Organizations and Agencies for Environmental Protection

There are a number of international and national organizations, agencies and programmes involved in different areas of environment, forestry, wildlife and other relevant aspects. Some of the important bodies of this type area as follows.

1. International Bodies

1. Earth scan: An agency, founded by UNEP in 1976, that commissions original articles on environmental matter and sells them as features to newspapers and magazines, especially in developing countries.

2. Convention on International Trade in Endangered Species (CITES). An international forum, whose membership for agreement is open to all countries. For India, the Ministry of Environment and Forests functions as nodal agency for participation in international agreements.

3. Environmental Protein Agency (EPA). This is an independent Federal Agency of the U.S. Government established in 1970. It deals with protection of environment by air, water, solid wastes, radiation, pesticides noise etc.

4. European Economic Community (EEC). It is community of 12 European nations with sound political, economic and legal base. The community has joint agricultural and scientific programmes. It has programmes of framing and implementation of coordinated policy for environmental improvement and conservation of natural resources. CPCB, India has taken up projects on air quality monitoring with assistance of EEC.

5. Human Exposure Assessment Location (HEAL). The project is a part of the Health Related Monitoring Programme by WHO in co-operation with UNEP. This project has three components, viz., (i) air monitoring (ii) water quality monitoring and (iii) food contamination monitoring on a global basis.

6. International Council of Scientific Unions (ICSU). A non-government organization based in Paris, that encourages the exchange of scientific information, initiates programmes requiring international scientific cooperation and studies and reports on matters related to social and political responsibilities in treatment of scientific community.

7. International Union for Conservation of Nature and Natural Resources (IUCN). An autonomous body, founded in 1948 with its Headquarters at Morges, Switzerland, that initiates and promotes scientifically based conservation measures. It also cooperates with United Nations and other intergovernmental agencies and sister bodies of World Wide Fund for Nature (WWF).

8. International Marine Consultative organization (IMCO). It regulates the operation of ship in high seas, from marine water pollution viewpoint.

9. South Asia co-operative Environment Programme (SACEP). This has been recently set up for exchange of professional knowledge and expertise on environmental issues among member countries – Afghanistan, Bangladesh, Bhutan, India, Iran, Pakistan and Sri Lanka.

10. United Nations Educational, Scientific and Cultural Organization (UNESCO). An United Nations agency, found in 1945 to support and implement the efforts of member states to promote education, scientific research and information, and the arts to develop the cultural aspects of world relations. It also holds conferences and seminars, promotes research and exchange of information and provides technical support. Its Headquarters are in Paris. Independently as well as in collaboration with other agencies like UNEP, it supports activities related to environmental quality, human settlements, training to environmental engineers and other socio-cultural programmes related to environment.

11. United Nations Environment programme (UNEP). A UN agency, responsible for co-operation of inter-governmental measures for environmental monitoring and protection. It was set up in 1972. There is a voluntary United Nations Environment Fund to finance environmental projects. There is an Environmental Coordination Board, to coordinate the UNEP programmes. Its Headquarters are in Nairobi, Kenya. UNEP was founded to study and formulate international guidelines for management of the environment. UNEP is assisting many such programmes in India.

12. World Commission on environment and Development (WCED). This is a 23 member commission, set up in 1984 in pursuance to a UN General Assembly resolution in 1983 to re-examine the critical environmental and development issues and to formulate proposals for them. This is a call for political action to manage better environmental resources to ensure human progress and survival. The commission makes an assessment of the level of understanding and commitment of individuals, voluntary organizations and governmental bodies on environmental issues.

13. Earthwatch Programme. A world wide programme, established in 1972 under the terms of the Declaration on the Human Environment. It monitors trends in the environment, based on a series of monitoring stations. Its activities are coordinated by UNEP.

14. Project Earth. Developed in collaboration with UNEP to inspire and educate young people worldwide on the crucial issues facing the Earth's Environment.

15. Man and Biosphere Programme (MAB).The programme is the outcome of International Biological Programme (IBP) that has already concluded its activities. MAB was formerly launched by UNESCO in 1971.

Man and the Biosphere Programme (MAB)

MAB is the outcome of the experience of those involved in the International Biological Programme (IBP). It was realized that several problems require collaboration of natural and social scientists, planners and managers and the local people. MAB was conceived at the International Biosphere Conference of UNESCO in 1968 and was officially given shape by General Conference at its 16th Session in 1970. The programme was formally launched by UNESCO in November 1971, when the MAB International Coordinating Council held its first session and identified 13 project areas of cooperative research. One more project area was added in 1974.

2. National Organizations

There are a number of governmental as well as non-governmental organizations, agencies and programmes engaged in environmental studies. A number of non-governmental, voluntary organizations have been doing good job in this area.

Most of the governmental bodies involved in environmental studies are either put under the administrative control of, or assisted by the Department of Environment, Forests and Wildlife in the Ministry of Environment Forests, Government of India.

Department of Environment, Forests and Wildlife of India

Department of Environment was set up in 1980 to serve as the local point in the administrative structure of the Government for planning, promotion and coordination of environmental programmes.

The present integrated Department of Environment, Forests and Wildlife in the Ministry of Environment and Forests was created in September 1985. The Ministry serves as the local point in the administrative structure of the Central Government of the planning, promotion and coordination of environmental and forestry programmes. The Ministry's main activities are, the survey and conservation of flora, forests and wildlife, prevention and control of pollution, afforestation and regeneration of the degraded areas of the environment.

2.1. Other National Organization

There are other governmental and non-governmental organizations / agencies involved in environmental issues. Some of the important ones are as follows:

(1) Advisory Board on Energy (ABE)

(2) Bombay Natural History Society (BNHS)

(3) Central Forestry Commission (CFC)

(4) Department of Non-Conventional Energy Sources (DNES)

(5) Industrial Toxicology Research Centre (ITRC)

(6) National Environmental Engineering Research Institute (NEERI)

(7) National Natural Development Board

(8) National Natural Research Management System

(9) National Wetland Management Committee

(10) State Pollution Control Board (SPCB)

(11) Tata Energy Research Institute (TERI)

(12) Several Research Institutes under I.C.A.R. including I.G.F.R.I., Jhansi, Central Soil Salinity Research Institute, Karnal.

Eutrophication

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

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

The Process of Eutrophication

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

1. Natural eutrophication

The lakes generally originate as oligotrophic and have only limited quantities of nutrients depending upon the mode of their formation and composition of original sediments. These nutrients are insufficient to produce any significant algal growth. At this stage the lakes have only autochthonous nutrients (indigenous nutrients cycling therein), which usually recycle completely in the absence of any outside supply. All the biological production is completely decomposed after death. As the **allochthonous** nutrients (nutrients from outside) start entering the lake, the process of eutrophication sets in. The principal natural sources of nutrients are the natural run-off, fall of leaves and twigs from the surrounding vegetation, periodical submergence of the nearby terrestrial vegetation, rain fall and bird droppings etc.

The build-up of nutrients through this slow mode of entry gradually starts increasing the growth of algae. When the algae die and decompose, the locked nutrients are again made available to the fresh algal growth. The tropical or hot climate usually supports a higher rate of eutrophication as it favours higher nutrients utilization and algal growth in comparison to cold and temperate climates.

2. Accelerated Eutrophication

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

Sources of nutrients

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

a) Rainfall and Atmospheric Deposition

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

b) Urban and Rural Run-Off

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

c) Agricultural Run-off

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

d) Domestic Sewage

Sewage is the commonest source of nutrients and organic matter, and undoubtedly the greatest contributor to the eutrophication of lakes. Large quantities of nitrogen and phosphorus are excreted by humans and animals which get their way into sewage. According to an estimate, an average of 2 g of PO_4-P per day is released through urine and faces by an average person, Phosphatic detergents in sewage are also important contributor of phosphorus.

e) Industrial Wastes

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

f) Water Fowl

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

g) Ground Water

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

Effects of Eutrophication

a. Physico – chemical effects

Pollution can be considered as a departure from the balance between photosynthesis and respiration. At equilibrium (P = R), the chemical and biological composition of water remains unchanged, a stage that mostly occurs only in non-polluted waters with no external supply of nutrients. An eutrophic water body is one where photosynthesis exceeds the respiration activity. It is characterized by a progressive accumulation of algae which ultimately leads to an organic overloading. When respiration exceeds photosynthesis, dissolved oxygen gets rapidly exhausted forcing reduction of several oxidized chemical species like NO_3, SO_4^{-2} and CO_2 into N_2, NH_4^+, H_2S and CH_4 which are harmful to several aquatic species and produce typical odours.

b. Biological effects

Many desirable species including fish are replaced by undesirable ones. There is an algal succession resulting in the dominance of blue green algae which have very low nutrition value in the food chains, and many of them produce the blooms. Some important bloom forming blue green algal genera include *Microcystis, Anabaena, Oscillatoria and Aphanizomenon.* Filamentous green algae, such as *Spirogyra, Cladophora, and Zygnema* form a dense floating mat or "blanket" on the surface when the density of the bloom becomes sufficient to reduce the intensity of solar light below the surface.

Nutrient enrichment has very limited direct effect on zooplankton communities, but indirect effect may be significant. The diversity of zooplankton remains high if the diversity of phytoplankton is also high as often found in case of oligotrophic or moderately enriched waters. As the changes occur in the water due to eutrophication, the characteristics of sediments also change. There is an accumulation of organic matter which affect the benthic communities.

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

Control of Eutrophication

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

a. Diversion of Nutrients from a Lake

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

b. Removal of Nutrients from Waste Waters

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

c. Flushing Out of Polluted Water by Nutrient Poor Water

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

d. Removal of Locked-up Nutrients

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

e. Dredging of Sediments

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

f. Covering of Sediments

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

g. Oxygenation and Mixing

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

h. Nutrient Inactivation

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

i. Zoning and Watershed Management

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

Biofilters and Bioindicators

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

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

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

1. Bioindicators

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

2. Biological Monitoring in Lakes and Streams

Small insects and other organisms that live on the bottom of streams and lakes form an important part of the aquatic food web. Ecologists call them benthic (which means “bottom-dwelling”) macro invertebrates. They are sensitive to many factors in their environment and are useful as indicators of the condition or “health” of streams and lakes. Routine macro invertebrate monitoring or sampling can indicate problems that may not easily be detected by chemical testing, and can detect pollution problems that may no longer be evident in water samples. Macro invertebrates depend on adequate water quality for survival. The time required for insect communities to return to their natural state after disturbances, such as those form point-source industrial pollutants, can be on the order of many years for streams and decades for lakes. As a result, changes in their numbers and species can indicate pollution from various sources.

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

3. Bio amelioration of problem soils

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

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

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

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

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

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

Bioremediation

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

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

1. Bio-mining of metals

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

2. Bio-decolourization of dyes

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

The bacterial decolourization is associated with azo-reductase enzyme activity. The colour removal was due to the structural alteration of chromophoric azo group and reduction of azo linkage to single bond (-N-N-) . The decolourization by the fungal strains is mainly due to lignin degrading enzyme system as well as adsorption to cell mass of the strains .The fungal enzyme possessing both oxidase and peroxidase activities and these enzymes oxidize the chromophores and remove the colour from waste water. Results from the microbial decolourization technique for treating the dyeing effluent are encouraging and also cheaper in terms of treatment cost. With further intensive research in this line, an efficient and environmentally safer method for treating the coloured effluents can easily be developed. The fungus *Cyathus bulleri* is found to decolourize triphenylmethane dyes, crystal violet, malachite green, bromophenol blue and polymeric dye, Poly R-478. Biodegradation of industrial effluent containing malachite green, navy blue, magenta dyes by white rot fungus, *Phaenerochaete chrysosporium* has been successfully demonstrated.

3. Removal of heavy metals

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

4. Biodegradation of organic matter

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

4.1. Bio oxidation

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

4.1.1. Microbial Oxidation of Hydrocarbons

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

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

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

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

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

4.2. Hydrolysis

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

4.3. Bio-reductions

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

GLOBAL AIR POLLUTION

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

Global warming

Carbon dioxide is a green house gas that is confined to the troposphere and its higher concentration may act as a serious pollutant. Under normal conditions the temperature at the surface of the earth is maintained by energy balance of the sun rays that strike the planet and heat that is reradiated back into space. However when there is an increase in CO_2 concentration, the thick layer of the gas prevents the heat from being reradiated out. This thick CO_2 layer functions like the glass panel of a green house, allowing the sun light to filter through but preventing the heat from being reradiated into outer space. Therefore, it is warmer inside the green house than outside. Similar condition is resulted in the troposphere of the earth and termed as **'Green house effect'**.

Carbon dioxide concentration of the troposphere has been increasing steadily due to industrial growth. Nearly hundred years ago the CO_2 concentration was 280 ppm, today it is 408 ppm and by the year 2040 it is expected to reach 450 ppm. Certain gases in the atmosphere, known as 'green house' gases like NO, CO_2, CH_4 are able to absorb and emit heat. When sunlight strikes the earth's surface it warms up, emits heat, which radiates upwards into space. This heat warms up the green house gases so that they also emit heat, some into space and some back down to earth, which results in heating up of the earth atmosphere, also known as **Global warming.**

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

Greenhouse Gases

Nitrogen and oxygen, the main constituents of the atmosphere, play no part in the green house effect. But there are approximately 35 trace gases that scientists believe contribute to global warming. **Carbon dioxide (CO_2)** is considered to be one of the most important of these greenhouse gases, absorbing most of the heat trapped by the atmosphere.

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

Potential impacts of global warming

One of the methods that scientists used to estimate the impacts of global warming involves computer analysis of mathematical equations that model earth's atmosphere. Typically, these sophisticated computer programs are called General Circulation Models (GCMs). As a basis for predicting future global impacts, most models assume that the concentration of greenhouse gases will effectively double. On this basis, the GCMs generally predict an average global warming of up to 42^{o}C (7.5^{o}F) and an overall increase in precipitation of about 10 per cent by the year 2050. It is also expected that global warming will create a more active hydrologic cycle, increasing cloudiness as well as precipitation.

Recent estimates suggest that global sea level has risen by about 0.15 m during the 20th century, with most of the rise occurring since 1930. Some scientists believe that, because of global warming, average sea levels may rise by at least 0.3 m and as much as 1.4 m by the year 2030. This is likely to cause extensive economic and social hardship in coastal areas all over the world.

Potential impacts of global warming on ecosystems mainly include the effects on agriculture and forest growth. Plant growth and development will be influenced by an increase in carbon di oxide levels, which stimulates photosynthesis and decreases water losses from transpiration.

In addition to affecting agriculture and forests, global warming is expected to have other impacts. For example, higher temperatures and humidity may increase the chances of disease in humans and animals in some parts of the world.

Methane emission and Mitigation options

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

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

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

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

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

Acid deposition/Acid rain

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

Acid rain is caused by the emission of sulfur and nitrogen oxides into the atmosphere, mostly from the burning of fossil fuels for electric power. Other sources from human activities include certain industrial processes and the gasoline powered automobile. Sulfur dioxide reacts with water vapour in the air to form sulfuric acid; nitrogen dioxide reacts with water vapour to form nitric acid. It has been found that the contribution of sulfur dioxide to acid rainfall is more than twice that from nitrogen oxides. Contributions of these gases from natural sources, such as swamps and volcanoes, are small in comparison to human sources.

A major environmental impact of acid deposition is the lowering of pH in lakes and rivers. Most aquatic life is disrupted as the pH drops. Phytoplankton populations are reduced, and many common water – dwelling invertebrates, such as may flies and stone flies, cannot survive when the pH falls below about 6.0. Some sensitive species of fish, including trout and salmon, are harmed when pH levels fall below 5.5. Acidity has a deleterious effect on the reproductive cycle of fish; when the pH is less than 4.9, reproduction of most fish species is unlikely. Acid dead lakes have pH below about 3.5.

Air pollution: causes, effects and their control

Atmosphere

The earth's vertically extended atmosphere, an envelope of gases is divided into the following layers : (i) troposphere (up to 5 km) – the lowest atmosphere in which temperature decreases with height bounded by land or sea surface below and by tropopause above, (ii) stratosphere (5 to 45 km) - the region above the troposphere, in which temperature increases up to 90^0C with height. This is limited by stratopause, (iii) mesosphere (45 to 80 km) – the part between stratosphere and thermosphere (ionosphere). Temperature again decreases up to – 80^0C. (iv) thermosphere (ionosphere) – above 80 km, the upper part in which temperature increases with height. There is no boundary between the atmosphere and void of outer space. About 75% of the earth's atmosphere lies within 16 km. of the surface and 99% of the atmosphere lies below an altitude of 30 km.

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

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

Gases	**Percent (by Volume)**
Nitrogen	78.084
Oxygen	20.948
Argon	0.934
Carbon dioxide	0.0314
Methane	0.0002
Hydrogen	0.00005
Other gases	minute

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

Air Pollution

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

Air pollution episodes

- ***London smog*** : SO_2 □ H_2SO_3 vapours in the atmosphere. When automobile exhausts are trapped by this smog and exposed to sunlight, it produces photochemical smog.
- ***Bhopal gas tragedy*** **:** The poisonous gas, methyl isocyanate (MTC) leakage in the pesticide manufacturing plant of Union Carbide of India Ltd., (UCIL), Bhopal, Madhya Pradesh on December 3, 1984. 46 tons of MIC was released spreading to 40 km. *Effects* : About 65,000 people suffered from various disorders in eyes, lungs, stomach, heart, etc. The immediate symptom is bronchospasm which causes coughing, chest pain and abdominal pain. Nearly 3000 people died within a short span of time, 1600 domestic animals died and crop yields were reduced.

- **Darkening effect of Taj Mahal**

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

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

  The acid rain reacts with marble stone ($CaCO_3$) to produce calcium sulphate, causing darkening and disfigurement.

Types, sources and effects of air pollution

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

Sources

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

1. **Industrial chimney wastes**: There are a number of industries which are source of air pollution. Petroleum refineries are the major source of gaseous pollutants. The chief gases are SO_2 and NO_x. Cement factories emit plenty of dust, which is potential health hazard. Stone crushers and hot mix plants also create a menace. Food and fertilizers industries which emit gaseous pollutants. Chemical manufacturing industries which emit acid vapours in air.
2. **Thermal power stations:** There are a number of thermal power stations and super thermal power stations in the country. The National thermal power corporation (NTPC) is setting up four mammoth coal-powered power stations to augment the energy generation. These are at Singrauli in U.P., Korba in M.P., Ramagundam in Andhra Pradesh and Farakka in W. Bengal. The coal consumption of thermal plants is several million tones. The chief pollutants are fly ash, SO_2 and other gases and hydrocarbons.
3. **Automobiles**: The toxic vehicular exhausts are a source of considerable air pollution, next only to thermal power plants. The ever increasing vehicular traffic density posed continued threat to the ambient air quality. Chief sources of emission in automobiles are (i) exhaust system, (ii) fuel tank and carburettor and (iii) crankcase. The exhaust produces many air pollutants including unburnt hydrocarbons, CO, NO_x and lead oxides. There are also traces of aldehydes, esters, ethers, peroxides and ketones which are chemically active and combine to form smog in presence of light. Evaporation from fuel tank goes on constantly due to volatile nature of petrol, causing emission of hydrocarbons. The evaporation through carburettor occurs when engine is stopped and heat builds up, and as much as 12 to 40 ml of fuel is lost during each long stop causing emission of hydrocarbons.

Criteria Air Pollutants

The five primary criteria pollutants include the gases- sulfur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO), solid or liquid particulates (smaller than 10 µm), and particulate lead.

Gaseous pollutants

Sulfur dioxide

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

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

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

- Over 80% of anthropogenic sulfur oxide emissions are the result of fossil fuel combustion in stationary sources. Of that, almost 85% is released from electric utility power plants. Only about 2% comes from highway vehicles.
- The only significant non combustion sources of Sulfur emissions are associated with petroleum refining, copper smelting and cement manufacture.
- Oil and coal generally contain appreciable quantities of sulfur (0.5-6%), either in the form of inorganic sulfides or as organic sulfur. When these fuels are burned, the sulfur is released mostly as sulfur dioxide (SO_2), but also with small amounts of sulfur trioxides (SO_3).

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

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

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

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

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

- Sulfuric acid molecules rapidly become particles by either condensing on existing particles in the air or by merging with water vapour to from $H_2O - H_2SO_4$ droplets.
- Often a significant fraction of particulate matter in the atmosphere consists of such sulfate (SO_4^{2-}) aerosols.
- The transformation from SO_2 gas to sulfate particles is gradual, taking a matter of days. In either form, sulfur can be deposited during precipitation (wet deposition) or by slow continuous removal processes that occur without precipitation (dry deposition).
- Most sulfate particles in urban air have en effective size of less than 2 µm, with most of them being in the range of 0.2 µm. Their size allows deep penetration into the respiratory system.
- SO_2 is highly water soluble (much more than any of the other criteria pollutants). As a result, when it is inhaled it is most likely to be absorbed in the most passages of the upper respiratory tract, the nose and upper air ways.
- However, when sulfur is entrained in an aerosol, the aerodynamic properties of the particles themselves affect the area of deposition and it is possible for sulfur oxides to reach far deeper into the lungs.
- The combination of particulate matter and sulfur oxides can than act synergistically, with the effects of both together being much more detrimental than either of them separately.
- Sulfur oxides can damage vegetation. Sulfur pollutants can discolour paint, corrode metals and cause organic fibres to weaken. Airborne sulfates significantly reduce visibility and discolour the atmosphere.

- Prolonged exposure to sulfates causes serious damage to building marble, lime stone ($CaCO_3$) and mortar, as the carbonates in these materials are replaced by sulfates.

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

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

Nitrogen oxides

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

- 7 oxides of nitrogen are known to occur – NO, NO_2, NO_3, N_2O, N_2O_3, N_2O_4 and N_2O_5.
- Nitric oxide (NO) and Nitrogen dioxide (NO_2) are important in air pollution study.
- There are two sources of nitrogen oxides (or NO_x):
  i. *Thermal* NO_x are created when nitrogen and oxygen in the combustion air are heated to a high enough temperature (> 1000 K) to oxidise nitrogen.
  ii. *Fuel* NO_x result from the oxidation of nitrogen compounds that are chemically bound in the fuel molecules themselves. Natural gas almost has no nitrogen in them and some coal can have 3% N by weight. Fuel NO_x is often the dominant source of NO_x.
- Almost all NO_x emissions are in the form of NO, which has no adverse health effects.
- However, NO can oxidise to NO_2, which in turn may react with hydrocarbons in the presence of sunlight to form photochemical smog, which is injurious.
- NO_2 also reacts with hydroxyl radical (HO) in the atmosphere to form nitric acid (HNO_3) and results in acid rain.
- NO_2 is an acute irritant at higher concentrations. Prolonged exposure to relatively low concentrations is linked to increased bronchitis in children. It can also damage plants. When converted to nitric acid it causes corrosion of metal surfaces.
- NO is a colourless gas, but NO_2 gives smog its reddish brown colour.
- Reductions in NO_x emissions have been harder to achieve.
- When mobile source controls are introduced, modifications to the combustion process that improve emissions of CO tend to make the NO_x problem worse and vice-versa. To control CO, it helps to increase the combustion air supply and to raise the temperature. To control NO_x, the opposite is true.

The NO-NO_2–O_3 photochemical reaction sequence

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

$NO_2 + hv$□ $NO + O$

$O+O_2+M$□O_3+M

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

- Ozone can then convert NO back to NO_2 : O_3+NO□NO_2+O_2

- Thus, NO concentrations rise as early morning traffic emits its load of NO. Then as morning progresses, there is a drop in NO and a rise in NO_2 as NO gets converted to NO_2. As the sun's intensity increases toward noon, the rate of photolysis of NO_2 increases; thus NO_2 begins to drop while O_3 rises. Ozone is so effective in its reaction with NO that as long as O_3 is present, NO concentrations do not rise through the rest of the afternoon, even though there may be new emissions. If only NO_2 photolytic cycle is involved, O_3 can not accumulate in sufficient quantity in photochemical smog to account for the actual measured data. The introduction of hydrocarbons upsets the balance in production and destruction of ozone, thus allowing more O_3 to accumulate.

Carbon Monoxide

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

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

- Carbon monoxide produced when carbonaceous fuels are burned under less than ideal conditions.
- Incomplete combustion, yielding CO instead of CO_2, results when any of the following variables are not kept sufficiently high:
  - i. Oxygen supply
  - ii. Flame temperature
  - iii. Gas residence time at high temperature and
  - iv. Combustion chamber turbulence.
- Most of the CO emissions are from the transportation sector. Hourly atmospheric concentrations of CO often reflect city driving patterns. Peaks occur on week days during the morning and late afternoon rush hours.
- The CO, at levels that occur in urban air has no detrimental effect on materials or plants; but adversely affects human health.
- CO interferes with the blood's ability to carry oxygen to the cells of the body. When inhaled, it readily binds to hemoglobin in the blood stream to form carboxyhemoglobin (COHb).
- Even small amounts of CO can seriously reduce the amount of oxygen conveyed throughout the body brain function is affected and heart rate increased in an attempt to offset the oxygen deficit.

Solid or liquid particulates

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

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

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

Ozone and Photochemical smog

Ozone (O_3), a secondary air pollutant in the troposphere, is formed by a set of exceedingly complex chemical reactions between nitrogen dioxide (NO_2) and volatile organic compounds (VOCs). VOCs are hydrocarbons that quickly evaporate under normal atmospheric conditions. The reactions are initiated by the ultraviolet energy in sunlight. Actually, a number of secondary pollutants (collectively termed photochemical oxidants) are formed in the reactions. Ozone, the most abundant of the oxidants, is the key component of photochemical smog.

- Ozone (O_3) is the most abundant photochemical oxidant responsible for chest constriction and irritation of the mucous membrane in people, cracking of rubber products and damage to vegetation.
- When oxides of nitrogen, various hydrocarbons and sunlight come together, they initiate a complex set of reactions that produce a number of secondary pollutants known as photochemical oxidants.
- Other components of the photochemical smog viz., formaldehyde, peroxy benzoyl nitrate (PBzN), peroxy acetyl nitrate (PAN) and acrolein cause eye irritation.
- The formation of photochemical smog can be expressed in the simples terms as : Hydrocarbons + NO_x + sunlight □ photochemical smog.

Lead particulates

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

- Most lead emissions in the past have been from motor vehicles burning gasoline containing the antiknock additive, tetraethyl lead, $(C_2H_5)_4Pb$.
- Lead is emitted to the atmosphere primarily in the form of inorganic particulates.
- Much of this is removed from the atmosphere by settling in the immediate vicinity of the source.
- Air borne lead may affect human populations by direct inhalation, in which case people living nearest to highways are at greatest risk, or it can be ingested after the lead is deposited onto food stuffs.
- Most of human exposure to airborne lead is the result of inhalation. It has been estimated that about one third of the lead particles inhaled are deposited in the respiratory system and that about half of those are absorbed by the blood stream.
- The NAAQS standard for lead – 1.5 $\mu g/m^3$.
- Lead poisoning can cause aggressive, hostile and destructive behavioral changes as well as learning disabilities, seizures, severe and permanent brain damage and even death. Children and pregnant women are at greatest risk.
- Blood lead levels associated with neurobehavioral changes in children appear to begin at 50-60 µg per decilitre (µg/dL). Encephalopathy, with possible brain damage or death occurs at levels some what 80 µg / dL.
- Sources of lead exposure → air emissions, drinking water (lead can be leached out of lead solder used in copper piping systems), ingestion of lead in food and leaded paint.

Particulate Matter

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

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

Particles larger than 10μm

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

Particles smaller than 10μm

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

Automobile emissions

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

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

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

Many exotic elements that are added to improve the performance of automotive fuels produce their own emissions. The best known is the anti-knock agent tetraethyl lead, which was added in such large quantities that it became the dominant source of lead particles in the air. A wide range of long-term health effects, such as lowering IQ, have been associated with exposure to lead. Although lead in urban populations is still rather high, the use of unleaded gasoline has decreased the problem somewhat.

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

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

Indoor Air Quality

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

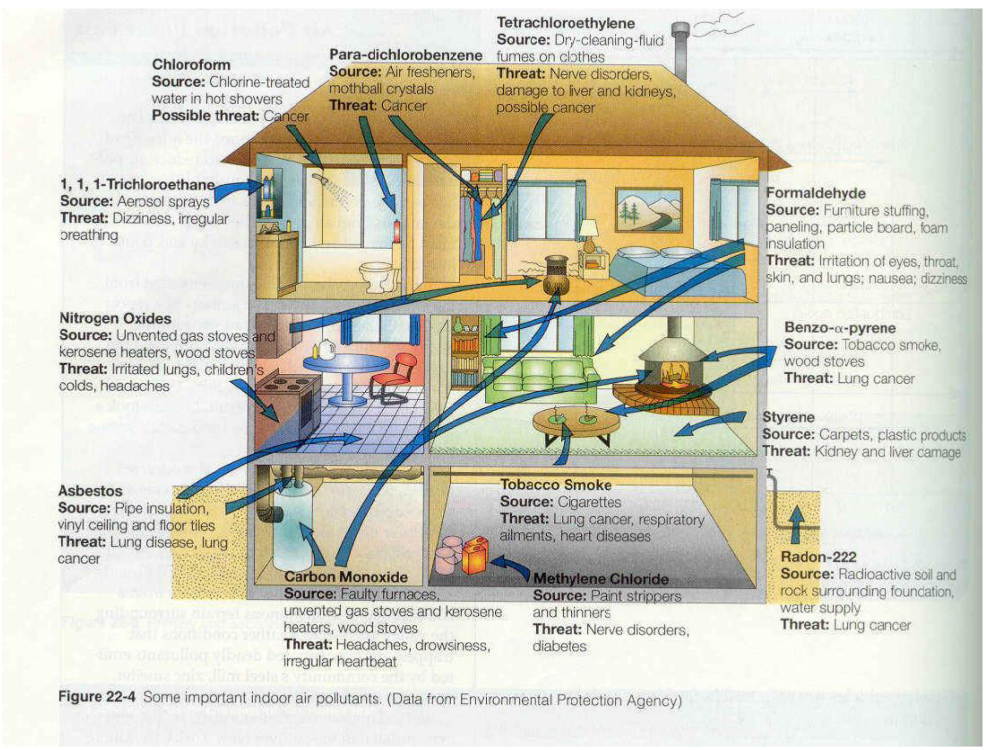


Figure 22-4 Some important indoor air pollutants. (Data from Environmental Protection Agency)

Sources of indoor air pollution

- Combustion (to heat water, cook and space heating) can produce elevated levels of CO and NO_X.
- Certain photocopying machines emit ozone.
- Formaldehyde emissions from particle board, plywood, urea – formaldehyde foam insulation.
- Asbestos used for fireproofing and insulation.
- Various volatile organics emitted from household cleaning products.
- Many pollutants, such as cigarette smoke and radon when emitted indoors can be concentrated, leading to harmful exposure levels.
- Tobacco smoke contains numerous known or suspected carcinogens, including benzene, hydrazine, benzo - **α**-pyrene (BaP) and Nickel.

- Smoke particles are small, averaging about 0.2 µm, so they are easily carried into the deepest regions of the lungs.
- A single cigarette smoke gives off on the order of 1012 smoke particles, most of which are released while the cigarette is simply smoldering in the air (*sidestream smoke*) rather than when a smoker takes a puff (*mainstream smoke*).
- Hence non smokers are also exposed to significant amount of smoke particles.
- Other indoor air pollutants arising from tobacco smoke include carbon monoxide, nicotine, nitrosamines, acrolein and other aldehydes.
- Another potentially important source of indoor air pollution is caused by wood-burning stoves and fireplaces.
- Wood combustion produces CO, NO_X, hydrocarbons and respirable particles and some emissions that are suspected carcinogens like benzo - **α**-pyrene.

Effects of ambient air pollution

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

Health effects

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

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

Effect on Materials

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

Effect on plants

Some gaseous pollutants enter leaf pores and damage the crop plants. Chronic exposure of leaves to air pollutants damages waxy coating, leads to damage from diseases, pests, drought and frost. Such exposure interferes with photosysthesis and plant growth, reduces nutrient uptake and causes leaves to turn yellow, brown or drop off. At higher concentrations of SO_2 most of the flower buds become stiff and hard and fall off. Prolonged exposure to higher levels of air pollutants from Iron smelters, coal burning power plants and industries, vehicles can damage trees and plants.

On Stratosphere

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

Air Pollution control strategies

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

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

An important approach for air pollution control is to encourage industries to make fuel substitutions or process changes. For example, making more use of solar, hydroelectric, and geothermal energy would eliminate much of the pollution caused by fossil fuel combustion at power generating plants. Nuclear power would do the same, but other problems related to high level radioactive waste disposal and safety remain to be solved.

Fuel substitutions are also effective in reducing pollution from mobile sources. For example, the use of reformulated gasoline or alternative fuels such as liquefied petroleum gas, compressed natural gas, or methanol for highway vehicles would help to clear the air.

The use of correct operation and maintenance practices is important for minimizing air pollution and should not be overlooked as an effective control strategy. Air pollution control strategies can be divided into two categories, the control of particulate emissions and the control of gaseous emissions. There are many kinds of equipment which can be used to reduce particulate emissions. Physical separation of the particulates from the air using settling chambers, cyclone collectors, impringers, wet scrubbers, electrostatic precipitators, and filtration devices, are some processes that are typically employed.

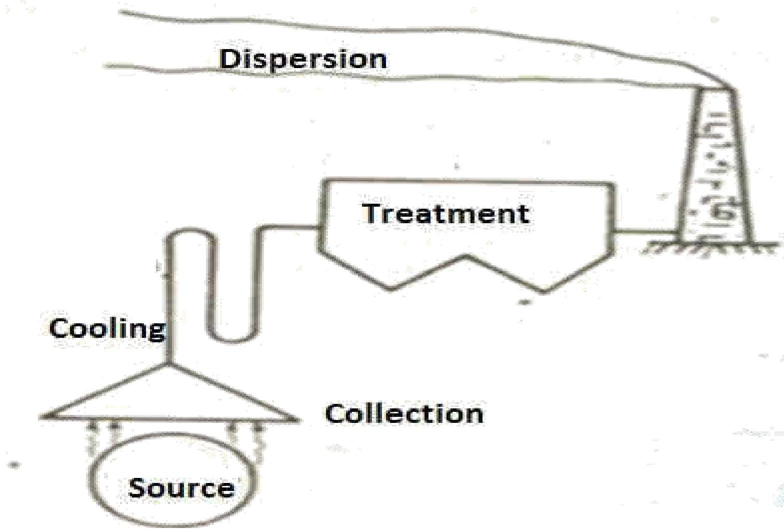
Gaseous emissions are controlled by similar devices and typically can be used in conjunction with particulate control options. Such devices include scrubbers, adsorption systems, condensers, flares, and incinerators.

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

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

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

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



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2. Collection of pollutants: Often the most serious problem in air pollution control is the collection of the pollutants so as to provide treatment. Automobiles are most dangerous, but only because the emissions can not be readily collected. If we could channel the exhausts from automobiles to some central facilities, their treatment would be much more reasonable than controlling each individual car. One success in collecting pollutants has been the recycling of blowby gases in the internal combustion engine. By reigniting these gases and emitting them through the car's exhaust system, the need of installing a separate treatment device for the car can be eliminated.

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

4. Treatment

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

(a) **Setting chambers** are nothing more than large places in the flues, similar to settling tanks in water treatment. These chambers remove only the large particulates.

(b) **Cyclones** are widely used for removing large particulars. The dirty air is blasted into a conical cylinder, but off the centerline. This creates violent swirl within the cone, and the heavy solids migrate to the wall of the cylinder where they slow down due to friction and exit at the bottom of the cone. The clean air is in the middle of the cylinder and exits out the top. Cyclones are widely used as pre-cleaners to remove the heavy material before further treatment.

(c) **Bag filters** operate like the common vacuum cleaner. Fabric bags are used to collect the dust which must be periodically shaken out of the bags. The fabric removes nearly all particulates. Bag filters are widely used in many industries, but are sensitive to high temperature and humidity.

(d) **Wet collectors** come in many shapes and styles. The simple spray tower is an effective method for removing large particulates. More efficient scrubbers promote the contact between air and water by violent action in a narrow throat section into which the water is introduced.

(e) **Electrostatic precipitators** are widely used in power plants. The particulate matter is removed by first being charged by electrons jumping from one high voltage electrode to the other, and then migrating to the positively charged electrode. The particulates will collect on the pipe and must be removed by banging the pipes with hammers. Electrostatic precipitators have no moving parts, require electricity, and are extremely effective in removing submicron particulates. They are expensive.

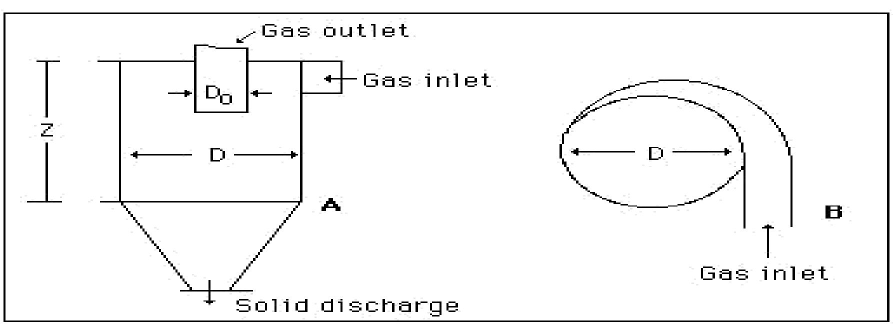
(f) **Gas scrubbers** are simply wet collectors as described above but are used for dissolving the gases.

(g) **Absorption** is the use of the material such as activated carbon to capture pollutants. Such adsorbers may be expensive to regenerate. Most of these work well for organics and have limited use for inorganic pollutants.

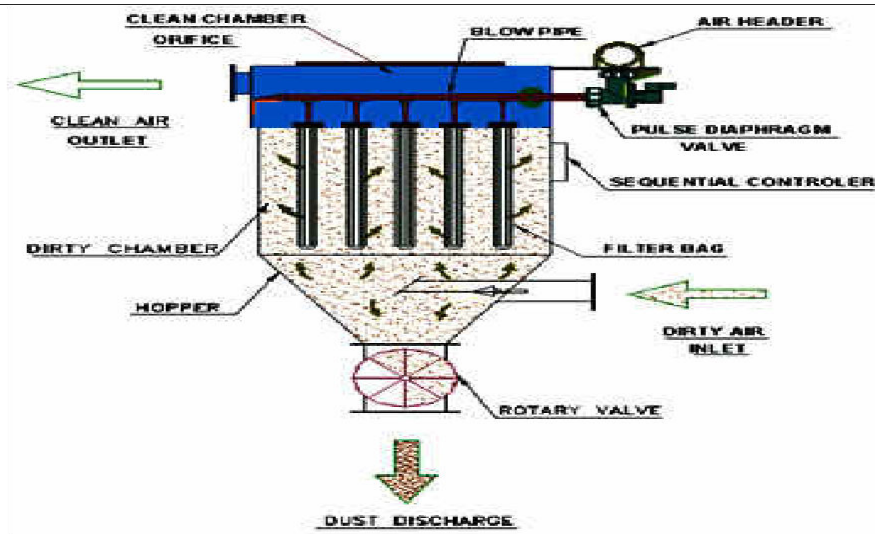
(h) **Incineration** is a method for removing gaseous pollutants by burning them to CO_2, H_2O and inerts. This works only for combustible vapours.

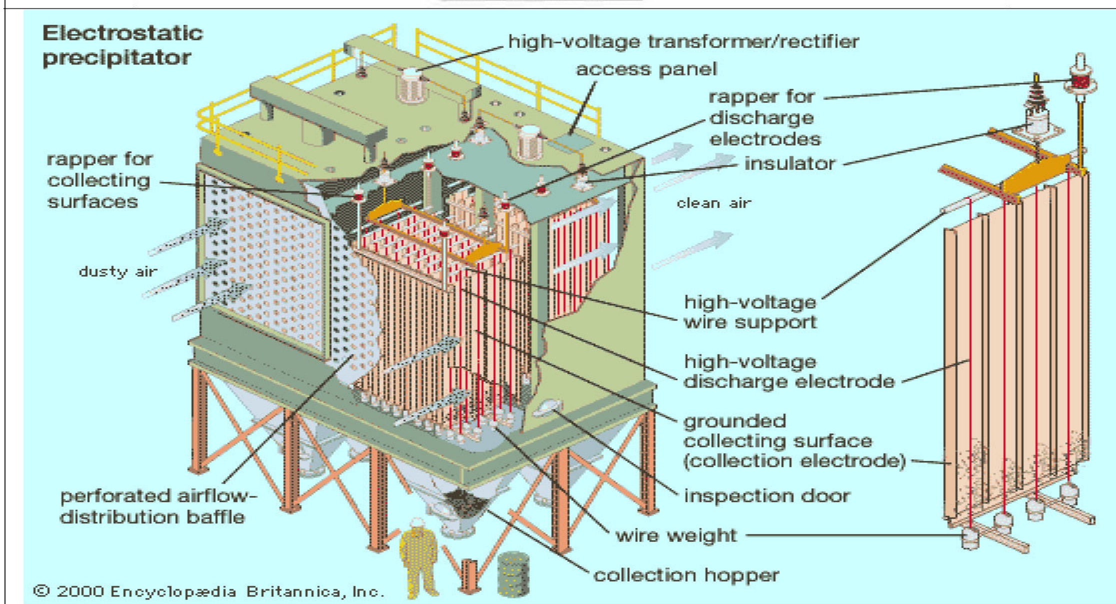
(i) **Catalytic combustion** involves the use of a catalyst to adsorb or chemically change the pollutants.

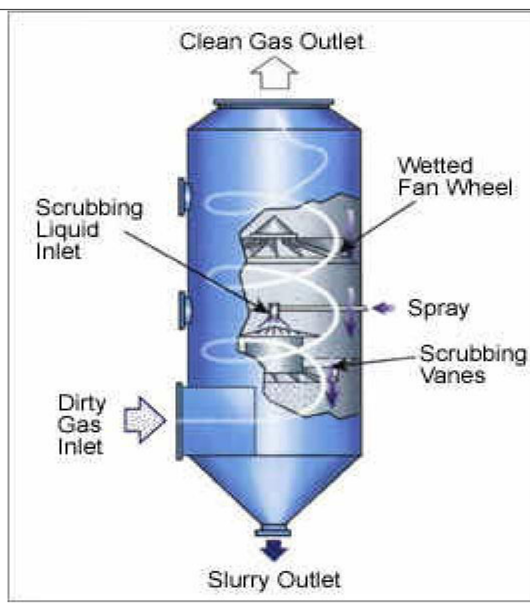
Cyclone separator



Bag Filter


CLEAN CHAMBER
ORIFICE
BLOW PIPE
AIR HEADER
CLEAN AIR OUTLET
PULSE DIAPHRAGM VALVE
SEQUENTIAL CONTROLER
DIRTY CHAMBER
FILTER BAG
HOPPER
DIRTY AIR INLET
ROTARY VALVE
DUST DISCHARGE


Electrostatic precipitator
high-voltage transformer/rectifier
access panel
rapper for discharge electrodes
insulator
rapper for collecting surfaces
clean air
dusty air
high-voltage wire support
high-voltage discharge electrode
grounded collecting surface (collection electrode)
inspection door
perforated airflow-distribution baffle
wire weight
collection hopper
© 2000 Encyclopædia Britannica, Inc.


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

5. Dispersion

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

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

Ambient Air quality Standards

Area	**SPM ($\mu g/m^3$)**	**SO_2 ($\mu g/m^3$)**	**CO ($\mu g/m^3$)**	**NO_x ($\mu g/m^3$)**
Industrial and Mixed use	500	120	5000	120
Residential and Rural	200	80	2000	80
Sensitive	100	3	1000	30

Integrated approach for air pollution Control

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

Marine pollution

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

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

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

Under some conditions, the polluting organisms multiply rapidly and consume most of the available oxygen. For instance, nutrients enter the river from sources like sewage treatment plants or urban/suburban runoff. Thus river suddenly develops a high nutrient content. Under these conditions algae may bloom rapidly. This leads to depletion of oxygen in water. There is very little oxygen available to the protozoa, small animals, fish and plants. Due to this non-availability of oxygen, a layer of dead organisms, mud and silt accumulate at the bottom and anaerobic species of *Clostridium, Desulfovibrio* etc. will flourish and they produce gases. One gas, H_2S combines with lead or iron to give a precipitate which makes the mud black and the water poisonous. Due to complete depletion of oxygen, the suspended bacteria die in their own waste products. There is hardly any life in water at this stage. The gas bubbles from the anaerobes in the mud break the surface and such processes lead to death of a river.

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

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

Marine pollution

It is defined as the discharge of waste substances into the sea, posing threat to living sources, hazard to human health, hindrance to fishery and impairment of quality of sea water. Marine pollution is associated with the change in physical, chemical and biological conditions of the sea water. Nearly

71% of Earth surfaces is covered with Oceans, which comprise a total of approximately 1.37 x 10^{39} litres. Ocean is an ideal place to dump all the man wastes.

Marine pollutants in the sea

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

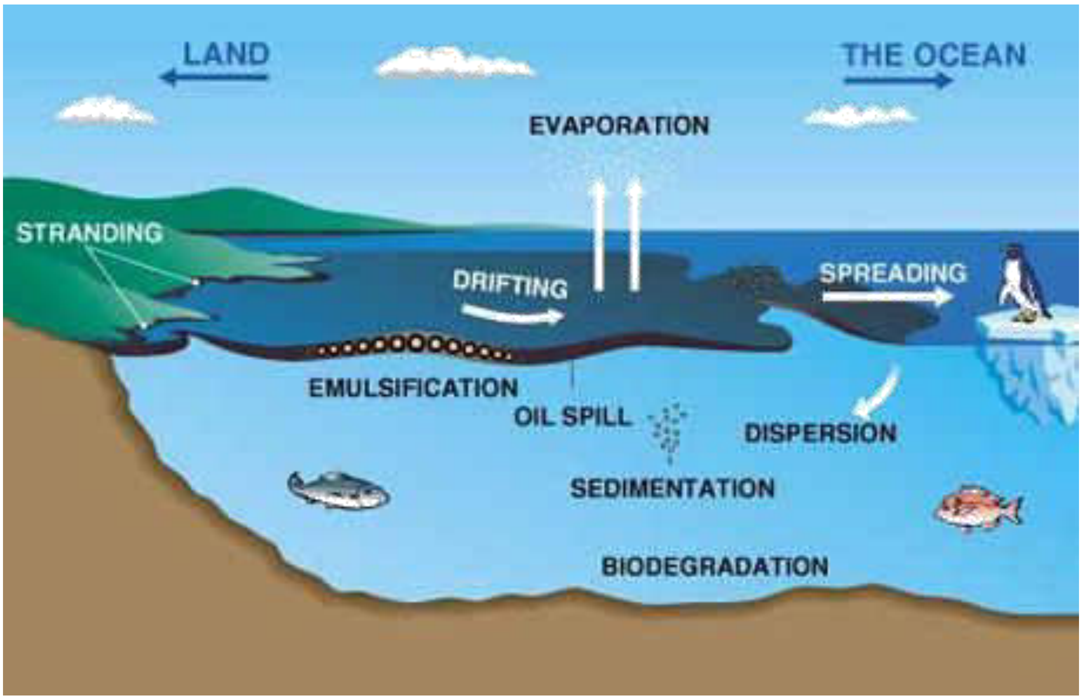
These pollutants comes from various sources. The Marine pollution may also off natural origin.

Sources of pollutants

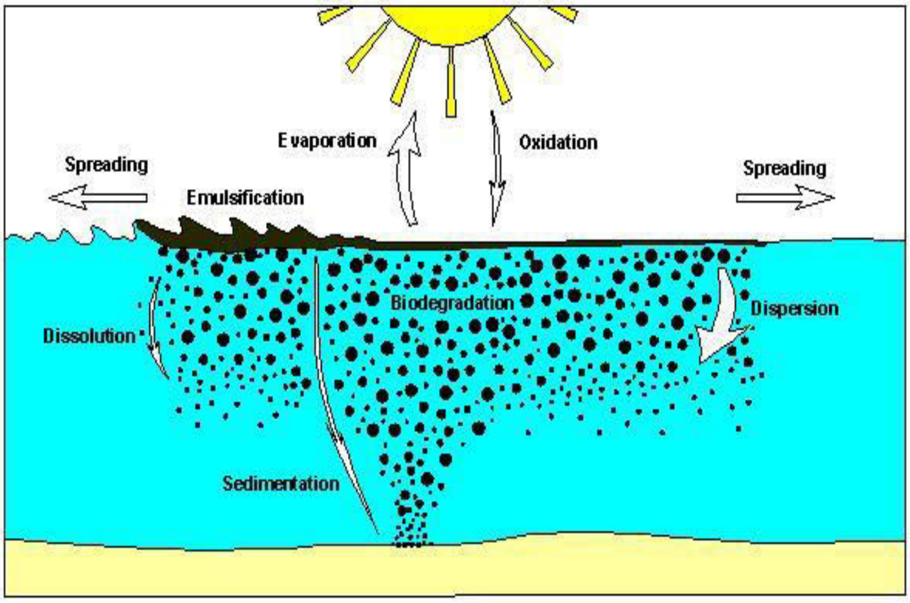
- Marine commerce
- Industry
- Electircal Power generation
- Sewage treatment
- Other Non Industrial Wastes
- Recreation
- Construction

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

Behaviour of Oil in Sea



Fate of Oil



Weathering

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

Evaporation

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

Oxidation

- Occurs when the lighter substances within the oil mixture become vapors
- Leaves heavier components of the oil, which may sink to the ocean floor spills kerosene and gasoline contain a high proportion of flammable components (evaporate completely within a few hours)
- Reducing the toxic effects to the environment.
- Heavier oils leave a thicker, more viscous residue, which may have serious physical and chemical impacts on the environment
- Wind, waves, and currents increase both evaporation and natural dispersion

Biodegradation

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

Emulsions

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

Spreading

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

Dispersion

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

Sedimentation/Sinking

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

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

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

Tanker operations

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

Two techniques have substantially reduced the oil pollution. In the load- on- top system, the compartments are cleaned by high pressure jets of water. The oily water is retained in the compartment until the oil floats to the top. The water underneath that contains only a little oil is then discharged into the sea and the oil is transferred tot a slope tank. At the loading terminal, fresh oil is loaded on top of the oil in the tank and hence the name of the technique. In the second method, called crude oil washing , the cling age is removed by jets of crude oil by the cargo is being unloaded. Some Modern Tankers have segregated ballast, where the ballast water does not come in contact with this oil. Thus with the introduction of these new methods of the ballast, the amount t of oil entering the sea has been considerable reduced.

Dry Docking

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

Bilge and fuel oils

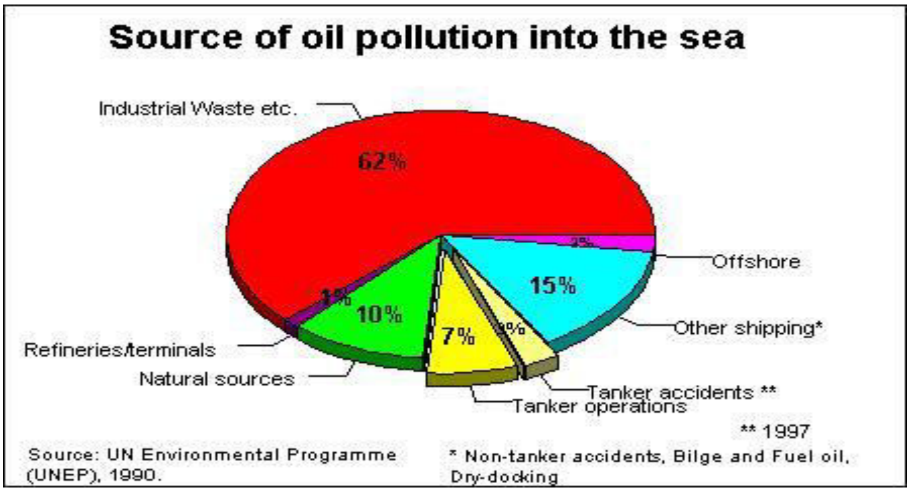
As ballast tanks take up valuable space, additional ballast is sometimes carried in empty fuel tnaks. While being pumped overboard it carries into the sea. Individually, the quantity of oil released may be small, but it sometimes becomes a considerable amount when all the shipping operations are taken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

Tanker accidents

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

Offshore Oil Pollution

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



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

Control of Oil Pollution

Physical methods

Skimming: The oil could be removed from the surface and oil can be removed by suitable absorbents Eg.Saw Dust, Polyurethane foam.

Chemical Methods

- Evaporation, Emulsification, Absorbents, burning of oil are effective methods
- Super bug has been proved to be effective to clean up the oil pollution
- Oleophilic fertilizers enrich the soil eating microbes like pseudomonas sp and hence they could be used.
- To reduce the thermal pollution due to industrial effluents, high efficient heat exchangers should be used.
- Each industry should have a separate treatment plant to meet the standards which are given by central and state pollution control Boards.

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

Oil Degradation by superbug

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

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

Water Pollution : causes, effects and their control

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

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

In general terms, water is considered to be polluted when it contains enough foreign material to render it unfit for specific beneficial use, such as for drinking, recreation, or fish propagation. Actually human activity is the cause of the poor water quality and cause water pollution. Some pollutants can be formed by way of concentrations and transformations of naturally occurring compounds during their domestic, agricultural or industrial use. The generation of sewage and the waste waters containing agrochemicals, certain pesticides and surfactants, petrochemicals, hydrocarbons, heavy metals and radionuclides are some important examples of pollutants originated in this way.

Classification of water pollutants

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

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

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

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

Types of water pollutants

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

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

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

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

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

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

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

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

Oxygen – Demanding Wastes

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

There are several measures of oxygen demand commonly used. The chemical oxygen demand, or COD, is the amount of oxygen needed to chemically oxidize the wastes, while the biochemical oxygen demand, or BOD, is the amount of oxygen required by microorganisms to biologically degrade the wastes.

BOD has traditionally been the most important measure of the strength of organic pollution, and the amount of BOD reduction in a wastewater treatment plant is a key indicator of process performance.

Pathogens

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

Nutrients

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

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

Not only is nitrogen capable of contributing to eutrophication problems, but when found in drinking water a particular form of it can pose a serious public health threat. Nitrogen in water is commonly found in the form of nitrate (NO_3), which is itself not particularly dangerous. However, certain bacteria commonly found in the intestinal tract of infants can convert nitrates to highly toxic nitrites (NO_2). Nitrites have a greater affinity for hemoglobin in the bloodstream than does oxygen, and when they replace that needed oxygen a condition known as methemoglobinemia results. The resulting oxygen starvation causes a bluish discoloration of the infant; hence, it is commonly referred to as the “blue baby” syndrome. In extreme cases the victim may die from suffocation.

Salts

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

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

Thermal Pollution

A large steam-electric power plant requires an enormous amount of cooling water. A typical nuclear plant, for example, warms about $40m^3/s$ of cooling water by 10^0C as it passes through the plant's condenser. If that heat is released into a local river or lake, the resulting rise in temperature can dramatically affect life in the vicinity of the thermal plume.

As water temperature increases, two factors combine to make it more difficult for aquatic life to get sufficient oxygen to meet its needs. The first results from the fact that metabolic rates tend to increase with temperature, generally by about a factor of 2 for each 10^0C rise in temperature. This causes an increase in the amount of oxygen required by organisms. At the same time, the available supplies of dissolved oxygen are reduced both because waste assimilation is quicker, drawing down DO at a faster rate, and because the amount of DO that the water can hold decreases with temperature. Thus, as temperatures increases, the demand for oxygen goes up while the amount of DO available goes down.

Heavy Metals

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

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

Pesticides

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

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

Other widely used organochlorines included methoxychlor, chlordane, heptachlor, aldrin, dieldrin, endrin, endosulfan, and kepone. Animal studies have shown dieldrin, heptachlor, and chlordane produce liver cancers, and aldrin, dieldrin, and endrin have been shown to cause birth defects in mice and hamsters. Given the ecosystem disruption, the toxicity, and the biological resistance to these pesticides that many insect species have developed, organochlorines have largely been replaced with organophosphates and carbamates.

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

Volatile Organic Compounds

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

Effects of Water Pollution

1. Physicochemical effects

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

2. Biological effects

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

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

3. Toxic effects

These are caused by pollutants such as heavy metals, biocides, cyanide and other organic and inorganic compounds which are detrimental to the other organisms. These substances usually have very low permissible limits in water and their presence beyond limits can render the water unfit for aquatic biota and even for human use

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

4. Pathogenic effects

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

5. Eutrophication

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

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

The Process of Eutrophication

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

1. Natural eutrophication

The lakes generally originate as oligotrophic and have only limited quantities of nutrients depending upon the mode of their formation and composition of original sediments. These nutrients are insufficient to produce any significant algal growth. At this stage the lakes have only autochthonous nutrients (indigenous nutrients cycling therein), which usually recycle completely in the absence of any outside supply. All the biological production is completely decomposed after death. As the **allochthonous** nutrients (nutrients from outside) start entering the lake, the process of eutrophication sets in. The principal natural sources of nutrients are the natural run-off, fall of leaves and twigs from the surrounding vegetation, periodical submergence of the nearby terrestrial vegetation, rain fall and bird droppings etc.

The build-up of nutrients through this slow mode of entry gradually starts increasing the growth of algae. When the algae die and decompose, the locked nutrients are again made available to the fresh algal growth. The tropical or hot climate usually supports a higher rate of eutrophication as it favours higher nutrients utilization and algal growth in comparison to cold and temperate climates.

2. Accelerated Eutrophication

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

Sources of nutrients

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

a) Rainfall and Atmospheric Deposition

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

b) Urban and Rural Run-Off

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

c) Agricultural Run-off

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

d) Domestic Sewage

Sewage is the commonest source of nutrients and organic matter, and undoubtedly the greatest contributor to the eutrophication of lakes. Large quantities of nitrogen and phosphorus are excreted by humans and animals which get their way into sewage. According to an estimate, an average of 2 g of PO_4-P per day is released through urine and faces by an average person, Phosphatic detergents in sewage are also important contributor of phosphorus.

e) Industrial Wastes

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

f) Water Fowl

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

g) Ground Water

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

Effects of Eutrophication

a. Physico – chemical effects

Pollution can be considered as a departure from the balance between photosynthesis and respiration. At equilibrium (P = R), the chemical and biological composition of water remains unchanged, a stage that mostly occurs only in non-polluted waters with no external supply of nutrients. An eutrophic water body is one where photosynthesis exceeds the respiration activity. It is characterized by a progressive accumulation of algae which ultimately leads to an organic overloading. When respiration exceeds photosynthesis, dissolved oxygen gets rapidly exhausted forcing reduction of several oxidized chemical species like NO_3, SO_4^{-2} and CO_2 into N_2, NH_4^+, H_2S and CH_4 which are harmful to several aquatic species and produce typical odours.

b. Biological effects

Many desirable species including fish are replaced by undesirable ones. There is an algal succession resulting in the dominance of blue green algae which have very low nutrition value in the food chains, and many of them produce the blooms. Some important bloom forming blue green algal genera include *Microcystis, Anabaena, Oscillatoria and Aphanizomenon.* Filamentous green algae, such as *Spirogyra, Cladophora, and Zygnema* form a dense floating mat or "blanket" on the surface when the density of the bloom becomes sufficient to reduce the intensity of solar light below the surface.

Nutrient enrichment has very limited direct effect on zooplankton communities, but indirect effect may be significant. The diversity of zooplankton remains high if the diversity of phytoplankton is also high as often found in case of oligotrophic or moderately enriched waters. As the changes occur in the water due to eutrophication, the characteristics of sediments also change. There is an accumulation of organic matter which affect the benthic communities.

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

Control of Eutrophication

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

a. Diversion of Nutrients from a Lake

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

b. Removal of Nutrients from Waste Waters

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

c. Flushing Out of Polluted Water by Nutrient Poor Water

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

d. Removal of Locked-up Nutrients

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

e. Dredging of Sediments

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

f. Covering of Sediments

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

g. Oxygenation and Mixing

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

h. Nutrient Inactivation

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

i. Zoning and Watershed Management

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

Biological Magnification

When a living organism cannot metabolize or excrete ingested substance that substance gradually accumulates in the organisms. This phenomenon, called biological accumulation (or bioaccumulation), refers to the process by which a substance first enters in to a food chain. The extent to which bioaccumulation will occur depends on an organism's metabolism and on the solubility of the substance first enters a food chain. If the substance is soluble in fat, it will typically accumulate in the fatty tissues of the organism. Bioaccumulation is of particular concern when the substance being concentrated is a toxic environmental pollutant and the organism is of a relatively low trophic level in a food chain.

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

Biomagnification occurs only when the pollutants are environmentally persistent (last a long time before breaking down into simpler compounds), mobile, and soluble in fats. Biomagnification can't occur

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

Impact of DDT

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

DDT is toxic to insects, but not very toxic to humans. It was much used in World War II to protect U.S. troops from tropical mosquito – borne malaria as well as to prevent the spread of lice and lice-borne disease among civilian populations in Europe. After the war, DDT was used to protect food crops from insects as well as to protect people from insect-borne disease. As one of the first of the modern pesticides, it was overused, and by the 1960s, the problems related to biomagnificantion of DDT became very apparent.

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

Control of Water pollution

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

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

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

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

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

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

Waste water treatment

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

Primary Treatment

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

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

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

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

Grit removal

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

Primary sedimentation (Settling)

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

Secondary (Biological) Treatment

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

Biological treatment of sewage involves the use of microorganisms. The microbes, including bacteria and protozoa, consume the organic pollutants as food. They metabolize the biodegradable organics, converting them into carbon dioxide, water and energy for their growth and reproduction. A biological sewage treatment system must provide the microorganisms with a comfortable home. In effect, the treatment plant allows the microbes to stabilize the organic pollutants in a controlled, artificial environment of steel and concrete, rather than in a stream or lake. This helps to protect the dissolved oxygen balance of the natural aquatic environment.

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

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

Aerobic waste water treatment method

Trickling filters

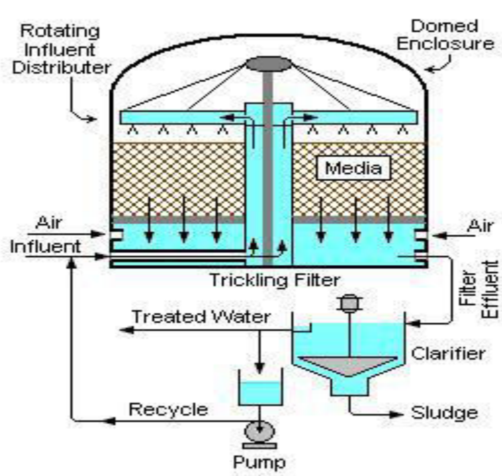
A trickling filter consists basically of a layer or bed of crushed rock about 2m (6ft) deep. It is usually circular in shape and may be built as large as 60 m (200 ft) in diameter. Trickling filters are always preceded by primary treatment to remove coarse and settleable solids. The primary effluent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

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

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

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

To maintain a relatively uniform flow rate thorough the trickling filter and to keep the distributor arm rotating even during periods of low sewage flow, some of the waste water may be recirculated. In other words, a portion of the effluent is pumped back to the trickling filter inlet so that it will pass through the bed of stones more than once. Recirculation can also serve to improve the pollutant removal efficiency; it allows the microbes to remove organics that flowed by them during the previous pass through the bed.



Activated sludge treatment

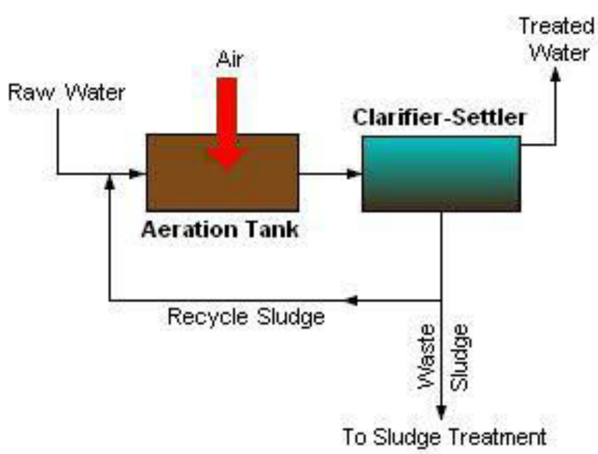
The basic components of an activated sludge sewage treatment system include an aeration tank a secondary settling basin or clarifier. Primary effluent is mixed with settled solids that are recycled from the secondary clarifier and then introduced into the aeration tank. Compressed air is injected continuously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

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

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

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

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



Tertiary (Advanced) Treatment

Secondary treatment can remove between 85 and 95 per cent of the BOD and TSS in raw sanitary sewage. Generally, this leaves 30 mg / L or less of BOD and TSS in the secondary effluent. But sometimes this level of sewage treatment is not sufficient to protect the aquatic environment.

Another limitation of secondary treatment is that it does not significantly reduce the effluent concentrations of nitrogen and phosphorous in the sewage. Nitrogen and phosphorous are important plant nutrients. If they are discharged into a lake, algal blooms and accelerated lake aging or cultural eutrophication may be the result. Also, the nitrogen in the sewage effluent may be present mostly in the form of ammonia compounds. These compounds are toxic to fish if the concentrations are high enough. Yet another problem with the ammonia is that it exerts a nitrogenous oxygen demand in the receiving water as it is converted to nitrates. This process is called nitrification.

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

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

Effluent polishing

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

Phosphorus Removal

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

One chemical frequently used in this process is aluminium sulfate (Al_2SO_4). This is called **alum**, the same coagulant chemical used to purify drinking water. The aluminium ions in the alum react with the phosphate ions in the sewage to form the insoluble precipitate called aluminium phosphate. Other coagulant chemicals that may be used to precipitate the phosphorous include ferric chloride ($FeCl_3$), and lime(CaO).

Nitrogen Removal

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

A second biological treatment step is necessary to actually remove the nitrogen from the wastewater. This is called **de nitrification**. It is anaerobic process in which the organic chemical methanol is added to the nitrified effluent to serve as a source of carbon. The denitrifying bacteria *Pseudomonas* and other groups use the carbon from the methanol and the oxygen from the nitrates in their metabolic processes. One product of this biochemical reaction is molecular nitrogen (N_2), which escapes into the atmosphere as a gas.

Bioreactors

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

b. Anaerobic wastewater treatment methods

The generation and disposal of large quantities of biodegradable waste without adequate treatment result in widespread environmental pollution. Some waste streams can be treated by conventional methods like aeration. Compared to the aerobic method, anaerobic digestion proves to be more advantageous in terms of efficiency of treatment as well as potential energy savings. Biomethanation is the process of conversion of organic matter in the waste (liquid or solid) to biogas and manure by microbial action in the absence of air. Methane produced by methanogenic bacteria is also another potential energy source. Methane is used for generation of mechanical, heat and electrical energy. Anaerobic decomposition of waste materials produces large amounts of methane. Many sewage treatment plants produce this fuel. Efficient generation of methane can be achieved by using algal biomass grown in pond cultures, sewage sludge, municipal refuse, plant residue and animal waste. Methanogens (Archaebacteria) are obligate anaerobes and produce CH_4 by reducing acetate and/or CO_2. **Biogas**, a mixture of different gases is produced by anaerobic microbes using domestic and agricultural wastes. Bulk (about 50 – 70%) of biogas is **methane** (CH_4) and other gases are in low proportions. These include CO_2 (25 – 35%), H_2 (1 – 5%), N_2 (2 – 7%) and O_2 (0 – 0.1%). In India a large number of **gobar gas plants** are already in operation in rural areas. Left overs of these plants are good fertilizers also. Animal waste is first hydrolyzed by hydrolytic bacteria. It is followed by acid formation by a group of acetogenic bacteria, which convert monomers into simple compounds like NH_3, CO_2 and H_2. Finally methanogens reduce acetate and/or CO_2 to CH_4. In India, cattle dung is the chief source of biogas.

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

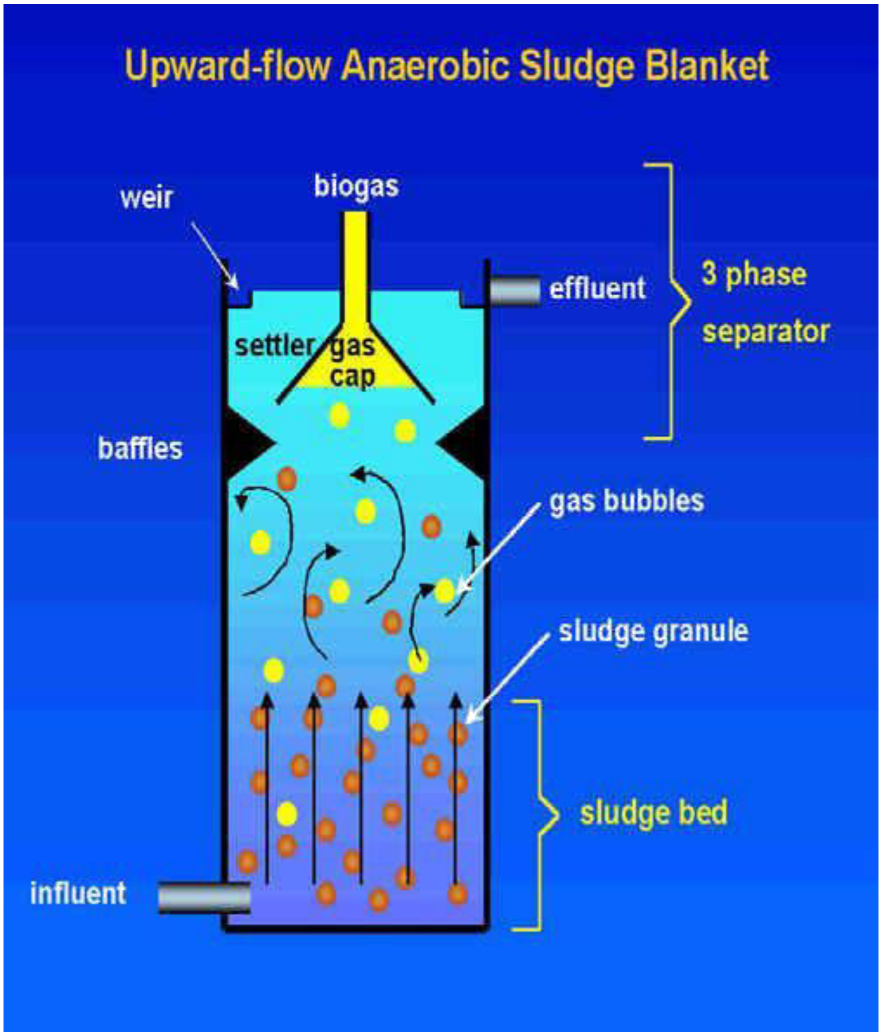
Anaerobic reactors for liquid waste

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

Upflow Anaerobic Sludge Blanket Reactor

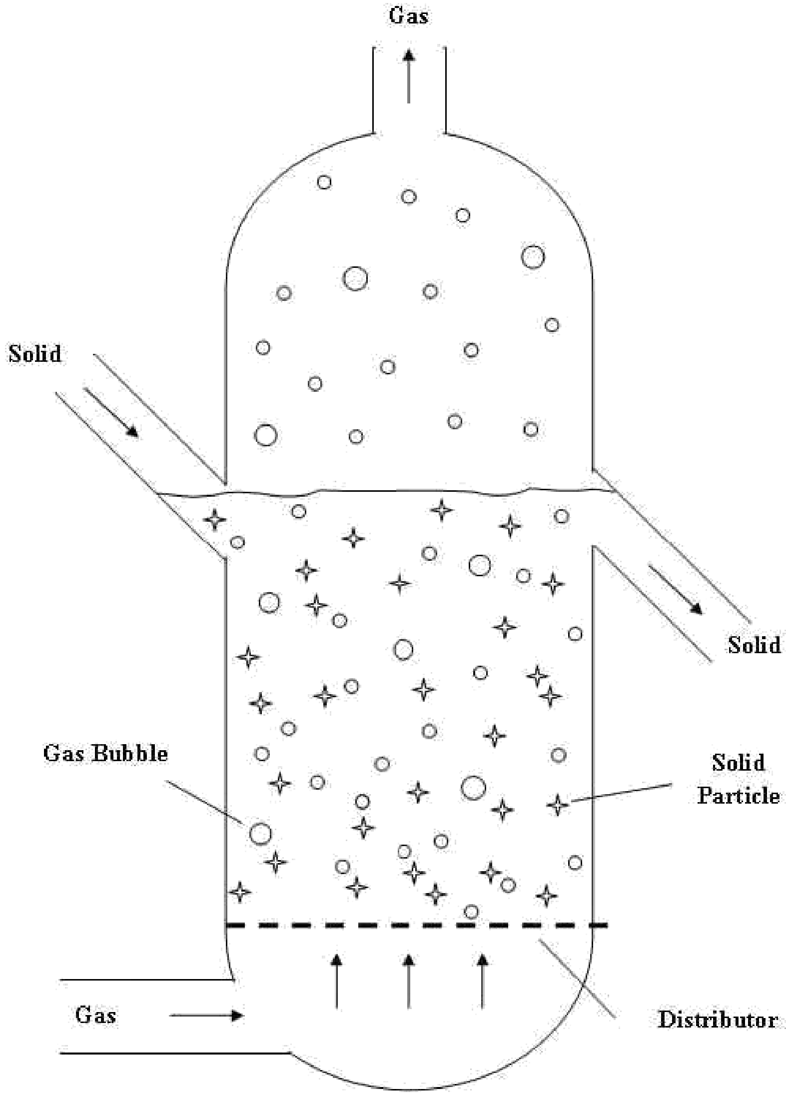
Developed at Wageningen Agricultural University, Netherlands (Lettinga, 1978), the UASB reactor employs anaerobic bacteria especially methanogens, which have a propensity to form self-immobilized granular structures with good settling properties inside the reactor. These anaerobic bacteria granules make a "blanket" through which the effluent flows up the reactor. The substrate present in the effluent diffuses into the sludge granules, where it is degraded by the anaerobic route. Thus, these reactors due to their high biomass concentrations can achieve conversions several folds higher than that possible by conventional anaerobic processes and tolerate fluctuations in influent feed, temperature and pH.

Moreover, since no support medium is required for attachment of the biomass it decreases the capital cost and minimizes the possibility of plugging. The energy requirement is also small because there is no mechanical mixing within the reactor, no recirculation of sludge, and no high recirculation of effluent.



Anaerobic Fluidized Bed (AFB) Reactors

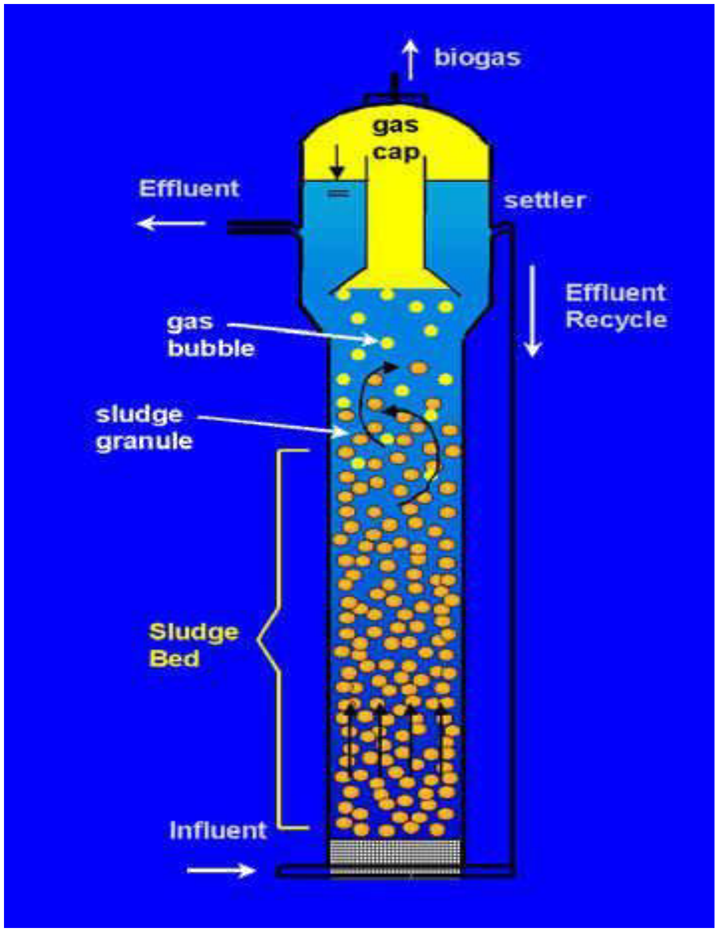
In these reactors mixed culture bacteria are made to grow as a film on the surface of some inert carrier particle. These particles are then maintained inside in a "fluidized" state using the energy of the incoming effluent stream. The linear velocity of the effluent is kept above the minimum fluidization velocity so that the film-covered particles are always in motion and the bed appears to be boiling. The substrate present in the liquid phase diffuses into the biofilm and gets converted to VFAs and ultimately to methane. These products then diffuse out through the biofilm into the bulk liquid. The mixing and mass transfer achieved in these reactors is excellent and the resulting conversions are comparable or even superior to those obtained for UASB reactors. These reactors have typical loading rates of 25 KgCOD/m^3 days. However, as the biofilm grows, the film-covered particles increase in size, which is accompanied by a decrease in their composite density. This causes the particle to move up in the bed ultimately resulting in its leaving the reactor, thereby leading to a reduction in the carrier particle concentration inside the reactor. This problem can be overcome by removing the biofilm from the carrier particle which has exited the reactor and then recycling the carrier particle (minus the biofilm) to the reactor. However, it is observed that the transport of solid particles as a rule creates too many operational problems let alone maintain strict anaerobic conditions within the reactor. Another drawback of AFB reactors is the high energy requirement due to the large recycle rates employed in these systems.



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

Expanded Granular Sludge Bed Reactor (EGSB)

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



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

Phytoremediation

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

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

metal-tolerant aquatic plants. For this purpose, plants must not only be metal-resistant but also have a high adsorption surface and must tolerate hypoxia.

3. Phytostabilization: Plants are used for immobilizing contaminant metals by root uptake, adsorption onto roots or precipitation in the rhizosphere. By decreasing metal mobility, these processes prevent leaching and groundwater pollution. Bioavailability is reduced and fewer metals enter the trophic web.
4. Phytodegradation: Elimination of organic pollutants by decomposition through plant enzymes or products.
5. Rhizodegradation: Decomposition of organic pollutants by means of rhizosphere microorganisms
6. Phytovolatilization: Organic pollutants absorbed by plants are released into the atmosphere by transpiration, either in their original form or after metabolic modification. In addition, certain metals can be absorbed and volatilized by certain organisms.

Mercury Pollution

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

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

Lead Pollution

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

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

Fluoride Pollution

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

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

Water quality standards

In the urbanized and industrialized world of today, it is necessary to have a legal basis for protecting water quality. It takes human effort, energy and money to keep water clean enough for the many different uses for which society requires it. Without a legal frame work to allow the enforcement of water quality standards, environmental quality and public health would be in constant jeopardy.

Water quality standards are limits on the amount of physical, chemical, or microbiological impurities allowed in water that is intended for a particular use. These are legally enforceable by governmental agencies and include rules and regulations for sampling, testing and reporting procedures.

Chemical parameters of water quality

Dissolved oxygen

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

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

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

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

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

Biochemical Oxygen Demand

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

When this process occurs in water, the oxygen consumed is the DO. If oxygen is not continually replaced in the water by artificial or natural means, then the DO level will decrease as the organics are decomposed by the microbes. This need for oxygen is called the **biochemical oxygen demand**. In effect, the microbes “demand” the oxygen for use in the biochemical reactions that sustain them. The abbreviation for biochemical oxygen demand is BOD; this is one of the most commonly used terms in water quality and pollution control technology.

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

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

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

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

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

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

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

BOD_L = ultimate BOD, mg/L

k = a constant representing the rate of the BOD reaction

t = time, d

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

Chemical Oxygen Demand

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

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

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

Sl. No.	Characteristics	Inland surface waters	Public sewers	Irrigation
1.	TSS (mg/l) max.	100	600	200
2.	DS (inorganics) (mg/l)	2100	2100	2100
3.	PH	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
4.	Oil and Grease (mg/l)	10	20	10
5.	Total Residual chlorine (mg/l)	1	-	-
6.	Ammoniacal nitrogen (as N) mg/l	50	50	-
7.	BOD (mg/l)	30	350	100
8.	COD (mg/l)	250	-	-
9.	Arsenic (as As) (mg/l)	0.2	0.2	0.2
10.	Mercury (as Hg) (mg/l)	0.01	0.01	-
11.	Lead (as Pb) (mg/l)	0.1	1	1
12.	Cadmium (as Cd) (mg/l)	2.0	1	1
13.	Hexavalent chromium (as Cr) (mg/l)	0.1	2	-

Soil Pollution: causes, effects and their control

Soil pollution

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

Soil pollutants

Pesticide pollution

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

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

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

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

Fertilizer pollution

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

Nitrate pollution

Nitrogen occurs in many forms in the environment and takes part in many biochemical reactions. The four forms of nitrogen that are of particular significance in environmental technology are organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. In water contaminated with sewage, most of the nitrogen is originally present in the form of complex organic molecules (protein) and ammonia (NH_3). These substances are eventually broken down by microbes to form nitrites and nitrates.

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

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

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

Heavy metal pollution

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

Effect of heavy metals on human health

S.No.	Heavy metal (forms)	Source	Effect
1.	Mercury: Hg^{++} (Mercuric) $C_6H_5Hg\ CH_3COO$	Methyl mercury fungicides, electrical and electronic industries, PVC, plastics, paints.	Irreversible damage in disease Neurological man, Minamoto
2.	Lead Pb^{2+}, Pb^{4+}	Automobile exhaust of leaded petrol (50%), Batteries, Pipes, Soldiering.	Cause mutation in algae and bacteria, blackening in fish, gradual paralysis in man.
3.	Arsenic As^{+++} Arsenic trioxide, Sodium arsenate	Herbicide, fungicide, wood preservative – Agro chemicals (70%), industrial chemicals – paints, bullets (20%), glass and glass wares (5%).	Accumulate in hair, nail, skin lesions, act as oxidative uncoupler, cause damage to kidney, respiratory tract and nervous disorders.
4.	Chromium Cr^{+6} CrO_3	Tanneries, electroplating and metal finishing processes, Khaki dyeing in textiles.	Toxic to aquatic organisms, Absorbed through intestinal tract in man.
5.	Cadmium (Cd)	Pigment and stabilizer for PVC, plastics, tires, rechargeable cells, electroplating, coal, oil and phosphate rocks.	Bones become brittle – Itai itai disease in Japan, gastro enteric distress and pain.

The unique physical, chemical and toxic properties of heavy metals have promoted their wide use in industrial processes and as biocides (fungicide and herbicide). As a result, higher concentration of these heavy metals accumulates in the environment, causing public health hazards and ecological problems. Removal of these metals is therefore a challenge to environmental management. The metals are generally removed by ion exchange and sorption to resins and precipitation as metal sulphides. Biodegradation of metals is not possible, because unlike organic pollutants, metals as elements cannot be mineralized to non-toxic compounds such as H_2O and CO_2. However, biomobilization is a valid concept in the management of metal pollution. Eukaryotic organisms detoxify heavy metals by binding to polythiols and bacteria have developed different and efficient mechanisms for tolerating heavy metals. They carry the genes controlling metal resistance on chromosome and plasmids, plasmids often contain genes resistance to several metals (Hg, Pb, As, Cr, Cd, Mo, U). As a result of biological action, metals undergo changes in valency and or conversion into organo metallic compounds.

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

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

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

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

Plastics : Plastics form a major part of global domestic and industrial waste. Not being biodegradable, waste plastic accumulates, adding to pollution. In USA plastic are 7% in weight of all solid waste but 30% of the volume. Standard plastic takes several hundreds of years to disintegrate, over 400 years for the plastic bottles used for mineral water. Using photodegradable plastic or biodegradable plastic can solve plastic pollution problem. Photodegradable plastic contains an element sensitive to UV rays. Under the effect of solar rays the element is activated and breaks the polymeric chain of the photodegradable plastic. It results in small fragments that are easily digested by microbes.

Biodegradable plastic

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

Excess Salts and Water

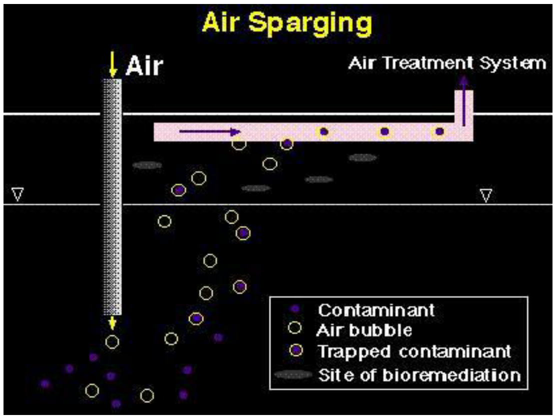
Irrigation water helps to produce more yield than rain fed land. Irrigation water contains dissolved salts and in dry season, water is in the form of saline solution evaporates leaving its salts such as NaCl in the top soil. This saline soil causes stunted plant growth, lower yield. Flushing out salts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

Control of Soil Pollution

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

Methods of Soil treatment

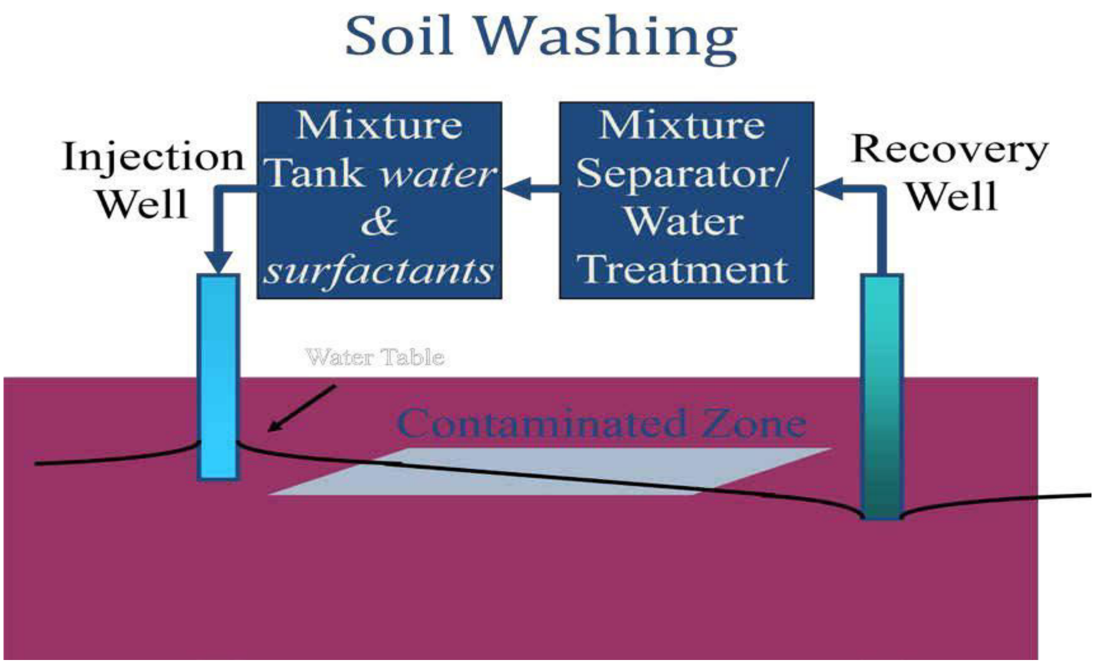
Air sparging is an *in situ* remedial technology that reduces concentrations of volatile constituents in petroleum products that are adsorbed to soils and dissolved in groundwater. This technology, which is also known as "*in situ* air stripping" and "*in situ* volatilization," involves the injection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



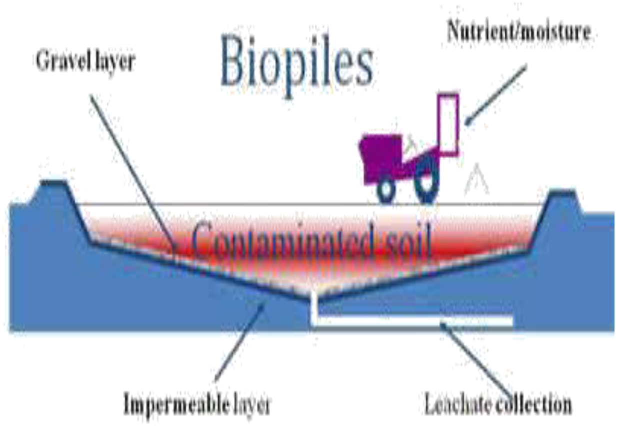
Soil washing is a water-based process for scrubbing soils ex situ to remove contaminants. The process removes contaminants from soils in one of the following two ways:

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

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



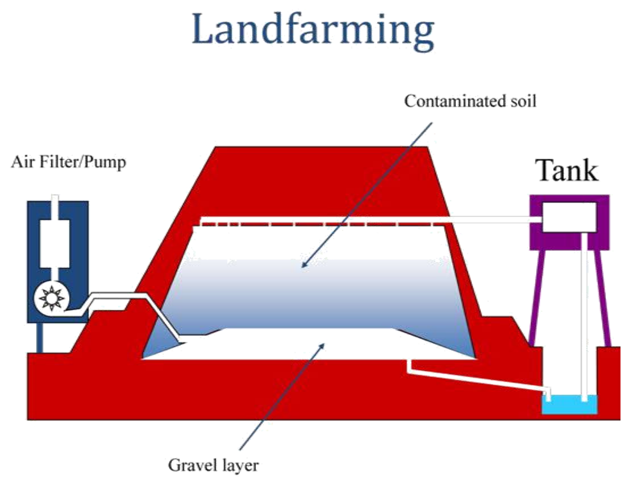
Biopile treatment is a technology in which excavated soils are mixed with soil amendments and placed on a treatment area that includes leachate collection systems and some form of aeration. It is used to reduce concentrations of petroleum constituents in excavated soils through the use of biodegradation.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



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

Soil piles and cells commonly have an air distribution system buried under the soil to pass air through the soil either by vacuum or by positive pressure. The soil piles in this case can be up to 20 feet high (generally not recommended, 2-3 meters maximum). Soil piles may be covered with plastic to control runoff, evaporation, and volatilization and to promote solar heating. If there are VOCs in the soil that will volatilize into the air stream, the air leaving the soil may be treated to remove or destroy the VOCs before they are discharged to the atmosphere. It is a short-term technology. Duration of operation and maintenance may last a few weeks to several months.

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



Soil conservation

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

- **Biological methods**

Agronomic practices
- Contour farming
- Mulching
- crop rotation
- Strip cropping

Dry farming

Agrostological methods
- Lay farming
- Retiring of land to gra

- **Mechanical methods**

1. Basin listing
2. Contour terracing

- **Other methods**

1. Gully control
2. Afforestation

Soil Amelioration

1. Soil Amelioration

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

- *Quicklime*- oxide of lime is usually known as burned lime or quicklime.

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

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

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

Amelioration of Saline and Alkali Soil

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

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

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

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

2. Prevention of solid wste dumping

Open dumping of solid waste should be segregated and recyclable materials could be recycled. Other garbage can be conveted into organic manure by suitable technology.

3. Usage of bio-fertilizers and bio-pesticides.

4. Following the concept of Integrated Plant Nutrient System (IPNS).

Organic / Sustainable Agriculture

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

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

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

Concepts of Organic Farming

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

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

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

Organic Farming Requirements

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

a. Maintaining soil fertility

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

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

b. Plant Protection methods

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

c. Animal husbandry

The basis for including animal husbandry in the system is to respect the physiological and ecological needs of animals. This is achieved by providing sufficient quantities of good quality organic fodder, Shelters according to their behavioral needs and also by proper veterinary treatment. Animals are an important part of organic system because they act as the agents for recycling of byproducts with value addition. Further contribute to complete the nutrient cycle and maintaining soil fertility. They also contribute draught energy for agricultural operations and provide essential manure for soil nutrition and urine for pesticides.

d. Processing of organic products

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

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

Scope and Importance of Environmental Studies

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

Scope of environmental studies

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

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

Importance of environmental study

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

Importance

- World population is increasing at an alarming rate especially in developing countries.
- The natural resources endowment in the earth is limited.
- The methods and techniques of exploiting natural resources are advanced.

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

Environmental studies deals with every issue that affects an organism. It is essentially a multidisciplinary approach that brings about an appreciation of our natural world and human impacts on its integrity. It is an applied science as it seeks practical answers to making human civilization sustainable on the earth's finite resources. Its components include:

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

Major environmental issues

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

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

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

Industrial / Vehicular pollution

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

Climate Change

The rising concentrations of greenhouse gases (GHGs) of anthropogenic origin in the atmosphere such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have increased, since the late 19th century. According to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change, because of the increase in concentration of greenhouse gases in the atmosphere (for e.g., CO_2 by 29 per cent, CH_4 by 150 per cent and N_2O by 15 per cent) in the last 100 years, the mean surface temperature has risen by 0.4–0.8°C globally. The precipitation has become spatially variable and the intensity and frequency of extreme events has increased. The sea level also has risen at an average annual rate of 1–2 mm during this period. The continued increase in concentration of GHG in the atmosphere is likely to lead to climate change resulting in large changes in ecosystems, leading to possible catastrophic disruptions of livelihoods, economic activity, living conditions, and human health. The United Nations Framework Convention on Climate Change requires the parties to protect the climate system in accordance with their ‘common but differentiated responsibilities’ and respective capabilities. In the year 1990, the developed world (Australia, Canada, USA, Europe, former USSR and Japan) emitted around 66 per cent of the total global GHG emissions, which though has reduced to 54 per cent in 2000, mainly offset by the rise in Chinese emissions. The South Asian region, including three-fourths emission share of India, contributed only 3 per cent of the total global GHG emissions in 1990 and the share of emissions from South Asia has grown merely by 4 per cent in 2000.

Water pollution

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

Poisoned by Pesticides

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

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

Important pesticide episodes are

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

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

Pesticides in Soft Drinks

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

Sample Analysis

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

- Among the total pesticide found in 18 cities in India, Kolkata is on the top and Guwahati is in the bottom of that list. Kolkata has pesticide content in cold drinks of about 51.7 ppb. The pesticides cause irreparable harm to the human body.

- It has been shown time and again that these pesticides can be used to kill bacteria in bathrooms. The acidic content of these drinks are harmful to the human body.

Hazardous Waste

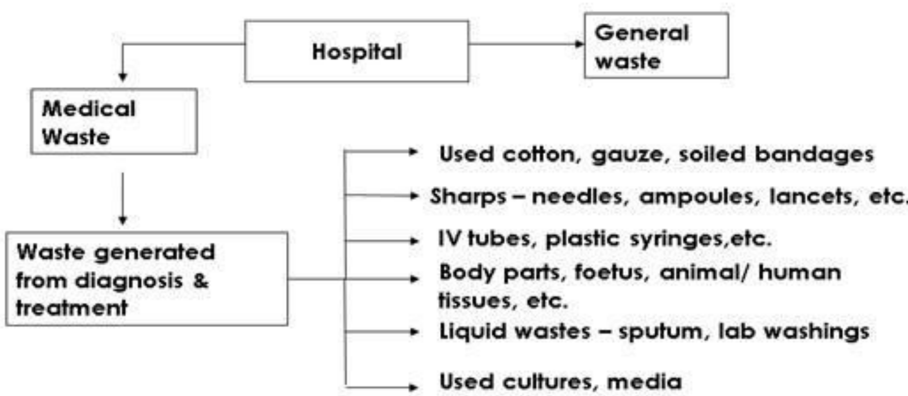
Hazardous waste may be liquid, solid or gas and all have one thing in common are dangerous and can pose a substantial hazard to human health and environment when not managed properly. In India, generation of hazardous waste to the tune of 6-7 million tonnes per year and may vary depending on the nature and quantity of hazardous waste generated in India. The major hazardous waste in India is petrochemicals, pharmaceuticals, pesticides, paints, dyes, fertilizers, chlor-alkali and other different industries.

The lack of a preventative approach to waste management has led to generation of more and more hazardous wastes and sadly, controlling hazardous waste has become a serious problem in India and no special care is taken in their management. Implementation of the ban on the ground is very negligent and hazardous waste is coming to our shores in regular phenomenon. Apart-from generating their own hazardous wastes, India invites import to such waste in the name of reuse and recycling, though there is lack of environmental friendly technology to reuse and recycle hazardous waste.

Thus indiscriminate generations, improper handling, storage and disposal of hazardous waste are the main factors contributing to the environmental and human health impact. The pressing need is to rethink the present approach of pollution control and end-of-the-pipe approaches and focus on pollution prevention, waste minimization, cleaner production and toxics reduction.

Biomedical Waste

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



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

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

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

Plastics constitute a major chunk of medical waste. In fact, in India, the market for medical disposable has grown from US$2.350 million (1979) to 4,000 million (1986). The use of plastics in medical equipment is now growing at the rate of 6% per annum. Even though plastics reduce the possibility of transmission of infection with in the hospital, there are many problems related to its use and disposal.

Mercury is more poisonous and Dangerous than Lead and Arsenic.

Cracking down on crackers

Over the years, Diwali has turned into a festival of pollution by noise, crackers, artificially coloured sweets and serious health hazards. On this day, cities turn into gas chambers increases toxic fumes and gases like CO_2, SO_2, NO_2, as well as suspended particulate matter (SPM), in the air. The worst affected are children. Pregnant women and those suffering from respiratory problems. In addition, the factories making crackers float safety norms and exploit child labour. These children work for 16-18 hrs each day in unhygienic dingy, make-shift and suffocating factories-for only Rs.10-15 per day. They handle chemical that cause deadly diseases of the lungs, kidneys, skin and eyes.

E**Waste**

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

International Scenario

- 20-50 MT / yr of e waste are generated world-wide.
- USA accounts 1% to 3% of the total municipal waste generation.
- EU - 5 to 7 million tonnes per annum or about 14 to 15 kg per capita and is expected to grow at a rate of 3% to 5% per year.
- In developed countries, currently it equals 1% of total solid waste generation and is expected to grow to 2% by 2010.

Magnitude of the problem in India

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

Loss of Biodiversity

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

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

What still needs to be known?

Improvement in monitoring and verification protocols for carbon sequestration in soil plant ecosystems is needed for quantitative economic and policy analyses. Such protocols must be acceptable, both domestically and internationally, to scientists, policy makers, landowners, and business groups. These protocols must be suitable for use by employees of government agencies and licensed professionals. Practical techniques to quantify the overall net beneficial impact of agricultural and silvicultural practices on all greenhouse gases, including methane (CH_4) and nitrous oxide (N_2O) are needed. Other beneficial services derived from improved land practices, such as changes in soil quality, productivity, water and air quality, and erosion must also be recognized and evaluated. Recommended carbon sequestration practices must show benefit for the total environment from a whole ecosystem accounting perspective. Long term studies are needed to insure that current effective carbon sequestration practices result in stable carbon forms for the long term (at least 20-50 years).

1. ENVIRONMENTAL SCIENCE AND AGROECOLOGY

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

The earth is the only known planet habited by man and other life forms, plants and vegetation. Man and nature have lived together and so long as man's wants were in conformity with nature, there was no problem. But unfortunately, man's ambition for limitless enjoyment and comfort has led him towards the exploitation of nature's wealth so indiscriminately and so shamelessly as to reduce nature's capacity for self stabilization. The indiscriminate exploitation of nature over centuries has created numerous environmental problems. Man's voracious appetite for resources and his desire to conquer nature has put him on collision course with environment. The demands of his explosive technological society impose intense stress on the state of equilibrium with the environment.

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

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

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

1.1. Environmental science

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

Environmental science is not ecology, though that discipline may be included. Ecologists are interested in the interactions between some kind of organism and its surroundings. Most ecological research and training does not focus on environmental problems except as those problems impact the organism of interest. Environmental scientists may or may not include organisms in their field of view. They mostly focus on the environmental problem, which may be purely physical in nature. For example, acid deposition can be studied as a problem of emissions and characteristics of the atmosphere without necessarily examining its impact on organisms. An alternate focus might be on the acidification of lakes and the resulting implications for resident fish. Both studies require expertise from more than one traditional discipline.

1.2. Agro ecology

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

2. ECOLOGY AND ENVIRONMENT

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

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

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

2.1. Structural units of ecology

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

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

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

2.2. Energy flow and productivity in an ecosystem

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

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

2.3. Ecological pyramids

The trophic structure and function at successive trophic levels, i.e. producers - herbivores - carnivores, may be shown graphically by means of ecological pyramids where the first or producer level constitutes the base of the pyramid and the successive levels, the tiers making the apex. Ecological of pyramids are of the three general types (i) **pyramid of numbers**, showing the number of individual organisms at each level (ii) **pyramid of biomass**, showing the total dry weight and other suitable measure of the total amount of living matter, and (iii) **pyramid of energy**, showing the rate of energy flow and/ productivity at successive trophic levels. The pyramids of numbers and biomass may be upright or inverted depending upon the nature of the food chain in the particular ecosystem, whereas pyramids of energy are always upright.

2.4. Photosynthesis and respiration:

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

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

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

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

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

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

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

3. BIODIVERSITY

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

3.1. Biodiversity loss

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

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

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

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

3.2. Biodiversity benefits

3.2.1. Utilitarian value

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

3.2.2. Diversity and ecosystem stability

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

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

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

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

3.3. Preserving biodiversity

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

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

Preserving biodiversity also takes place at the molecular level in the conservation of genetic diversity. All around the world efforts are being made to collect and preserve endangered organisms' DNA, the molecule that contains their genes. These collections, or *gene banks*, may consist of frozen samples of blood or tissue, or in some cases, they may consist of live organisms. Biologists use gene banks to broaden the gene pool of a species, increasing the likelihood that it will adapt to meet the environmental challenges that confront it. Many zoos, aquariums, and botanical gardens work together to carefully maintain the genetic diversity in captive populations of endangered animals and plants, such as the giant panda, the orangutan, or the rosy periwinkle. Captive animals are bred with wild populations, or occasionally released in hopes that they will breed freely with members of the wild population, thus increasing its genetic diversity. These gene banks are also an essential resource to replenish the genetic diversity of crops, enabling plant breeders and bioengineers to strengthen their stocks against disease and changing climate conditions

4. BIOSPHERE

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

4.1. Lithosphere

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

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

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

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

4.2. Hydrosphere

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

4.2.1. Aquatic ecosystem

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

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

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

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

4.2.2. Hydrology

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

4.2.3. Hydrological cycle

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

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

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

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

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

4.3. Atmosphere

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

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

The composition of the atmosphere changes over time and space. Outside of water vapor (which can vary from 0-4 per cent in the local atmosphere) the concentrations of the major components varies little in time. Above 31 miles (50 km) from sea level, however, the relative proportions of component gases change significantly. As a result, the atmosphere is divided into two compositional components: below 31 miles (50 km) is the homosphere and above 31 miles (50 km) is the heterosphere.

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

4.4. Ecosystem biomes

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

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

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

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

Pollution and Pollutant

India today is one of the first ten industrialized countries of the world. Today we have a good industrial infrastructure in core industries like metals, chemicals, fertilizers, petroleum, food etc. what has come out of these? Pesticides, detergents, plastics, solvents, fuels, paints, dyes, food additives etc. are some examples. Due to progress in atomic energy, there has also been an increase in radioactivity in the biosphere. Besides these, there are a number of industrial effluents and emissions particularly poisonous gases in the atmosphere. Mining activities also added to this problem particularly as solid waste. Thus, pollution is a necessary evil of all development. Due to lack of development of a culture of pollution control, there had resulted a heavy backlog of gaseous, liquid and solid pollution in our country. It is to be cleaned. Thus pollution control in our country is a recent environmental concern.

What is pollution?

Pollution is defined as an undesirable change in the physical, chemical or biological characteristics of air, water and soil that may harmfully affect the life or create a potential health hazard of any living organism and cultural assets.

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

The pollution may be due to human activities or natural ecosystems. Natural pollution contaminates the air by storms, forest fire, volcanoes and natural processes (methane from marshy lands). Nature by and large treats, recycles and makes good use of the pollutants and renders them less harmful, whereas man-made pollutants threaten the integrity of the nature. Pollution is thus direct or indirect changes in any component of the biosphere that is harmful to the living component(s), and in particular undesirable for man, affecting adversely the industrial progress, cultural and natural assets or general environment.

What are pollutants?

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

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

Environmental Pollutants

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

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

Types of pollution

The various types of pollution are classified based on the environment, based on sources of pollutant or nature of pollutants. Soil pollution, water pollution, air pollution, are the three major types of pollution based on environment. Based on sources of pollutants, they are classified as automobile pollution, agricultural pollution and industrial pollution (tanneries, nuclear power plants, chemical industries, etc.). Based on nature of pollutants, pollution is classified as pesticide pollution, plastic pollution, heavy metal pollution, radiation pollution, oil pollution, sewage pollution, noise pollution, etc. Of the variety of pollutants, we recognize the following two basic types of pollutants: non degradable and biodegradable.

(1) Nondegradable pollutants

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

(2) Biodegradable pollutants

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