

Disadvantages : Disadvantages of a lecture-demonstration method are the same as of demonstration method.

Like lecture, Lecture-Demonstration Method (8.8) can also be improved. Here along with Teacher-Learner Interaction (TLI) and Learner-Learner Interaction (LLI) two more interactions, Teacher Material Interaction (TMI) and Learner-Material Interaction (LMI) are to be added in Lecture-Demonstration (8.8). Adding all the four interactions — TLI LLI TMI and LMI with the Lecture Demonstration (8.8) some of the disadvantages of the Lecture Demonstration (8.8) can be removed. TLI and LLI will improve the Lecture part, and TMI and LMI will improve the Demonstration part of the Lecture Demonstration. This will be (Improved) Lecture Demonstration Method, much better than the Lecture-Demonstration Method of Teaching.

When demonstrating involve students with you instead just teacher demonstrating (TMI) involve also students individually or in small groups in handling the equipment and doing the activities themselves (LMI). During TMI and LMI involve students in TLI and LLI just like you do in (Improved) Lecture. Thus using (Improved) Lecture-Demonstration method students will understand and enjoy the lesson much better.

Laboratory Method : In this method students perform laboratory experiments or laboratory exercises by their own hands individually or in small groups. So here they are more active and involved unlike demonstration method, where teacher was

performing experiments involving few students and most of the students in the class were just passive observers.

Unless students carry out experiments by themselves, they will never get to know what science really is. In this method they get an opportunity to do experiments individually or in small groups. In our schools set up there is a provision of separate science labs but in the West like in USA in most of the schools there are classroom cum labs. There is a provision for 55 to 60 minutes class periods. It is upto the teachers, they can utilise this time for theory or practical or both. They carry the needed equipment and material in the classroom-cum laboratory in trolleys, students pick up the material from trolleys, take it to their work tables, and return it to trolleys after doing the laboratory work.

In our schools at secondary and senior secondary stage students go to science labs to do practical work. Usually in every school there are three science labs — Physics Chemistry and Biology For lab work two continuous periods (of about 30 minutes each) are given. At secondary stage students go to lab work once a week If one week they do Physics, the second week they will do Chemistry and the third week they will do Biology, and the same cycle is repeated. Thus for each subject (Physics, Chemistry and Biology) the turn comes every three weeks. At senior secondary stage students go to lab work twice a week in every subject — Physics, Chemistry and Biology. Usually students work in groups of about 20.

If there are 40 students in a class, they are divided into 2 groups (if one group is doing Physics, the other will be doing Chemistry or Biology) so that the teacher may supervise their students work (in a smaller group) more satisfactorily as well as to guide them individually or in still smaller groups.

Generally lab experiments are of five kinds :

1. Experiments to illustrate scientific principles
2. Experiments to find numerical results
3. Experiments to produce something as preparation of gases or biological slides.

4. Experiments to verify experiments carried out by other scientists.
5. Original work or investigatory science projects or open-ended experiments.

In our science courses there are usually the first four types of experiments. Now a little importance is also being given to the fifth type, the investigatory experiments, at senior secondary stage. Usually there is no coordination between theory and practical work.

The science courses in USA like PSSC, BSCS and CHEM study have employed a more heuristic approach with the practical work embedded right in the middle of the theory. A cycle of events is envisaged. The pupil is given a laboratory problem and his observations give rise to discussion and hypotheses. These hypotheses are tested by experiment, and so the cycle ends where it started at the laboratory table.

Open-ended experiments, are more difficult to organise and supervise than the traditional ones. The heuristic approach (8.15) demands that the pupils should be allowed to stop and think, discuss and suggest modifications for further experiments.

Objectives : When teaching science by laboratory method, the following objectives should be kept in mind:

1. To develop manipulative skills.
2. To arouse and maintain interest in science.
3. To encourage accurate observations and careful recording.
4. To make biological, chemical and physical phenomenon more real through actual experience.
5. To be integral part of the process of finding facts by investigation and arriving at principles.
6. To train the students in science processes and scientific method.
7. To give training in problem solving. To verify facts and principles already taught in theory.

8. To elucidate the theoretical work so as to aid comprehension.
9. To prepare the students for practical examination.

Advantages

1. Learning by doing.
2. Opportunity to handle materials.
3. Learning to follow directions carefully.
4. Learning skills in performing experiments, recording observations and results, summarising data and drawing conclusions.
5. Opportunity for critical thinking.

Disadvantages

1. More expensive if separate equipment is provided to each student.
2. Difficult to schedule in the school timetable when double periods are provided.
3. More time consuming compared to demonstration method as students are unskilled workers and or not as competent to handle apparatus as their teachers.
4. No guarantee that the students will learn to solve problems or think scientifically.

When there are more students and the equipment is not enough for each student to do experiments, then a large number of experiments should be arranged, and different students could do different experiments at the same time. If possible typed instructions should be given to students for each experiment. This will facilitate, students to work on their own and teacher will have time to go to students who need him most.

Scientific Method : Scientific method is one of the methods for discovery. Training in scientific method necessitates discouraging traditional demonstrations and laboratory experiments. When teaching by scientific method, the students do not perform the prescribed list of experiments in which emphasis is on the verification

of some already known science principles and laws. Instead they are involved in investigatory problems whose solutions are not available either in textbook or lab manuals.

Steps of Scientific Method

1. *Problem.* What does a student want to learn?
2. *Hypothesis.* What does a student think the answer would be?
3. *Experiment*
 - (a) Testing of Hypothesis by an Experiment. How could a student tell the answer would be what he predicted?
 - (b) Collection of Data
 - (c) Interpretation of Data. What happened when a student tested his hypothesis?
4. *Conclusion.* What do the results of the experiment show? Is the hypothesis accepted, rejected or needs modification.

Advantages

1. Students do their own learning under the guidance of their teacher.
2. They learn to propose, formulate and structure problems.
3. They learn to collect varied pieces of information relevant to the problem from different sources.
4. They collect the evidence to prove or disprove the identified hypotheses.
5. They learn to solve everyday problems.
6. They are more closely familiar with various things, their applications and relationships instead of having mere knowledge.
7. They establish a healthy and favourable relationship with their teachers.

Disadvantages

1. This method is very slow, long and time consuming. Therefore the syllabus (knowledge and information) could

not be covered in the allotted time. Thus a different syllabus is needed for this method as in some American science programmes like PSSC, BSCS and CHEM Study of which formulation of hypotheses and their testing is the dominant feature.

2. There is too much emphasis on practical work which may give a wrong concept of the nature and philosophy of science in general. Learning science is a joyful process but too much practical work may make it dull and routine type of affair.
3. Most of the teachers are perhaps not able to teach by this method, as they have not practised teaching science by this method.
4. All students are not capable to learn by this method.

Project Method : A project is any purposeful activity. It may or may not involve investigation. If it involves investigation it will be investigatory project. In progressive schools students are allotted some projects during summer holidays. It may be a curricular or enrichment activity. Teacher try to cover a part of syllabus by this method. Parents also help their wards when they work on their projects. Titles of some projects generally given to students are as follows:

1. Indian Scientists
2. Story of Wheel
3. From earth to moon

Here students read some reference material, talk to some professional people and the public, observe what is going on around them and so on. This is how they gather data. Then they analyse their data, and prepare their project reports. The report may be handwritten or typed and it may include pictures, charts, graphs, models and so on. Students learn a lot when these project reports are discussed in the Class. Project Method is an example of Assignment Method.

The Investigatory Project Method involves investigation, discovery and finding out something which was not known to the

student before. An investigation is much more than the repetition of a standard experiment. Here the student is to decide what experiments are necessary and how he is going to carry them out. He may have to design his own apparatus, if that is not available in the laboratory. He has to search for the appropriate principles, laws, formulae, apparatus and data; and originate solution to a problem. The student will act like a scientist.

This method involves the steps of scientific method:

1. Problem
2. Hypotheses
3. Experiment
 - (i) Testing of hypotheses by experiments
 - (ii) Collection of data
 - (iii) Interpretation of data
4. Conclusion.

This is the least used method of teaching science in our schools. In USA, Canada and UK teachers try to cover a part of syllabus by this method. In this method a group of students select a problem in consultation with their teacher/ and then through discussion develop the plan of action and design the type of equipment needed to carry out the experiments to reach the conclusion. Students thus are trained in science processes and scientific method.

Advantages

1. It creates interest in science.
2. It develops understanding.
3. It develops self-confidence, cooperation, leadership and emotional stability.
4. It promotes curiosity and develops scientific temper, interest and appreciation.
5. It develops abstract and concrete scientific skills.
6. It develops interest in scientific hobbies in the right use of leisure time later on.

Limitations

1. This is the most difficult method for the teacher, requiring more planning and more effort of execution.

Though it is the most difficult method for the teacher requiring more effort and planning, the lack of this effort is one of the reasons for much of the mediocre teaching that is done. The results of this method, when it is properly executed, are more than compensate for the extra work that is required.

2. If properly operated it calls for somewhat more materials and equipment than in the strictly demonstration method.

The necessity for more materials and equipment is generally an excuse rather than a reason for not using it. The problems and experiments can be so devised that they will require nothing that cannot be had at little or no expense.

3. The amount of time consumed by the projects may be so great as to make it impossible to cover a wide variety of topics thus resulting in an incomplete course.

Also to the economy of time, there is much doubt as to whether time spent upon less subject matter might not be worthwhile to the student than the same time spent in hurrying over more subject matter.

4. It may result in a task of proper coordination of subject matter when individualised, since students may be working upon different problems or projects.

The lack of coordination which sometimes is the result of individual work is little more than the result of poor planning and less execution upon the part of the teacher.

5. Difficulties of method increase when there are more students in large classes and more periods per day of the teacher.

In no other method there is equal provision for the essential factors demanded by our objectives. The solving of problems is essential to the training in scientific thinking and the following of

projects is a vital part of the production of those attitudes which should be the outgrowth of science teaching. Proper planning will provide for group or even class participation as a means of diminishing the problem of number of students and number of classes that must be taught and will still make possible a sufficient amount of independent work to provide for the necessary individualisation.

Problem Solving Method : Problem is not a problem if a child can solve it by his previous knowledge. Problem solving takes place only when student's previous knowledge is insufficient to enable him to provide an acceptable solution, and solution becomes possible only when he acquires new knowledge which he does not have before. A method to solve a problem is called a problem solving method.

Steps in Problem Solving Method

I. Problem

- (i) Identification of problem after problem survey;
- (ii) Statement of the problem — a clear description;
- (iii) Explanation of the problem — discussing with students ensuring that they clearly understand what the problem is;
- (iv) Delimitation of the problem — isolating only those parts of the problem which are within the reach of students.

II. Hypotheses

III. Experiment

IV. Concluding

These are the four steps of scientific method. Scientific method is a problem solving method.

In problem solving method step III may be eliminated, and for testing the hypotheses information from some other sources (reference books, journals, newspapers, discussion with some experts etc.) may be taken.

Sometime even steps II and III both may be eliminated in problem solving method, and information from some other sources (mentioned above) may be used to find the solution of the problem.

Advantages : Its advantages are the same as of Scientific Method or Project Method of teaching science.

Disadvantages or Limitations : Its limitations are also the same as of Scientific Method or Project Method of teaching science.

Heuristic Method : Heuristic means discovery in Greek. Professor Henry Edward Armstrong of Imperial College, London, was a strong advocate of Heuristic Method. Professor Armstrong tried his best to place his students in the position of original discoverers. He involved his students in finding out by themselves instead of telling them. Laboratory work was compulsory for every student where they could discover instead of being told. His method was quite simple. He used to provide instruction sheet to his students concerning the problem and students were expected to take observations and conduct experiments according to these instructions. Students used to record their observations in their record-books. From these observations they were asked to draw their own conclusions. Thus, they were introduced to reasoning from their own observations and experiments.

Heuristic Method demands that the students should be allowed to stop and think, discuss and suggest modifications for further experiments.

Advantages and Disadvantages. Heuristic Method develops spirit of enquiry in students, but this method can never be the main method for science teaching. This method is a time consuming process by which students gain less worthwhile and significant knowledge in more time. Students are not expected to rediscover all the knowledge which already exists; they are expected to know at least a part of it.

Example. One day an electric bulb blew out in the class. "What happened" asked the students. The teacher took out the bulb from the bulb holder, and showed it to the students. The students

gathered around the teacher. He passed it around them and said, "Look at it and try to develop a hypothesis about what happened." "What is inside the bulb" asked one of the students. "I do not know," said the teacher. "Is there air inside the bulb," asked another student. "No," said the teacher. "Is there any other gas inside the bulb," asked another student. "No," said the teacher.

The students were puzzled and they started looking at one another. Finally one student asked, "Is it vacuum inside the bulb?" "Yes," said the teacher. "Is it complete vacuum," someone asked. "Almost" replied the teacher. "What is that little wire made of," asked another student. "I do not know," said the teacher. "Is that little wire made of some metal," asked some students. "Yes," the teacher said.

Such Yes-No Answer questions continued between teacher-students interaction, till students identified the material of the wire inside the electric bulb, and the events that took place without teacher's readymade answers. Finally students began to formulate hypotheses about what happened. After the students formulated some hypotheses, they started searching through Reference Books (in the library or at home) in order to verify them.

This is an example of Inquiry Approach of teaching science. Students are trained for inquiry. Inquiry begins with a puzzling event like "an electric bulb blew out in the class." Students inquired (what happened — a problem) when they were puzzled.

After the puzzling event is presented to the students, they ask the teacher some questions. The teacher should answer the questions in "Yes" or "No." The answer of each question may be a small hypothesis.

Inquiry Approach of teaching science may have the following steps.

1. Encounter with the Problem.
2. Formulation of Hypotheses.
3. Data Gathering — Experimentation and Verification.
4. Conclusion — Solution of the problem.

When teaching science by lecture method or lecture-demonstration method, if students are involved in discussion (interaction) they are in a much more better situation of learning science. As discussed under lecture method, the teacher should not lecture continuously for more than a very limited time so that the teacher should not lose the concentration of their students.

For this he can do a change of activity, and discussion (interaction) is one of the several activities in which students can be involved very actively. So by using lecture-cum-discussion method some of the disadvantages of the lecture method can be taken care of.

Similarly when lecture-demonstration method is combined with a well directed discussion (interaction), it may prove to be a successful technique of teaching science.

In our schools lecture method and lecture-demonstration method are most commonly used. If we add “discussion” or “interaction” into it, these methods may come out to be much more effective,

There may be 4 types of interactions.

- (i) Teacher-Learner Interaction (TLI)
- (ii) Learner-Learner Interaction (LLI)
- (iii) Teacher-Material Interaction (TMI)
- (iv) Learner-Material Interaction (LMI)

When teacher is lecturing, TLI may be initiated. When children are discussing in small groups, like tutorials, LLI may be initiated. When teacher is demonstrating, he is using some teaching aids (material) he can use TMI along with TLI for more effective teaching. When children are doing some experiments in small groups, LMI will be of better use along with LLI and TLI.

Programmed Instruction Method : Programmed Instructional Materials as discussed in the elsewhere, provide self-learning units. Such units may prove to be very useful when our science teachers are heavily loaded, and they do not have time to interact specially those students individually, who really need them.

There are some topics in every field of science (Physics, Chemistry and Biology) which the students can learn on their own if programmed learning units are available on these topics. But in our country programmed learning units are not available in the market. So the only choice remains that some innovative science teachers should write some programmed units on selected topics to be used by their students. These guidelines may be used when writing programmed units. Such units when written, may be shared by other science teachers in their classes. Self-Learning Modules are as good as Programmed Instruction Materials for self-learning.

Like Programmed Instruction, Self-learning modules and Multimedia Packages if available on some topics, may also be given to students to cover part of syllabus on their own. Multimedia packages can also be developed by teachers. Such packages once developed may be used again and again. This is Multimedia Package Approach of teaching.

Individualised Instruction Method : Not all students are alike, but we teach them the same thing by the same method. In a classroom there are students of different science background. Most of them perhaps do not have aptitude for science, if they have a choice perhaps they will not offer science. But we are to teach the same science to all of them, and we usually use the same method to teach all students, without taking into consideration their individual differences.

Usually we can classify our students in three groups — average, below average and above average. When we teach science we assume some pre-requisites or entry behaviours of our students, we assume that this much they already know, and then we start our lesson. When we do so, we take into consideration only the average students, and forget about the below and the above average. The result is that only the average students are satisfied and the below and the above average are frustrated. The only solution remains that some individualised instruction and some other self-learning materials be developed and used to satisfy all the students.

Programmed Instruction is one way of individualised instruction. Self-learning modules, slide-tape programmes, and multi-media packages are some other means. Though such materials are not available in the market, yet they can be developed by some innovative teachers for the use of their students. Then their materials can also be shared by other science teachers in their classes.

Use of self-learning modules in teaching is another form of individualised instruction. This is called Modular Approach of teaching and learning. If self-learning modules are available on some topics, they can be given to students as assignment for self-learning. Teachers can also develop such modules on some topics. Such modules once developed can be used again and again.

Teacher Centred Approach (TCA): If we observe classrooms, we find it is the teacher who speaks most of the time, and the children either given no opportunity to speak or a very little opportunity to speak — ask questions or interact. This is a Teacher Centred Approach of Teaching.

Example : In a study about 1000 classes were observed (I-XII) in all subjects and in all types of schools, and it was found that on an average 95 per cent of the time teacher was speaking and 5 per cent of the time the children were speaking. This is an example of Teacher Centred Approach of Teaching.

Lecture Method and Lecture Demonstration Method are Teacher Centred Approaches of Teaching. Teacher Centred Approach is a very effective method for teaching skills (processes). Reading a thermometer, reading a spring balance, preparing gases like hydrogen, oxygen and carbon dioxide, salt analysis, volumetric and gravimetric exercises, setting up a microscope, making a slide and seeing it through a microscope, setting the experiment for photosynthesis etc., are all skills. Until a child perfectly learns a skill, the teacher is very much involved in telling the child “what to do” and “how to do.” The teacher has to use Teacher Centred Approach. Cooking; sewing; driving a scooter, a motor cycle or a car; repairing; playing musical instruments; dancing etc., are all skills. Teaching each of these skills, a teacher is needed who teaches these skills by Teacher Centred Approach.

Example : Reading a thermometer is a skill. According to a study children and even teachers not taught this skill by Teacher Centred Approach, generally read the thermometer wrong. If the reading was 46°C , they read 40.6°C . Then came the teacher to teach this skill. He pointed at 40 and asked “What is the reading?” The child said “ 40°C ”. Then he pointed at 50 and asked “What is the reading?” The child said, “ 50°C ”. Then the teacher asked, “How many marks are there between 40°C and 50°C ?” When the child failed to answer, the teacher himself counted — 1, 2, 3, 4, 5, 6, 7, 8, 9,10.

Then the teacher asked “How much is one mark?” Then the child replied “ 1°C .” (This is actually the least count of the thermometer which the child was not knowing, and therefore he read 40.6°C instead of 46°C). Then the teacher asked, “How many marks is the mercury above 40°C ”? And the child counted, “1, 2, 3, 4, 5, 6.” Then the teacher asked, “Now tell, what is the reading of the thermometer?” And the child again counted, “41, 42, 43, 44, 45, 46,” and then said, “Thermometer reads 46°C and not 40.6°C ”.

Now look at the approach, teacher used to teach the child to read the thermometer correctly. In this approach the teacher was more involved than the child, and therefore this is Teacher Centred Approach. Reading a thermometer is a skill. Therefore Teacher Centred Approach (TCA) should be used to teach skills (processes) to the child.

Child Centred Approach : Some innovative teachers themselves speak less in the class, and give opportunity to their children to speak more. Here the science teacher acts as moderator (leading and moderating discussions) and a guide (helping slow learners). This is Child Centred Approach. In teaching science by Lecture Method or by Lecture-Demonstration Method, these innovative teachers involve their children in interaction and question-answer sessions that even their lecture and Lecture-demonstration become child centred. Inquiry Approach, Problem Solving Approach, Laboratory Method, Scientific Method, Project Method and Investigatory Project Method are Child Centred Approaches.

Example : A teacher is teaching a concept “Air has weight” by scientific method. It involves “weighing” by a spring balance, which is a *skill (process)*. The teacher teaches the skill (process) of weighing to the children by Teacher Centred Approach before he teaches the concept “Air has weight.”

Then he starts the lesson with a:

1. *Problem* : Does air has weight? (This is TCA). Then children formulate their own
2. *Hypotheses* : (i) Yes, (ii) No. (This is CCA). Then children (as already know the skill of weighing or reading a spring balance) test their hypotheses themselves with an experiment.
3. *Experiment* : weighing an empty football bladder, and the same football bladder full of air. (This is CCA). Then they themselves draw the conclusion.
4. *Conclusion* : that air has weight. Hypotheses “yes” is right, and hypotheses “no” is wrong. (This is CCA).

Here step — 1 is Teacher Centred as teacher asks the question or poses a problem. Steps — 2, 3, 4 are Child Centred. Therefore Scientific Method is 25 per cent teacher centred and 75 per cent child centred. Thus as a whole Scientific Method is Child Centred Approach (CCA).

Note “weight” is a concept and “weighing” is a skill. When skill of “weighing” already taught by the teacher to the children by Teacher Centred Approach, the concept of “weight” is to be taught by Child Centred Approach. Do not tell to the child “air has weight,” let him find out himself whether or not “air has weight” by the Child Centred Approach (CCA).

Remember

1. Teach skills (processes) by TCA, and
2. Teach concepts by CCA.

“Believe nothing because you have been told about it. Don’t believe what your teacher tells you merely out of respect for the teacher.”

Who said this? When this question is put to science teachers in seminars the reply is 'some scientist'. Actually it is the statement of Lord Buddha.

Many times teachers teach and children do not understand. This is because children are conditioned in accepting and memorising what teacher tells them, without questioning and understanding.

In science there are many facts, principles, laws, concepts and skills, which children memorise without understanding. Have you ever thought why is it so?

Cognitive Development of Children : There are three types of children:

1. *Formal operational* : They can understand science without activities.
2. *Concrete operational* : They can understand science only if they do activities by their own hands.
3. *Pre-operational* : They can understand science if they do activities repeatedly by their own hands.

This is the way Piaget categorised the children. These are the children's cognitive stages of development.

Example : Siddiqis worked with Piaget at Florida State University (USA) in 1970 when he came as a Visiting Professor. He went to the neighbouring schools to demonstrate how children at these cognitive stages look at things, think and response. There it was found that only 5 per cent children at primary level (I-V) were at formal operational stage, the remaining 95 per cent children were either concrete operational or pre-operational.

By using Piagetian tasks, Siddiqis conducted Research Studies on 1206 Primary school children in Delhi from all type of schools during 1975-77. The average interview time with each child was about 15 mmutes. So it took about 300 hours to complete the task. It was found that only 4.4 per cent children at primary level (I-V) were at formal operational stage. In Class V formal operational were 9.4 per cent, concrete operational 69.3 per cent and pre-operational 21.3 per cent.

Even at Upper Primary Level (VI-VIII) a good number of children will be at concrete operational stage. This shows that specially at primary and upper primary levels, if children are not involved in doing activities or get first-hand observations, the concepts do not become clear. They may memorise and recall without understanding. When the concepts are not made clear in lower classes, their cumulative effect is seen in higher classes. Other than this there are new concepts at secondary and senior secondary levels which can be clarified through activities or relevant demonstrations.

Generally in our schools, science is taught by giving Lectures, and sometime by demonstrating few experiments. Children are not really involved in doing activities by their own hands. Teachers should also learn a lesson from the following saying:

“I heard and I forgot,
I saw and I remembered,
I did and I understood”

This is not just a saying. As hypotheses these were tested by Siddiqis and they were found correct.

If our objective is that the child may remember the content for sometime. Lecture Method may be relevant without even using Audio-Visual Aids. If the objective is that the child may remember for longer duration. Lecture will not work. But Lecture-Demonstration will be more effective. Care should be taken that every child is able to observe what is being demonstrated using all the 5 senses (see, touch, smell, taste, hear).

But if the objective is that the child must understand then doing is the only method for pre-operational and concrete operational children. Lecture and Lecture-Demonstration are not going to work. The children will have to be involved in doing activities by their own hands.

Thus Activity Based Science-Teaching is the only way of teaching science, if we want our children to learn science. Learning science is understanding science, and not just memorising.

Sample science Activities for primary, upper primary and secondary classes have been given. Some of the activities from this list may be selected according to the science topics to be taught by you in various classes. These activities may be demonstrated by you, or may be done by your students by their own hands, in science classes. These activities will make science teaching quite interesting and learning science by Activity Approach will be a fun for students.

Another important aspect of Activity Based Science Teaching is Teaching with Process Approach.

“If you will teach content, then who will teach science” D.S. Kothari. Science is not just content. Science is content plus something. That something is Process. If our stress shifts from content to process, content will automatically be included and much more meaningfully.

American Association for the Advancement of Science (AAAS) has identified 13 science processes — observing, classifying, using numbers, measuring, using space-time relationships, communicating, predicting, inferring, defining operationally, formulating hypotheses, interpreting data, controlling variables and experimenting.

If we teach science through process approach, it automatically becomes activity based. If a child learns science through process approach, he learns lot of science on his own. Thus Process Approach is one of the best ways of teaching science, as it motivates the children, and they get involved in doing activities.

Certain competencies are to be developed in children while teaching science like spirit of inquiry; objectivity; courage to question; problem solving; decision making; investigating; developing scientific attitude or temper; using scientific method; reducing all sorts of prejudices based on sex, caste, religion and language etc. “ These are also the objectives of NPE — 1986. These competencies may be developed in children through Process Approach of Teaching Science, more meaningfully.

Although one has to devote a little more time when teaching science through Process Approach, but teaching-learning process becomes more interesting and effective. There are teachers who use Process Approach for teaching science in their classes, and for their children learning science is fun.

Use materials (like plants, animals, human body, living-non-living, natural-manmade, wind, hails, snow, dew etc.) and phenomena (like rains, lightning, day and night, seasons, dispersion, rainbow, photosynthesis etc.) of the environment around you (like family, house, neighbourhood, school, earth, sky, human body etc.) as teaching aids, when teaching science. Involve students in discussions based on what they observe in their environment in and outside classroom.

Make an exhaustive list of materials and phenomena available in your environment. Add more items whenever you see some more, in your list. Classify them according to the topics you teach in science, and use them again when teaching science. Your students will enjoy learning and you will enjoy teaching science by EVS approach.

About 1000 Science teachers from 250 Schools of the country (12 states) were oriented in Teaching of Science in the 'In-service Teachers Training' workshops during (1997-2000) conducted by D.M.N. Siddiqi.

Himachal Pradesh

- | | | |
|------------|----------|---------------|
| 1. Kangara | 2. Mandi | 3. Chandigarh |
|------------|----------|---------------|

Punjab

- | | |
|-------------|--------------|
| 4. Bhatinda | 5. Jalandhar |
|-------------|--------------|

Haryana

- | | |
|-----------|-----------|
| 6. Hissar | 7. Ambala |
|-----------|-----------|

Bihar

- | | |
|-----------|----------|
| 8. Ranchi | 9. Patna |
|-----------|----------|

Uttar Pradesh

10. Brij Vihar

Rajasthan, Gujarat

11. Padma Biriani

Andhra Pradesh, Tamil Nadu, Karnataka

Hyderabad

Delhi

13. Delhi SCERT, Delhi DIETs, Municipal Corporation Delhi (MCD) Science Centres and Research & Training Institute.

All the 22 Methods were tried out : The following 11 methods were found most effective. When teachers taught, children also learned (understood).

Child Centered Approach (CCA) : for teaching Science Concepts.

Teacher Centered Approach (TCA) : for teaching Science Skills or Processes.

Scientific Method : Problem, Hypotheses, Experiment, Conclusion.

Process Approach : observing, classifying, using numbers, measuring, using space-time relationship, communicating, predicting, inferring, defining operationally, formulating hypotheses, Interpreting data. Controlling variables and experimenting.

EVS Approach : Our Body, Our family. Our House, Our Neighbourhood, Our School, Our Earth, Our Sky.

Discussion or Interactive Approach

- (i) Teacher — Child Interaction (TCI)
- (ii) Child — Child Interaction (CCI)
- (iii) Teacher — Material (Teaching Aid) Interaction (TMI)
- (iv) Child — Material Interaction (CMI)

(Improved) Lecture : add 6 [(i), (ii)]

(Improved) Lecture : Demonstration — add 6 [(i), (ii), (iii), (iv)]

Self-Learning Methods

- Self-Learning Modules
- Programmed Learning Technique, (now is becoming old, but still effective)
- CDs (Computer Discs)
- Multimedia Packages (Printed Material, Audio-Tapes, Videotapes, CDs, Internet, Internet etc.)

Concrete to Abstract Approach. Direct purposeful experiences. Contrived experiences. Dramatic participation, Demonstrations, Field trips or Excursions, Exhibits, Motion pictures and Television, Radio recordings and still pictures. Visual symbols and Verbal symbols.

Activity Based Teaching Approach

What do we mean by UNDERSTANDING ? This QUESTION was asked by a good number of children learning Science at various levels. Their answers are summarised below:

I feel, I understand Science because:

1. state it in my own words.
2. give its examples.
3. recognise it in various guises and circumstances.
4. see connections between it and other facts or ideas.
5. make use of it in various ways.
6. foresee some of its consequences.
7. state its opposite or concourse.

Strengths, Weakness And Suggestions For Further Improvement : The participating science teachers gave their feedback for the teachers training programmes. This is summarised below :

- We learnt several new techniques for teaching of science which we were not taught in our B.Ed. Programme. Now we are better equipped for Activity Based Science Teaching. When we will use the methods we have learnt here in our science classes, our students will hopefully understand better and enjoy science more.
- (Improved) Lecture and (Improved) Lecture - Demonstration seem to be more effective than just Lecture and Lecture-Demonstration methods.
- Now we know that for teaching science Concepts we should use LCA, and for teaching science skills/processes we should use TCA.
- We think that the LLI, the EVS Approach and Scientific Method are the best techniques for science teaching.

Concluding Remarks : Our Science courses are mostly content-oriented. Whenever the courses are updated more content is added. Courses become heavier and heavier while time allotted in the school time-table remains just about the same. Thus, students have to cover much more content in comparatively much lesser time. Moreover classes are crowded and teachers are heavily loaded. Thus in spite of sufficiently available Science equipment for experiments and demonstrations, the content is covered by asking students to read books or giving lectures to cover more content in lesser time without demonstrations and experiments.

Under such classroom conditions we have to devise and use some self-Learning techniques in teaching Science. These along with some other researched methods/approaches LIKE Learner Centred Approach, Teacher Centered Approach, (Improved) Lecture Method, (Improved) Lecture-Demonstration Method, Concrete to Abstract Approach, and Activity Based Teaching Approach will be more effective in science teaching.

Every teaching method is unique. Different teaching methods are not just a matter of fashion or personal whim. There are grounds for choosing a particular method for a particular situation. A teaching method may prove to be suitable for one situation but completely inappropriate for another.

Our teaching method should be compatible to our objectives. Suppose our objectives are:

1. To ensure that the students obtain the factual knowledge of the subject.
2. To give the students an understanding of the basic concepts.
3. To help the students acquire practical laboratory skills.
4. To promote the interest of the students in the subject.
5. To develop the students' ability to communicate his understanding of the subject in their own words.

If we look at these objectives and choose suitable methods to achieve these objectives, we will see that in order to achieve objectives No. 1 and 2 'lecture method' will be more appropriate, but by this method we will not be able to achieve objectives No. 3 and 4, for which perhaps the laboratory method would be more suitable. The lecture method probably will also be suitable to achieve objective No. 5, if during the lecture notes are not dictated, but students take their own notes.

You learned several methods for science teaching. You also learned how to select particular method or methods for teaching a particular lesson. Now you are to teach science, and all you learned is mostly theoretical. As a practising teacher, you should practise these methods or at least some teaching skills before facing the class. One of the most effective, efficient and dependable methods for developing teaching skills is "microteaching." What is microteaching? How can you use this technique for developing your teaching skills? Answers to such questions might help you to make yourself a better practising teacher.

Microteaching : Practising teachers, when they go to teach in the schools, they face many problems even after completing many theoretical aspects of pedagogy in their course work. Actually teaching is not a simple process. It involves many aspects like class organisation, command on the language, control on the class, probing the students explaining concepts, ideas and so on. The whole idea of microteaching was started at the Stanford University in 1960 by Alien and others. It was initially designed for

practising teachers to do practice in teaching in front of their own classmates (it was also recorded on a videotape) before going to the actual classrooms. The feedback given by the peer group and received by the video replay helped the teacher to identify his/her shortcomings and do more practice in identified areas.

The idea of the whole process was to bring improvements in one's teaching. Microteaching was found quite an effective process in developing teaching skills in preservice teachers during their training period. Since then it has gained quite a popularity in various teaching training institutes and other training centres. A large number of researches have been done in the field of microteaching and many microteaching centres and research units have been established. Other than preservice teachers training, microteaching is being used for in-service teachers training and in many professional fields like medicine and nursing etc.

As the name indicates microteaching means teaching a short (micro) lesson, for a short time (5-10 minutes); teaching to a small group or may be their own peer group or a small group of students, concentrating on one particular aspect of teaching. The rationale for this approach is that teaching is a complex process involving various aspects, microteaching helps in concentrating on one aspect at a time, therefore reduces the situations to a manageable proportion. The experts and research in microteaching have identified many skills in teaching such as — skill of introducing a lesson, class management and organisation, maintaining students attention, art of questioning, use of chalkboard, lecturing, using the audio-visual aids, reinforcement or encouraging the desired behaviour, explaining things and many more. In microteaching session each skill is practised and mastered individually. Once the various skills have been practised in the Simulated situation the teacher will be able to combine all or some skills of teaching in the real situation of classroom teaching.

Before actually starting any practice in microteaching it is important to orient the trainee teachers with the philosophy and technique of microteaching. This could be done by supervisors or other subject experts, then the skills have to be identified for

microteaching practice. One way of doing this is to plan and give a regular teaching lesson in simulated situation (in front of the peer group). From this simulated teaching the weak areas of skills can be identified after getting proper feedback, or it can be decided by the subject expert or the supervisor to give practice in some skills which will be more important in teaching, for example, in science teaching, problem solving, inquiry approach and some others can be identified.

The microteaching may be done in the following steps.

Misicrolesson Planning : After deciding on the skills to be developed the first step is the planning of a misicrolesson on the identified teaching skill say introducing a lesson on a selected topic for a short period of time say five-six minutes.

Practice of the Teaching Skill : The-second step is the teaching session where the planned lesson on the specific teaching skill will be delivered to a selected number of classmates who can play the role of that level of students for which the lesson has been developed. The rest of the classmates and the supervisor are observers.

Feedback Session : The teaching session will be followed by a short session where the feedback is given by the classmates as well as by the supervisor. At Stanford University the video-tape was used for the purpose of feedback which was discussed in the class and by actually seeing himself/herself the teacher was able to improve. In some places video-tape records are being used in microteaching sessions. But it involves heavy expenditure therefore it can be avoided.

Re-plan Session : In the light of the feedback received from the students and teachers' the lesson will be replanned.

Re-teach Session : The replanned lesson will be retaught to the same group or roles can be exchanged by the students for about the same time.

Re-feedback Session : The teacher will again receive the feedback from student-teachers (observers) and the supervisor. If

needed the same cycle can be repeated to achieve the desired level of performance. Usually there are two cycles but for some there may be three cycles and for others only one cycle is sufficient.

If some sessions of microteaching are planned and arranged in the training colleges for the science teaching, practising teachers will be better equipped and will go to their practice teaching classes with more confidence.

- (i) You learned several methods of teaching science. You also learned how to select a particular method/methods for a particular topic and situation. You also learned some teaching skills for science class. According to NPE — 1986 “All teachers will teach, and all students will study”. Now you will teach science effectively, as you know ‘how to teach’. But just teaching is not enough. Your students should also study after you taught them some science. For effective learning, your students should be trained for some study skills, so that they know, how they should study?
- (ii) A student should develop and employ study skills in order to derive the maximum benefit from the teacher’s talk (lecture) along with T-L Interaction (Discussion) in the classroom, observations and experiments in the laboratory, reading books and journals in the library and doing assignments (homework) at home. While some universities abroad have started courses on “Learning to Learn (Development of Study Skills),” at least we should make a beginning.
- (iii) “How should I study”, should be the objective of every student, you or your student. There is a great deal of literature based upon researches on learning, retention, thinking, cognitive styles, reading techniques, information processing, scheme, metacognition, note taking, problem solving, time management and related subjects. We should take its advantage to get the answer of this question. We should discover the difference between teaching-learning of Science in the School of Today and Yesterday. In order to complete the Today’s Science Course, the class contact

hours are less compared to the content to be taught, and hence our students are overloaded. Therefore Today's Education should provide an opportunity to students, to learn by reflective thinking, to internalise the concepts and to demonstrate creativity. Besides, Today's Education should encourage and motivate students to learn for themselves (self-learning) and pursue lifelong learning.

- (iv) *Subskills for Learning* : There are a number of subskills (ingredients of study skills) for learning. Reflective Thinking constitutes the core. Listening (Paying Attention) is "indeed the starting point of studying in the classroom. Likewise, Reading Skills are basic to self-study. Note Taking, Question-Answer Technique, and Communication Skills greatly add to the learning process. Knowledge about Information Processing and Schematisation may enable - to adopt more effective study skills.
- (v) *The Learning Process* : How students learn, retain and recall information has been the subject of intensive research by cognitive psychologists. The more active the learning is, more easily connections between new information and already existing information are made. More connections facilitate easy recall and longer retention. Meaningful conclusions can be drawn from the findings of the cognitive research studies. Some of them are as follow:
- Readiness to learn and motivation to learn are most essential pre-requisites to all Learning in order to generate your own motivation.
 - Objectives of learning *i.e.* the intended capabilities after learning must be kept in view. It saves great deal of time and effort to go by objectives.
 - Variation of activity during learning engages you in learning for a longer time,
 - Incremental *i.e.* step-by-step learning or learning in small chunks, and self-evaluation during each chunk of learning ensure more permanent learning. Each chunk should have one new idea.

- Thinking while learning ensures your involvement in the process of learning. Mere note taking is not sufficient. Try to understand what you are learning. Recall previous topic. Look for links (connections) between present topic and the previous topic. This reinforces learning on both the topics.
- Memorisation and recall of facts and figures is often aided by remembering cue words, flow diagrams, acronyms etc., e.g. acronym VIBGYOR aids in recalling the seven colours of a rainbow.

Sustained research on learning shows that you cannot continue to learn at a stretch. Nor is the rate of learning constant with time. In a classroom, the period of time, for an adolescent, over which the learning is sustained with a reasonable rate of learning *i.e.* attention span of learner is about 20 minutes. So after every 20 minutes the teacher should change the activity for effective learning. They may use different teaching aids, tell a joke, make a mistake, ask a question, give a quiz test etc.

(vi) *Memorising Facts and Figures* : Whatever innovations in teaching and learning may take place, one thing is sure you will have to memorise at least some facts and figures. You cannot afford to device equations and think but all possible facts in the examination hall. There are a number of learning strategies for memorising. Some of them are as follows:

- Reviewing, repeating or rehearsing the facts are necessary. Repetition and restatement in your own words help in conceptualising and remembering things.
- Never attempt to memorise what you do not understand. For your understanding explain something difficult to someone else.
- Clustering, categorising and grouping of facts are excellent aids to memory.
- Making acronyms, one words, and analogies may aid recall. Different students prefer different techniques of

memorising. You must also have memorised many facts and figures, and so your friends. Share your experiences. What techniques you have used for memorising. Discuss. You can discover your own preferred methods for memorising.

- (vii) *Questions During Lectures* : Lecture Method is not the best method of teaching Science. What, then can you do about it if your teacher decides to use Lecture Method? The least you can do is to ensure you get the message during a lecture. When in doubt, always raise your hand and pose question. If your teacher asks questions during lecturing, raise your hand to show willingness to respond. Do not miss this chance. And when you as a teacher lecture, encourage your students to ask questions. You also ask questions to ensure that your students are understanding what you are teaching. Have a healthy Teacher-Learner Interaction (Discussion) during your lecture.
- (viii) *Reading Skills* : As a science student you are to read a lot. If you develop some Reading Skills in you and then in your students it will help a lot in learning science.

A reading strategy called SQ3R technique is frequently advocated for effective reading.

S Surveying the subject matter

Q Questioning oneself about the need of reading

R Reading and deriving meaning

R Recalling the previous learning

R Reviewing the salient points

Another method of effective reading is *MURDER* Technique.

M Mood Setting the mood for study doing something relevant and then switching over the study.

LJ Understanding Making important and difficult ideas.

R Recalling Material without referring to the text.

D Digesting	Internalising the material.
E Expanding	Knowledge by self-questioning.
R Reviewing	Learning from mistakes.

- (ix) **Note Taking** : There are many good reasons for taking notes while listening to a teacher or reading a book. Note taking promotes listening, thinking, deriving meaning, concentrating, and helps in keeping record for future reference.

Different students adopt different techniques of taking notes. Some students write in the margins of the books, some on cards and others on proper notebooks. Some students write cue words, some half sentences, others make scheme maps i.e. cue diagrams beside key words. One needs not write what the teacher speaks; one may also not write what the teacher writes on the chalkboard or what he shows through overhead projection. One may develop notes in one's own style of adding-on-information in blocks, flow diagrams, schematics etc. After all, one's notes are primarily for oneself. Good note taking is, as much a process of learning as good notes are a product of learning.

It is recommended that. students should use note sheets with adequate margins for future additions, recognition, revision, arrows etc.

A recent malpractice is to photocopy someone else's class notes. It does not work. One's own notes are the best. In your own notes, you can build links to your previous knowledge, you can create your own memory aids — these are more powerful for you than other people's aids, your own notes can concentrate on those things which you find difficult to understand.

- (x) **Communication Skills** : You have a great deal of scope for developing oral and written communication skills in your professional studies. How are these skills acquired?
- (a) **Skills of Oral Communication** : One should learn how to ask a question (Question Skill), how to be precise, how to respond,, how to offer a suggestion, how to

propose a solution, and how to speak in public. It is necessary to listen when you speak. One should contribute in group discussions through critical thinking and quick responses. Quite often, someone else has just said what you wanted to say. Why not you? At times, take a lead. Tutorial classes are friendly meetings with free flow of ideas. You should take advantage of your tutorials to develop skills of oral communication in you.

- (b) *Skills of Written Communication.* Assignments and laboratory experiments should be written up independently. While writing, think visuals; draw graphs and other diagrams to convey your thought effectively. Writing is the process of expression of thoughts in black and white. The term 'black and white' includes written words, figures, tables and the use of desk computers. It is necessary to develop writing skills because you need to write out notes, project proposals and reports, executive summaries, critical appraisals etc. all your professional life. Remember: 'A picture is worth more than thousand words.' So try to put words in a visual form by making effective diagrams.
- (xi) *Problem Solving Skills :* One of the best ways to learn how to solve a problem is to ask some one else to explain how he proceeded to solve it and why. A heuristic approach to problem solving suggests such strategies as:
- Thinking aloud
 - Working backward
 - Using trial and error
 - Considering other possibilities
 - Using means for analysis
 - Subgoaling and working by parts etc.

Practice in solving problems leads one to think creatively, to employ different techniques and to arrive at acceptable solutions. Consider the formal type of problem solving that we do in science,

e.g. problems like 'Prove that.../ 'Show that...,' etc., in which case the answer is known. In problems like 'Evaluate...; Determine...; etc., you have to check your solution by answering some questions to yourself, like:

- Is the answer sensible?
 - Does the answer fit in the original data?
 - Is the answer unique? Would any other answer fits just as well? If so, how can I decide which is more likely to be correct?
- (xii) *Time Management* : You are to do co-curricular activities along with curricular activities — assignments, homework, self study. You have to do all this plus a lot more of your own. You have just 24 hours in a day. You cannot increase that. So you are to manage your time. There is no cut and dried formula for time management. You are to lay down your own priorities for the work you are to do and complete. It is worthwhile to be regular in homework, and complete your assignments and projects well in tune to avoid undue tension relax. A relaxed mind learns much better. Time for relaxation should be budgeted in the work plan. Make your daily, weekly, monthly and annual work plans, and then stick to the schedules of your plans. This will make your learning a joyful learning.
- (xiii) *Learning Environment* : It is for you to create an environment conducive to your learning. The best environment is that where you as an individual feel motivated and reasonably comfortable to study. Reasonable comfort includes your body posture with no or minimum stress, lighted study corner with fresh air and controlled dust, heat and noise. Concept of noise may differ. Some students can study perfectly comfortably with radio or music deck at full volume, some like it in the background and others cannot bear it at all.
- (xiv) *Preparing for Tests and Test Taking* : Having developed study skills and even after reading and preparing for a test,

one may not still score well in a test. This is because Test Taking is a reverse process compared to the acquisition of knowledge. In a test, one has to recall, recognise, manipulate data, compute, analyse and write. Not only this, one has to adopt a strategy of scoring.

(a) *Pre-examination Preparation* : For pre-examination preparation, complete any outstanding work as quickly as possible, even if this means sacrificing the quality somewhat. Your notes are the most helpful tools for preparation. Organise your notes and highlight the key points. Look at those problems particularly which you do not know well. Answer the questions of the past years question papers. Explaining a concept to someone else makes you understand better. All this will give you a good deal of confidence.

(b) *Test Taking* : You should know the art of Test Taking to score more. SCORER will help you to score more.

S	stands for	Scheduling the time
C	stands for	Cue words
O	stands for	Ordering of questions to be attempted
R	stands for	Reading between the lines
E	stands for	Estimation of answers
R	stands for	Review and Revision.

(xv) *Relax* : Relaxation is Basic to good study skills. One can think better and respond better when relaxed. Once you are able to think/ may it be in classroom, laboratory, field or at home, you will be able to grasp the subject. Some knowledge about the process of learning, information processing, note taking etc. discussed here would lead you to better organisation and management of learning.

Value of Learning

Part and Participle of the Course

What we teach in Science is 'Content'. Now the question arises, 'What is Science?' Science is a way of describing and explaining some aspects of the world around us. To the extent that a lot of human effort has already been expended in developing such explanations, our students do not have to 'start with scratch'. A large and ever-increasing body of scientific knowledge already exists, and evidently part of the task as teacher is to pass some of it to the students. But this is only part of the job, for Science is also a package of processes by which we can increase our knowledge of the external world.

Teaching Science implies involving our students in investigation, so that they become 'Scientists for the day'. There are facts, theories, concepts and also a way of working which together constitute 'the subject Science'. Thus Science is not just content. Science is content plus processes.

One of the things you will be doing as a science teacher is familiarising your students with theories, helping them to develop concepts and appreciate the structure which connects them.

Content to be taught at Upper Primary level (VI-VIII) or at any level should be carefully selected. It is a hard task. Scientific

knowledge keeps on increasing. It doubles every decade. Our students are to keep pace with increasing scientific knowledge. We should teach them what they really need at this level. If it is more to be completed in a classroom in the allotted time, we should develop such techniques so that students could learn a part of content on their own outside the classroom.

‘What we teach (Content)’ should be compatible with:

- (i) cognitive level of students,
- (ii) identified objectives, and
- (iii) existing classroom conditions.

The ‘Content’ presented to the student should be such that he could understand it, and not just memorise. Learning is understanding, and not memorising. In every class there is some content in Science, which most of the students, memorise without understanding. Such content should not be included at that level, but shifted to a level where students can really understand it.

Syllabus given by the education departments or school education boards are usually outlines. Therefore different authors go to different depths for the same content when writing the textbooks. If our Science Syllabi are well-defined in the form of ‘objectives written in behavioural terms’ the authors will know exactly what they are to write, students will know what they are to learn and teachers will know what they are to teach.

Various Angles

Physicists, Chemists and Biologists are specialists in Physics, Chemistry and Biology respectively. Our students at Upper Primary Level (VI-VIII) are not specialists. For them each of Physics, Chemistry and Biology is Science. So when teaching Science at this level, we should not compartmentalise Science into Physics, Chemistry and Biology, as it was the case since mid-sixties, and we used to teach NCERT developed Disciplined Science Courses (Physics, Chemistry and Biology) in classes VI, VII and VIII. We should teach Science at this level as a package of Integrated Science Course.

You as a teacher trainee of Second year will teach Science to classes VI—VIII during your practice teaching. So along with learning methodology of teaching Science at this level you should also enrich yourself in Science content. Go through the science syllabus and the Science textbooks of classes VI—VIII. Analyse them. For your convenience VI—VIII Integrated Science Syllabus is divided into 8 units, and is given as under :

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- Unit-1 : Science in Everyday Life
 - Unit-2 : The Measurement
 - Unit-3 : The Universe
 - Unit-4 : Motion, Force and Machines
 - Unit-5 : Work and Energy-energy, heat; sound; light; light and optical instruments; static electricity; electric current; conservation of natural resources; alternative sources of energy; magnetism.
 - Unit-6 : Matter, Its Structure and Properties—nature and composition of substances; acids, bases and salts; carbon and its compounds; metals and non-metals; man-made materials.
 - Unit-7 : Air and Water
 - Unit-8 : Living World—the living world; structure and function of living body; balance in nature; organisation of the living body; life processes; food, health and diseases; soils; agricultural practices and implements; the microbial world; adaptation and organic evolution; useful plants and animals.
-

Many of the processes we see in nature are not classifiable as Chemistry only, or only Physics, or purely Biological. For example, when the polar bear hibernates in the Arctic winter, its action is biological. During this fact, we should be thankful for the stored fat and its properties. For the physical property of the fat 'fat is a bad conductor of heat' aids the bear in keeping warm, for the chemical property of fat 'it lowers oxygen content' makes it energy-

rich fuel, better than carbohydrates, and for the biology of being able to take and store the fat in its tissues. This shows how Physics, Chemistry and Biology are integrated. With this philosophy in mind 'an Integrated Science Syllabus' was framed for Upper Primary classes (VI-VIII), and based on this syllabus Integrated Science Textbooks, 'SCIENCE' were written for classes VI, VII and VIII by NCERT, which are being used in our schools these days.

NPE—1986 has laid greater emphasis on teaching of Science at all levels, and so at Upper Primary level. According to its recommendations, "Science education is to be strengthened so as to develop in the child well-defined abilities and values such as the spirit of inquiry, creativity, objectivity and the courage to ask questions. Science education programmes are to be designed to enable the learner to acquire problem-solving and decision-making skills". These recommendations were taken into consideration when NCERT framed Integrated Science Syllabus and wrote Integrated Science Textbooks for classes VI, VII and VIII.

Select any Sub-unit : Write behavioural objectives, covering the whole syllabus of the sub-unit. Go through the Science textbook for that sub-unit, and see whether all the behavioural objectives are covered in the book for that sub-unit.

Science as Basis

Unit 1. Science in Everyday Life

Role of Science in solving many basic problems in our everyday life and misuse of Science.

Unit 2. The Measurement

Use of various devices in measuring length, area, volume; measurement of mass; need for accurate measurements in daily life; measurement of temperature, various types of thermometers, measurement of time.

Unit 3. The Universe

Numerous stars and planets in the universe; classification of heavenly bodies, galaxy, shapes and sizes of the heavenly bodies

and idea of their distance from the earth; artificial satellites; various uses of artificial satellites; meteors and meteorites.

Unit 4. Motion, Force and Machines

Different types of motion—linear, random, rotatory, circular, periodic, oscillatory; speed, force; change in speed, direction and shape by applying force; various types of forces; magnetic force, electrostatic force, frictional force; advantages and disadvantages of friction. Different kinds of simple machines—lever, inclined plane, pulley and wheel; complex machines—a combination of simple machines; maintenance and care of machines.

Force, its magnitude and direction; pressure; atmospheric pressure; thrust; buoyancy; Pascal's law; Archimedes' Principle; floatation of bodies.

Unit 5. Work and Energy

Energy

Energy, relationship between work and energy; renewable and non-renewable sources of energy; electric energy from coal; solar energy, wind energy, energy from water, energy from biomass; mechanical energy; potential and kinetic energies; transformation of energy.

Heat

Temperature and its measurement; heat and its measurement; units of heat; melting and boiling points; expansion of solids, liquids and gases, properties of substances used in constructing thermometers; transfer of heat by conduction, convection and radiation; thermal properties of substances.

Sound

Various types of sound; modes of production of sound; formation of echo, noise and its hazards; human ear.

Light

Formation of shadow; solar and lunar eclipses, laws of reflection; image formation in plane and spherical mirrors.

Light and Optical Instrument

Refraction of light and its applications in daily life; convex lenses; formation of images in lenses; microscope; telescope; binoculars.

Static Electricity

Charging of bodies; like and unlike charges; attraction and repulsion of charges; flow of charges: electroscope; conductors and insulators.

Electric Current

Source of electric current; dry cells; generator; storage battery. A.C. and D.C. transformation of electricity; conductors and insulators; electric circuits; effects of electric current; hazards of electricity.

Conservation of Natural Resources

Matter or material from earth; energy from Sun; energy directly or indirectly from the Sun; proper distribution of resources; various types of natural resources, renewable and non-renewable, depletion of resources and their causes, conservation of natural resources for human survival; conservation efforts at individual/ community/ governmental/international level necessary.

Alternative Sources of Energy

Source of energy; Fossil fuels; hydro-energy; bio-energy, wind energy as renewable sources of energy; energy needs; development of energy; judicious use of energy.

Magnetism

Magnet and its properties, repulsion of like poles and attraction of unlike poles; electromagnets; Earth as a magnet.

Unit 6. Matter, Its Structure and Properties**Nature and Composition of Substances**

Different states of matter, molecules constituting particles and

matter, forces between molecules; gap between molecules—diffusion, plasticity; elements, compounds and mixtures; preparation of oxygen; molecules; atom; symbol of elements; significance of symbols; chemical formulae of elements and compounds; significance of chemical formula; representation of chemical reaction by an equation.

Acids, Bases and Salts

Oxides; formation of metallic (basic) and non-metallic (acidic) oxides; acids; bases; some common physical and chemical properties of acids and bases; preparation of hydrogen; neutralization; formation of salt; various uses of acids; bases and salts in domestic and industrial areas.

Carbon and Its Compounds

Uses of carbon compounds; forms of carbon; hydrocarbons; fuels; petroleum and its products; domestic cooking gas; coal and its products; combustion; fire extinguishing.

Metals and Non-metals

Rocks and minerals; ores; extraction of metals from ores; characteristics of metals; alloys and their uses.

Man-made Materials

Various types of materials and their application; synthetic fibres; plastics and its uses in daily life; glass and its formation; ceramics; soaps and detergents; fertilizers; pesticides.

Unit 7. Air and Water

Air

Composition of air; oxygen—a supporter of combustion and life; necessity of air for substances of life; various uses of air to human beings.

Various constituents of air; oxygen an important constituent of air, air pollution; acid rain; uses of various constituents of air.

Water

Importance of water for living beings; sources of water; purification of water for drinking; some special physical properties of water; different forms of water; change of one form into another; water cycle in nature; uses of water in day-to-day life; need of conservation of water.

Composition of water; electrolysis of water; electrical attraction of water; some chemical properties of water dissolution of various minerals and salts in sea-water; hard and soft water; removal of hardness; water pollution.

Unit 8. Living World

Variety in shape, food habits, habitats, structure and mode of living; individuals with close similarities in form with above characteristics, species, naming species, classification of living and non-living; characteristics of living forms; classification of plants into flowering or non-flowering or the nature of roots, stems and leaves, life span, animals, classification—presence or absence of backbone and other characteristics.

Structure and Function of Living Body

Organization of the living body to perform different functions; loss of part affects functioning; parts of plant-root and shoot systems; roots, stems, leaves, flowers, fruits and seeds have definite functions; modification of plant parts.

Animal organ systems for different functions; digestive system; respiratory system; nervous system; excretory system; locomotion and reproduction.

Balance in Nature

Living and non-living components of environment; interdependence; food and energy relations; balance in nature; indiscriminate human interferences are often harmful.

Organisation of the Living Body

Definite organization of living bodies for functioning; Levels of

organization, unicellular and multicellular organisms; cell structures and functions; differences between the plant and animal cells; cells arise from pre-existing cells; plant tissues and their function; conduction, mechanical support; animal tissues and their function; epithelia, connective, muscular and nervous.

Life Processes

Basic life processes; photosynthesis by green plants; nutrition in non-green plants; animal nutrition: the alimentation process; respiration—organs, common cellular processes; aerobic and anaerobic respiration; transport of materials in animals (mention of blood transfusion) and plants; excretion—organs and modes of removal of wastes; coordination—nervous and hormonal; movements, continuity of life; vegetative, asexual and sexual reproduction; growth and development in plants and animals.

Food, Health and Diseases

Basic constituents, their main functions including water and roughage; balanced diet in relation to age and work; judicious choice of food; avoidance of fats: malnutrition; deficiency diseases: food preservation; contamination/spoilage; healthy living depends on oil hygiene: sanitation and habits; diseases; disorders; role and spread of disease causing micro-organism; personal hygiene and environmental sanitation; non-communicable diseases; smoking, alcohol and drug addiction as health hazards.

Soils

Composition of Soils : gravel, clay, organic matter; humus and living organisms in top soil, soil formed by weathering; soil as important natural resource; soil erosion and conservation; soil pollution.

Agricultural Practices and Implements

Management of Plants and Animals : usefulness, general methods; improved agricultural practices for increased food production; basic practices; sequencing; variation from crop to crop; practices common to gardening, agricultural implements and

their uses and care; qualitative and quantitative improvement of crop yields; necessity and methods, improved practices and varieties; judicious use of soil, fertilizers and pesticides; animal management; need for keeping animals; general needs and maintenance of domestic animals with special reference to cattle, sheep, poultry, bee and fish rearing.

The Microbial World

Micro-organisms have diverse forms; fungi, protozoa, bacteria, viruses and certain algae; causes of disease in man and animal bacteria (cholera, typhoid): virus (cold, measles, polio, chicken pox), protozoa in fungi (malaria, dysentery, etc.) : animal diseases (anthrax and foot and mouth), plant diseases (rust, bacterial wilt, leaf curl, mosaic) : modes of transmission of diseases; vectors; control of microbial disease; proper storage and preservation to prevent microbial damage to clothing, timber and food.

Adaptation and Organic Evolution

Meaning of adaptation; adaptation of aquatic, terrestrial and volant organisms; origin of life from simple substances; origin of complex forms from simpler forms; evidence of evolution, external and internal structures, fossils, organic evolution through the process of natural selection.

Useful Plants and Animals

Harmful and useful plants of economic importance—wild and cultivated; useful animals; animal products from wild and domesticated animals (ivory, lac, horn, lime, pearls, leather, honey, etc.).

Science as Discipline : There are facts, theories, concepts and also a way of working which together constitute 'the subject Science'. Thus Science is not just content. Science is content plus processes. 'What we teach in Science i.e. content' should be compatible with cognitive level of children, identified objectives, and existing classroom conditions.

Science syllabus given by the education departments or

education boards are usually outlines, that is why it does not mean the same for authors, teachers, students and paper-setters. If our science syllabus is well defined in the form of 'objectives written in behavioural terms,' the authors will know exactly what they are to write, teachers will know what they are to teach, students will know what they are to learn and paper-setters will know what questions they are to set. Thus such a syllabus will mean the same for all of them.

Physicists, Chemists and Biologists are specialists in Physics, Chemistry and Biology. Our students at Upper Primary level are not specialists. For them each of Physics, Chemistry and Biology is Science. That is why NCERT switched over from disciplined Science (Physics, Chemistry and Biology) of mid-sixties to Integrated Science at Upper Primary level.

NPE—1986 has laid greater emphasis on teaching of Science at all levels, and so at Upper Primary level. According to its recommendations, "Science education is to be strengthened so as to develop in the child well-defined abilities and values such as the spirit of inquiry, creativity, objectivity and the courage to ask questions. Science education programmes are to be designed to enable the learner to acquire problem solving and decision making skills." These recommendations were taken into consideration when NCERT formed Integrated Science syllabus and wrote Integrated Science textbooks for classes VI-VIII.

If you analyse VI-VIII Integrated Science syllabus, it could be divided into several units—Science in everyday life; energy; matter, its structure and properties; air and water; living world. All this content can be translated into objectives in behavioural terms.

Learning Programme

Percentage of our science teachers (Physics, Chemistry and Biology) have good background in their respective subjects, and they take interest in teaching and trying out new science programmes. Even in the schools which have enough science equipment and the science labs are well equipped, the lecture-demonstration method is the one most commonly used, as our science teachers are heavily loaded and they get a very little or sometime even no time for planning their lessons during school hours. Our schools have usually 8 periods of 30-40 minutes duration. Regular teachers also work as substitute teachers (where in America if a teacher is on leave, a substitute teacher is invited from outside to teach his classes) during their planning periods besides their teaching 6-7 (out of 8) periods daily, six days a week (where in Western countries schools work five days a week), and Sunday is the only holiday.

Our textbooks are written in a traditional way. If our science teachers could have well sequenced programmed materials, it would be a great help to them, as mentioned above, they are heavily loaded. Also if the programmed materials provided activities of 20-25 minutes duration, students would have more opportunity to do the experiments themselves even in smaller periods. So well sequenced programmed materials would be more useful for

teachers to teach and for students to learn than the materials now available.

The Perception

Let us look at some of the definitions of programmed instruction.

- (1) Cronbach describes a programme of instruction as follows: "A programme is a pre-arranged sequence of explanations and questions. A programme whether for a brief unit or for an entire course, is a carefully planned progression of ideas, beginning with elementary notions and working upto relatively complex theories or applications.
- (2) According to B.F. Skinner a programmed instruction is simply a matter of breaking the material to be learned into easy steps, arranging steps in logical order with no gaps, making sure the student understands one step before moving to another and then incidently, making sure that he is successful.
- (3) According to Espich and Williams a programmed instruction may be defined as a planned sequence of experiences, leading to the proficiency, in terms of stimulus response relationships. By this definition a programme is an educational device that causes a student to progress through a series of experiences, which lead to the students proficiency. The experience here is student's own experience in the learning process, not just the teacher telling. Planned sequence determines what experiences and in what order should occur. What is the student supposed to be able to do after completing the programme? How well? How quickly? All such questions implied in leading to proficiency in terms of stimulus-response relationships refer to the basic behavioural science concepts on which programmed instruction is based, and which are taken into consideration when a programme is written.

Taught as a Discipline

No one knows for certain how or why programmed instruction works, but it is generally agreed that basic behavioural psychology

is somehow involved. At least the originators of programmed instruction attributed its success to some basic tenets of behavioural psychology.

The results of the change in behaviour called learning are observable or measurable. All behavioural changes of students as a result of learning may be of three types: (1) Psychomotor; (2) Cognitive; and (3) Affective (Chapter 3). (1) and (2) are comparatively easier to measure than (3).

In any teaching situation for effective learning the best method is:

1. Present the stimulus to the student.
2. Help the student to make the desired response to the stimulus by giving him clues, by leading him towards it, or by telling him the response itself.
3. When the student makes the desired response to the stimulus, immediately reinforces that response.

Programmed instruction takes advantage of the basic human drive for success. The programmer guides the student toward making the correct response. He then shows or tells the student that he has given the desired response—that he has been successful. Each time he makes the correct response, he is positively reinforced by being told that he is correct, his drive for success is satisfied. Each time his drive for success is satisfied, the probability increases that he will make the correct response to the given stimulus in future situations.

The programmed instruction does have a number of advantages over conventional methods. It allows for individual rates of learning and it gives immediate reinforcement of correct responses. According to Burner the technically most interesting features of automatic devices are that they can take some of the load of teaching of the teacher's shoulders. For this time the teacher can be used by his students who need him and whenever they need him. According to James this type of teaching is very frustrating and tiring but extremely rewarding. When science teachers have worked as long at individualized instruction as they have to make

grouped instruction workable, the rewards may be proportionally increased.

Functional Aspects

In teaching science, a continuing area of concern to educators has been the problem of integrating laboratory experimentation with instruction in scientific theory. The need to individualize course content for students is also recognized. Programmed instruction may offer one solution to both of these difficulties. If the science curriculum can be programmed so that individual rates could be dealt with more effectively, and if laboratory material can be developed which enable students to conduct experiments effectively on an independent basis, laboratory experimentation may be integrated more satisfactorily into the typical science course.

A summary of the subject area in which programmed instruction has been used reveals that these areas which require laboratory activities are rare. Cowan indicated that there were no auto-instructional materials available in physics that provided students with laboratory experiences. Cowan and Siddiqi developed and used such materials in their research studies.

Hundreds of good science textbooks are available in the market. They are not designed to teach but to convey information to the student. In a programme a programmer determines for a student, what he should and what he should not assimilate. In a programme, the student is guided along a path and given those experiences that will cause him to learn those things. No such guidance is given with a textbook. Adjunct programming can be a link between programmed instruction and a good textbook. It combines some of the progressive features of programmed instruction with the comprehensiveness of textbooks. The goal of adjunct programming is to enable the student to learn as effectively as possible from a good textbook.

An Adjunct Programme may be one of two types (1) The text itself is kept intact and the programme is supplied as a separate unit, or (2) sections of the textbook are extracted vibration and used in the programme as the basic information. The most popular

procedure as used by Cowan and Siddiqi is to leave the textbook intact. Their programmed materials which they developed for the PSSC Physics Text, provide a very good example of adjunct programming. They used these materials in their research studies. Students using the auto instructional materials studied from the same text, worked the same problems, viewed the same films, and performed the same experiments as regular physics students. Cowan did not use a qualified physics teacher in the classroom to direct their studies.

The use of auto instructional materials prepared for this study evidently provided a good physics programme, as students using these materials were able to demonstrate as well in achievement as those not using these materials but taught by a qualified PSSC physics teacher. In Siddiqi's study students of experimental group used the auto-instructional materials under the guidance of their physics teacher, while, the students of the control group did not use such materials, they were taught by their teacher in a conventional way. The experimental group demonstrated statistically higher mean level of achievement in PSSC physics.

Siddiqi developed an Adjunct Programme for PSSC physics. It was student self-directed study guide in PSSC physics. Here are the comments (unedited) of some of the students who used it.

Strengths

1. "Students can do whenever they want to do. If we do not understand anything now, we can do it some other time."
2. "When you learn on your own, you are more apt to remember it."
3. "Student learns more if he goes on his own rate. In conventional classes superior students get frustrated. They want to go ahead. Slow students don't understand. Teacher stops the whole class. With these materials superior students also have an opportunity to go ahead. Every student is able to go on his own rate, not waiting for anybody, not trying to catch up with anybody."

4. "Teacher gets more time, when he can go and help other students. He goes to the student who has problems, and not to the student who does not have any problem; so he does not waste his time. Teacher's time can be put to better use. We do not need the teacher all the time. We only use him when we need him. Teacher can enrich the student more when he talks individually."
5. "PSSC text was easy to understand with these materials. Text was too complicated, and the guide made it simplified."
6. "Guide has more hints to do labs than does the lab manual."
7. "Self-tests were good. When I missed something, I went over it and it helped me very much to learn physics."

Weaknesses

1. "These materials were unable to motivate those who were not self-motivated to use these materials."
2. "This approach did not work for lazy students. Some students need a push and without a teacher always available to keep them working they have a tendency not to study. It's hard for some people to pace. It requires more discipline to work on your own."
3. "This approach is good for those who want to learn by this approach. If the student is the type who cannot go on his own, this approach is not good; he should (probably) be taught by the conventional method."
4. "Sometimes a student is isolated by this approach — text guide, problems, lab, text, guide; that's all he has to work with."
5. "Physics is such a hard subject that you have to have more teacher help."
6. "I did not like it too much, because I am lazy by nature."

Teachers who taught the students using programmed instruction materials also pointed out some strengths and some weaknesses of this approach of teaching.

Strengths

1. "These materials are excellent for those who have difficulty with PSSC physics."
2. "These materials enabled some students to achieve what they were unable to achieve without them."
3. "These materials developed in students an attitude of doing independent work, which they will need when they will go to College and University."

Weaknesses

1. "Only those students who feel responsibility learn more by this approach."
2. "These materials are not good for slow learners."
3. "Some students go behind and behind not because they were not capable to move but because they were lazy. Some students can read but they don't want to read. There is a problem of keeping the student motivated."
4. "This approach is more time consuming. Some students took more time to finish the same material."
5. "When working on their own only half of the students use their time effectively while others use their time doing something else."

The conclusion of a group of students regarding the autoinstructional material was: "With autoinstructional materials, the text, and a teacher to explain, the self-study would be most practical and best for students."

In general most of the students and teachers liked the programmed instructional materials and this approach of instruction. They pointed out individualisation, independence, self-pacing, self-evaluation, and better use of teacher's time as some of the major strengths of this type of instruction. More than half of the students and teachers liked individualised instruction. They reported that using this approach for instruction, the teacher got more time to interact with individual students. They pointed out that the PSSC Physics Students Guide made PSSC Physics easier for the students.

They also pointed out that this approach of instruction was best suited for superior students. More than half of the students liked the idea of moving according to their own pace, but the teachers did not like this idea very much, as it was hard for them to cope with their students, when different students were doing different things in the same period. Most of the students and all the teachers pointed out that lack of self-motivation was the main weakness of this type of instruction.

Some of you as a science teacher will like to use programmed instruction materials in your science classes. Usually programmes are not available in the market. Though developing programmed instruction materials is a time consuming job, yet some of you will like to develop some programmed instruction units. It will be a good project for your instruction.

Before developing programmed instruction units, it will be nice if you learn how to develop them. One such programmed unit “Structure of an Atom” is given here as a Sample. You go through it, and after that we will discuss, how it is developed.

Gradual Cultivation

In developing this unit the System Approach was used. The System Approach has the following steps:

1. Identify problems and state terminal objectives.
2. Conduct task analysis.
3. Describe entry behaviours of students.
4. State sub-objectives in behavioural terms.
5. Develop evaluation instruments.
6. Determine instructional sequence.
7. Select appropriate media and instructional procedures.
8. Develop instructional materials.
9. Conduct formative and summative evaluation.

Given the atomic weight and atomic number of an element the students will find out the number of protons and neutrons in the

nucleus and the number of electrons in the various shells of the atom.

Hierarchical methodology was chosen for the programme Structure of an Atom. There is an ordered relationship between sub-skills which ultimately help to learn the terminal objective. The simple things are given first that makes the basis for more complex concepts.

The assumed entry behaviours for this programme were the following:

1. Knowledge of some common elements such as oxygen, hydrogen, nitrogen, carbon, sulphur, sodium, chlorine etc.
2. Simple addition, subtraction, multiplication and division.
3. Knowledge of positive and negative charges.
4. Basic skills of reading, writing, generalizing, and following directions.

Objectives and Aims

Behavioural objectives were prepared in such a way that they were consistent with each task in the task analysis.

All the behavioural objectives contain an observable response, important condition under which the behaviour will be evaluated, and the criterion for satisfactory performance.

The test was made to test all the eleven behavioural objectives. It contained 16 test items. There were one or two test items to test each behavioural objective. All the test items are multiple choice tests and seems to be appropriate to test the task required in the behavioural objectives. The language used in writing test items was kept easy enough to be understood by the students.

This test was used as a Pre-Test, in which the items are sequenced in the same manner as they would appear in the programme (in the Sequence of Tasks and Behavioural Objectives). The same test can also be used as Post-Test (though a separate Post-Test is preferred), whose items should be scrambled, so that they are not in the same order as in the programme. In the multiple choice questions the order of correct responses was random.

The frames were constructed in the same sequence as shown in the task analysis. The frames were sequenced in such a way that by completing all the frames the terminal objective might be achieved by the students.

Medium of Instruction : The strategy of linear programming was chosen. The self-learning unit was an instructional programme, having enough practice frames.

Devices and Tools : A Programmed Instruction Unit Structure of an Atom was developed.

Formative Evaluation : After writing the programme and the tests (pre-test and post-test) one IX class student was selected for one-on-one evaluation. This student was of an average ability. Two copies of the programme were prepared, one for the student and other for the programmer. When the student was using the programme, the programmer noted down his reactions and suggestions, which seemed to be important in revising the programme. The following feedback was received from one-to-one evaluation.

1. There was smooth flow or material in the programme, that is, the arrangement of the frames was logical.
2. At some places difficult language was used.
3. The programme needed more practice frames.
4. Frame No. 18 was not well explained, cue and prompt were also needed in this frame.

The programme was revised according to the feedback received from one-on-one evaluation. Then the programme was tried out on a small group consisting of five IX class students. Each student was given pre-test, the programme and the post-test. Before starting the programme the group was told about the programme and the importance of the criticism. They were also asked to write any suggestions if they have. They all took 40-55 minutes to complete the programme. Finally they were interviewed by the programmer and were asked to give their suggestions. The programme was further revised according to the feedback received from small group evaluation.

Summative Evaluation : The revised programme was given to the target population, (150 IX class students) after giving the pre-test. There were few students who asked questions when going through the programme, but when they were asked to read the matter again they seemed to understand it. All of them were able to complete the programme in time (about 2 periods of 30 minutes duration). Post-test was given the next day.

The pre-test and post-test gain shows that 72 per cent of the students achieved 80 per cent or more objectives. The majority of the students used in the summative evaluation programme showed enthusiasm in working with the programme. Many of them said that they liked the new system of instruction and wanted to have more programmes like this. The vast pre-test to post-test gains exhibited by most of the students generated a great deal of excitement and confidence. This fact alone made the whole project a worthwhile experience for the students.

Constructed Response Frame : As the word Constructed implies, no choice are presented to the student in a Constructed Response Frame. He does not select one response from many, as in the Discrimination Frame. Instead, the student constructs his own response each time. That is, he supplies the answer from his own knowledge.

The response the student constructs can take many frames. He may be asked to write or supply a word or statement, draw a diagram, or perform any other type of over action requiring a response from within his own repertory.

Examples : Frames No. 1, 2, 8,11,12,13,14,16,17,18,19,20, 21,22 and 23. The Constructed Response frame is basically a two-part structure, the set frame and at least one *practice frame*. It may be desirable to have several practice frames with each set frame.

Set Frame : Whenever the response asked for is found in the data portion of the frame, it is known as a set frame. The student may never have seen the desired response prior to reaching this frame, but he is able to supply this response simply by deducing it from the data within the frame itself.

Examples : Frames No. 1, 2,11,12,13,14,16,18 and 21.

Practice Frame : The set frame is followed by a practice frame. The practice frame gives the student a chance to practise what he has learned in the set frame.

Examples : Frames No. 8,19, 20, 22 and 23.

Discrimination Frame : As the name implies, this construction technique is used to teach student to make discrimination. A student who has been taught to make fine discriminations through the use of Discrimination Frame sequence will find that he can go beyond the programme material and approach the subject matter from any direction. For example, if taught a definition by Discrimination Frame Sequence, he will be able to define it when given the term; if given the definition, he will be able to name the item; if physically possible, he will be able to illustrate it.

Examples : Frames No. 3,4,5,6, 7,9 and 15.

Baboon Frame : In this frame the student is asked to make a choice from among four answers: Choice A, Choice B, both A and B, or neither A nor B.

Examples : Frame No. 10.

Basically, the BABOON Frame Sequence consists of three frames similar in purpose to those of the Constructed Response Frame Sequence. The first frame is a set frame; it contains enough information to enable the student to come up with the correct response when asked to respond. This frame is followed by a practice frame; here the student is asked to demonstrate, with a little prompting. In the final frame, the minimum amount of stimulus is presented to the student and a maximum response is called for.

Examples

1. A Trapezium is a figure with four sides, two of which are parallel. Place a check mark (^) before the correct statement below check only one Answer.
 A. Figure A is a trapezium.
 B. Figure \hat{A} is a trapezium.

.... C. Both Figure A and Figure \hat{A} are trapeziums.

.... D. Neither Figure A nor Figure \hat{A} is a trapezium.

B. Figure A is a trapezium.

2. Place a check mark (^) before the correct statement below.
Check only one answer.

Fig. A

Fig. B

(A) Figure A is a trapezium.

(B) Figure B is a trapezium.

(C) Figure A and Figure B are trapeziums.

(D) Neither Figure A nor Figure B is a trapezium. D. Neither Figure A nor Figure B is a trapezium. 3. Define "Trapezium" and draw two figures. A trapezium is a figure with four sides, two of which are parallel (or words to this effect). The example figures that you have drawn should match this definition.

Various Types of Material

Linear Programme : In linear programmes, all of the students are normally required to take all of the frame.

Example : The self-learning unit, "Structure of an atom" is a linear programme.

Linear Programme strategy was used in writing this Programme due to the following reasons:

1. The topic was new for most of the students for whom it was developed, and they were needed to be provided with a lot of practice.
2. The topic of the programme was of such nature that the subject matter involved ascending order of complex skills to be learned/ therefore it was felt that all the students should be required to take all frames.
3. The type of learning task necessitated mostly constructed response answers.

Branching Programme : The word branching suggests any

deviation from the straight line, A Branching Programme allows for greater differences in student abilities.

The Branching Frame Sequence Technique : This technique presents the student with remedial information/ if necessary and permits him to take steps that are as large as his capabilities allow. A particularly adept student may go through a programme in a minimum number of steps, whereas his less able cohort may require twice that number to learn, the same amount of material. The Branching Programme offers the student alternate paths from which to choose, and the path he takes depends upon the response he makes in each frame.

Hence now you know how to develop a programmed instructional unit. Identify some topics in your field, on which you feel good programmes may be developed. Develop, evaluate and revise programmed instructional units on these topics, and share these self-learning units with your fellow teachers.

Evaluation Process

Various Measurements

If a teacher wishes to have an adequate basis for judging the quality of his instruction, he should use tests that accurately and representatively reflect his objectives. How can he assure this accuracy? Unless he has access to prepared items, he must get into the business of writing tests himself.

Tests that the teacher produced have the advantage of being right on the instructions format that is essentially equivalent to the teachers' instructional goals.

The performance of students therefore, can be used to make valid judgements regarding the performance of the teacher, generally in terms of the previously established class minimal level of students' performance.

Tests designed exclusively to measure the objectives taught are called criterion-referenced tests. Their purpose unlike that of norm-referenced (standardized) tests is not to make differentiations among achievement levels of various students but to measure accurately how well each student has attained stated objectives. Norm-referenced tests are relative measures.

Criterion-referenced tests are usually employed at the conclusion of an instructional sequence. Testing is usually product based knowledge, understanding and application (Based on Bloom's Taxonomy of Educational Objectives).

Evaluation of Skill

Knowledge : It includes the recall of specifics and universals. The recall of methods and procedures, or the recall of a pattern structure, or setting. For measurement purposes, the recall situation involves little more than bringing to mind the appropriate material. The mental ability involved in this operation is just memory and not any higher ability.

Examples

Objective type (Multiple Choice) : Put a tick mark (ü) on the statement which is most appropriate. Food stuff which is a rich source of energy is named :

1. Vegetable
2. Cereals
3. Pulses
4. Fruits

Short Answered

Mention two uses of bacteria.

Long Answered

Why cycling is less strenuous on a smooth road as compared to a rough road ?

Understanding : It is based on knowledge. Knowledge is necessary but not sufficient for understanding, because the latter requires the ability to translate, to interpret, or to extrapolate. One example of understanding may be taken from Science, where one is required to translate verbal material into a symbolic statement and vice-versa.

Statement that if we add dilute hydrochloric acid on marble

pieces, carbon dioxide gas is given out, if translated in formula we write :



Examples

Multiple Choice

Put a tick (☑) mark on the statement which is most appropriate.
Gas which helps in extinguishing fire is called :

- (1) Hydrogen
- (2) Nitrogen
- (3) Oxygen
- (4) Carbon dioxide
- (5) Chlorine

Short Answered

How moving water can be used as a source of energy ?

Application It requires something more than knowledge and understanding. Application is a step ahead of this level. It implies the ability to apply an abstraction e.g. formula, principle, law etc., to an unfamiliar or novel situation. In fact, this is one of those abilities or skills, which are of great functional importance in every day life. The test of useful or meaningful learning is that it can be applied in relevant situation other than the one in which it has been acquired.

Short Answered

1. Why does it take longer time to make tea or cook food in hill stations ?
2. A lighted candle is fixed on a small metal plate and is kept in a trough half filled with water, and then a glass is inverted over the lighted candle, keeping the mouth of the beaker under water. After some time the candle gets extinguished and the level of water inside the glass increases. Why the water level inside the glass increases?

Various Type of Tests

It has already been stated that process skill in science can be divided into 13 areas—observing, classifying, using numbers, measuring, using space-time relationships. Communicating, predicting, inferring, defining operationally, formulating hypotheses, interpreting data, controlling variables, and experimenting.

Example : Children are taken for outing in the tour. Students may be grouped in small batches and advised to see and make a note of things in their copy book. Objective of the outing is to get children acquainted with the phenomenon or Force, Work and Energy, in their surroundings.

Before they are taken for outing, lesson on force, work and energy, has already been taught in the school.

Teachers ask them to observe the things around them. They will observe many things, may be some tools in a workshop, bullock cart, cycle, bus, cars, scooters, etc. being plied on the smooth or rough roads. They might come across some labourers loading or unloading heavy articles from a truck or they might see flour mill or tools of a carpenter or of a tailor master.

On the basis of observation a list of all the things observed is prepared. Groups compare their notes. Teacher now asks them to classify the things, where force has been used, work is being done, and the energy which helps in the working.

In the school, different groups will communicate [Learner—Learner Interaction (LLI)] with each other on the basis of their observations or may be, they might make some sort of communication with the carpenters or the owner of tailoring shop. They can also be asked to make models of the tools they observed. Experimentation starts which follows interpretation and prediction.

Following Questions can be asked by the Teacher:

1. Name four situations where force is used to move objects.
2. Why on a rough road the speed of cyclist was slow as compared to a smooth road ?

3. What was the source of energy in moving a cart, cycle, car or train ?
4. What are the alternative sources of energy ?
5. Give two examples where friction is used.
6. Why cannot we walk comfortably on ice ?
7. Why do we slip if our feet fall on banana scale lying on a road ?
8. Give two examples where work is done, even when force is applied.
9. Can air be used as alternative source of energy? Give examples.
10. How a flour mill works ?

Interests and attitudes are non-scholastic areas.

Interests : Observation is made by the teacher and rating scales can be prepared on the following topics pertaining to science :

Scientific Areas:

1. Reads science literature.
2. Prepares charts and models.
3. Improvises science apparatus.
4. Takes part in science activities like debates, chart making, science clubs, contributing articles to magazines on scientific topic.
5. Collects material pertaining to science, insects, flowers, leaves, seeds, fruits, small scientific toys, museum specimen etc.
6. Maintains herbarium or aquarium.
7. Has interest in visiting places of scientific interest.
8. Meets people working in the field of science and discusses with them.
9. Appreciates inventions and discoveries.
10. Makes scientific models and participates in science quizzes etc.

Attitudes

1. Listens to the teacher attentively in the class.
2. Puts problems and solutions before teaching.
3. Is curious to learn more and at times uses the library.
4. Participates in science clubs, fairs, exhibition etc.
5. Contributes to the scientific activities.
6. Helps the teacher in finding solutions in scientific field.
7. Cooperates with school mates.
8. Prevents others from disturbing the functioning of science fairs, science clubs, exhibitions, and museums.
9. Is considerate with his class mates.
10. Contributes to science activities.

Exercise: For evaluating Interests and Attitudes you can observe your students. Discuss how will you do this Evaluation?

Criterion referenced tests are the tests designed to measure the identified objectives. They measure how well each student has attained stated objectives. These tests are usually used at the conclusion of an instructional sequence. They test knowledge, understanding and application. Norm referenced tests make differentiations among achievement levels or various students. They are relative measures.

For each knowledge, understanding and application you can construct different types of tests-multiple choice, very short answered, short answered, long answered (essay type), true and false, matching etc. It will be very useful if you identify a topic, and its content, and write objectives in behavioural terms before constructing test items. Then for each objective construct one or more test items.

Observing, classifying, measuring, communicating, experimenting, inferring, interpreting and predicting are some examples of science processes when students are doing some science activities. You can test whether your students have learned

science processes, by looking at them, listening to their discussion, interacting with them and asking them to do something.

Interests and attitudes are non-scholastic areas. Written tests perhaps will not be able to test whether your students are interested in science or have scientific attitude. For this you are to identify some activities for scientific interest and some activities for scientific attitude, say ten each. Then observe which activities they really do. If they do all the activities, grade them as A; if they do more than half the activities, grade them as B; if they do about half the activities, grade them as C; if they do less than half the activities, grade them as D; if they do none of the activities, grade them as E. This is only suggestive. This will tell you where your students stand in scientific interest and scientific attitude.

Technological Aspects

Before, five centuries, when the first book was printed, no longer did students need to cluster at the feet of their teachers to listen and memorise what was read to them from a precious, laboriously produced hand-written manuscript. The printed book was a form of automation, a kind of teaching machine. Each student could have his own copy of the text to study. It seemed that the teacher has been permanently replaced, but the teacher increased in importance. His function changed. Relieved of the chore of reading to his students, now he had time to counsel and to explain and expound, to interpret and correlate the mass of information and knowledge that books made available to all.

For centuries the teacher's chief job has been that of presenting information and testing students to see whether they can remember it on cue or not. But now it is clear that assignment of lists of non-functional facts to be studied and remembered is out of place. Changes in a society usually bring changes to its institutions including education.

The educational institutions are also affected by rapid increase in number of students, increased mobility of students, increased range of students' abilities and broadened backgrounds. Opinions as to what should be done often contradict each other, but there

is a clear demand for action that will enhance the learning of the individual students, the effectiveness of schools and colleges and ultimately the quality of the nation's life.

Today we are seeing the beginning of another forward surge that may prove even greater. The electronic age is changing our traditional notion of education. Since last few decades innovations of all kinds are being experimented and the education has come more and more to understand that learning is an active process. The role of teacher, the role of the classroom, as well as the nature of the learning process itself must be re-examined in the light of new technology, for the sake of the nation's quality education.

The first step towards improving quality would be to free the teacher from much of his daily routine in order to give him time to serve as diagnostician and organiser or manager of functionally varied learning experiences. The second step would be to provide teachers with a large number of teaching techniques and specific curricular material. A third positive step would be the development of teaching material of a highly individualised nature in each subject. Each of these steps could be realised with the widespread use of electronic teaching aids that could take over much of the routine involvement in teaching and also provide better course materials. Classroom teacher then could give more individual attention to their students.

Lot of educators do believe that if technology is properly supported and wisely used, could help meet most of the pressing educational needs and many teaching problems can be solved partly or wholly by the proper use of the rich experiences that can be gained through certain media. In this technological age, therefore, today's teacher should take the full advantage of the existing technological resources for quality education.

Meaning and Perception

Any definition of Educational Technology must be subject to the concept held by the definer, and this involves consideration of at least two distinct concepts— the physical science or media

concept, and the behavioural science concept. Here various definitions of Educational Technology are being given.

- (i) The Educational Technology can be defined as the purposeful utilisation, in combination or separately of objectives, techniques, devices, events and relationships to increase the effectiveness of educational process. Educational Technology is fundamentally aimed at improving the efficiency of educational systems by increasing the rate, depth, precision and value of the learning which takes place.
- (ii) Educational Technology concerns the systematic use of modern methods of technologies in teaching and learning. It involves teachers in a variety of roles, some of which are traditional and some still emerging. In this definition special consideration is given to the adaptive role of the teacher.
- (iii) Educational Technology is a systematic way of designing, carrying out and evaluating the total process of learning and teaching in terms of specific objectives based on research in human learning, a combination of human and non-human resources to bring about more effective instruction.

Outside the limits of speech, man is dependent upon the tools of his age for his ability to educate or to learn from others. Twenty-first century man has acquired more tools of communication, more power to educate in last fifty years than he ever possessed in the hundreds of thousands of years of pre-recorded history. With the increasing rate of scientific advance and discovery the need has arisen for clarification of new methods of communication and their application. This is the core situation with which educational technology has to deal.

The greater the pace of change in the world, the more urgent it becomes for us to develop efficiency in the way our young people learn. This is true because education is a bridge between present and future, it is a bridge between what we are and what we may

become — as individual, as a nation, as a world. But the test of the value of a new technique for education is not whether learning occurs. Learning is always occurring but we are to test whether the new technique improves the learning rate and depth of understanding as compared with the existing approach.

Educational Technology is still largely a classroom supplement. Teachers now have access to film projectors, slide projectors, tape-recorders. Video Cassette Recorders (VCRs), Video Cassette Players (VCPs) and computers etc. Teaching machines may ultimately prove more effective in a specific learning situation than text and printed material, since they offer greater control over the contingencies involving in learning.

The teacher normally supplements his verbal output with such materials as textbooks, blackboards, maps, posters, slides, overhead projectors, etc. Essentially these devices are limited to the presentation of immobile two-dimensional/orres.

In United States a Commission on Instructional Technology was established long back to determine whether the belief in technology's value for education is justified and whether it is justified to recommend actions to provide for the most effective possible application of technology to American Education. The Commission took 'Learning' as starting point instead of technology. The heart of education is the student learning and the value of any technology used in education must, therefore, be measured by its capacity to improve learning.

Technology will assist and support educational functions. Thus increasing the productivity of the teaching force and freeing them of the multitude of clerical record keeping chores and the elementary task of simply presenting information for students consumption. This can restore the personal touch to the educational process.

But there are many problems in adopting educational technology.

1. Well intentioned resistance to the introduction of technology—some people think that it will dehumanise a very human process.

2. Getting educational research applied—innovators and leaders have problems in transitioning from research to application. Many successful researches are not carried out towards its application.
3. Scarcity of trained personnel to install/ maintain and supply new methods and equipment.

Few basic principles will affect the successful application of educational technology. The key to success is training and particularly in-service training. The real mass attack on training must take place at school and college level. In-service training needs to be developed on at least at two levels.

- (a) At the elementary levels to ensure the elimination of fear and ignorance of the hardware and to show the productive potential in a curriculum situation.
- (b) At the advanced level especially in its application to curriculum development.

If educational hardware is going to be used effectively during teaching situations the colleges and schools must be supported by an adequate technical assistance service. Every teacher should take this training in the first few years of his teaching career. Because of the size of turnover of staff in educational institutions, it is essential that in-service training in the handling of technical equipment be continuous until all have learned its use.

Next stage in training could be more advanced, concerned with the techniques of production. One can use this technique in the lecture room situation to take 'Off Air' programmes to enable large groups of students to see a detailed scientific demonstration clearly, or to use it in certain areas of the curriculum.

In order to use educational technology we should be familiar with the existing hard and softwares.

Hardwares (Technology in Education): Hardwares include all sorts of teaching machines. Some common ones are listed below:

Projectors

- (a) 16 mm film projector
- (b) 8 mm/super 8 mm film projector (not being used now)
- (c) 35 mm slide projector
- (d) Opaque projector (Episcope)
- (e) Overhead projector (OHP)
- (f) Micro-projector

Tape-Recorders

- (a) Spool tape-recorders (not much in use now in educational institutions)
- (b) Cassette tape-recorder

Television

- (a) Closed circuit TV/ VCR, VCP
- (b) TV telecast

Computers

Softwares (Technology of Education): They include the hand-written or printed materials for effective teaching.

- (a) Programmed instructional materials
- (b) Self-learning modules
- (c) Films, slides, OHP transparencies
- (d) Audio-video tapes
- (e) Multimedia packages
- (f) Computer Discs (CDs)

Now let us discuss these Hardwares and Softwares of Educational Technology very briefly.

Varied Aspects

16 mm Film Projectors : A 16 mm teaching film though less flexible than verbal statement or description, is often far more effective. There is much to be learned which is incapable of demonstration. This can be done by controlling the speed of visual

presentation, e.g , the flapping of a bird's wing, the unfolding of a petal, the clogging of an artery and the control of spacecraft etc., 16 mm films are available in India in every field of education. In Delhi there are some good resources for such films, like CIET of National Council of Educational Research and Training (NCERT), British Council and United States Information Service (USIS). Educational Institutions can ask for their catalogues and the films can be borrowed. Similar resources can be explored in each state or city. In addition to this some colleges, IASEs and University Departments have their own film libraries. These films are also available in the market for educational institutions to buy.

16 mm film projectors are now very common and most of the educational institutions have these projectors. These projectors make it possible to use 16 mm films (software of 16 mm film projectors) which go along with the lesson. These films can be used as introduction, enrichment or follow-up of the lesson. These films are now being videotaped.

8 mm/Super 8 mm Projectors : 8 mm and super 8 mm educational films in different fields are also available in the market. They are lot less expensive than 16 mm films. They can also be produced very easily if the school or college is provided with 8 mm/super. 8 mm movie camera. These films shown with 8 mm/super 8 mm projector are an asset to classroom teaching. The teachers can give their own commentary or it can be audio taped before hand to be replayed whenever these films are used. But now these projectors are not being used in educational institutions.

35 mm Slide Projectors : 35 mm slides and film strips (software of 35 mm slide projectors) because of their characteristic similarities lead to joint treatment. Both are similar materials, both use the same basic principle of projection. Both can be adopted for sound accompaniment. But 35 mm film strips are not being used now. 35 mm slides on different subjects are easily available in the market, which are not very expensive. Such slides could also be made as desired if college or school has its own 35 mm camera. These cameras are getting common these days in India. 35 mm

slides projectors project 35 mm slides. These projectors are available almost in every educational institution. Thus they could be used in coordination with classroom teaching. The teaching value of magnified projection has a dramatic impact and there is a further advantage that the class can examine the pictures etc., on the screen as long as desirable.

Overhead Projector : Overhead projector though very often being used in schools and colleges in western world, is not very common in India even now when we are entering twenty-first century. But now it is being manufactured by several firms in our country. Here the transparencies (software of overhead projector) black and white and coloured-photocopied or hand-made can be projected overhead. Thus the teacher can stand in front rather than at the rear of the classroom. These transparencies use transparent plastic material on which instructor writes or draws in the course of the lesson and this appears on the screen and a large class can see clearly what would be visible to only a small group if the chalkboards were used instead.

Micro-Projector : Microscopic slides can be projected by micro-projector and the entire class can see it at the same time. These projectors are either attachments for a microscopic or separate projectors with built-in micro-lenses. They are used much as slide projector but adjustment is more complex and the image is usually not so bright that is why the micro-projectors require complete dark rooms. Micro-projectors are also available for projecting microfilms.

Two types of recordings are in general use, those engraved on a disc and those magnetised on tape.

- (i) The discs vary in the speed with which they rotate on the machines, because of these variations speed as well as size, the 'play back' machines the 'record-player' must be suited to the requirement of the records and vice versa. This is not being used now in educational institutions.
- (ii) The second type of recording made on magnetic tape, involves a totally different sort of play back equipment. The

magnetic play back or the 'tape records' can also be used for making recordings. These magnetic tapes could be in a spool or in the form of a cassette (software of cassette tape recorder); both of these involve different machines, the spool tape recorder and cassette tape-recorder respectively. But spool tape- recorders are not being used now in educational institutions.

Most of the colleges and schools have their own cassette tape-recorders or players. They can be used very effectively in classroom teaching by imaginative teachers. For example, instead of giving the same lecture to several classes a day or repeating the same lecture every year, a teacher would be able to devote days or even weeks to the preparation of one outstanding presentation to be audio taped and repeated, and up-dated as often as needed.

TV Telecast : Educational Television programme is another technique for effective teaching. The Educational TV project started in 1961 for Delhi schools. Since then it showed tremendous improvement. Due to the coordination with classroom teaching, this programme proved to be very useful for the students. Teachers knew before-hand what lessons at what date and time will be received on TV and what portions of the syllabus they were to cover in the classroom. Now such TV programmes are not being telecast.

Closed Circuit TV : Due to rapid technical advances, specially in the field of video tape recording the emphasis of closed TV (CCTV) has altered over the past several years and has become a powerful media. For this a TV camera, a Video Tape-Recorder and a TV Receiver are needed. The use of CCTV, rather than films etc., is justified by its facility to be immediate and the fact that it is easier to manage. Close-ups of demonstrations of scientific experiments can be shown very clearly to a big class and to several classes at the same time. Some of the good demonstrations or techniques can be video-taped and shown whenever desired.

But due to its high cost and lack of knowledge for its utility it is not very common in our schools, colleges and universities.

Instead TV Educational Video Tapes-Video-Cassettes (software of VCRs and VCPs) are used in our schools with VCRs and VCPs. It will be nice if such equipment is used by us quite frequently.

Some Uses of Computers : Classroom uses of the computers generally fall into one of three categories. Computers are being used as a direct means of instruction in many developed countries. This use of the computer is often referred to as computer assisted instructions (CAI). Another widespread use of the computers in educational institutions is for calculating and analysing data. A third use of the computer is a device for computer simulated experiments. Other uses of computers in education are scoring of papers, filling up the grade sheets or mark sheets, time table preparation (scheduling), guidance, counselling and curriculum development. Now CDs and Internet are also in use.

Computer is a powerful and evolving tool for managing and sharing knowledge. Today clever software can turn a computer into a television, a canvas, or make it replay images and music, snap photographs, synthesise human speech, organise databases and libraries, and present a combination of animated drawings. Computers and communications are progressively becoming cheaper and faster.

Computers: Distance Medical and Surgical Facilities : Convergence of computers, communication, speech, text and images also presents an extraordinary opportunity in multimedia services and applications. These developments will change the way we live, learn, work, transact our business and communicate. For example, these techniques could allow doctors to examine patients in another continent and even monitor surgical operations at very far off places.

Computers: Future Attentive Assistants : Scientists are also working on image and pattern recognition techniques that can make computers ubiquitous. Speech recognition would replace the computer keyboard for most of the uses. There are attempts to develop computer systems for recognising faces, expressions and gestures. Such developments would enable us to create smart

rooms which could see that people are in a meeting and shield them from interruptions. Such smart rooms would be networked and furnished with cameras and microphones. Thus these rooms could relay information from the room to other interested parties on the network. The computers could also assess what people in the room are saying or doing. Computers could compare the incoming information with models they have stored in memory, and arrive at decisions by tracking people's movement, identifying them and recognising their expressions. Therefore, in future computers will thus be playing the role of attentive assistants.

Internet

(i) *Present:* The Internet is a large and global network of computers. Anybody can be a part of this network and share information with its users. The Internet provides access to essentially unlimited sources of information. Internet allows dialogue and exchange of ideas through Electronic Mail (E-Mail). Communication can be carried out at all hours and across large distances.

(ii) *Future:* Friendly ways of helping users to find what they want are already becoming available. In the course of time procedures for information quality control will also develop. The Internet will have all the essential features of a massive library system. It will of course take time before Internet possesses a large store of knowledge to rival the best of our libraries. The Internet and its successor technologies will have a profound effect on society.

(iii) *What India is to do?* We in India should develop a national information infrastructure, where using phone lines, cables, high speed data networks will allow open access for all to the electronic superhighway of information. All our universities and national laboratories should be connected to this information superhighway, so that researchers cannot only have access to important research journals and other library material but can also collaborate across large distances. The status of libraries in our universities is very unsatisfactory. Unless we do something about it, the research in universities will suffer greatly in quality. Low cost computers and

internet connectively could provide a satisfactory solution to this problem. Today many of our higher educational and research institutions have working internet facilities, but many of them are operating at low bandwidth.

In the area of software India has a lot of potential. We should now aim at high quality software development for automation, networking, design activities and tele-communications. As of now most of the internet software is imported. There is scope for us to design software for specific applications on the Internet appropriate to Indian needs. We should make every effort to see that India is not marginalized in this rapid race of information technology.

Can Computers recognise the owner? Have you ever wondered about the fact that while you can recognise your computer, your computer cannot recognise you? How would a computer go about recognising its owner?

It would recognise you by:

- (i) *The way you speak:* Most PCs today are equipped with a microphone. It would not be too hard to write programmes that can detect and identify voices to a limited extent.
- (ii) *The way you look:* This is very difficult and involves having a video camera connected to the PC. The image from the camera would then be analysed to identify the person in front of the PC. This is an active area of research.
- (iii) *The way you type:* Just as handwriting is unique, so is the way in which you press the key on a keyboard. A statistical analysis of patterns of key depressions (for how long, how hard and in what order you press keys while typing) can provide good clues to who the user might be.
- (iv) *The way you move the mouse:* Hand-eye coordination is fairly unique in human beings. By analysing the way in which you move your mouse, a PC might be able to figure out who you are.

These are some of the ways in which a PC of the future might recognise its owner.

Programmed Learning Units. Programmed learning was first associated with teaching machines, and there appears to have been two schools of thought. One was represented by the Harvard Psychologist, Skinner who transferred his theories based on the clinical observation of animal behaviour to the field of learning in the classroom. His programmes were divided into different segments each called a frame. The learner reads the frame and because of its form prompted into making a reply, usually written one and is encouraged to go to the next frame and so on through a series of positive reinforcement.

The careful shaping of these stimuli and responses was aimed at securing a carefully prescribed behaviour pattern at the end of the programme. The individual could go at his own pace and learning was secure and certain. The second view, seen at one time to be divergent and the learner should be offered alternative answers. This approach was associated with Crowder. The Skinner programmes were called “linear” and the Crowderian ones “branching.”

A programmer, nowadays seeks to arrange an environment within which learning activities appropriate to the programme’s objectives are provided. No such guidance is given with a text book.

Adjunct Programming another development can be the link between programmed instruction and a good textbook. It combines some of the progressive features of Programmed Instruction (PI) with the comprehensiveness of textbook. The goal of adjunct programming is to enable the student to learn as efficiently as possible from a good textbook.

What is generally considered an advantage of programmed instruction is the systematic, controlled, and sequential fashion in which content is presented to the learner. In programmed instruction provision can be made for differentiated instruction to accommodate individual differences.

Programmed Learning Units are self-learning programmes.

Students learn on their own with these programmes. Teacher is free to guide those students who really need his guidance.

Self-Learning Modules : Modularization of Instruction is another form of individualisation of instruction and self-learning; Modularization of Instruction is done by selecting, re-arranging or organising material and activities and breaking them into smaller sub-units in order to promote better understanding. The instructions are given in such a way that students know what specific objectives they are supposed to reach.

Each sub-unit may have optional activities, from which students choose accordingly, all enabling them to reach the same objectives. Through such instruction the students can direct themselves through learning activities, with minimum assistance from the teacher; *i.e.* they can work at a particular rate that suits them.

Siddiqi developed a Self-learning Module “Man and Environment” and used it in her research study entitled “Development of Self-learning Material for Senior Secondary Biology and Analysis of Its Effectiveness”. She found that students who used this module achieved statistically higher than those who did not use the module, and taught by the teacher in a conventional way.

Use of Self-learning Material : You can use programmed learning units and self-learning modules for effective science teaching.

Media’s Role

Teaching ideas mainly through one medium, namely, the printed word, is no longer wise either pedagogically or technologically. Taking into account individual differences in the way students learn, it will be wise to use a variety of learning aids assembling them in an integrated form known a multimedia package consisting of (for example) programmed instruction booklets, self-learning modules/ books, slides, tapes (audio/ video), films, transparencies, experiments, CDs etc.

The students who do not learn best through reading a text have, therefore, the chance of learning more or better by working

with films, slides, tapes and CDs so forth. For the sake of differences in individuals, knowledge should be presented in different forms.

Such packages though so useful, effective, interesting and instructive are not being used in our country. It will be wise to develop some of such packages at least for try-out.

Example : A slide-tape programme is a Multimedia Package. On any topic you can make 35 mm coloured slides (35 mm slides on various topics are also available in the market) by your 35 mm camera. Load your camera with 35 mm coloured slide film. Take pictures. Give the film for developing. You will get a set of 35 mm coloured slides.

Write the commentary for each slide. Audiotape the commentary. Now your Slide-Tape Programme is ready. You can use it again and again in your classroom.

The goals and expectations of science education change, and with them the curriculum. As the curriculum evolves so must the optimum-role of the science teacher. Today's science teacher is faced with numerous problems of how to teach what is given in his hands. Many science educators believe that the traditional teaching methods which are geared towards inculcating students mostly with factual knowledge, should be revised. Educational technology is here for our rescue.

It is important that it should be used wisely as some of the earlier attempts to use teaching machines effectively failed because they were employed as alternatives to the presence of a teacher rather than as extension of his capabilities. It is upto us how best we can use the existing tools in science education.

There are several tools as mentioned above which can be used in classroom for effective learning. But these materials are not being used in our educational institutions as effectively as could possibly be. Some of them are not available in the institutions due to their high cost or unfamiliarity of their utility. Some of us are against the use of technological tools with a plea that India's economy cannot afford the use of these expensive machines. But

even those machines which are already available in the schools and colleges are also not being used fully.

Science education is likely to expand substantially even explosively, over the next few decades and that can be achieved through the application of educational technology. It will be wise if the school and college science teachers should gather to learn the effective use of various technological tools and take with them the ideas which they think are wise and feasible for their classroom teaching.

A report commissioned by the US National Science Foundation speculates that by the end of twentieth century electronic information technology will have transformed western home, business, manufacturer, school, family and political life. The report suggests that one-way and two-way home information systems, called Teletext and Videotex, will penetrate deeply into daily life, with an effect on society as profound as those of the automobile and commercial television earlier in this century. This proved true. Now the, same is going to happen in developing countries like India in twenty-first century.

The study focused on the emerging Videotex industry, formed by the combination of two older technologies, communication and computing. It was estimated that 40 per cent of households in the US will have two-way Videotex by the end of the twentieth century, and this estimation came out true; Videotex system would enable individuals to create their own newspapers, design their own consumer guides. Furthermore this system will bring an increased flow of information and services into the home and at the same time, carry on stream of information out of the home about the preferences and behaviour of its occupants. All this hopefully is going to happen in the developing countries like India in twenty-first century.

Indian Scenario

INSAT-1A was up in space on September 4, 1982 with capabilities for telecommunications, meteorology and country-wide TV telecasts,

but it was declared dead on September 6, 1982. Though it was possible to take this failure rather philosophically as a forerunner of future success, yet it was a serious setback to all our communicational developments. Then INSAT-IB was successfully launched by India on August 30, 1983, though INSAT-IC launched on July 12, 1988 could not be a success. Afterwards both INSAT-ID launched on June 12, 1990 and INSAT-2A launched on July 10, 1992 were a success. (For more satellites launched by India, see the Table) We enjoy many benefits of satellite technology. An all-India transmission of TV programmes has been possible through INSAT. The satellites bring to us live programmes in any part of the world. Satellite communication, weather monitoring, remote sensing, and collection of information about planets and outer space are some other applications of satellite technology.

It would be nice if we could produce enough software material for maximum utilisation of INSAT. The developing countries like India will have to use TV for reaching out the masses in the dark ghosts of illiteracy/ ignorance, disease, poverty and exploitation with a view to providing fundamental education. This is a tremendous task for all educators in general and educational technologists in particular.

It seems that the new media are still quite expensive and their penetration is relatively limited, but future developments hold a promise of considerably cost-reduction and competitive productionization. The cost of computer memory in the developed world for a bit of information was 100 cents in 1954, 1 cent in 1964, 0.5 cent in 1974 and 0.004 cent in the year 1984. This cost will further decrease in the years to come. In India, the cost of a transistorised radio set has shown consistent reduction inspite of inconsistent price-rise. We do hope that the story would be repeated also a case of TV and Videotex.

It is estimated that by 2000, more than six million households would own Videotex in the western world. The developing countries like India would have to chalk out their own plans and priorities in the field of educational technology. In order to do so, we would have to think globally and act locally.

Launching of Indian Satellites

S.No.	Name of the satellite	Date of launching	Result
1.	Aryabhata	19 March 1975	Success
2.	Bhaskara-1	7 June 1979	Success
3.	Rohini	10 August 1979	Failure
4.	Rohini	18 July 1980	Success
5.	APPLE	19 June 1981	Success
6.	Bhaskara-2	20 November 1981	Success
7.	Rohini	31 May 1981	Failure
8.	INSAT-1A	4 September 1982	Failure
9.	Rohini	17 April 1983	Success
10.	INSAT-1B	30 August 1983	Success
11.	SROSS-1	24 March 1987	Failure
12.	IRS-1A	19 March 1988	Success
13.	INSAT-1C	12 July 1988	Failure
14.	SROSS-2	13 July 1988	Failure
15.	INSAT-1D	12 June 1990	Success
16.	IRS-1B	29 August 1991	Success
17.	SROSS-3	19 May 1992	Success
18.	INSAT-2A	10 July 1992	Success

In India, in several States and Union Territories, Educational Technology cells have been started functioning with 100 per cent financial support (for the first 5 years) from the Ministry of Education, under guidance of Central Institute of Educational Technology (CIET) of NCERT in New Delhi. The remaining States and Union Territories will also open similar cells gradually. Hopefully these cells will assist our teachers in effective science teaching using educational technology.

NCERT organised the first ever interactive satellite based interactive teacher training programme to train primary school teachers on various topics of primary education using INSAT transponder with one-way video and two-way audio technology.

In the first phase the programme was launched in Karnataka on January 7-13, 1996 (7 days) covering about 850 teachers and 80 facilitators and course directors assembled in 20 different district centres (learning ends).

In the second phase, the programme was organised in Madhya Pradesh on August 2-8, 1996 (7 days) covering about 1400 teachers and 170 facilitators and course directors assembled in 45 district centres (learning ends).

The 7 days programmes each for Karnataka and MP had 14 Sessions, each of which were on various topics such as MLL, use of OB materials, multigrade teaching strategies, teaching of Maths, EVS (Science and Social Studies) and Language etc. Each of the sessions was about 3½ hours (2 hours of live interaction and 1½ hours of individual and group activities). Each session comprised of presentation, demonstration and discussion. Participating teachers interacted with panelists through telephone and fax, followed by group activities.

During the 7 days programme of Karnataka about 600 telephone calls and 240 fax sheets were received, and in case of MP about 700 telephone calls and 200 fax sheets were received, altogether about 7000 questions were asked through telephone and fax.

This experiment was highly appreciated by educationists, distance education experts, education administrators and teachers. Such programmes hopefully will be common in India in the years to come.

Another achievement of this Experiment is the successful networking of various national, state and district level agencies in the implementation of the project.

What is served to India, is what is cooking in Delhi. What you will get in education is now included in Ninth Five Year Plan.

Educational Technology in the Ninth Plan is going to take a significant and massive turn. The focus in primary education during the Ninth Plan will have to be on quality because without enhanced, retention and performance of students, universalisation of education will remain elusive. The National Action Plan for continuing education of primary teachers envisages a series of change in the Ninth Plan. The main approach is to develop a training module using multi-channel learning which includes self-learning, action learning, face to face interactive learning and learning through interactive television.

The entire multi-channel learning is a capsule model instructional design which is the core of educational technology. Self study materials, which are the basis of self-learning, are semi-structured learning modules. Action learning is conceptualised to be action experience and studies within the schools. Face-to-face interactive learning is proposed to build interactive and problem solving skills among the teachers to interact with the guidance of an expert tutor. The interactive television will bring in an opportunity for primary teachers to interact directly with the experts at the regional, state, and national level

The proposal is to set network in selected national, regional, state and district level institutes through satellite communication. The proposal also includes the setting up of block level resource centres with educational technology facilities for face to face interaction. With block and district level training centres, primary teachers would have access to more than 5500 centres in the country.

The proposed training network will have the capacity of training a few million people every year in the country. In view of both extended capacity of the training system and the need for training the supervisors and teacher educators who play critical role in teachers' performance will also be provided specially designed training modules once every 2 years.

This is for the primary teachers. It is likely that the training network will be extended for upper primary and secondary teachers as well. The universities are not far behind. IGNOU has proposed

a network called OPENET interconnecting its study centres, state open universities and other distance education institutes and centres. The proposal is to use VSAT for delivery of courses.

From programmed learning, one way television and radio broadcast and educational technology equipments as teaching aids, India seems to be ready to graduate to satellite communication and computer communication. The new educational technology is likely to sweep the country very fast rather we, the teachers should get ready to receive and respond to this massive change which is being conceptualised.

Rationale : With the advancement of science and technology many new developments have taken place in the field of education. The conventional ideas about teaching are proving obsolete and inadequate. With the changing times the expectations from teachers have also increased. A teacher is not only a trainer or instructor in basic skills but he is also an organiser of worthwhile experiences for children. To meet these challenges, a teacher has no option but to adopt new technological aid. With the help of mass media, quality education can be provided to children and adults even in remote and inaccessible areas. The services of competent teachers and subject experts can be made available at any place, without their presence in actual classroom situation. Teacher is now expected to be part of an educational system where in machines, materials and media are important constituents of instructional process. The teacher has, therefore, to understand his roles in the new educational system, and it is for this reason that the present course has been included in the ETE curriculum.

On completion of the course, the teacher trainee will be able to:

- explain the concept and scope of educational technology and use of teaching-learning process develop skills to use and maintain hardwares.
- develop skills of preparing softwares and making their effective use.
- develop skills of effective use of blackboard, school TV programmes, educational radio broadcasts, educational

video programmes develop skills to make use of waste material or low cost material available locally for developing teaching aids.

- develop skills for evaluating effectiveness of various technological aids, media and strategies.

Course Outline External 40 marks Internal 10 marks

Tune 45 hrs Unit 1 Introduction to Educational Technology

5 marks Meaning, need and scope of educational technology. Difference between 'Technology of education' and 'Technology in Education'.

Unit 2- Hardware and Software 12 hrs 10 marks

Hardware

- Effective use of hardwares in teaching-learning process, their general maintenance and safety precautions.
- Television, VCR/VCP, Tape-recorder, Radio-cum-cassette player, overhead projector, slide projector.

Software

- Planning, preparation/development; effective use of charts, maps, flash cards;
- display materials for flannel board and bulletin board, transparencies, slides, audio programmes, slide-tape programme.

Unit 3: Audio-Visual Aids and Mass Media 12 hrs. 10 marks

- Meaning of A.V. aids and mass media, classification of A.V. aids
- Projected and non-projected aids
- Selection of appropriate teaching aids-Edgar Dale's Cone of Experiences
- Advantages and limitations of A.V. aids and mass media
- Effective use of Educational Television and Educational Radio, pre-telecast and post-telecast activities

Unit 4: Innovative Trends in 15 hrs. 15 marks

Educational Technology

- Micro-teaching
- Simulated teaching
- Team teaching
- Programmed instruction Multi-media package
- Satellite TV transmission
- Computer aided learning

Practical Work: (for Internal Assessment) 07 hrs. 10 marks

- Any two out of the following:
- Preparation of an audio programme
- Preparation of learning packages in one school subject
- Preparation of any low cost teaching aid.

Audio-Visual Aids

In an introductory class of audio-visual education from B.Ed. students it was asked some of their earliest school experiences. Following were some of their answers:

- (i) "The earliest school experience was when I made things out of plasticine."
- (ii) "When in class 3rd we made a model of iglu out of sugar cubes."
- (iii) "When I went to see a zoo in my 2nd grade."
- (iv) "When we did gardening in a small comer of the school."
- (v) "When I played the role of little red riding hood in kindergarten."
- (vi) "The puppet show I saw in the school."

Dozens of similar experiences were reported by these (college) students. All these are varied experiences but we see one similarity, they could remember the experiences where they are involved in doing something, when they were active, when more senses were

involved. These are some of the experiences where effort was not made to memorise them, on the other hand we do not always remember the facts or concepts that we try hard to memorise. From this we can generalise that learning becomes comparatively permanent when concreteness is there in the experiences. The various experiences help in developing concepts.

The process of building concepts operates naturally from the time a child begins to draw certain conclusions from his experiences and applies these conclusions to new situations. It continues thereafter as he makes new generalisations from new experiences and experiences in which new and old experiences are combined. The overall activity of building concepts, therefore is a realistic definition of Education. Now we can say that two elements are involved in building concepts: (1) Certain amount of concrete experiences, and (2) Combining and recombining these concrete experiences in many ways. When we apply this to classroom teaching, audio-visual aids play a very important role in concept formation and therefore in permanent learning.

The Need and Importance : If we see teaching of science in schools of our country by and large we will find teachers lecturing or even reading out from the books and explaining few things on the blackboard. Some teachers use some demonstrations, charts and models but not very frequently and many a times students memorise things without understanding. Audio-visual aids if properly used help in teaching learning process in many ways (as given below) and can ensure quick and effective learning.

- (i) The timely use of proper aids compels attention, develops interest and motivates students.
- (ii) They break the monotony of teacher's talk, reduce verbalism, save time (of long verbal explanations) and give a better idea of the real things.
- (iii) Audio-visual aids can make learning experiences far more concrete; therefore clarification of concepts, better understanding and long lasting learning are possible.
- (iv) Great many teaching problems can be solved partly or

wholly by the proper use of rich experiences (through audio-visual aids); therefore they offer great opportunities for improved learning.

The Kinds

Variety of audio-visual aids can be used in science teaching. They can be classified in various ways.

(a) One way of grouping them is as follows:

Visual Aids : charts, photographs, diagrams, static and working models, etc.

Auditory Aids : radio, recordings on tapes, and cassettes.

Audio-visual Aids : films, T.V. etc.

(b) Another way of classifying can be:

Graphic Aids : diagrams, photographs, charts, play cards.

Three-Dimensional Aids : models, specimens, real objects, apparatus, dioramas etc.

Projected Aids : slides, films, etc.

Aids Through Activity : excursions, projects setting and maintenance of aquarium, vivarium, botanical garden etc.

Some of these aids are more concrete in nature and some of them are comparatively more abstract. Edger Dale has arranged the various audio-visual aids in pictorial form which he called "Cone of Experiences" as shown in (Fig.).

This is a kind of visual aid to visualise and explain the interrelationship of various types of audio-visual material as well as their position in learning process.

At the top of the Cone are verbal symbols which are most abstract and at the base are the direct purposeful experiences which are most concrete form of experiences. This is only a pictorial form where all sorts of aids and experiences are arranged in a Cone. The various bands of the cone representing various experiences and aids, should not be considered as rigid divisions

or watertight compartments. They overlap and blend with each other. For example you can be a viewer of an exhibit or a person who made it, you can observe a demonstration or can demonstrate it yourself. It is also not being suggested that the various aids and materials are arranged in the form of their effectiveness but they are arranged from most abstract to most concrete. As a teacher we should also know that abstract ideas, concepts, or generalisations are not possible without rich meaningful concrete experiences. A science teacher has to pick and choose the aids according to the maturity levels of the students and the topic to be studied. We will discuss the strengths and limitations of each in teaching sciences.

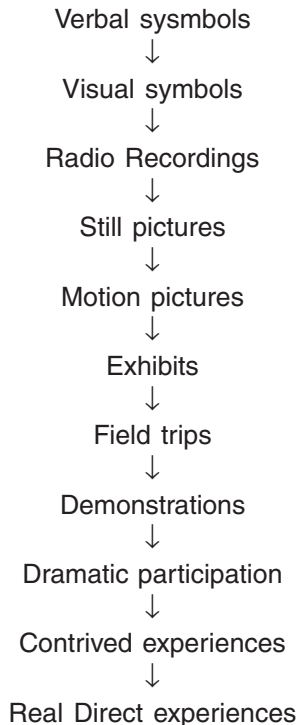


Fig. *Edger Dale Cone of Experiences*

Practicability: The base of the Cone of experiences represents “direct purposeful experiences.” Here the word ‘purposeful’ is very

important. Every direct experience may not be very meaningful, therefore, it may not be purposeful. We have to see the direct experience in terms to learning outcome. In cases where the real things are too small or too big to comprehend, direct experiences are not very effective and therefore are not purposeful. For example, “structure of atom,” “working of a factory,” “water supply in a city” etc., can be understood better by some indirect experiences like models, maps or charts, etc.

In teaching science many direct experiences can be given to the students for effective comprehension. Some examples are: observing real flowers, leaves, plants, insects; dissecting animals; taking a walk through woods; going to the seashore and observing marine animals; doing salt analysis in the lab; setting and maintaining an aquarium, etc. In such cases learning is by direct participation.

The science teacher has to decide what direct experiences will be purposeful for his classes and then try to give them as many experiences as possible because direct and concrete experiences soon become associated with abstractions and help in developing more difficult concepts.

What are contrived experiences? Next in the hierarchy towards abstraction are contrived experiences. Examples of contrived experiences are static models, working models, specimens, dioramas, etc. Contrived experiences may differ from the original in size (big things are made smaller and smaller things are made bigger) and complexity. It usually is a simplified and edited version of the real thing, where the unnecessary details can be removed to make the learning clear.

For example a petroleum refinery is difficult to comprehend in a real situation but its model will be more meaningful. In the same way models of places where it is difficult or impossible to reach and see can give a clear idea, like models of globe, volcano, parts and systems of the body, bottom of the ocean, view of a forest, polar region, etc. Sometimes we imitate the whole natural habitat in the form of dioramas and keep in museums. Cut-away or half

cut models are extremely useful in teaching internal structure of eye, ear, stem, root and automobile, etc.

There are some examples where nobody has seen the real thing, the models are made on the basis of indirect evidences like model of atom, DNA structure. Here the whole concept is developed on the basis of these imaginary models.

While teaching through the models, teacher should give the idea of the real thing, regarding their size and complexity. All models are not correct reproduction of their originals, they are only simplified versions.

Objects and Specimens : Objects and specimens are very common in science laboratories. These are also examples of contrived experiences. We collect rocks from various places. Different kinds of plants and animals are collected; pressing, preserving and sniffing are done for storing and study purposes. The objects and specimens are taken from the real settings. They are samples of real things minus real settings.

The specimens are collected and stored so that they are readily available for study purposes. Another most important advantage of objects and specimens which is not otherwise possible in direct experience is that they can be arranged into groups and classes.

This has been placed on the 3rd band of Cone of experiences. Dramatisation means substitute for real experience of reconstruction of the original reality. There are many things we cannot possibly experience at first hand. There is a great value of dramatisation in education. Students can participate in a dramatisation or watch some kind of dramatisation. Both are valuable experiences but participation is much more meaningful and closer to reality than only watching.

The question is “What is the scope of dramatisation in science teaching?” Dramatic acts are quite popular in languages and social sciences. In sciences also the scope is not limited.

The films made on the work of various scientists are only

possible because of dramatisation. Such films are quite effective as such experiences are otherwise not possible.

Students of primary and middle classes participate in scientific dramatised act in schools, such activities are also brought to science fairs etc. Some very abstract and uninteresting ideas are taken for dramatisations, for example, different students act as various components of solar system with proper costumes, dialogues, songs, music and dance, and the abstract concepts become clear and leave a long lasting impact on participants and viewers; students act as various petroleum products and explain how they are formed and utilised like coal, petrol, vaseline, synthetic rubber and plastic etc. Functions of vitamins and other components of food can also be taught through dramatisation.

It is also possible to use dramatisation in classroom teaching where costumes are not necessarily required but different students can remember their parts and act out in the classroom.

Interdependence of various components of an ecosystem and balance of nature can also be explained interestingly through dramatisation. An imaginative science teacher can think of many such topics which can be taught more effectively through such activities. Thus dramatisation can become an effective teaching aid in teaching science.

Fairs and Exhibition : Demonstrations are quite familiar activities in science class-rooms. Their merits and demerits have been discussed at length in the Cone of experiences they have been placed on the fourth band from the base because it is essentially a process of observing. It differs from the first three bands, which are essentially doing. Demonstrations are used to show how something is done or not done. When demonstration is followed by doing on the part of students, it becomes very much meaningful.

Demonstrations are used to clarify ideas, and help to develop skills, processes and attitudes. They are not limited only to demonstrations through apparatus only. They can be used to clarify abstract ideas on the chalkboard, through slides or motion picture also.

Demonstrations can be improved to a great extent if certain points are kept in mind while planning and doing a demonstration.

- Plan all steps of demonstration in advance.
- Rehearse the demonstration before going to the classroom.
- Keep the demonstration simple as far as possible.
- Keep the students involved.
- Make it sure that all the students can see it.
- Outline various points on the board.
- Keep summarising various steps.

What is Field Trip or Excursion? A field trip or excursion is a planned visit to a point outside the regular classroom. It may be in the school, out in the community or it could be a long trip to far away places. Usually in field trips to places like visits to a factory, observatory, agricultural institute, poultry farms, museums etc., we often see other people doing things. As spectators we are not involved but we directly watch it and get a first hand knowledge. Therefore field trip is an excellent bridge between the work of the classroom and the work of the outside world. The chief difference between a field trip and other educational experiences is that the student get their experiences in the field and not in the classroom.

Because of its nature to be mostly observation it is kept on the 5th band of the Cone of experiences as less concrete than other experiences discussed before. But if the field trips are planned and arranged in such a way that they go beyond observation, for example of a sea-beach, on a pond where they can also touch, feel and collect things, it becomes a *direct experience* for them. Such a variation in the field trip indicates again how the bands of the Cone interlap and blend into one another.

Importance of the Field Trips : Excursions or Field Trips are of great educational value especially in science subjects. The classroom is a limited place, bounded normally by four walls and meagrely equipped for the task or providing students with worthwhile

experiences. The environment outside the classroom has no bounds; it has almost every conceivable situation that a teacher might wish to utilise. In school corridor students may study writing system for supply of electricity to different rooms and laboratories, may determine the power (in watts). On school grounds there may be various types of plants, birds, insects, different kinds of soil, sunshine and shadows, building materials, bicycles, scooters and cars. And just beyond the school boundaries lie the unlimited resources of community.

Contributions of an Excursion or Field Trip

- (i) Field experiences are first hand experiences. They arise from direct learning situations. Sometimes they play the same role or even better in the learning of science as do experiments and demonstrations.
- (ii) Field experiences tend to be much more meaningful and permit easier transfer of learning to solutions of real life problems.
- (iii) Fieldwork if properly organised awakens many interests that classroom work cannot arouse. Fieldwork is the study of actual objects which stimulate more curiosity than to ideas. Out of almost any situation encountered in the field can develop into some challenging problems.
- (iv) Fieldwork permits first-hand study of many things that cannot be brought into the classroom because of size and other inconvenience, *e.g.*, it is only outside the class that the students can be acquainted with the flora and fauna of the area.
- (v) Fieldwork permits a class to engage in activities that are too noisy or too violent to be used in the classroom, *e.g.*, a model airplane, gasoline engine if demonstrated in the classroom would disturb the other neighbouring classes too.
- (vi) Outdoors, students are able to work with large size materials, *e.g.*, an iron piece pipe makes a more impressive lever than a routine stick and erosion is better demonstrated

from a garden hose than with a tiny trickle from a jet drawn in a glass tube.

Some Special Experiences of Field Trips : Fieldwork brings students in contact with many objects. The observation and manipulation of objects in the environment are bound to arise questions. Attempts to answer questions give rise to new problems.

Field trips can be used for review and drill. Ideas learnt in classroom can be better fixed in mind in actual situations, *e.g.*, by visiting factories the ideas of running a plant and the products manufactured can be better fixed in students' minds, or visiting a zoological park or a botanical garden, more abstract ideas about animal and plant life can be more clarified to students.

Difficulties Experienced in Arranging Field Trips : Lack of availability of good inventories regarding field experiences, school policies, and transportation problems create hurdles in arranging field trips. Therefore the teacher will have to take a key role if he wants to arrange the trip.

Procedure to Arrange Field Trips

1. Survey of the place of excursion should be taken before going to the field trip, so that the teacher knows beforehand what their students are to see there; or what relevant literature should be studied if places are far away.
2. Objectives of the field trips should be very carefully identified to make a field trip a success. If this is done teacher knows what he is going to teach and the students know what they are going to learn there.
3. Permission from the authorities and parents of students should be taken well in advance.
4. Appropriate activities compatible to the identified objectives should be listed and given as well as discussed with the students beforehand.
5. If there is a need for transport and place to stay they should be arranged in advance.

Preparation of Students/or Excursion

1. It is essential to brief students after arriving at the area. This should be as minimum as possible. A long lecture may deprive the students of an opportunity to explore the place.
2. Students should be divided into small groups appointing a group leader for each group. Group leaders may help in running fieldwork smoothly and quickly.
3. You as a teacher should be aware of the fact that there are slow as well as rapid learners. Activities and responsibilities should be so divided among the students as to be equally shared by both type of students without any feeling that they are slow learners or rapid learners.
4. Students should be made aware that there may be some difficulties like: (a) noise while visiting any working plant in a factory, (b) listening to the guide due to distance while standing around him, or (c) technical language used in explaining particular process; and they should try to solve such difficulties themselves as far as possible.
5. Students may be advised to take notes and draw diagrams, whenever they think it is necessary.

Teacher's Role : The teacher's role is very important for a successful field trip. Some of them are listed below:

1. Watches students closely and gives specific help as and when needed.
2. Recognises student's achievement.
3. Avoids frequent interruption in student's work but occasionally if it is justified.
4. Does not lecture while in field ?
5. Avoids loud voiced comments.
6. Acts as a guide, resource person or consultant.
7. Does the relevant follow-up activities of the trip ?

Follow-up Activities : Follow-up activities are very important

in any kind of field trip, it may be a short trip just outside the classroom or a long excursion to various far away places.

Follow-up activities vary according to the nature of excursion. If the field trip is taken just outside the classroom in the school lawns to find the population densities of various species of plants, the follow-up activity will include the pooling up of data collected by each student or each group of students and discussion on the result. If the field trip is an observational trip to places like factories, mills, observatories or hospitals, discussion about what they have learned is important. Field trip can also be taken to study the fauna and flora and collection of specimens from seashore, hill stations or any other places.

If such field trip is taken by the students follow-up activities will include pressing of plants, preservation of animals, drying of insects, classification and displaying of material. If proper care has not been taken just after or during the trip (in case of long trips) the materials collected cannot be utilised properly and goes to waste. Sometimes the students and teachers are quite enthusiastic while planning and taking the field trip, but forget about the material after the big excitement or do not do the follow-up activities properly, therefore, the field trip is not as effective as it should be.

In short we can say that follow-up activities should be planned according to the objectives of the field trip. Science teachers should plan their objectives for the field trip well and do the follow-up accordingly for better understanding.

Kinds of Exhibits. There is a big variety of exhibits. Sometimes they are three-dimensional working models, sometimes a series of photographs or photographs mixed with charts, models and real objects. But exhibits are essentially something one sees as a spectator. Usually one is not involved in handling any thing or working with the material. Science teachers take their students to show the science fairs where different kinds of exhibits can be seen. They are also of great educational value. Sometimes they may also influence the attitudes.

When students are involved in making exhibits, it becomes a direct experience for them. Investigatory science projects done by

students can be displayed as exhibits. Exhibits can also be used by the science teachers to teach subject matter.

Museum : Museums are places where items and exhibits of knowledge are assembled, protected and studied. In big cities there are public museums of various kinds like art museums, history museums, science museums, and natural history museums etc. Here we are concerned with science and natural history museums. In our country there are not very many science and natural history museums. But if they are available in your cities, advantage should be taken from them. Mostly Science and Natural History Museums (Science museum in Bangalore, Natural History Museum in Darjeeling and New Delhi) have two functions: (i) presentation and display of the materials, and (ii) to work with classroom teachers on specific curriculum unit. If this facility is given by the public museums, science teachers should take full advantage of such arrangements.

The other kind of museums are college and school museums for various subjects. Biology museums are quite common museums established in some form or the other in many schools and colleges. Museum should not be considered as a collection of various items and objects. It is more than that, it must be viewed with an idea, a process, and an objective. Therefore science museums should not emphasise only on the product of science but due importance should also be given to science processes. There is a big scope of displaying of specimens and objects collected by students. Models and projects made by students could also be displayed there. In fact development of museum can be taken as one of the science club activities.

Role of Mass Media : Next on the cone towards little more abstraction comes the TV and motion pictures because we are only the viewers of these audio-visual aids. First we will discuss the motion pictures.

16-mm Educational Films : It is not possible to learn everything by doing or first-hand viewing. We have to get some of our experiences indirectly, 16-mm films play a very important role in giving this indirect experience. Motion pictures present an

abstracted version of the real events omitting unnecessary and unimportant details, they can, sometimes dramatised events so effectively filmed that we feel as though we are present at the reality itself. No other medium has brought so much information and scientific knowledge to the classrooms as the educational sound motion pictures.

There are various kinds of motion pictures. Here we are concerned with the *educational films*. Educational films include *documentary* and *instructional films*. Though some documentary films can be used in classroom teaching but they are especially planned for classroom teaching purposes. On the other hand *instructional films* are specially planned to achieve certain educational objectives and are made in specific subject areas for teaching purposes.

These films can be background films or direct teaching films. They help to promote to achieve a skill, an attitude or to convey certain facts, information, phenomenon or theory. As a science teacher we will be mainly concerned with the instructional films in our areas. Though we are only spectators before a motion picture but the learning outcomes are quite effective because of certain specific values of motion pictures.

For 16-mm films, 16-mm movie projectors are needed. Now video cassettes of 16-mm films are available, which can be seen on TV. with V.C.P. or V.C.R.

Strengths of Motion Pictures

- (a) Motion pictures motivate the students and compel attention.
- (b) Movement can very effectively be shown by motion pictures which is not possible in any other aid except direct experience.
- (c) It is an edited version of reality, the editing involves manipulation of time, space and by eliminating distractions; it gives relationships of things, ideas and events that might well be overlooked in real life. For example, food web, food chain, etc., can be seen as continuous processes which is not possible in reality.

- (d) Time can be controlled in a motion picture with the help of slow motion photography, “movements in animals, insects, flight of birds” can be understood very easily. With the help of time-lapse photography it is possible to see the blooming of flowers, germination of seeds, growths of plants, etc.
- (e) Motion pictures can enlarge or reduce the actual size of the objects for better compensation. By means of microscopic lens attachments microscopic organisms like algae, fungi, protozoas, and blood circulation in capillaries etc. can easily be seen and understood by students.
- (f) By X-ray cine photography techniques movements of internal organs of animals — action of arms, legs, movement of the heel, swallowing of food, heart-beating/ living movements, etc., can be shown.
- (g) Motion pictures can bring past and distant present into the classroom.
- (h) With the help of animation techniques motion pictures can show processes which cannot be seen by human eye even with the help of microscope or telescope. For example, behaviour of molecules in solids, liquids and gases, phenomenon of nuclear fission and fusion, etc.
- (i) Motion pictures can reproduce the record of events like lunar and solar eclipses, etc. which are not always possible to see. Complicated techniques can be filmed and reproduced when required.
- (j) Motion pictures promote understanding of abstract relationship, offer a satisfying aesthetic experience, influence and even change in attitudes.

With so many values, motion pictures not only expedite the rate of learning but they also increase the scope of teaching. This is an important consideration in the field of science where mass of learning and the learning processes are expanding so rapidly that it is to keep hand up with them. Motion pictures enable the teacher to clarify the difficult concepts in less time than with any other technique.

In order to get the most effective use of films or video tapes, the following necessary information and skills should be acquired:

- (i) Where to obtain appropriate films or video tapes?
- (ii) How to use such films and video tapes in your teaching?
- (iii) How to operate the 16-mm film projector, V.C.R, V.C.R.?

School, college and university teachers have to spend some time to find films or video cassettes which they can integrate into their courses. It is possible to find suitable films or video cassettes on various science subjects. Securing catalogues will be important for this purpose.

For an effective use of films or video cassettes, preparation and follow-up are two very important steps to be taken by a teacher. Teacher should select the film or video cassette which goes along with the topic. The film or video cassette should be previewed and important points to be covered in the lesson should be outlined.

It will be advisable to frame few short answer questions. These questions can be given to the students before showing the film or video. During the follow-up activity unanswered questions and other important points should be discussed. Such activities help in coordinating the film or video with the topic. In the absence of such coordination sometimes the film or video becomes a wastage of time and effort.

The next point is to learn to operate the 16-mm projector and V.C.P./V.C.R. which is not very difficult to learn. Ordinarily only a few hours instruction followed by a brief practice results in satisfactory operation. Simple threading and operating instructions are given somewhere on the projector, which should be followed carefully. The possibilities of error should not discourage the teacher but it should be taken as challenge. The thrill of this educational device will compensate for minor disappointments.

Caution to be Observed in Using Films or Videos : Motion pictures may not necessarily be effective for teaching everything. As a teacher you have to be cautious about certain things.

- You have to think about the *effectiveness* of the film or video. If other experiences like direct or contrived are more meaningful, film or video should not be used.
- Sometimes the film or video gives a wrong idea about the *time notion* and *size notion*. It should be clarified to the students by comparing it with a known object or by giving a familiar example.
- If inexpensive devices are available with the *same effectiveness* as motion pictures, then less expensive devices should be used.
- Teacher should see that the film or video is adequate for the comprehension of his/her students.

School T.V. Programmes : Television has all the potentialities of motion picture with a little more concreteness because of the “on the spot coverage” and the nature of the TV programmes, as most of them are specially produced for a particular audience. This is more so for educational TV programmes. In many countries educational TV programmes include series of science programmes.

Educational TV in India : Experimental TV Service was inaugurated on September 15th, 1959. This programme was planned for educational and cultural values of community and designed for community viewing. In the meantime Ford Foundation in India was approached to assist in the development of educational TV. Ford Foundation team of TV experts visited India in February 1960. In 1961 Television was started in India as an educational TV project. The project was launched in close collaboration with the Delhi Directorate of Education and with the financial assistance of the Ford Foundation in 1961.

The educational TV programmes were integrated with the school syllabus based on the principle of direct teaching. Direct teaching implied that the TV programmes were directly related with the school syllabus. They were proposed to help in classroom teaching by bringing into classroom additional resources through the medium of TV. The students were benefited from talented teachers, best and expensive equipment and other audio-visual aids which were not usually available in schools.

In the project the teachers were also fully involved from the planning to evaluation. This arrangement of instructional TV was working well in Delhi schools because there was a set prescribed syllabus. In some other advanced countries there is not any set syllabus for all but they have different syllabi chosen by teachers and students. Their educational TV programmes are not strictly integrated with the syllabi.

In Delhi the educational programmes started in General Science, Social Studies, Physics and Chemistry. Later Biology Maths and Geography were also included.

For proper functioning of educational TV and better coordination between Doordarshan and Schools a Television Branch was set up in 1967 in Delhi Directorate of Education. The TV branch used to divide the syllabus term-wise and week-wise, and select lessons for TV teaching. To ensure close relationship between TV and classroom teaching, a package of a uniform time-table, set examination days and working hours, and a uniform weekly syllabus in the form of a TV booklet was to be distributed to all viewing schools in the beginning of the school session. Such TV booklets used to be prepared for each subject taught on TV. But now we do not have such school TV programmes in Delhi or elsewhere in the country.

This kind of educational TV programme if started again can solve several problems of science teaching in our schools.

Merits

1. It solves the problem of unequipped laboratories to certain extent. Students are able to see effective demonstrations and expensive apparatus which is otherwise not possible for them to see.
2. TV teachers prepare and rehearse a lesson, spend enough time to collect relevant material and up-to-date information.
3. It has all advantages of films plus being a live presentation seems more natural. Only relevant portions of films are shown, along with teacher's explanation and other visual material.

Demerits

1. It is a one way process and students are passive viewers.
2. There is no opportunity for an active participation of the learner during TV lesson.

Better Utilisation of Educational TV : The disadvantages can be removed if some preparation is done and precautions are taken by the classroom teacher.

For effective use of any mass media three things are important: proper reception, proper seating arrangement, carefully planned preparation and follow-up.

Good reception is one of the basic important things for effective viewing. The television branch in Delhi had the responsibility of installing and maintenance of TV sets. The coordination had to be done by the teachers and administration of the school. Classroom teacher was also be familiar with proper handling and minor adjustments of a TV set.

Next important thing is the proper seating arrangements. If a big crowd is sitting on the floor (without any discipline) in an auditorium or classroom, not sure of proper viewing, this kind of arrangement will be a waste of time. The classroom teacher was to see that there was proper seating arrangement.

TV presentation is only one part of the learning procedure. Preparation for the TV lesson or the pre-telecast activities and the follow-up or post-telecast activities by the classroom teacher are equally important without which the TV lesson may not be very much meaningful.

Pre-telecast activities included the preparation by the subject teacher. Preparation varied with class to class and also depended on the topic, the classroom teacher could see the topic of the TV lesson in advance from the TV booklet. During pre-telecast activities his job was to make the students ready to receive the TV instructions. He could ask motivational questions. If some background knowledge was needed it was to be given at this time. The time-table was arranged in such a way that there were about 10 minutes before

and after the actual telecast, usually the presentation was of 20 minutes duration, and class periods varied from 35-40 minutes.

After the TV presentation follow-up activities included clarification of points of doubts raised by students. Recapitulation questions could also be asked to see how much they have grasped. With little encouragement by the classroom teacher many activities could be followed by students as continuation of the TV presentation for better understanding.

The TV branch of Delhi also tried to evaluate the lessons. They used to send a printed pad of evaluation check sheets to each school for the constant feedback of TV lessons. If various people connected with educational TV production do their jobs consciously the E.T.V. programmes can be quite effective. You as a science teacher has to play an important role. During your practice teaching you can observe some science lessons on video tapes, evaluate them according to the evaluation check sheet developed by you and give suggestions for further improvement.

Various Uses

A variety of teaching aids has been discussed in this chapter with some details. It is difficult to select few aids and to say that they are more important than others, or mis should be used more often than others etc. The value of an aid does not depend wholly on its quality itself but it also greatly depends upon the way it is used and the particular time it is used.

The qualities of various aids have also been discussed. No matter how perfect the aid may be, if it is irrelevant to the occasion of its use then it is of little value and an ordinary aid with not too many qualities becomes indispensable if it is used relevantly at the right time. For example, there is film which shows the animals under the sea or life in a desert in relation to their ecology. Neither the materials nor this relationship could be shown in a class by any other media or field trip as effectively as the film could. But always it should not be used as a substitute for other materials of the classroom.

National Concerns

The environ scenario of India is very wide indeed. At the first level, special attention must be paid to the school going children and women (about 50% of the population). They are to be made aware of health, nutrition, sanitation, hygiene, development, water and food contamination, fodder and fuel wood etc. Non-government organizations (NGO's) have to play a significant role. In the Directory of the Dept. of Environment, there are 200 NGO's which work in the area of EE and awareness. Moreover, children are to be told the real meaning of wildlife. They are to be educated for plants, smaller animals, microbes etc. i.e. holistic approach to wildlife.

Environmental Education

The chief goals of EE in India must be:

1. To improve the quality of environment.
2. To create an awareness among people on environmental protection.
3. To develop the capabilities of decision making.

The spectrum of EE has four major interrelated components i.e. (i) awareness, that include making the individual conscious about the physical, social and aesthetic aspects of environment, (ii) real-life situations, that link environment to life, these conditions

are locational specific, thus problems and properties of each area may be different, (iii) conservation and (iv) sustainable development, where spot light would be on utilisation and not on exploitation. In the former, the idea is that all resources are finite and there is also a limit to the growth of living systems. Thus resources are to be used in wise manner. Sustainable development aims at utilization of resources not only by the present but also by the future generations in a manner that utilization (and not exploitation) is balanced. Utilization of resources for development is always associated with some negative impacts. Thus efforts are to be made to contain or minimise them.

Primary School Stage : The attempt is made to sensitize the child about environs. Emphasis should be mostly (75%) on building up awareness, followed by real life situation (20%) and conservation (5%). The contents to be used are surrounding from home to school to outdoor situation.

Teaching strategy includes audio-visual and field visits.

Lower Secondary Stage : At this level objective must be real life experience, awareness and problem identification. The quantum of awareness must decrease with increase in real life situations. The contents are supplemented with general science. Teaching, practicals and field visits are to be made.

Higher Secondary School Stage : The emphasis must be on conservation, assimilation of knowledge, problem identification and action skills. Contents may be science based and action oriented work. There should be proper teaching, practicals and field work.

College Stage : Maximum emphasis should be on knowledge regarding sustainable development based on experience with conservation. The contents must be college based on Science and Technology.

Teaching practicals and action-oriented field work is to be done. In the school education NCERT has been playing vital role in designing syllabi, text books, guide books, charts, kits, teaching materials and other aids.

University Education : EE at this level is being looked after the UGC. There are about 10 universities teaching environmental sciences. The University education has three major components- Teaching, Research and Extension. At post graduate level, four major areas are recognised -

1. *Environment Engineering* : It includes subjects like architecture, civil engineering, town and country planning, including human settlement, slum improvement, landscape architecture, industrial design, regional science and urban ecosystem studies.
2. *Conservation and Management* : It includes fields like land use, forestry, agriculture, energy, waste management, wild life management, national parks, biosphere reserves, biological diversities, water management, mining management, non-polluting renewable energy development etc.
3. *Environmental Health* : This deals with public health and hygiene, sanitary and chemical engineering, occupational health, toxicology, nutrition and drug use etc.
4. *Social Ecology* : It includes subjects like ecology, sociology, social planning, cost-benefit, community organisation and services, psychology and counselling, environmental ethics and related areas of humanities.

There are some institutes, centres assisted by Dept. of Environment which provide formal education/training in environmental areas e.g., Centre for Environmental Education (CEE), Ahmedabad, Indian Institute of Forest Management, Bhopal and Indira Gandhi National Forest Academy, Dehradun.

Non-formal Education : This education is designed for any age group, participating in cultural, social, economic development of the country. They form clubs and arrange exhibitions, public lectures, meetings, environmental campaigns. Following are the main constituents of this education.

Adult Education : Adults may influence the society to protect

the precious environs by generating posters, slides, audio-visual and information pictures.

Rural Youth and Non-student Youth : They may act as volunteers.

Tribals and Forest Dwellers : They are an important media to protect the forest wealth.

Children Activities : Dept. of Environ with the help of United School Organisations of India organised essay competitions among different age group children. School term courses are also given by NMNH in EE every year. The National Museum of Natural History (NMNH) conducts spot painting, modelling and poster design about environment for children.

Eco-development Camps : A set of guidelines has been prepared by D.O. En (1984). The objectives are:

- (i) To create awareness in youth about basic ecological principles.
- (ii) To identify root cause of ecological problems as related to human activities.
- (iii) To promote for solving ecological problems
- (iv) To develop a spirit of national integration.

Non-government Organisations : There are more than 200 NGOs of which most are involved in EE and awareness. Others in pollution control, nature protection and conversation, rural development, waste utilization, wild life conservation, floristic and funal studies, afforestation and social forestry and eco-development.

Public Representative : India has environmental forums for MPs and MLAs to discuss environmental problems facing the country. They may be sound public opinion and stimulate public interest for saving the environs.

Training Executives : Regular courses should be arranged for environ activities among administrators.

Research and Development Programme : Such R and D efforts are supported by D.O. Environment in Biosphere and Man as well as solving basic and applied environmental problems.

Foundation Courses : The courses for the probationers selected for IAS, IFS, IPS and cadets of three wings of Armed Forces need to be supplemented with foundation courses on environment relevant to their area of specialisation.

Development of Educational Material and Teaching Aids : Materials for media (T.V., radio films, newspaper etc.), audio, mobile exhibitions, audio-visual materials must be operated by competent manpower. One such centre in India is centre for Environmental Education, Ahmedabad.

Development of Trained Manpower : Dept. of Environment (DOE) must organise training programmes for the professors, technical personnel, lecturers and legal experts.

National Environment Awareness Campaign or National Environment Month : Commencing from 1986, DOE conducts NEAC and NEM, from November 19th to December 18th every year is observed as NEM. Each year there is major environmental theme.

World Environmental Day : All Govt. in the states, UTs, Universities, Schools, Colleges, academic institutions and voluntary organisations organise suitable activities on WED, i.e. 5th June of each year DOE supports the function financially.

National Environment Awareness Campaign/National Environment Month : Commencing from 1986, Department of Environment conducts NEAC and NEM; from November 19th to December 18th every year is observed as NEM. Each year there is a major environmental theme.

Development of the Curriculum

The environmental education may be thought not as an end in itself but as a means to an end. Education is the process of development of child's personality. The Review Committee (1977)

on curriculum of EE has emphasized the need for stressing more environment based education. The committee has also recommended that physical and bio-sciences, life sciences curriculum should be made environmental oriented with emphasis on problem related to environment.

The review of literature on the theme of environment reveals that it is related to physical, biological and social sciences, thus, the edifice of environment, knowledge and understanding is interdisciplinary in nature. Therefore, it can be adequately designed and included in the course curriculum of teacher education programme.

The teaching methodology of physical sciences, bio-science and social sciences are taught and practised under the main course of teacher-education. Therefore, the related concept and components of environment can be easily included in these teaching subjects of teacher education curriculum.

The universities and educational institutions have designed the course content of Environmental education for B.Ed, and M.Ed, level. The main emphasis has been given on physical and biological component of the environment.

Content Course

1. Historical Development of E.E. - Ancient view point and recent concept of E.E.
2. Concept of Environment-meaning structure and processes. Types of environment and components.
3. Concept of Education - meaning, objectives, content and status, interdisciplinary approach to education.
4. Concept of Environmental Education - Relationship between Environment and Education, meaning and definition characteristics and objectives, content, method and techniques.
5. Concepts related to E.E. - Ecology, Ecosystem, Autecology, Biomes and Pollution.

6. Physical Environment and Education - Meaning components, Air, Water, Sound/Noise Pollution. Meaning, structure, components, factors affecting environmental, industry, urbanisation, traffic etc and role of education and interdependency of various factors of environment.
7. Social and Cultural Environment and Education—Meaning and structure, Pollution, colonisation, urbanisation due to social changes and mobility. Development of media, factors influencing the environment and role of teachers and schools, method health and community health.
8. Agencies of Environmental Protection and Information-Steps taken. The governmental organisation, private organisation, legal steps, role of educational institutions.

Approach Method

As already mentioned that the contents of EE is largely interdisciplinary in nature. It is both art (doing) and science (understanding), organised from primary to university level, the objectives of EE are not confined upto knowledge and awareness but include skills, attitudes and values. Thus strategies of teaching and learning have wide coverage, based on content, its components, levels of education and the objective of E.E.

The major objectives of E.E. are awareness, attitude and action. Therefore, a student should be allowed and asked to observe simple phenomena of earth and sky. The teacher should also translate awareness in his action which will be the model for the students. Thus the doing part much more important for the teacher.

The role of teacher is very significant in realizing the above objectives of E.E. A number of projects can be assigned to the students in school situations for making herbarium, plantation in school campus. It is the teacher who can sensitize his students for improving the quality of environment.

The objectives of E.E. can be realized through formal and non-formal system of education. The strategies of E.E. have been summarized in the following table:

**Strategies of Teaching of Environmental Education with
Reference to Objectives and Levels.**

Strategies of Teaching	Objective of Environmental Education			
Primary Level	Awareness	Skills	Attitudes	Action
1. Observation method	+ + + +	————	++————	————
2. Playway method	+ + + +	+———	+ +———	————
3. Field trips	+ + + +	+———	++———	————
4. Dramatisation	+ + + +	————	++———	+———
Secondary Level				
1. Lecture method	+ + + +	————	++———	————
2. Questions-Answer	+ + + +	————	————	————
3. Project method	+ + ——	————	————	————
4. Educational tours	+ + + +	————	++———	————
5. Dramatization	+ + + +	————	++———	++———
6. Observation	+ + + +	————	+++———	————
Higher Level				
1. Lecture method	+ + + +	————	++———	————
2. Group discussion	+ + + +	————	++++	————
3. Seminar and w.s.	+ + + +	+++———	+++———	++———
4. Survey method	+ + + +	————	+++———	————
5. Action research	+ + + +	+++———	+++———	++++——
6. Experimentation	+ + + +	++———	+++———	++———
7. Inter-disciplinary approach.	+ + + +	————	++++——	++———
8. Demonstration	+ + + +	++———	++++——	++———

From the given table it is evident that E.E. employs scientific and non-scientific methods of teaching. All the methods provide the awareness but skills and attitudes are equally important objective in teaching environment education.

Field Trips : Ryan developed 'Educational Excursion Method' of teaching which is commonly used in geography, botany, zoology, study of nature and history teaching. There are a number of topics in E.E. which can be taught effectively by this method.

Significance on Paper

The following are the theoretical basis of this method.

- (i) It provides the real experience about the E.E. to the learners.
- (ii) It involves the observations imagination and ability of discovering the cause effect relationship among the environment components.
- (iii) It develops the feeling of cooperation and group work as social principles.

Educational Excursion

- (i) To develop the tendency of excursion and its utility for the understanding.
- (ii) To provide awareness about the environment.
- (iii) To develop the ability of observation, imagination and discovering.
- (iv) To develop ability of cooperation and team work.

Planning

The following steps are taken is organising educational excursion.

- (i) The specific objectives are to be formulated.
- (ii) A schedule - date, time, number of students, duration and financial aspects should be finalized.
- (iii) A guide sheet is prepared and supplied to the students.
- (iv) The students are asked to prepare a report about their observations and visiting different places.
- (v) The visiting organisations are to be contacted for the arrangement.

- (vi) The excursion should be followed group discussion to highlight the environmental components and source of pollution.

Utility

- (i) Teaching can be made effective and interesting by real experiences.
- (ii) It helps in developing ability of observation and imagination.
- (iii) The objectives of teaching can be realized by this method.
- (iv) It develops feeling of cooperation and team work.

Co-curricular Activities : The co-curricular activities of education are the most appropriate means for providing opportunities for the action. The teacher is the main means for implementing the programmes and realizing and objectives of E.E. and organisation of co-curricular activities in schools and outside the school. There are two main programmes recommended by Educational Commission and policy i.e. National Social Scheme (NSS) and socially useful productive work (SUPW). The activities organised through these programmes are:

- (i) To clean the environment through NSS camps.
- (ii) To grow plants and develop gardens for protection.
- (iii) To clean the public places and parks etc.
- (iv) To construct roads and dig pits for the wastes.
- (v) To develop sense of sanitation among the people by organising cultural programmes.
- (vi) To develop the consciousness about population education by organising camps of population education or family planning.
- (vii) To encourage the students to prepare charts related to environmental pollution and its protection.
- (viii) To motivate the students for using stories and essays on the environmental education.

The Review Committee (1977) on curriculum E.E. has stressed the need for more environment based education. There are more

than two hundred non-government organisations engaged in environmental education awareness and training youths on different areas. Recently the university departments are organising seminars and workshops on E.E. to develop the course content for B.Ed and M.Ed classes. The courses are to be designed at two levels - first in the core course and second is the specialized course. The core course is compulsory for B.Ed students and specialized course is the part of teaching methodology course.

Various Projects

1. Aswan High Dam in Egypt (1964). It is the biggest dam in the world. It was constructed at Aswan in 1964 on river Nile. It has caused several environmental problems of serious consequences because the likely or probable impact of dam and reservoir on environmental conditions were not properly assessed. It caused several kinds of biotic and abiotic problems.
2. Earthscan. An agency founded by UNEP in 1976 that commission's original articles on environmental matters and sells them as features to newspapers and magazines especially in developing countries.
3. 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.
4. Environmental Protection 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, radiations, pesticides, noise etc.
5. European Economic Community (EEC). It is a community of 12 European nations with sound political, economic and legal base. The community has joint agricultural and scientific programme between its members. It also assists other countries in environmental programmes. It has

programmes of framing and implementation of coordinated policy for environmental improvement and conservation of natural resources. CPCB, India has recently taken up a project on air quality monitoring with assistance of EEC.

6. Human Exposure Assessment Location (HEAL). The project is a part of the Health Related Monitoring Programme by WHO in cooperation with UNEP. The project has three components viz. (i) air monitoring (ii) water quality monitoring and (iii) food contamination monitoring on a global basis.
7. International Council of Scientific Unions (ICSU). A non-governmental organisation, based in Paris, that encourages the exchange of scientific information, initiates programmes requiring international scientific cooperation and studies and reports on matters to social and political responsibilities in treatment of scientific community.
8. International Union for Conservation of Nature and Natural Resources (IUCN). An autonomous body founded in 1948, with its Head quarters at Morges, Switzerland, that initiates and promotes scientifically based conservation measures. It also cooperates with United Nations and other inter-governmental agencies and with sister bodies of world wildlife fund (WWF).
9. Trans-Alaska pipe line in USA (1977). This project was initiated to carry mineral oil and natural gas through 1270 kms long underground pipelines from the newly discovered oil wells near Prudhoe Bay on north Coast of Alaska to port Valdez to south coast of Alaska. This project has not affected Alaska and marine and environment except the political problems that the route and pipe line involves Canada. It is not advisable due to safety and strategic point of view.
10. International Marine Consultative Organisation (IMCO). It regulates the operation of ships in high seas, from marine water pollution viewpoint.

11. United Nations Educational, Scientific and Cultural Organisation (UNESCO). A United Nations agency founded 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 informations 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.
12. United Nations Environment Programme (UNEP). An UN agency, co ordination of inter government 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.
13. Earth watch Programme. A worldwide 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. Man and the Biosphere Programme (MAB). The programme is the outcome of International Biological Programme (IBP) that has already concluded its activities. MAB was formally launched by UNESCO in 1971. There are 14 project areas under this programme. We shall provide here the details of MAB with special reference to major activities in our own country so far done under the same, and the priority areas for future.

15. Project Earth. Developed in collaboration with UNEP to inspire, interest and educate young people world wide on crucial issues facing the Earth's Environment. The project is led by Mr. Robert Swan, UNEP Good will Ambassador for youth. He is the only person to have reached the North Pole and the South Pole on foot.
16. Tehri High Dam Project (India). It is one of the most controversial river projects in world as regards the conflict between environmentalists, local people, project authorities and government. It is being constructed on the Ganga river below the confluence of its two main tributaries- Bhagirathi and Bhilangane at Tehri of Uttar Pradesh. Tehri Hydro corporation (THDC) was formed in 1989 and construction work was taken over by Union Government of India with soviet technical and economic aid. It is 260.5 meter highest rock fill dam in the country. Before planning this dam, proper assessment was not done to visualize the probable adverse effects.
17. Sardar Sarovar (SS). Project near Navagam in Bharauch district of Gujarat is one of the costliest projects affecting villages in three states - M.P., Maharashtra and Gujarat. About 245 villages will be submerged of which about 193 in M.P. alone. Over 75000 people will be evicted. Additional displacement is likely to be caused during social and environmental rehabilitation work undertaken to repair the dislocation and damages caused by the project.
18. Narmada Valley Project (NVP). The world's largest river valley project has attracted the greatest attention. The 30 big dams and over 3000 medium and minor dams are envisaged at cost of Rs. 25,000 crores. It would displace one million people, mostly tribals, submerge 56,000 ha of fertile agriculture land. Total forest area of nearly 60,000 ha. will be destroyed . About 25 species of birds will be deprived of their habitats.
19. Bodhghat Project. On Indravati river in M.P. is in heavily forested Bastar district. The project will destroy teak and

sal forests. The criticism of the project forced the Government and the World Bank to reconsider it.

Biosphere Programme : MAB in fact is the outcome of the experience of those involved in the International Biological Programme (IBP). It was realised 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 at its 16th session in 1970. The programme was formally launched by UNESCO in November 1971, when the MAB International Coordinating Council held its first session and identified 13 project areas of cooperative research. One more area of project area was added in 1974.

Information on Environment

Department of Environment could set a plan programme - Environmental Information System (ENVIS) in 1982. It is decentralised system using distributed network of data bases for collection of environmental information. ENVIS Network with department of environment, its focal point consists of 10 ENVIS centres on diverse area of environment, established in specialised and reputed institutions in the country.

Objectives of MAB : The general objective of the programme is to develop the basis within the natural and social sciences for the rational use and conservation of the resources of the biosphere and for the improvement of the global relationships between man and the environment; to predict the consequences of today's actions on tomorrow's world and thereby to increase man's ability to manage efficiently the natural resources of the biosphere.

Approach : The programme aims to provide scientific basis to solve real practical problems of resources management through understanding the environmental problems in the ecosystem context.

Organisation : Internationally MAB is guided by International Coordinating Council (ICC) but in India, the MAB is serviced and funded by the Department of Environment, Forest and Wild Life.

Indian National Man and Biosphere Committee, was first constituted in 1972 which supervise and directs the programme.

Project Areas : Research under MAB Programme is divided into 14 broad themes which are given.

Project Area 1. Ecological Effects of Increasing Human Activities on Tropical and Subtropical Forest Ecosystems:

The broad themes include:

- (i) baseline studies in natural tropical forest ecosystem.
- (ii) problems involved in the management and natural regeneration of exploited tropical forest ecosystem.
- (iii) investigations into the methods of regeneration of exploited tropical forest ecosystem.
- (iv) effects of various methods of cultivation and land use on soil structure.

Project Area 2. Ecological Effects of Different Land Uses and Management Practices on Temperate and Mediterranean Forest Landscapes

- (i) to identify and assess changes due to man's activities on such landscapes and the effects of these changes on man
- (ii) a comparative study of inter-relationship between natural and man made forest ecosystems and impact of changes in human population.
- (iii) to develop ways of measuring quantitative and qualitative changes in forest environment.
- (iv) ecological impact of forest fire and effect of air pollution on forest ecosystem.

Project Area 3. Impact of Human Activities and Land Use Practices on Grazing Lands.

- (i) to secure information from natural and social sciences research on grazing lands in order to provide guidelines for management of these lands under different climatic and socio-economic conditions.

Project Area 4. Impact of Human Activities on the Dynamics of Arid and Semi-arid Zone Ecosystems with Particular Attention to Effects of Irrigation.

The main aim is:

- (i) ecological improvement of arid and semi-arid regions with special emphasis on the effects of irrigation.

Project Area 5. Impact of Human Activities on Mountain Ecosystems.

The chief objectives are;

- (i) effect of shifting agriculture, over grazing, deforestation
- (ii) impact of large scale technology such as hydroelectric power and water storage dams
- (iii) effect of tourism and recreation

Project Area 6. Conservation of Natural Areas and the Gene Material They contain.

The main area of interest are:

- (i) preparation of list of rare and threatened plant and animal species.
- (ii) protection in the form of biosphere reserves and National Parks etc.
- (iii) development of techniques for rapid multiplication of threatened and rare plant and animal species.

Project Area 7. Ecological Assessment of Pest Management and Fertiliser Use on Terrestrial and Aquatic Ecosystem

The programme lays emphasis on development of methods for control of pests of agriculture and public health importance.

Project Area 8. Ecological Aspects of Urban Systems with particular Emphasis on Energy Utilisation.

The area of research are, energy and material flows into the urban areas and pattern of their utilisation.

Project Area 9. Perception of Environmental Quality

- (i) perception of environmental hazards.
- (ii) perception of National Parks and other relatively unmodified natural areas.
- (iii) perception of quality in urban environment.

Project Area 10. Research on Environmental Pollution and its Effects on the Biosphere

The major areas in the project are:

- (i) to identify the environmental indicator.
- (ii) acute and long term effects of pollutants from domestic, industrial, agriculture or other sources.
- (iii) to monitor the level of different pollutants in the environment.

Project Area 11. Ecological Effects of Human Activities on the Value and Resources of Lakes, Marshes, Rivers, Deltas, Estuaries and Coastal zone 5.

The main objectives are:

- (i) origin, nature and extent of pollution and its effect on aquatic life.
- (ii) sewage problems.
- (iii) harnessing the river for agriculture, animal husbandry, drinking and industrial water supply.
- (iv) tidal movement effect on ecosystem.

Project Area 12. Ecology and Rational Use of Island Ecosystem.**Project Area 13. Effects of Major Engineering Works on Man and his Environment.****Project Area 14. Interaction between Environment Transformation and the Adaptive, Demographic and Genetic Structure of Human Population.**

The above project has following objectives:

- (i) Folklore survey and collection and identification of plants and animals used by tribals.

- (ii) Conservation of plants used by them.
- (iii) Impact of tribal culture on vegetation and wild life.
- (iv) Technology of development of tribal communities.

A number of research projects on these aspects have been sponsored. A unit of Genetic Toxicology is established at Kolkata University to study (i) the chronic effects of sub-toxic doses of pollutant on human systems in relation with different modifying factors as genetic polymorphism, nutrition, etc. and (ii) identify the species of vegetation genetically tolerant to various pollutants.

A project is initiated to study the effect of SO₂ and particulate matter on vegetation in the urban and industrial areas. The organisations involved are, B.H.U., Varanasi, J.N.U., New Delhi, N.B.R.I., Lucknow, B.S.I., Kolkata National Organisations.

A number of Government and non-government organisations are engaged in environmental studies. Department of Environment Forest and Wild life of India was set up in 1980 to serve as the focal point in the administrative structure of the Government for planning, promotion and coordination of environmental programmes.

International Concerns

Environment is defined as “the sum total of all conditions and influences that affected the development and life of organisms.” The interplay of material cycles and energy flow in natural ecosystem generates a self-correcting homeostasis with no outside control or set points.

The eco system is capable of self-maintenance. However, the equilibrium is very sensitive to external stimuli such as human activities promoted by socio-economic goals. The global community recognised the seriousness of the U.N. declared 1990s as the International Decade for “Natural Disaster Reduction.” As a part of this world wide programme of education and action has called upon to make people aware of the danger ahead and the steps they must take to check and mitigate their ill effects.

As we know that Global climate is changing due to green house effect” i.e. due to the accumulation of green house gases such as carbon dioxide, chlorofluorocarbons (CFCs) methane, nitrous oxide and ground level ozone gas. Half of the global warming is alone by carbondioxide gas. Temporary stability can be achieved if annual emission of CO₂ could be reduced by shifting fossil fuel use from coal to oil to natural gas. This can also be achieved if we shift to other alternate sources of energy like solar, geothermal, tidal, hydro etc.

The ozone layer present in stratosphere protects us from the ultraviolet rays which would cause different ailments like sunburns, skin cancer, eye damage etc. This is also depleting because of released of CFCs, nitrous oxide and other gases. In order to avert the worst effect of warming due to green house effect serious efforts are being made all over the world to reduce the release of these gases into the atmosphere.

Protection of Environment

Conservation has been defined as “the management for the benefit of all life including human kind of the biosphere so that it may yield sustainable benefit to the present generation while maintaining its potential to meet the needs and aspiration of the future generation.” As the earth is the only planet where life can exist, population on the earth is increasing at an alarming rate which is putting stress on the natural resources at much larger scale. Continuous increase in population caused an increasing demand for resources. This created a situation when the non-renewable resources may come to an end after some time.

Basically there are two main reasons for exploitation of environment and its resources. One reason is poverty while the other is rich people. Although development is necessary for man but it should be in a way that it should not destroy the resources. All the available resources available on the earth should be used judiciously so that they should not be depleted. The people should be made aware of the consequences of this depletion. Since the natural resources are over exploiting there should be a check or control over it.

Objectives of Preservation

The main objectives to conserve the natural resources are:

- (i) to maintain the proper ecological balance and life support system.
- (ii) to preserve biological diversity.
- (iii) to ensure that any utilisation of species and ecosystems is sustainable.

Conservation, therefore, makes important contributions to social and economic development.

The Techniques

At global level there are only two strategies

- (a) Special Interest Conservation Strategies. Conservation is to be done of only important and limited resources.
- (b) Total Ecosystem Conservation. Conservation of all species of the organisms on the earth.

U.N. Conference on Human Environment for Stockholm declaration in year 1972 from 5th June to 16th June held in Stockholm. The following recommendations were made by the conference.

- (i) Every human being has the right to live in healthy environment and his fundamental duty is to protect the environment and its surroundings.
- (ii) Ecological balance should be maintained.
- (iii) For the protection of the society the wild life should be properly managed.
- (iv) Natural renewable resources should be maintained on the earth.
- (v) No interference in geological balance, or over exploitation of natural resource as they lead to pollution.
- (vi) Waste and pollutants should not be discharged directly into oceans.
- (vii) Science and technology should be used for the identification of various disasters of environmental pollutants.
- (viii) Every country must take into account that any work done in their country should not effect the other country.
- (ix) Environment effects the economic development and quality of living of the human beings.
- (x) Every one should be given education about the ill effect of deterioration of environment.

The late Prime Minister, Smt. Indira Gandhi played a vital role in the above conference. She had taken initiative and come forward with a definite programme on environmental conservation. She made 42nd amendment in the constitution. According to this amendment, the problems regarding forests, wild life and environment were considered. Laws have been made and fundamental duties imposed on every citizen of this country.

Under the auspices of the International Union of Conservation of Nature and Natural Resources (IUCN), World Wildlife Fund (WWF) and UNEP, a World Conservation strategy was prepared and released for adoption and implementation in India on March 5, 1980. The WCS is to ensure the management of human use of biosphere in a manner which may yield greater sustainable benefit to the present generation while maintaining its potential to meet the needs and aspirations of future generation.

Keeping in view the need for environmental protection, the Indian Parliament passed the water (Prevention and Control of Pollution) Act, 1974 which became effective from 23 March 1974. The Central Board for Prevention and Control of Water Pollution (CBPCW) was constituted in Sept. 1974. The Air (Prevention and Control of Pollution) Act 1981 was promulgated on 16 May, 1981. The Environment (Protection) Act 1986, was promulgated on 23 May, 1986.

The main instruments presently for control of air, water and noise pollution in country are:

- (1) The water (Prevention and Control of Pollution) Act 1974.
- (2) The Air (Prevention and Control of Pollution) Act 1981.
- (3) The Environment (Protection) Act 1986.
- (4) The Motor Vehicles Act, 1988.

Besides there are other acts to conserve our environment.

Factories Act (1948) — Amended in (1987)

In Section 12 of our constitution it is stated that it is the duty of every industrialist to properly treat and manage the waste according to the plans laid down by the state government.

- (i) In Section 11 of the act, it is given that it is the duty of the factory owner to check the factory is free from any effluent.
- (ii) Any effluent producing factory should be away from human habitat.
- (iii) Only limited amount of harmful waste should be emitted.
- (iv) Machineries should be properly maintained and should be periodically checked.

Environment (Conservation) Act 1980 — (Amended 1988)

According to this law:

1. Natural forests on the earth cannot be changed into other kind of plantation without prior permission of the Government.
2. If any one converted forest area for development project, the same area is to be planted by him.
3. Forest planning and management should be stressed.
4. No area should be deforested with the purpose of reforesting it.
5. There should be controlled grazing.
6. A forestation near the hills and slopes of the hills.
7. Encouragement to the tribal community.
8. Penalties for any disobedience of laws.

Forest (Conservation) Act, 1980 — (Amended 1988)

National Forest Policy 1952 enunciated that one third of the geographic area of the country should be under forests. However there had been continuous deforestation in the country for various reasons, and it is estimated that 4.23 8 Mha of forest land was officially diverted to non-forest purposes between 1951-52 and 1979-80. With a view to conserve forests, Govt. of India could enact the Forest (Conservation) Act, 1980.

1. Act was enacted with a view to check indiscriminate dereservation and diversion of forest land to non-forest purposes.

2. Under this act prior approval of Central Government is required before any reserved forest is declared as dereserved, or forest land is diverted to non-forest purposes.
3. If diversion is permitted, compensatory afforestation is insisted upon and other suitable conditions imposed.
4. Where non-forest lands are available compensatory afforestation be raised over equivalent area of non-forest land.
5. Where non-forest lands are not available, compensatory plantation be raised over degraded forests twice in extent to the area being diverted.
6. A control should be exerted over shifting cultivation and encroachments.
7. Grazing problems of the area should be studied and appropriate measure be adopted.
8. All forest working plans should stress conservation and have multi-disciplinary approach.
9. All critical areas in the hills, catchment areas, steep slopes and other parts under erosion must be protected and quickly afforested.

Six regional offices have been set up to monitor the conditions of forests and to find out the steps for their conservation. There are located at Bangalore, Shillong, Bhopal, Bhubaneshwar, Lucknow and Chandigarh.

However there are certain limitation to this Act.

- (i) Since the prices of timber at rise therefore stealing and smuggling of finest timbers have incresed.
- (ii) The people have started encroachment in the forest area.
- (iii) Since the number of grazing animals is on increase they usually roam in restricted areas.
- (iv) The forests have been destructed for construction of roads, water supply schemes etc.
- (v) It is very difficult in forests to apprehend the offenders.

Wildlife (Protection) Act, 1972 — (Amended 1991)

Wild life includes both plants and animals, is a living component of nature. It is must to maintain ecological balance, to prevent soil erosion and to obtain products which are economically important such as wood, medicines and drugs, resins, gums, fodder etc. A number of wild life acts have been made from time to time, by state as well as Union Government for wildlife conservation such as: (a) Madras Wild Elephant Preservation Act, 1873 (b) All-India Elephant Preservation Act, 1879 (c) The Wild Birds and Animals Protection Act, 1912 (d) Bengal Rhinoceros Preservation Act, 1932. (e) Assam Rhinoceros Preservation Act, 1954 (f) Wild Life (Protection) Act, 1972.

Indian Board of Wildlife (IBWL) is the main advisory body of the Govt. of India. It was first constituted in 1952 as an advisory body under the name Central Board of Wild Life. Later it was renamed as IBWL. At its first meeting, the board made a recommendation for unified legislation for wildlife conservation in India. The Wildlife (Protection) Act was enacted in 1972 which was amended in 1991, which has been adopted by all states. The Indian Board of Wildlife which act under this act is chaired by Prime Minister. IBWL has asked both B.S.I. (Botanical Survey of India and Z.S.I. (Zoological Survey of India) to prepare a list of threatened species (which is likely to become extinct) of both plants and animals. These species are recorded in Red Data Book of IUCN (International Union for Conservation of Nature and Natural Resources).

At the 15th meeting of the IBWL held on 1st Oct. 1982, the then Prime Minister, Late Smt. Indira Gandhi gave a 12 Point strategy for an Action Plan for the conservation of wild life in India. This included the establishment of a net work of scientifically managed protected areas including National Parks, Sanctuaries, Biosphere reserves.

National Parks are the areas maintained by Govt. where cultivation, grazing, forestry and habitat manipulations are not allowed.

Sanctuaries are tracts of land with or without cakes where hunting of animals is not allowed but other activities such as tilling of land, collection of forest products etc. are allowed.

Biosphere reserves are multipurpose protected areas where wild life, tribals, domesticated plants and animals are allowed to live in harmony.

The main recommendations of the act are:

- (i) Trapping and hunting of wild life should be prohibited.
- (ii) Conservation and effective control of poaching wild life.
- (iii) Setting of national parks, sanctuaries and zoological gardens.
- (iv) Ban on the export of living animals, skins, fur, leather and other wild life products.
- (v) Human activity is not allowed in the core zone of biosphere reserve and national parks.
- (vi) Uprooting, picking and sale of endangered plants not allowed.
- (vii) No arm licence is to be issued in an area within 10km of a Sanctuary.

Limitations

- (a) Less attention is given to endangered plant species
- (b) Exploitation of plant species continue under the garb of traditional medicine as the plants of medicinal importance are not cultivated.
- (c) Wildlife authorities take a lot of time to decide whether an animal is dangerous and by the time it is decided it would have killed a number of domestic animals.
- (d) Stress is given only on conservation of one or two species not all.

Environment (Protection) Act, 1986

The Act was promulgated to provide for the protection and improvement of environment and matters connected therewith. As

per Environment (Protection) Act 'environment' includes water air and land and the inter relationships which exists among and between water, air and land and human beings, other living creatures, plants, micro-organisms and property; "environment pollutant" means any solid liquid or gaseous substance present in such concentration as may be injurious to environment; "environment pollution" means the presence in the environment of any environmental pollutant, and "hazardous substance" means any substance which is liable to cause harm to human beings and other living creatures. The Act provides general power to the central government to take all necessary measures for the purpose of :

- (a) Protecting and improving the quality of the environment.
- (b) Preventing, controlling and abating environmental pollution.

The functions of Central Govt, are:

1. Planning and execution of nation wide programme for the prevention, control and abatement of environmental pollution.
2. Laying down standards for quality of environment in its various aspects.
3. Laying down standard for emission or discharge of environmental pollutants from various sources.
4. Carry out and sponsor investigations and research.
5. Collection and dissemination of information on environmental pollution.
6. Examination of such manufacturing processes materials and substances which are likely to cause environmental pollution.
7. Demarcation of areas in which certain industries/processes/ operations shall be not or shall be carried out subject to certain safeguards.
8. Laying down procedures and safeguards for tackling of restricted prohibited and hazardous substances.
9. Preparation of manuals, codes and guides regarding

prevention, control and abatement of environmental pollution.

10. Establishment or recognition of environmental laboratories.

Air (Prevention and Control of Pollution) Act, 1981 (Amended 1987)

Air (Prevention and Control of Pollution) Act was promulgated under article 253 of constitution for prevention control and abatement of air pollution by creating central and state boards. Central Board exercises powers and performs the functions of State Board for Union Territories either directly or by delegating powers.

The various functions of Central Board are:

- (i) To provide guidance and technical assistance to state boards and the industries.
- (ii) To advise both Central Government and State Government regarding improvement in methods related to check air pollution.
- (iii) To provide training to the persons involved in the field of air pollution.
- (iv) To set up laboratories to check all kinds of samples.
- (v) To educate people with the assistance of mass media.

The various functions of State Board are:

- (i) To advise State Government to combat with the problem of air pollution.
- (ii) To collect information regarding causes, prevention and control of air pollution.
- (iii) To lay down standards for air quality.
- (iv) To inspect air quality periodically to check air pollution.

As per Air (Prevention and Control of Pollution) Act both Central and State Boards have been given certain powers to meet the consequences due to air pollution.

- (a) To declare any area within the state as air polluting area.

- (b) Before setting up any unit every industrial establishment has to take clearance from the board. The board has got power to refuse or grant consent depending upon whether the industry fulfils the specification laid down by the board.
- (c) The board has got power to stop industrial operations in air pollution control areas.
- (d) The board collects the samples of air or emission for analysis.
- (e) The board has got power to cancel the consent given to industry at any time.
- (f) The board officials have got power to go to any industry at any time to check compliance with requirements of act.
- (g) The board has got power to prosecute any defaulter.

The Air (Prevention and Control of Pollution) Act, 1981 was amended in 1987 to remove the difficulties encountered during implementation, to confer more powers on the implementing agencies and to impose more stringent penalties for violation of the provisions of the Act. The main point was also to amend the definition of air pollutants to include noise also.

The Water (Prevention and Control of Pollution) Act, 1974 (Amended 1988)

The Water (Prevention and Control of Pollution) Act was enacted under article 252 (1) of Constitution as measure to prevent and control water pollution. The pollution under the act includes (a) any contamination in water (b) any physical, chemical or biological alteration in water (c) direct or indirect discharge of sewage, trade effluent or any other substance in water, (d) the discharge causing nuisance or harmful to public health. Central and State boards were created to meet the problem regarding water pollution.

The water (Prevention and Control of Pollution) Act, 1974 was amended in 1988. An important amendment was to rename the Central State Boards for Prevention and Control of Water Pollution as Central/ State Pollution Control Boards as Boards also deal with air pollution. More powers were given to CPCB.

Functions of Central Board

- (i) To advise Central Government and State Governments about issues related to water pollution.
- (ii) To provide guidance and training to persons in the field of water pollution.
- (iii) To educate people through mass media.
- (iv) To provide technical assistance and guidance to state boards and industries.
- (v) To set up laboratories to analyse samples.

Functions of State Board

- (i) To advise state Government regarding issues related to water pollution.
- (ii) To seek guidance and training of persons connected with prevention and control of water pollution.
- (iii) To collect information regarding causes, prevention and control of water pollution.
- (iv) To organise programmes to control water pollution.
- (v) To find out recent methods for disposal of treated sewage and effluents.

Water (Prevention and Control of Pollution) Act has provided different powers to both Central/State Pollution Control Boards:

1. It is the duty of each industrial establishment to take consent from state board on a specific application about the methods of treatment of disposal of sewage and other industrial effluent be discharged in the water body.
2. Board has got power to take sample of any sewage, industrial effluent from any water body.
3. Board has power to enter any industrial premises for inspection.
4. Board has got power to move any application to court after an offence is detected.
5. Board can ask closure of any unit any time It can stop water supply, electricity to the units of defaulters.

The Motor Vehicle Act, 1938 (Amended 1988)

This Act has come into force from 1st July 1989. The salient features of the provisions of the Act, besides other things also include the requirements to be observed in matter of vehicle fitness. Some of the features are as follows:

1. For registration of a new vehicle, the same is to be produced before the registering authority for inspection to satisfy that vehicle is fit for registration. The certificate of fitness is to be issued for a new vehicle for a period of two years. Thereafter, the renewal shall be for period of one year till the vehicle attains the age of 10 years.
2. Every vehicle is required to meet the safety stands of components.
3. Each vehicle must have all the components of the standard laid down by Bureau of Indian Standards.
4. The vehicle must have tested by VRDE, Ahmadnagar, ARAI, Pune or CMITI, Budni or any other agency specified by the Central Government.
5. Manufacturer is to ensure that the vehicle does not cause pollution i.e. It is pollution free.
6. The horn to be used is to be in accordance with the approved specifications of Bureau of Indian Standards.
7. The vehicle should be fitted with tune up and catalytic converter.
8. Each vehicle is required to obtain "Pollution under control" certificate every 6 month.
9. All future vehicles are to have engines based on unleaded petrol.
10. Transportation of Goods of dangerous or hazardous nature to human life has been regulated under the Act. The vehicle carrying such goods should have prescribed labels indicating the nature of hazardous goods. The package containing such goods should also bear specific labels.

Global Warming : Global warming or green house effect is the warming of the earth due to emission of the harmful gases from the earth, which forms the blanket over the earth and do not allow the gases to move upward to the atmosphere. Since CO_2 is confined exclusively to the troposphere, its higher concentration may act a serious pollutant. Under normal conditions (with normal CO_2 concentration). 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 radiated back into the space. However, when there is an increase in CO_2 concentration, the thick layer of this gas prevents the heat from being re-radiated out.

This thick carbon dioxide layer thus functions like the glass panels of a green house (or the glass windows of a motor car), allowing the sunlight to filter through but preventing the heat from being re-radiated out in outer space. This is the so called green house effect. Thus most heat is absorbed by CO_2 layer and water vapours in the atmosphere, which adds to the heat that is already present. The net result is the heating up of earth's atmosphere. Thus increasing CO_2 levels tend to warm the air in lower layers of atmosphere on a global scale. Other gases of the green house effect on earth are methane, chlorofluorocarbons and nitrogen oxides.

These are called green house gases. These gases are emitted to the atmosphere through burning of fossil fuels like coal, wood, oils etc. It is estimated that more than 18×10^{12} tonnes of CO_2 is being produced annually from the fossil fuels only CO_2 concentration has increased from 280 ppm in 1800 to 359 ppm in 1994 due to increasing use of fossil fuels and decreasing forest cover. More methane is being released from paddy fields due to intensive cultivation, cattle due to large population and escape from gas plants. Combustion of fossil fuels (along with excessive use of nitrogen fertilizers) is also the causative agent for higher concentration of nitrogen oxides.

They react with hydrocarbons to form ozone. As there is an increase in the release of CO_2 it is estimated that temperature increases after every 100 years from 0.3° to 0.7°C . If these gases

are not minimised in the year 2030 the concentration of CO₂ will increase twice the present range and the temperature of the earth surface will increase by 1.5°C to 4.5°C.

Effects

1. Global warming shall cause partial melting of polar and alpine ice caps that would result in raising sea level. Already the sea level has risen 15 cm in the past century. If the trend continues, there is a danger of submersion of large area e.g. Maldives, and six other Coral atoll countries, several thousand islands.
2. A continuous increase of green house gases, leads to the rise in mean global temperature which affects the climate leading to change in rainfall pattern, conversion of fertile lands into deserts, shortage of water due to evaporation.
3. Due to change in weather conditions, the production of crops is also affected and reduces the yield of grains like rice, maize, wheat etc.
4. Chances of hurricanes, cyclones and floods will increase.
5. Green house effects disturb the food chain and destroy many cold habitat species.
6. The forests present in the middle latitudes will be wiped out.
7. Several lakes would dry up.

So, UNEP has appropriately chosen the slogan “Global Warming: Global Warming” and since 1989 5th June is celebrated as World Environment Day.

These problems can be overcome by awareness among people and plantation of trees and use of non-conventional sources of energy.