

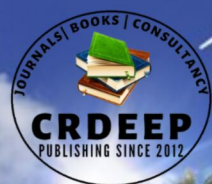
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IQBAL SINGH

Dr. Iqbal Singh obtained his Bachelor's degree in Science & master degree in Zoology from a prestigious university, where he developed a deep understanding of the complexities of ecosystems and the human impact on the environment. He went on to pursue his Ph.D. in Environmental Studies, specializing in accumulation & health risk of heavy metals in vegetables irrigated with untreated urban wastewater. A case study of Sri Ganganagar city Rajasthan. Sh. Singh has dedicated his career to 32-year teaching, studying and writing about environmental issues and inspiring positive change through his works. Throughout his educational journey, Sh. Singh engaged in extensive fieldwork, studying diverse habitats and ecosystems worldwide. His hands-on experience allowed him to witness first-hand the delicate balance of nature and the impact of human activities on the environment. This knowledge formed the basis of his later writings, combining scientific rigor with a heartfelt call to action going on conference workshops extension lecture in the field of environmental literature, has made significant contributions to raising awareness about environmental issues. Through his insightful writings, he combines scientific knowledge with personal experiences, inspiring readers to appreciate the beauty of nature and take action to protect our planet. Driven by a passion for conservation and sustainability, Sh. Singh continues to advocate for a more harmonious relationship between humanity and the natural world, urging individuals to embrace sustainable practices and safeguard the Earth's legacy for future generations.



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TEXT BOOK

ENVIRONMENTAL MANAGEMENT

2023



For UG and PG Students of all Indian Universities

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Author:

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ENVIRONMENTAL MANAGEMENT

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PREFACE

ACKNOWLEDGEMENTS

I express my heartiest gratitude to my parents, my in-laws, my sisters for encouraging me to write a book on current issues. A very special thanks to my beloved wife Mrs. Gurpreet Kaur, my daughter Arshdeep Kaur, Son-in-law Major Gurpreet Singh and son Pavneet Singh, who are the source of constant inspiration and encouragement.

I am thankful to my colleagues Dr. Ajay Kumar Gautam & Mrs. Praveen Saini for their support and help in completing my work successfully.

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Last but not least, I would also want to extend my appreciation to those who could not be mentioned here but have well played their role to inspire me behind the curtain.

Above all, I owe it all to the supreme power, 'The Almighty God', who happens to be always with me and hold my hand throughout the whole journey.

(Iqbal Singh)

CONTENTS

CHAPTER-1

INTRODUCTION TO ECOLOGY & ENVIRONMENTAL SCIENCES

The term Ecology is derived from the word '*Oekologie*' which was introduced for the first time by German biologist **Ernst Haeckel** in **1866**. Oekologie is derived from two Greek words, *Oikos* meaning *house* or *habitat* and *Logos* meaning *Knowledge* or *Study*. Thus, ecology is the knowledge of the house. This house is not a closed house as buildings in which we live, however, it is the biospheric house where different organisms live together, survive together and complete their life cycles. As such ecology is the knowledge of the biosphere or ecosphere. This biosphere must be studied as a whole but it is difficult work and thus it is studied in units of convenient size and the unit of biosphere is known as ecosystem. As such, ecology is defined as the '*the study of ecosystems*' (Odum 1971, Misra 1978, Tiwari 1992). Ecological studies are best carried by the team of workers who are united in their objectives to discover the properties of the whole but have different skills and secondary interests. The ecology, is then, not an interdisciplinary but an integrative discipline which deals with the supraindividual levels of organization and links the natural and social sciences as economics, sociology and politics and provides the basic theory to solve the present day national and international problems for the welfare of the human being.

The basic unit of biosphere-ecosystem is infact comprises by piece of vegetation or an area inhabited by organisms. A complete ecosystem consists of non living organic and inorganic material, autotrophs which can manufacture

organic and inorganic materials, heterotrophs and decomposers which degrade organic materials into inorganic compounds..

Ecology is studied at organism or population level. Ecosystem level is the heart of ecological science which deals with various processes (as indicated above) of a system in terms of mathematical or statistical interpretations and models. Thus, there is difference between ecology and biology. Biology deals with the identification, classification, evolution, structure and function and life history of organism while ecology deals with the systems consisting of one or more organisms, together with the various components of their biotic and abiotic environment* with which they are functionally interrelated. As such, ecology is the branch of science which deals with the systems of supraindividual organization. The proper management of any ecosystem requires detailed study at organism, community and ecosystem levels. Ecosystem level includes the reciprocal relationship between abiotic and biotic environment.

Each ecological system has two aspects viz., structural and functional. Materials and energy flow give the system functional activity. In the system the material (bio-geo-chemical cycles) flow in cyclic pattern whereas the energy flows in one direction (unidirectional). The quantity of biological material in the given area or volume of space is known as standing crop biomass. However, the quantity of abiotic material like minerals present in the given area or volume of space is known as standing state of material e.g., standing state of nitrogen. In the ecological system green plants produce food by photosynthesis known as primary producers. Herbivores take food from plants. Herbivores are eaten by carnivores or omnivores and these in turn are eaten by top carnivores. All animals (herbivores, carnivores and top carnivores) are known as secondary producers because animals consume plants or their organic material as food, after breakdown in the digestion process new type of organic

materials like animal tissue, proteins, etc, are formed. As such animals are also busy in the production of organic matter. After death of primary and secondary producers these are decomposed by microorganisms like fungi and bacteria and are known as decomposers which decompose the dead organic materials into simpler inorganic substances and they take their food from them during this process.

Any ecological system develops or evolves gradually. This takes hundreds to thousands of years. The long term changes are usually cumulative in nature and non-cyclic, and are known as succession. The succession progresses towards climax. In this stage the system stabilizes and there occurs harmony between biotic and abiotic environment and the system remains more or less unchanged. However, this stability is not a static stage, but it is the dynamic equilibrium between abiotic and biotic environments.

1.1 Fields of Ecology: As we learnt earlier that the term ecology means the knowledge or house and in which different organisms live together, interact and survive. It is composed of three broad units having different environment.

1. Natural unit
2. Man's unit
3. Partial unit.

The natural unit is composed of solar powered natural ecosystems. The man's unit is fuel powered, urban industrial ecosystem and the partial unit is fuel subsidized, and solar powered agro ecosystems. All these three broad units constitute and identify Man's Total Environment.

The natural unit is that part of man's life support system which operates without energetic or economic input from the power flows directly controlled by man. Examples are: natural forests, grasslands, rivers, estuaries, oceans, etc, which produce useful products and recycle wastes on a continuous basis without any cost to man. These are self maintaining ecological systems which run on sun energy. The man's unit e.g., city ecosystems and partial unit e.g., sub-urban developments, agricultural fields, channelized rivers etc. requires energy from man controlled power flows or by auxiliary power flows from fossils or other concentrated fuels that supplement or replace the natural energy flow of the sun. These systems are not self maintaining systems intact; natural unit incorporates natural ecosystems whereas man's and partial units are developed ecosystems, because these two systems have been developed by man for his own benefits. Developed systems are parasitic on natural systems because they are dependent on the natural systems not only for energy and materials but also for vital support of life processes. As the magnitude or intensity of developed systems increases the impact on natural systems becomes increasingly critical with air, water and food increasingly contaminated or in short supply or both due to stress caused by energy drain and reduction in storage capacity that developed systems impose on natural systems.

Today, the advancing technology and population growth produce a strong drive to convert natural environment into developed environment. As a result more and more auxiliary fuel energy is used to power machinery, make fertilizers and pesticides, to irrigate and transport and to process food. The agro ecosystems come more and more to be like the industrial systems in terms of demands and impacts on natural environment (Odum 1977). It is due to in coupling of natural and developed environments. Thus, it would seem obvious that serious attention must be given to the recoupling of natural and developed

environments so that total environment can be preserved and the quality of life thereupon can be improved. As such there is an urgent need to recouple the three units of the biospheric house and science and technology be integrated with recorded social, economic and political goals.

1.2 The term Environment. It refers to '*surrounding*'- *the external conditions influencing development or growth of people, animals or plants; living or working conditions*'. Environment is taken from a French word '*environ*' or '*environner*' meaning '*around*', '*round-about*', '*to surround*' or '*to encompass*'.

Definitions of Environment: Some important definitions of environment are as under:

Boring defines Environment as '*A person's environment consists of the sum total of the stimulation which he receives from his conception until his death.*' It can be concluded from the above definition that Environment comprises various types of forces such as physical, intellectual, economic, political, cultural, social, moral and emotional. Environment is the sum total of all the external forces, influences and conditions, which affect the life, nature, behavior and the growth, development and maturation of living organisms.

Environment consists of four segments as

- **Atmosphere:** It is an important part of the system and comprises the gaseous envelope of the earth.
- **Hydrosphere:** This includes the liquid water distributed over the surface of earth, consisting of oceans, lakes, rivers and ground water. The oceans are important for climatic variations.

- **Lithosphere:** Land masses over the surface of earth are features of lithosphere. This includes mountain and ocean basin together with surface rock, sediments and soil.
- **Biosphere:** This comprises the plant cover on land and in the ocean, and animals of the air, sea and land.

1.3 Structure of Environment: Traditionally, the environment, either natural or developed is divided into three categories:

a. **Physical environment or abiotic environment:** It includes air, temperature, rocks, minerals, light, soil moisture, soil texture, etc. It can be further divided into three categories as:

- Solid (It represents lithosphere)
- Liquid (It represents hydrosphere)
- Gases (It represents atmosphere)

b. **Chemical environment:** includes the composition of minerals in soil, phosphate in water, CO₂ in air, etc

c. **Biological environment or biotic environment:** It includes plants (flora), animals (fauna). It consists of organisms of same or different species, and the interrelated actions and reactions which individual organism directly or indirectly imposes on each other.

CHAPTER-2

ECOSYSTEM CONCEPT

2.1 Introduction: The fundamental unit of study in ecology is known as ecosystem. This term was first proposed by a British ecologist **A.G Tansley in 1935**. According to him *‘it includes not only the organism complex but the whole complex of physical factors forming what we call the environment’*. It is true that the term ecosystem was coined and expressed by Tansley in 1935.

Ecosystems are of three types; *1. Natural 2. Urban - industrial and 3. Agro ecosystems*. These are further divided as: Natural ecosystems are solar powered self sustaining units. Urban-industrial ecosystems are fuel powered and agro ecosystems are fuel subsidized, solar powered units.

2.2 Concept of an Ecosystem

An ecosystem not only includes the biological complex (living part) but whole complex of physical factors (non-living part), acting together in an ecological system. The living and the non-living parts are so interwoven into the fabric of nature that it is difficult to separate them. Elements and compounds are in a constant state of flux between the living and the non living stages. A typical ecosystem (fig 5.1) consists of:

1. Green plants capable of producing food from inorganic substances,
2. Macro consumers or phototrophs which cannot produce their own food, however, particulate organic matter,
3. Non-living organic materials, i.e., dead remains of plants and animals
4. Micro consumers or saprotrophs, e.g., bacteria and fungi which can degrade organic materials into inorganic compounds
5. Inorganic materials, and
6. Climatic regime.

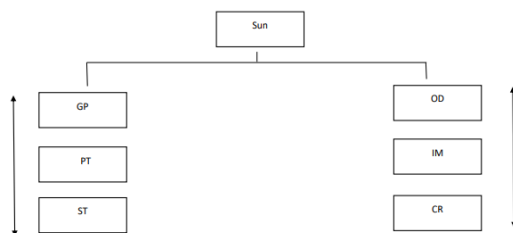


Fig. 2.1 A complete ecosystem (GP= Green plants; PT=Phagotrophs; ST= Saprotrophs; OD=Organic dead remains; IM=Inorganic material; CR=Climatic regime)

Green plants fix solar energy into potential energy which is stored in form of carbohydrates, proteins, fat and other molecules. Thus, green plants in the ecosystem act as a potential energy stores. This energy is transferred from one organism to another (from one trophic level to other) in the ecosystem by feeding process. In each transfer of energy from one trophic level to another, a large part of it is changed into heat and soon lost from the ecosystem. The energy transformations that occur within the ecosystems are known as *flow of energy*. Another characteristic is the flow of materials, i.e. the elements are primarily absorbed by plants for the production of organic materials and then are transferred from organism to organism by feeding process in the ecosystem. In a balanced condition when living organisms and the biotic environment mutually adjust through adaptational changes, the ecosystem is known as *self regulated* i.e., the ecosystem has the capacity of self maintenance and self regulation a condition known as *homeostasis*. However, organisms and their environment both are dynamic in nature. Any change in the proportion or quality of organism (proportion of plants and animals or new arrival of plants and animals) or any change in the environment (as the degree of pollution) tends to disturb the balanced ecosystem. Man is the part of his life supporting system composed of air, water, mineral, soil, plants, animals and microorganisms which function together to keep the whole visible i.e., an ecosystem. Infact, man has succeeded in modifying natural balanced ecosystems for his own advantages; however, this attitude of man to rush natural ecosystems for his selfishness seems to be dangerous for his own future generations. Thus, natural ecosystems must not be disturbed to the extent of degradation. The above discussion clearly indicates that the ecosystem is a functional unit consisting of plants, animals and the physical environment, that

all are interrelated as a whole where exchange of materials and flow of energy takes place at a characteristic rate. The ecosystem acts as an open system where solar energy, water, nutrients and atmospheric gases enter the system while heat, oxygen, carbon dioxide, other gases, humic compounds and non living materials are carried away from the system by water, air or any other media. All ecosystems are linked to one another, e.g., a city ecosystem is dependent on village ecosystem and vice-versa; forests, grasslands, etc., are dependent on oceans for water as precipitation, etc.

An ecological organization at higher level than the ecosystem is known as **biome**. The sum of total ecosystem is known as *biosphere or ecosphere*. The biosphere is the zone of earth occupied by living organisms and is defined '*as a house in which all the living organisms of the earth are interacting with the physical environment as a whole*'. The biospheric house is distinguished by its mosaic structure with very high degree of species diversity.

2.3 Structure and Functions of an Ecosystem

There are two aspects of an ecosystem. These are: **Structural aspect** and **Functional aspect**.

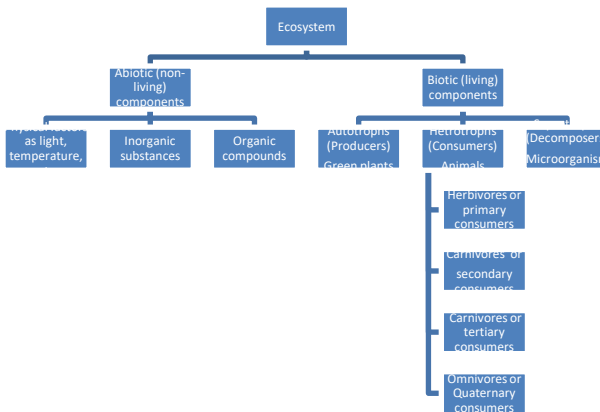


Fig. 2.2 Structure of an Ecosystem

Structural Aspect: The various types of abiotic and biotic components that provided ecosystem its structure is called structural aspect of an ecosystem.

Functional aspect: It includes 1. Trapping of light energy by photosynthesis and its passage into various trophic levels viz., herbivores, carnivores, parasites or saprophytes. It is known as ***energy flow or productivity***. 2. Interchanges of chemical substances (nutrient cycling) among both the biotic and abiotic components of the ecosystem. It is known as ***bio geo chemical cycles***.

Concept of Energy flow in an Ecosystem

As discussed earlier, the term ecosystem was coined and expressed by A.G. Tansley in 1935, but the real content of the ecosystem was given by R.L. Lindemann in 1942. He studied a senescent lake in relation to trophic dynamics and laid the conceptual framework by giving the idea of trophic or feeding levels. He established the relationship between the body size and trophic level. He also emphasized that the organisms take their energy from the primary energy sources, i.e., the sun. He defined **productivity** as *the rate at which energy enters a trophic level*. Thus, he was the first person to be able to explain the trophic-dynamic aspect of ecology, i.e., the basic theme of ecosystem. The two approaches (Tansley coined the term ecosystem and Lindemann analyzed the ecosystem and presented real content of ecosystem) have helped to bring the term ecosystem to the lime light all over the world.

In the ecosystem energy flows only in one direction through feeding process. This flow of energy in the ecosystem takes place in accordance with the laws of chemical thermodynamic.

The first law of thermodynamics states that:

‘Energy cannot be created or destroyed but can be converted into its different forms’.

For any ecosystem, the source of energy is solar energy. Plants cannot use this energy as such and it is first converted into chemical (food) energy by plants and then utilized by other organisms of the ecosystem. The biotic components are able to transform and transmit this energy. The light energy is transformed into potential (chemical) energy of organic compounds by plants (of the total light energy reaching the ground surface of the earth, only a small fraction i.e.,

1-5% is used by plant and rest is used in other processes like evaporation of water, etc. This potential energy is transmitted in the ecosystem through food chains.

The second law of thermodynamics states that:

'No process involving an energy transformation will spontaneously occur unless there is a degradation of the energy from a concentrated form into a dispersed form'.

In simple words it can be expressed as 'the energy is degraded into non-available form during the transformation from one form to another'. The definition clearly states that no energy transfer is 100% efficient.

Lindemann Concept of Energy Flow in an Ecosystem

Lindemann (1942) was the first person to demonstrate the energy flow through an ecosystem. He was able to demonstrate the stages of energy transfer from one trophic level to another and the losses of energy at each trophic level. Lindemann used many symbols in the model of energy flow as

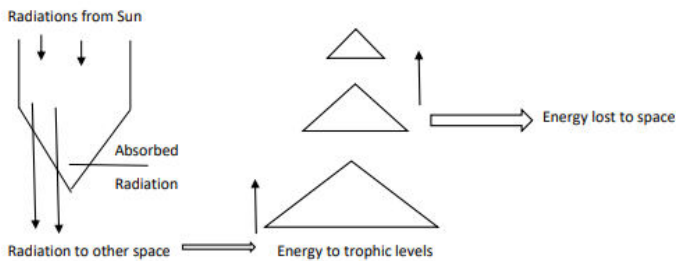


Fig. 2.3 Flow of energy among different trophic levels based on Lindeman's (1942) terminology (After Phillipson, 1966).

It must be remembered that the energy available at one trophic level is not all utilized or assimilated by the next trophic level, but at each transfer from one trophic level to other, a large part of energy is lost from the system usually in the form of respiratory loss (energy is also lost in the form animal feeding process, excreta etc). It has been estimated that at each step of energy transfer from primary producers to other trophic levels, approximately $9/10^{\text{th}}$ of the

energy content is wasted. It means the amount of energy available (net production) at each successive trophic level is approximately $1/10^{\text{th}}$ (10%)* that of preceding level. When energy transfer takes place from one organism to another the energy is stored in the organism, and its flow is stopped for sometime, until that organism becomes food (source of energy) for other organism. Energy once used by the organism converts into heat and soon lost from the ecosystem. Thus, during the flow of energy from primary producers to different trophic level the entire energy trapped by autotrophs to one time is lost. The lost energy cannot be reutilized, i.e, energy cannot be recycled. Hence, the energy must enter continuously into the system from the outside for its proper functioning. A scheme for energy flow through an ecosystem is shown in figure.

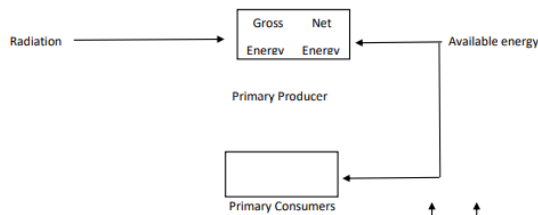


Fig. 2.4 Scheme for energy flow through an ecological unit.

A simplified scheme for the energy flow through an ecosystem under natural condition is shown in Figure . It is known as a 'Y' shaped or 2- channel energy flow diagram that separates a grazing food chin from a detritus food chain. There are two routes 'A' and 'B' of energy flow to primary consumers. Route 'A' belongs to grazing food chain when green plants (primary producers) are eaten (consumed) by herbivores (primary consumers and herbivores are eaten by carnivores (secondary consumers)) so and so forth. Route 'B' belongs to detritus food chain were detritus (dead organic substances) is consumed by detrivore (organism feeding on detritus), and thus known a s primary consumers. The detrivore and consumed by carnivores and then by higher carnivores. These two types of food chains are usually not isolated in the ecosystem, however, the abysmal region and the caves were green plants don't survive due to lack of light, detrivore play an important role and import the food (energy) from neighboring ecosystem (Tiwari, 1992).

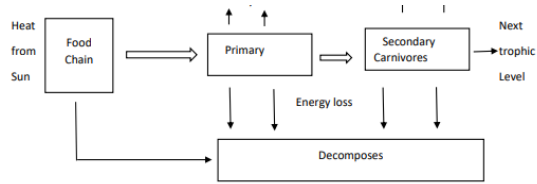


Fig. 6.3 A 'Y' shaped or '2-channel' energy flow through an ecosystem that separates a grazing food chain from a detritus food chain.

CHAPTER-3: BIOGEOCHEMICAL CYCLES

Biogeochemical Cycling

Cycling of the abiotic constituents of the environment through the biotic components back to the environment is known as bio- geo chemical cycling. This process is also known as nutrient cycling because the process is involved with the movement of these elements and inorganic compounds that are essential for life. This process is also known as mineral cycle because after the decomposition process the minerals are returned to the soil and are absorbed by plants through their roots. The term mineral nutrient is usually used to refer to an inorganic ion obtained from the soil and required for plant growth.

Types of bio-geochemical cycles

1. **Gaseous cycles:** In these cycles the reservoir for the element is either atmosphere or hydrosphere (ocean) and thus cycling is characterized by gas or water phase. These elements include water, nitrogen, oxygen, carbon dioxide, sulphur, chlorine, bromine and fluorine.
2. **Sedimentary Cycles:** In these cycles the reservoir is in the earth crust. The elements associated with such cycles are made available to the ecosystem either through weathering of rocks or through the decomposition of the sediments, and thus, these material cycles through soil and organism.

Carbon Cycle

The gaseous carbon dioxide is the most important one regarding climatic changes as it always exhibits a warming effect, and influences over solar radiation and heat budget of the earth. This gas is of prime importance because it is required by the autotrophs for the synthesis of the organic materials through the process of photosynthesis. The only source of carbon for autotrophs is the small amount of carbon dioxide (0.03% U.V) in the atmosphere or dissolved in water. Heterotrophs obtain much of their carbon requirement from autotrophs through feeding process of trophic levels, some forms may fix carbon directly from the salts dissolved in water (fig 9.2). In the atmosphere carbon

dioxide comes from the respiration of animals and a small amount also comes from the respiration of plants, decay and fermentation of organic matter, volcanic actions, solution of sedimentary rocks and springs, burning of coal, oil, gas and plants, etc. In the atmosphere carbon exists in the form of carbon dioxide and this gas is converted into carbohydrates (organic compounds) by the process of photosynthesis. It has been estimated that CO_2 reserves in the atmosphere contains 700 billion tones and 115 billion tons of carbon are fixed in photosynthesis annually by terrestrial plants (75 billion tons) and phytoplankton's (40 billion tons). As such, after photosynthesis the carbon becomes a part of simple carbohydrates, a portion of which may be converted into polysaccharides, proteins, lipids and other complex organic compounds which are stored in plant tissues. The plants re eaten by herbivores and later by carnivores, and at each trophic level the organic matter is also consumed by microorganisms. Thus, the organic compounds of plants are consumed by herbivores and after digestion the herbivores resynthesize these organic compounds into other form. The same process is repeated by carnivores. Thus, carbon is transferred from one organism to another and during this process the carbon atoms are constantly shifted from one kind of molecule to other. Of the organic substances produced by plants and animals are oxidized during respiration and thus, a part of CO_2 is released back to the atmosphere. After death of plants and animals the rest of the organic substances are oxidized in the decomposition process and CO_2 is released. The indigested organic matter wasted in excreta by animals is also oxidized during decomposition and CO_2 is released.

It has been estimated that through in the process of respiration 115 billion tons of carbon is released per year (21 by land plants, 54 by consumers and decomposers on land, 20 by phytoplanktons and 20 billion tons by consumers and decomposers of aquatic environment, especially oceans). We have learnt earlier that 75 billion tons of carbon is reduced by the terrestrial plants and 40 billion tons by the phytoplanktons. The data of the respiration also indicted that the same amount is released by the organisms. Thus, atmospheric carbon dioxide is removed continuously by photosynthetic uptake and returned through the process of respiration by autotrophs and hetrotrophs. As such, the production of carbon dioxide from organism as decomposition and respiration is balanced on a net annual basis by photosynthetic consumption.

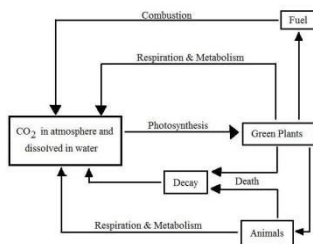


Fig. 3.1 A simplified diagram of Carbon cycle

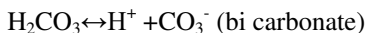
The fossil like coal and petroleum products also consists of carbon in the reduced organic form (geological history of plants and animals reveal that the tissues of giant animals and plants did not go in complete decomposition process, and thus, there remains are now available as fossil carbon in the form of commercially exploitable deposits of coal and petroleum products. It has been estimated that coal and oil consists 10,000 billions of tons of carbon). After burning of these fossil fuels CO₂ is released to the atmosphere. The burning of the fossil fuels is responsible for the continuous increase of CO₂ in the atmosphere. (It has been suggested that the present day CO₂ concentration has been increased about 13% since 1850 and it may reach 30% by 2000AD). This increasing* CO₂ in the atmosphere is responsible for thermal pollution (CO₂ absorbs long wave radiation and thus, has a green house effect*. Therefore, an increase in CO₂ concentration would cause global warming effect by rising atmospheric temperature). CO₂ is also replenished by volcanoes and weathering of rocks especially limes tone. In fact, the sedimentary rock on the earth crust consists of fraction of carbon, primarily in the form of calcium and magnesium carbonates of limestone and dolomites. It is considered that these rocks were deposited during the early Paleozoic era.

It hydrosphere,(water) carbon occurs primarily as dissolved CO₂ low pH 5, as HCO₃(bicarbonates between pH 5 and 7, and as CO₃ (carbonates) above pH10. Greatest quantity of carbon is located in sea water (about 50 times more than that of atmosphere) in the form of carbonate and bicarbonate ions (35,000 billions of tons of carbon). There occurs an interchange between atmospheric and aquatic CO₂. Bolin (1970) reported that about 100 billions of tons of carbon (1/7th carbon of the atmospheric pool) is exchanged between atmosphere and oceans per year. The interchange occurs through diffusion, and the

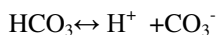
direction of diffusion depends upon the relative concentration in the two environments. The CO_2 dissolves in water in the form of carbonic acid as:



The carbonic acid is dissociated into hydrogen and bi carbonate ions as:



The bi carbonate ion gives hydrogen and carbonate ions as :



All these reactions can be represented as:



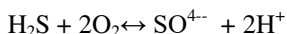
All these reactions are reversible and movement of CO_2 takes place from higher carbon concentrated to lower carbon concentrated environment because, the sea water is alkaline and rich in calcium, it accelerates the process, as a result the calcium-bi-carbonate rocks and coral reefs are common in tropical oceans. Considering the facts, the richest store of carbon today is the seas where it occurs in the form of carbonate and bicarbonate ions. Thus, carbon goes on cycling in different spheres and biota, and alternating between organic and inorganic, and reduced and oxidized forms.

Sulphur Cycle

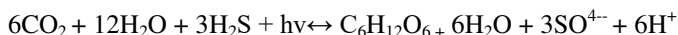
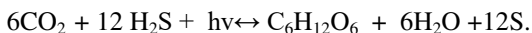
Sulphur is an essential part of organic compounds and is an essential part of protein and amino acids. Sulphur cycle has both gaseous and sedimentary phases. Gaseous phase in which sulphur circulates on a global scale is less pronounced than the sedimentary phases where the sulphur is deposited in organic and inorganic forms and after weathering and decomposition of sediments it is carried in the form of salt solution to various terrestrial and aquatic ecosystems. The plants make use of inorganic sulphur, i.e., in the form of sulphates, SO_4^{4-} . Though some organisms are also capable of utilizing organic

form of sulphur as sulphur amino acids, like, cysteine and methionine. These organisms belong to bacteria associated with detritus food chain.

In sulphur cycle there are two reservoirs, one is large in the earth (sedimentary) and small in the atmosphere (gaseous). According to an estimate, the total amount of sulphur been introduced in the atmosphere in the form of sulphur-dioxide (SO_2) exceed more than 20 millions of tons by man's activity only. Man's activity includes combustion of fossil fuels which yield an enormous amount of SO_2 enters into the atmosphere. The mining and processing operations during the extraction of metals produces a lot of sulphur routed to atmosphere. Volcanic emissions, the only known natural source of SO_2 contribute about 2×10^9 to 5×10^9 kg of sulphur per year and the industries produce about 83×10^9 kg of sulphur routed to atmosphere. SO_2 is responsible for causing Acid rains. Microorganisms like bacteria and fungi carry the mineralization of biologically incorporated sulphur through decomposition. *Aspergillus*, *Pneurospora*, etc., play an active role in the process. In this decomposition bacteria associated with detritus food chain produce hydrogen sulphide (H_2S) which is oxidized to sulphate which is used again by plants as:



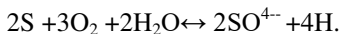
In the habitats like bottom of lake or sea where O_2 is not available to oxidize the H_2S by this means (in anaerobic conditions also bacteria like *E.coli* and *Proteus* reduce sulphur to sulphite including H_2S), the bacteria which can use IR radiations manufacture carbohydrates and oxidize sulphide either to elemental sulphur or sulphate as:



This sulphate is made available to plants under aerobic conditions. Elemental sulphur can also oxidize to sulphates by bacteria in the presence of nitrate as :



Elementary sulphur can be utilized quite rapidly by bacteria to sulphate as



Since these reactions are reversible, thus under certain conditions sulphate SO_4^{4-} can be reduced by bacteria to sulphide or elemental sulphur. As such decomposers from organic matter provide sulphur in the form of sulphate to plants (autotrophs) which passes to food chain. A number of bacteria like *Escherichia coli*, *Aerobactor*, reduce sulphate to sulphide and elemental sulphur (as discussed above) under anaerobic conditions. These sulphate reducing heterotrophic bacteria use sulphate as hydrogen acceptor. Hydrogen sulphide (H_2S) is oxidized to elemental sulphur by *Beggiatoa* species. *Thiobacillus* oxidizes it to sulphates (SO_4^{4-}). The chemosynthetic bacteria, viz, green sulphur bacteria such as *Chlorobium* and *Chlorobacterium* reduce CO_2 using hydrogen sulphide (H_2S) and converting the later into elemental sulphur. Purple sulphur bacteria like *Chromatium* assimilate CO_2 in the presence of variety of sulphur compounds, and oxidize them to sulphate (reaction no. 3 above). Sulphur deposits are also produced by the activity of anaerobic bacteria.

Beggiatoa species by H_2S gas and there is rapid exploitation of such sulphur deposits by man, resulting faster consumption of sulphur than they are formed naturally, results less available sulphur deposits for coming generations.

Like nitrate and phosphate, sulphate is chief available form that is reduced by autotrophs and incorporates into proteins (amino acids like methionine and cysteine).

By incomplete combustion of fossil fuels, a part of organic sulphur is converted into sulphur dioxide (SO_2) and enters into gaseous reservoir. Inorganic sulphur as sulphates is precipitated out and turns into a source of elemental sulphur in the ecosystem owing to its solubility. Infact sulphur enters the gaseous reservoir (atmosphere) as hydrogen sulphide (H_2S) by many means as incomplete combustion of fossil fuels, volcanic eruptions, gaseous released by decomposition at the surface of ocean etc. H_2S is oxidized rapidly into another volatile form, SO_2 which is soluble in water converted back to earth in the form of rain water as weak sulphuric acid (H_2SO_4). Acid rains as has been discussed earlier. Owing to soluble nature of sulphur it turns into a source of (SO_4^{4-}) absorbed by plant roots and passed into different trophic levels. The dead

material at each trophic level and excreta (faeces etc.) reach the soil where it is decomposed by bacteria to sulphate form.

Thus, in conclusion it can be said that major reservoir of sulphur on earth is deposits of sulphide (S^{2-}) and sulphate(SO_4^{2-}) while organic sulphur occurs in the autotrophs and hetrotrophs. Secretions of plant and animal and decomposition of dead organic matter yields H_2S gas which is converted to SO_4^{4-} by bacteria and is taken by plants as SO_4^{4-} . Bacterial action may turn some sulphates to H_2S which is changed to SO_4^{4-} again for the absorption of plants.

The sulphur requirement of the ecosystem is not high as nitrogen or phosphorus and is never a limiting factor to life. However, sulphur cycle is an important one as it interacts with various mineral cycles and their biological and chemical regulations. In the sediments, sulphur cycle involves precipitation of sulphur under anaerobic conditions in the presence of iron. As iron sulphide is insoluble in neutral or alkaline water, the availability of sulphur is governed by the amount of iron present in the soil. Similarly, other nutrients like cadmium, cobalt, copper and zinc can also be trapped. A simplified diagram of sulphur cycle is presented in fig 3.2 (Tiwari, 1992).

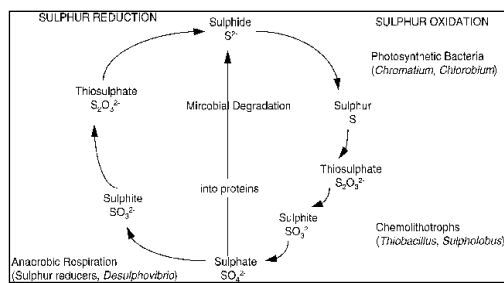
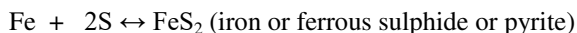
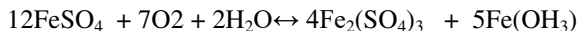
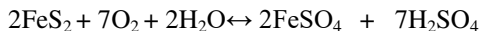


Fig. 3.2 A simplified diagram of Sulphur cycle (After Tiwari 1992)



Some FeS_2 is found in sedimentary rocks overlying coal deposits. When it is exposed to air, ferrous sulphide oxidizes and in the presence of water produces ferrous sulphate and sulphuric acid as:



The compounds so produced are harmful to aquatic organisms and the water becomes acidic.

Nitrogen Cycle

The **nitrogen cycle** is the process by which nitrogen is converted between its various chemical forms. This transformation can be carried out via both biological and non-biological processes. Important processes in the nitrogen cycle include fixation, mineralization, nitrification, and denitrification. The majority of Earth's atmosphere (approximately 78%) is nitrogen,^[1] making it the largest pool of nitrogen. Nitrogen is essential for many processes; it is crucial for any life on Earth. It is a component in all amino acids, is incorporated into proteins, and is present in the bases that make up nucleic acids, such as DNA and RNA. In plants, much of the nitrogen is used in chlorophyll molecules, which are essential for photosynthesis and further growth.^[2] Although Earth's atmosphere is an abundant source of nitrogen, most is relatively unusable by plants.^[3] Chemical processing, or natural fixation (through processes such as bacterial conversion— rhizobium), are necessary to convert gaseous nitrogen into forms usable by living organisms, which makes nitrogen a crucial component of food production. The abundance or scarcity of this "fixed" form of nitrogen, (also known as reactive nitrogen), dictates how much food can be grown on a piece of land.

Process of Nitrogen Cycling

Nitrogen is present in the environment in a wide variety of chemical forms including organic nitrogen, ammonium (NH_4^+), nitrite (NO_2^-), nitrate (NO_3^-), and nitrogen gas (N_2). The organic nitrogen may be in the form of any living organism, or humus, and in the intermediate

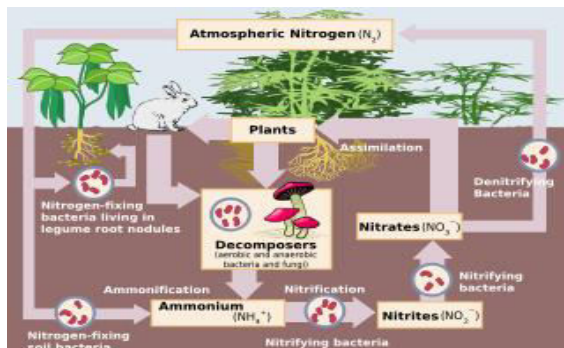


Fig. 3.3 A simplified diagram showing Nitrogen Cycle

products of organic matter decomposition or humus built up. The processes of the nitrogen cycle transform nitrogen from one chemical form to another. Many of the processes are carried out by [microbes](#) either to produce energy or to accumulate nitrogen in the form needed for growth. Fig. 7.3 below shows how these processes fit together to form the nitrogen cycle.

Nitrogen fixation

Atmospheric nitrogen must be processed, or "fixed" to be used by plants. Some fixation occurs by lightning strikes, but most fixations is done by free-living or symbiotic bacteria. These bacteria have the nitrogenase enzyme that combines gaseous nitrogen with hydrogen to produce ammonia, which is then further converted by the bacteria to make their own organic compounds. Most biological nitrogen fixation occurs by the activity of Mo-nitrogenase, found in a wide variety of bacteria and some Archaea. Mo-nitrogenase is a complex two component enzyme that contains multiple metal-containing prosthetic groups. Some nitrogen fixing bacteria, such as *Rhizobium*, live in the root nodules of legumes (such as peas or beans). Here they form a mutualistic relationship with the plant, producing ammonia in exchange for carbohydrates. Nutrient-poor soils can be planted with legumes to enrich them with nitrogen. A few other plants can form such symbioses. Today, about 30% of the total fixed nitrogen is manufactured in ammonia chemical plants.

Conversion of N₂

The conversion of nitrogen (N₂) from the atmosphere into a form readily available to plants and hence to animals and humans is an important step in the nitrogen cycle, which distributes the supply of this essential nutrient. There are four ways to convert N₂ (atmospheric nitrogen gas) into more chemically reactive forms:

1. **Biological fixation:** some symbiotic bacteria (most often associated with leguminous plants) and some free-living bacteria are able to fix nitrogen as organic nitrogen. An example of mutualistic nitrogen fixing bacteria are the *Rhizobium* bacteria, which live in legume root nodules. An example of the free-living bacteria is *Azotobacter*.
2. **Non-biological fixation:** In addition, the formation of NO from N₂ and O₂ due to photons and especially thunder storms and lightning, can fix nitrogen.

Assimilation

Plants can absorb nitrate or ammonium ions from the soil via their root hairs. If nitrate is absorbed, it is first reduced to nitrite ions and then ammonium ions for incorporation into amino acids, nucleic acids, and chlorophyll. In plants that have a mutualistic relationship with rhizobia, some nitrogen is assimilated in the form of ammonium ions directly from the nodules. Animals, fungi, and other heterotrophic organisms obtain nitrogen as amino acids, nucleotides and other small organic molecules.

Ammonification

When a plant or animal dies, or an animal expels waste, the initial form of nitrogen is organic. Bacteria, or fungi in some cases, convert the organic nitrogen within the remains back into ammonium (NH₄⁺), a process called ammonification.

Nitrification

The conversion of ammonium to nitrate is performed primarily by soil-living bacteria and other nitrifying bacteria. The primary stage of nitrification, the oxidation of ammonium (NH_4^+) is performed by bacteria such as the *Nitrosomonas* species, which converts ammonia to nitrites (NO_2^-). Other bacterial species, such as the *Nitrobacter*, are responsible for the oxidation of the nitrites into nitrates (NO_3^-).^[2] It is important for the nitrites to be converted to nitrates because accumulated nitrites are toxic to plant life.

Denitrification

Denitrification is the reduction of nitrates back into the largely inert nitrogen gas (N_2), completing the nitrogen cycle. This process is performed by bacterial species such as *Pseudomonas* and *Clostridium* in anaerobic conditions. They use the nitrate as an electron acceptor in the place of oxygen during respiration. These facultative anaerobic bacteria can also live in aerobic conditions.

Phosphorus Cycle

Initially, phosphate weathers from rocks. The small losses in a terrestrial system caused by leaching through the action of rain are balanced in the gains from weathering rocks. In soil, phosphate is absorbed on clay surfaces and organic matter particles and becomes incorporated (immobilized). Plants dissolve ionized forms of phosphate. Herbivores obtain phosphorus by eating plants, and carnivores by eating herbivores. Herbivores and carnivores excrete phosphorus as a waste product in urine and feces. Phosphorus is released back to the soil when plants or animal matter decomposes and the cycle repeats.

- a. Transfer of element in the ecosystem.
- b. Incomplete decomposition of ancient giant animals and plants.
- c. Acid rains.
- d. Nitrogen fixation
- e. Denitrification

CHAPTER-4: POLLUTION AND ITS MANAGEMENT

Pollution is the introduction of contaminants into a natural environment that causes instability, disorder, harm or discomfort to the ecosystem i.e. physical systems or living organisms. **Pollutants**, the elements of pollution, can be foreign substances or energies, or naturally occurring.

The term pollution is taken from a Latin word '**Pollutioneum**' which means to defile or to making dirty or to contaminate.

4.1 Classification of pollutants

Pollutants are classified as:

Depending on the form they persist in the environment after being released, the pollutants can be classified into two types as:

Primary Pollutants: These are those substances that are emitted directly from their source and remain in the form in which they are added. Examples are fumes, dust, sulphur dioxide, hydrocarbons, etc.

Secondary Pollutants: These are those which are formed from the primary pollutants by chemical interaction with some constituents present in the atmosphere. Example PAN (Per oxy acetyl Nitrate).

From the ecosystem point of view, pollutants are of two types:

Biodegradable Pollutants: These are those which are rapidly decomposed and recycled, e.g., domestic sewage can be decomposed either naturally or mechanically by means of sewage treatment plant.

Non biodegradable pollutants: These are those which are not readily breakdown to harmless substances or broken down very slowly in the natural environment. Such pollutants include mercurial salts, aluminum cans, DDT, TDE, long chain phenolic chemicals, etc. These substances not only accumulate but are generally transferred from organism to organism in food chains, and move in biogeochemical cycles. Because these pollutants move along the food chain and some substances concentrated instead of dispersed

with each link in the food chain, and thus are known as biologically magnified and such magnification is known as **biological magnification**. Sometimes, these pollutants cause toxic effects only after long period of accumulation.

On the basis of their existence in nature:

Quantitative Pollutants: These substances are present in environment but are termed as pollutant when their concentration increases due to various anthropogenic activities. eg. Increase in the level of carbon-di-oxide in atmosphere due to various human activities.

Qualitative Pollutants: These substances are not naturally present in environment but are introduced by man-made activities.eg. Fertilizers.

Types of Environmental Pollution:

The various types of pollution are:

1. Air Pollution.
2. Water Pollution
3. Soil Pollution
4. Marine Pollution
5. Radioactive Pollution
6. Noise Pollution
7. Thermal Pollution

4.2 Air Pollution

Before discussing about air pollution, its causes, effects and control it is important to know about the atmosphere where air pollution generates.

Atmosphere

An **atmosphere** (New Latin *atmosfera*, created in the 17th century from Greek *atmos* "vapor" and *sphaira* "sphere") is a layer of gases that may surround a material body of sufficient mass,^[3] and that is held in place by the gravity of the body.

Earth's atmosphere, which contains oxygen used by most organisms for respiration and carbon dioxide used by plants, algae and cyanobacteria for photosynthesis, also protects living organisms from genetic damage by solar ultraviolet radiation. Its current composition is the product of billions of years of biochemical modification of the paleoatmosphere by living organisms.

Composition

Earth's atmosphere contains roughly (by molar content/volume) 78.08% nitrogen, 20.95% oxygen, a variable amount (average around 1.247%, National Center for Atmospheric Research) water vapor, 0.93% argon, 0.038% carbon dioxide, and traces of hydrogen, helium, and other "noble" gases.

Structure

The Earth's atmosphere consists, from the ground up, of the troposphere (which includes the planetary boundary layer, stratosphere (which includes the ozone layer), mesosphere, thermosphere (which contains the ionosphere), exosphere and also the magnetosphere. Each of the layers has a different lapse rate, defining the rate of change in temperature with height. The temperature drops as we go up through the troposphere, but it rises as we move through the next layer, the stratosphere. The farther away from earth, the thinner the atmosphere gets.

1.Troposphere

This is the layer of the atmosphere closest to the Earth's surface, extending up to about 10-15 km above the Earth's surface. It contains 75% of the atmosphere's mass. The troposphere is wider at the equator than at the poles. Temperature and pressure drops as you go higher up the troposphere.

Tropopause: At the very top of the troposphere is the tropopause where the temperature reaches a (stable) minimum. Some scientists call the tropopause a "cold trap" because this is a point where rising water vapor cannot go higher because it changes into ice and is trapped.

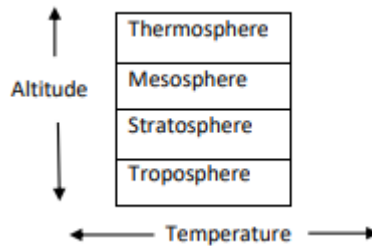


Fig. 4.1 Structure (Layers) of Atmosphere

The uneven heating of the regions of the troposphere by the Sun causes convection currents and winds. Warm air from Earth's surface rises and cold air above it rushes in to replace it. When warm air reaches the tropopause, it cannot go higher as the air above it (in the stratosphere) is warmer and lighter ... preventing much air convection beyond the tropopause. The tropopause acts like an invisible barrier and is the reason why most clouds form and weather phenomena occur within the troposphere.

The Greenhouse Effect: Heat from the Sun warms the Earth's surface but most of it is radiated and sent back into space. Water vapor and carbon dioxide in the troposphere trap some of this heat, preventing it from escaping thus keep the Earth warm. This trapping of heat is called the "greenhouse effect".

2.Stratosphere

This layer lies directly above the troposphere and is about 35 km deep. It extends from about 15 to 50 km above the Earth's surface. The lower portion of the stratosphere has a nearly constant temperature with height but in the upper portion the temperature increases with altitude because of absorption of sunlight by ozone. This temperature increase with altitude is the opposite of the situation in the troposphere.

The stratosphere contains a thin layer of ozone which absorbs most of the harmful ultraviolet radiation from the Sun. The ozone layer is being depleted,

and is getting thinner over Europe, Asia, North American and Antarctica --- "holes" are appearing in the ozonelayer.

Ozone is also highly concentrated at the Earth's surface in and around cities. Most of this ozone is created as a by product of human created photochemical smog. This buildup of ozone is toxic to organisms living at the Earth's surface.

3.Mesosphere

Directly above the stratosphere, extending from 50 to 80 km above the Earth's surface, the mesosphere is a cold layer where the temperature generally decreases with increasing altitude. Here in the mesosphere, the atmosphere is very rarefied nevertheless thick enough to slow down meteors hurtling into the atmosphere, where they burn up, leaving fiery trails in the night sky.

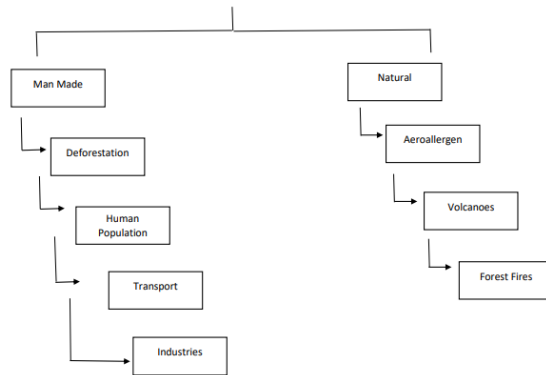
4.Thermosphere

The thermosphere extends from 80 km above the Earth's surface to outer space. The temperature is hot and may be as high as thousands of degrees as the few molecules that are present in the thermosphere receive extraordinary large amounts of energy from the Sun. However, the thermosphere would actually feel very cold to us because of the probability that these few molecules will hit our skin and transfer enough energy to cause appreciable heat is extremely low.

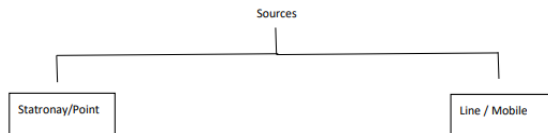
Definition of Air Pollution

Air pollution is the introduction of chemicals, particulate matter, or biological materials that cause harm or discomfort to humans or other living organisms, or cause damage to the natural environment or built environment, into the atmosphere. **World Health Organization (WHO)** defines air pollution as *'limited to situations in which the outdoor ambient atmosphere contains materials in concentrations which are harmful to man and his environment'*.

Causes of Air Pollution



Sources of Air Pollution



Major Air Pollutants

Major primary pollutants include:

- **Sulfur oxides (SO_x)** - especially sulphur dioxide, a chemical compound with the formula SO₂. SO₂ is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulphur compounds, their combustion generates sulfur dioxide. Further oxidation of SO₂, usually in the presence of a catalyst such as NO₂, forms H₂SO₄, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.
- **Nitrogen oxides (NO_x)** - especially nitrogen dioxide are emitted from high temperature combustion. Can be seen as the brown haze dome above or plume downwind of cities. Nitrogen dioxide is the chemical compound with the formula NO₂. It is one of the several nitrogen oxides. This reddish-brown toxic

gas has a characteristic sharp, biting odor. NO_2 is one of the most prominent air pollutants.

- **Carbon monoxide (CO)**- is a colorless, odorless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.
- **Carbon dioxide (CO_2)** - a colorless, odorless, non-toxic greenhouse gas associated with ocean acidification, emitted from sources such as combustion, cement production, and respiration
- **Volatile organic compounds - VOCs** are an important outdoor air pollutant. In this field they are often divided into the separate categories of methane (CH_4) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhance global warming. Other hydrocarbon VOCs are also significant greenhouse gases via their role in creating ozone and in prolonging the life of methane in the atmosphere, although the effect varies depending on local air quality. Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukemia through prolonged exposure. 1,3-butadiene is another dangerous compound which is often associated with industrial uses.
- **Particulate matter** - Particulates alternatively referred to as particulate matter (PM) or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to particles and the gas together. Sources of particulate matter can be man made or natural. Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols. Averaged over the globe, anthropogenic aerosols—those made by human activities—currently account for about 10 percent of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.
- **Toxic metals**, such as lead, cadmium and copper.
- **Chlorofluorocarbons (CFCs)** - harmful to the ozone layer emitted from products currently banned from use.

- **Ammonia (NH₃)** - emitted from agricultural processes. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous.
- **Odors** — such as from garbage, sewage, and industrial processes
- **Radioactive pollutants** - produced by nuclear explosions, war explosives, and natural processes such as the radioactive decay of radon.

Secondary pollutants include:

- **Particulate matter** formed from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution; the word "smog" is a mixture of smoke and fog. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulfur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to form photochemical smog.
- **Ground level ozone (O₃)** formed from NO_x and VOCs. Ozone (O₃) is a key constituent of the troposphere. It is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer.
- **Peroxyacetyl nitrate (PAN)** - similarly formed from NO_x and VOCs.

Interactions of air pollutants produce photochemical smog, a well known example of synergism (the term smog is used to denote a combination of smoke and fog. Nitrogen oxides and hydrocarbons react together in the atmosphere under the influence of ultraviolet radiations from the sun produces ozone, a variety of complex organic gases and compounds such as Peroxyacetyl nitrate (PAN) and particulates known as photochemical smog as:

Nitrogen oxides + unburned hydrocarbons → Peroxyacetyl Nitrate (PAN) + Ozone.

Effects of Air Pollution on:

Human Health

- Difficulty in breathing,
- Sneezing,
- Coughing and
- Aggravation of existing respiratory and cardiac conditions

Plants

- Chlorosis (loss of chlorophyll by SO_2).
- Abscission (premature leaf fall due to effect of NO_2)
- Necrosis (killing of tissue due to exposure of ozone)
- Epinasty (downward curvature of leaf)

Animals and Materials

- Animals get poisoned by airborne contaminants when they feed on contaminated vegetation.
- Building material gets damaged when comes in contact with constituents of acid rain.

Control of Air Pollution

Air Pollution Control Equipments are generally categorized in two parts:

- a. Control devices for coarse particulates
- b. Control devices for fine particulates
- c. Control devices for gaseous pollutants

Control equipments used for the collection of coarse particulates includes:

- Gravity Settling Chamber
- Cyclone separator.

Control equipments used for the collection of fine particulates includes:

- Bag filters
- Electrostatic precipitators
- Wet collectors (Scrubbers)

Control equipments used for the collection of gaseous pollutants includes:

- Absorption
- Adsorption
- Combustion

Gravity Settling Chambers

Principle: Dust (pollutants) is separated from polluted gas stream under the effect of gravity

Mechanism: The polluted gas stream is allowed to enter gravity settling chamber. The velocity is reduced to about 0.3m/s and sufficient time is provided so that the particles can settle down in horizontal trays under the influence of gravity. Coarser particles settle down in trays from where they are removed. (Fig. 12.2).

Electrostatic precipitator:

Principle: In it the dust particles are removed from polluted gas stream under the influence of electrical field.

Mechanism: Electrostatic dust collectors use electrostatic charges to separate dust from the dusty air stream. A number of high voltage, direct current electrodes (carrying negative charge called discharge electrodes) are placed between grounded electrodes (carrying positive charge called collecting electrodes). The dust borne air stream is passed through the passage between the discharging (negative) electrodes and collecting (positive) electrodes. Dust particles receive a negative charge from the discharging electrodes (ionizing section) and are attracted to the positively charged grounded electrode (collection plates) and fasten on to it. Cleaning is done by rapping or vibrating the collecting electrode wherein dust particles fall away. Cleaning can be done without interrupting the flow. (Fig 12.3 and 12.4)

ESP Advantages

Electrostatic precipitators have the following advantages:

- They have high efficiencies (exceeds 99.9% in some applications)
- Fine dust particles are collected efficiently
- Can function at high temperatures (as high as 700 degree F – 1300 degree F)
- Pressure and temperature changes are small
- Difficult material like acid and tars can be collected
- They withstand extremely corrosive material
- Low power requirement for cleaning
- Dry dust is collected making recovery of lost product easy
- Large flow rates are possible

ESP Disadvantages

- High initial cost
- Materials with very high or low resistivity are difficult to collect
- Inefficiencies could arise in the system due to variable condition of airflow (though automatic voltage control improves collector efficiency)
- They can be larger than baghouses (fabric collectors) and cartridge units, and can occupy greater space
- Material in gaseous phase cannot be removed by electrostatic method
- Dust loads may be needed to be reduced before precipitation process (precleaner may be needed)

Cyclone separators:

Principle: In it the pollutants are removed from gas stream by generation of centrifugal forces.

Working: The dust laden gas from the top of cyclone enters tangentially and hits the wall of the cyclone. From top it starts to move down in circular fashion thereby generating centrifugal forces. Hence, the dust particles are separated from the gas steam till it reaches the bottom of the cyclone. At the bottom the

gas stream follows the middle portion of cyclone and leaves from the top outlet. The collected gas is collected in dust collectors. (fig. 12.4)

Bag filters(Bag houses) Fabric dust collectors are commonly known as baghouses and for some applications are one of the most efficient and cost effective dust collector models. In **baghouse collectors**, the dust filled air stream passes through fabric bags that filter the dust particles. Bags are made of different material such as woven or felted cotton, synthetic, or glass-fiber.

Principle: The dust from polluted air stream is separated by means of a fabric filter (filter cloth.).

Working: It is of 2 types: **a Plenum type:** In it the top end of tubular bag is closed at the upper end and the bottom end is free and has a hopper (for dust collection) attached at the lower end **b. Reverse air bag houses:** In it the bags are clumped at both the ends.

Plenum type: Bags are hung in a bag house. Dust laden gas enters the bag filters which allow the dust to attach onto their surfaces and clean gas to pass through. The collected dust from bags fall into hoppers due to a vibration motion produced by mechanical device attached at the top of the bag house.

Reverse Air Bag House: Also known as the reverse blower dust collector, the reverse air cleaning bag house collects dust which forms regularly forms into a hard 'dust cake' on the dirty side of the filter bag. This type of a dust collector uses high-pressure 'cleaning' air, blown in the 'reverse' or opposite direction of the dust laden stream, to clean the dust cake. In a **reverse fan cleaning dust collector**, polluted air enters the filter bags from the inlet at the bottom and passes through the inside of the bag. Dust particles collect on the walls of the bag. A chain driven motor powered traveling manifold moves across the mouth of the envelope filter bags to provide the cleaning air. The flexing of the collecting bags causes the dust cake to crack and fall into the hopper. The reverse air stream can be used to clean one bag or one row of bags at a time.

Disadvantages

Reverse fan pulse collectors have the following disadvantages:

- Limited use. High manufacturing costs for fans with both high positive air pressure and at high air flow rates
- Expensive and slow damper cleaning operations
- Reversing air fan motor operates continuously to provide pulsed air for cleaning

Scrubber

Traditionally, the term "scrubber" has referred to pollution control devices that use liquid to wash unwanted pollutants from a gas stream.

Wet scrubbing

A wet scrubber is used to clean air, flue gas or other gases of various pollutants and dust particles. Wet scrubbing works via the contact of target compounds or particulate matter with the scrubbing solution. Solutions may simply be water (for dust) or solutions of reagents that specifically target certain compounds.

Dry scrubbing

Dry scrubbing systems are used to remove acid gases (such as SO_2 and HCl) primarily from combustion sources. These are often used for the removal of odorous and corrosive gases from wastewater treatment plant operations. The media used is typically an activated alumina compound impregnated with materials to handle specific gases such as hydrogen sulfide. Media used can be mixed together to offer a wide range of removal for other odorous compounds such as methyl mercaptans, aldehydes, volatile organic compounds, dimethyl sulfide, and dimethyl disulfide.

Spray Tower (Wet scrubbing)

Principle: Dust particulates are removed from polluted gas stream by incorporating liquid droplets.

Mechanism: In it liquid phase is introduced by means of spray nozzles. When dust laden gas stream is introduced from the bottom of spray tower and it moves upwards the particulates collide with water droplets being sprayed by spray nozzles. Thus, dust gets detached from gas stream and gets settled at the bottom of spray tower.(Fig. 12.7)

4.3 Water Pollution

Introduction. A hydrosphere (from Greek *hydor*, "water" and *sphaira*, "sphere") in physical geography describes the combined mass of water found on, under, and over the surface of a planet.

The total mass of the Earth's hydrosphere is about 1.4×10^{18} tonnes, which is about 0.023% of the Earth's total mass. About 20×10^{12} tonnes of this is in the Earth's atmosphere (the volume of one tonne of water is approximately 1 cubic metre). Approximately 75% of the Earth's surface, an area of some 361 million square kilometres (139.5 million square miles), is covered by ocean. The average salinity of the Earth's oceans is about 35 grams of salt per kilogram of sea water (3.5%). Table 12.2 shows the standards for drinking water as per Bureau of Indian Standards specifications.

Definition

'It is defines as presence of foreign substances in water in such quantity that it becomes harmful for living biota if consumed'.

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans and groundwater). Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.

It has been suggested that it is the leading worldwide cause of deaths and diseases, and that it accounts for the deaths of more than 14,000 people daily. An estimated 700 million Indians have no access to a proper toilet, and 1,000 Indian children die of diarrheal sickness every day. Some 90% of China's cities suffer from some degree of water pollution, and nearly 500 million people lack access to safe drinking water. In addition to the acute problems of water pollution in developing countries, industrialized countries continue to struggle with pollution problems as well. In the most recent national report on water quality in the United States, 45 percent of assessed stream miles, 47 percent of assessed lake acres, and 32 percent of assessed bay and estuarine square miles were classified as polluted.

Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources.

Sewage is correctly the subset of wastewater that is contaminated with feces or urine, but is often used to mean any waste water. "Sewage" includes domestic, municipal, or industrial liquid waste products disposed of, usually via a pipe or sewer.

Physical, Chemical and Biological characteristics of Water

A. Physical Characteristics:

- *Total Suspended Solids*
- *Turbidity*
- *Color*
- *Taste and Odor*
- *Temperature*

A. Chemical Characteristics

- *Total Dissolved Solids*
- *Alkalinity*
- *Metals*
- *Fluorides*
- *Organic Matter*
- *Nutrients*
- *Hardness*

Biological Characteristics

Pathogens (Bacteria, Viruses, helminths, Protozoan)

Concept of Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

Dissolved Oxygen (DO): Domestic sewage consists of small amount of oxygen. In due course of time the aerobic bacteria will biochemically oxidize the organic matter present in waste and will utilize the dissolved oxygen from the waste water and hence the DO concentration will decrease and at a time will come when it will be zero. At this stage the sewage will be stable and anaerobic bacteria will start acting on the waste.

Definition: The concentration of oxygen (O_2) dissolved in water, usually expressed in milligrams per liter (mg/L), parts per million, or percent of saturation. DO levels are considered a most important indicator of a water body's ability to support desirable aquatic life.

Biochemical Oxygen Demand (BOD): It is the amount of oxygen required by aerobic bacteria to biochemically oxidize the organic matter present in waste. It is expressed in mg/l. The BOD of waste water can be calculated as follows:

$$\text{BOD (of waste water)} = \text{Depletion in DO} \times \text{Dilution factor}$$

$$\text{Depletion in DO} = \text{DO before incubation} - \text{DO after incubation}$$

$$\text{Dilution factor} = \text{Vol. of undiluted sample (ml)} / \text{Vol. of BOD bottle}$$

Chemical Oxygen Demand (COD): In it chemical oxidants are used instead of aerobic bacteria to oxidize the organic matter.

Category of Water Pollution

Point sources

Point source refers to contaminants that enter a waterway from a single, identifiable source, such as a pipe or ditch.

Non-point sources

Non-point source (NPS) pollution refers to diffuse contamination that does not originate from a single discrete source. NPS pollution is often the cumulative effect of small amounts of contaminants gathered from a large area. A common

example is the leaching out of nitrogen compounds from fertilized agricultural lands. Nutrient runoff in storm water from "sheet flow" over an agricultural field or a forest are also cited as examples of NPS pollution.

Contaminants may include organic and inorganic substances.

Organic water pollutants include:

- Detergents
- Disinfection by-products found in chemically disinfected drinking water, such as chloroform
- Food processing waste, which can include oxygen-demanding substances, fats and grease
- Insecticides and herbicides, a huge range of organohalides and other chemical compounds
- Petroleum hydrocarbons, including fuels (gasoline, diesel fuel, jet fuels, and fuel oil) and lubricants (motor oil), and fuel combustion byproducts, from storm water runoff
- Tree and bush debris from logging operations
- Volatile organic compounds (VOCs), such as industrial solvents, from improper storage. Chlorinated solvents, which are dense non-aqueous phase liquids (DNAPLs), may fall to the bottom of reservoirs, since they don't mix well with water and are denser.
- Various chemical compounds found in personal hygiene and cosmetic products

Inorganic water pollutants include:

- Acidity caused by industrial discharges (especially sulfur dioxide from power plants)
- Ammonia from food processing waste
- Chemical waste as industrial by-products
- Fertilizers containing nutrients--nitrates and phosphates--which are found in storm water runoff from agriculture, as well as commercial and residential use
- Heavy metals from motor vehicles (via urban storm water runoff) and acid mine drainage

- Silt (sediment) in runoff from construction sites, logging, slash and burn practices or land clearing sites

Sources of Water Pollution

- *Domestic sewage*
- *Industrial sewage*
- *Agricultural Runoff*
- *Leachates from solid waste disposal sites*

Control of Water Pollution (Sewage Treatment Plant /STP)

Sewage treatment is the process of removing contaminants from wastewater and household sewage, both runoff (effluents) and domestic. It includes physical, chemical, and biological processes to remove physical, chemical and biological contaminants. Its objective is to produce an environmentally-safe fluid waste stream (or treated effluent) and a solid waste (or treated sludge) suitable for disposal or reuse (usually as farm fertilizer).

Sewage treatment plant (STP) generally involves three stages, called primary, secondary and tertiary treatment.

- *Primary treatment* also known as Mechanical Treatment consists of temporarily holding the sewage in a quiescent basin where heavy solids can settle to the bottom while oil, grease and lighter solids float to the surface. The settled and floating materials are removed and the remaining liquid may be discharged or subjected to secondary treatment.
- *Secondary treatment* also known as Biological treatment removes dissolved and suspended biological matter. Secondary treatment is typically performed by indigenous, water-borne micro-organisms in a managed habitat. Secondary treatment may require a separation process to remove the micro-organisms from the treated water prior to discharge or tertiary treatment.
- *Tertiary treatment* also known as Chemical treatment. In it water is disinfected chemically or physically (for example, by lagoons and microfiltration) prior to discharge into a stream, river, bay, lagoon or wetland, or it can be used for the

irrigation of a golf course, green way or park. If it is sufficiently clean, it can also be used for groundwater recharge or agricultural purposes. (fig. 12.7, 12.8)

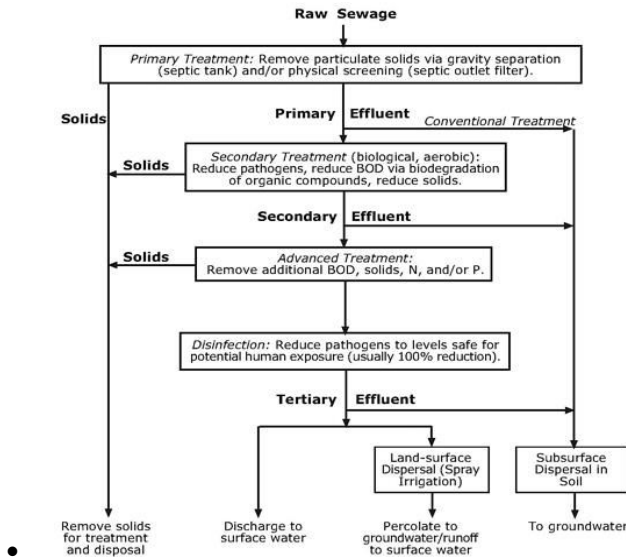


Fig. 12.8 Detailed Wastewater treatment process with all 3 stages

4.4 Noise pollution is excessive noise (unwanted) that disrupts the activity or balance of human or animal life. The word *noise* comes from the Latin word *nauseas*, meaning seasickness.

The source of most outdoor noise worldwide is mainly:

- Construction and transportation systems, including motor vehicle noise, aircraft noise and rail noise.
- Poor urban planning may give rise to noise pollution,
- Industrial and residential buildings can result in noise pollution in the residential area.

Effects of Noise

Human health

- Annoyance and aggression, hypertension, high stress levels, tinnitus, hearing loss, sleep disturbances, and other harmful effects.
- Chronic exposure to noise may cause noise-induced hearing loss. High noise levels can contribute to cardiovascular effects.

Wildlife health

- Noise can have a detrimental effect on animals, increasing the risk of death.
- Reduction of usable habitat that noisy areas may cause, which in the case of endangered species may be part of the path to extinction.

Measurement of Noise

Noise intensity is measured in decibel (dB) units. Decibel scale is a logarithmic scale; each 10 dB increase represents a 10 fold increase in noise intensity.

Control of Noise Pollution

- At Receiver end: Use of ear protection aids like ear muffs, ear plugs, etc to be used to decrease noise intensity.
- At source: Changes in design, etc of machinery and replacing old noisy machines with new quieter machines.
- Proper maintenance of machine parts by lubrication, oiling, etc. at regular specified intervals.
- Sound proof chambers can be designed for noisy machines.
- Automobile noise can be reduced by installing silencers.
- Increase Afforestation will help in noise reduction.

Thermal pollution is the change (degradation) of water quality by any process that changes ambient water temperature.

Cause

A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. When water used as a coolant is returned to the natural environment at a higher temperature, the change in temperature decreases oxygen supply, and affects ecosystem composition. When a power plant first opens or shuts down for repair or other causes, fish and other organisms adapted to particular temperature range can be killed by the abrupt rise in water temperature known as "thermal shock."

Effects

- Elevated temperature typically decreases the level of dissolved oxygen in water.
- Decrease in Biodiversity.
- High temperature limits oxygen dispersion into deeper waters, contributing to anaerobic conditions.
- Primary producers are severely affected because higher water temperature increases plant growth rates, resulting in a shorter lifespan and species overpopulation. This can cause an algae bloom which reduces oxygen levels.
- Temperature changes of even one to two degrees Celsius can cause significant changes in organism metabolism and other adverse cellular biology effects..
- In limited cases, warm water has little deleterious effect and may even lead to improved function of the receiving aquatic ecosystem. This phenomenon is seen especially in seasonal waters and is known as thermal enrichment.

4.5 Soil contamination/Soil pollution

Soil is a medium for plant growth. Plants are primary producers and are the source of food for all living beings. **Soil contamination** or **soil pollution** is caused by the presence of human-made chemicals or other alteration in the natural soil environment.

This type of contamination typically arises from the rupture of underground storage tanks, application of pesticides, percolation of contaminated surface water to subsurface strata, oil and fuel dumping, leaching of wastes from

landfills or direct discharge of industrial wastes to the soil. The most common chemicals involved are petroleum hydrocarbons, solvents, pesticides, lead and other heavy metals. This occurrence of this phenomenon is correlated with the degree of industrialization and intensities of chemical usage.

According to a scientific sampling, 100,000 square kilometers of China's cultivated land have been polluted, with contaminated water being used to irrigate a further 21,670 square kilometers and another 1,300 square kilometers covered or destroyed by solid waste. In total, the area accounts for one-tenth of China's cultivatable land, and are mostly in economically developed areas. An estimated 12 million tonnes of grain are contaminated by heavy metals every year, causing direct losses of 20 billion Yuan (US\$2.57 billion). It has been estimated that about 110 million urban population in India generates more than 55,000 tonnes of refuse everyday and is disposed away. Many laboratories and industries release wastes containing sufficient quantities of different toxic chemicals. These wastes not only destroy the soil ingredients but also pollute ground water after percolation. When waste products are disposed without proper treatments a number of pathogenic organisms are evolved and the habitat produces foul smell. Considerable amount of fertilizers are added to soil to get desired yield by farmers. These chemicals cause serious pollution problems when used carelessly.

Causes

Soil pollution typically arises from the following reasons:

- the rupture of underground storage tanks
- application of pesticides, fungicides, fertilizers
- percolation of contaminated surface water to subsurface strata,
- oil and fuel dumping,
- Leaching of wastes from landfills or direct discharge of industrial wastes to the soil. Treated sewage sludge, known in the industry as biosolids, has become controversial as a fertilizer to the land. As it is the byproduct of sewage treatment, it generally contains contaminants such as organisms, pesticides, and heavy metals than other soil.

Effects

- ***On Health***

Contaminated or polluted soil directly affects human health through direct contact with soil or via inhalation of soil contaminants which have vaporized; potentially greater threats are posed by the infiltration of soil contamination into groundwater aquifers used for human consumption, sometimes in areas apparently far removed from any apparent source of above ground contamination.

Health consequences from exposure to soil contamination vary greatly depending on pollutant type, pathway of attack and vulnerability of the exposed population. Chronic exposure to chromium, lead and other metals, petroleum, solvents, and many pesticide and herbicide formulations can be carcinogenic, can cause congenital disorders, or can cause other chronic health conditions. Industrial or man-made concentrations of naturally-occurring substances, such as nitrate and ammonia associated with livestock manure from agricultural operations, have also been identified as health hazards in soil and groundwater.

Chronic exposure to benzene at sufficient concentrations is known to be associated with higher incidence of leukemia. Mercury and cyclodienes are known to induce higher incidences of kidney damage, some irreversible. PCBs and cyclodienes are linked to liver toxicity. Organophosphates and carbamates can induce a chain of responses leading to neuromuscular blockage. Many chlorinated solvents induce liver changes, kidney changes and depression of the central nervous system. There is an entire spectrum of further health effects such as headache, nausea, fatigue, eye irritation and skin rash for the above cited and other chemicals. At sufficient dosages a large number of soil contaminants can cause death by exposure via direct contact, inhalation or ingestion of contaminants in groundwater contaminated through soil.

- ***On Ecosystem***

There are radical soil chemistry changes which can arise from the presence of many hazardous chemicals even at low concentration of the contaminant

species. These changes can manifest in the alteration of metabolism of endemic microorganisms and arthropods resident in a given soil environment. The result can be virtual eradication of some of the primary food chain, which in turn have major consequences for predator or consumer species.

Control of Soil Pollution

There are several principal strategies for remediation:

- Excavate soil and take it to a disposal site away from ready pathways for human or sensitive ecosystem contact. This technique also applies to dredging of bay muds containing toxins.
- Aeration of soils at the contaminated site (with attendant risk of creating air pollution)
- Thermal remediation by introduction of heat to raise subsurface temperatures sufficiently high to volatilize chemical contaminants out of the soil for vapor extraction.
- Bioremediation*, involving microbial digestion of certain organic chemicals. Techniques used in bioremediation include land farming, biostimulation and bioaugmentation of soil biota with commercially available microflora.
- Extraction of groundwater or soil vapor with an active electromechanical system, with subsequent stripping of the contaminants from the extract.
- Containment of the soil contaminants (such as by capping or paving over in place).
- Phytoremediation or using plants (such as willow) to extract heavy metals.

4.6 Marine Pollution occurs when harmful effects, or potentially harmful effects, can result from the entry into the ocean of chemicals, particles, industrial, agricultural and residential waste, noise, or the spread of invasive organisms. Most sources of marine pollution are land based. The pollution often comes from nonpoint sources such as agricultural runoff and wind blown debris.

Sources

There are three main types of inputs of pollution into the ocean:

- direct discharge of waste into the oceans,
- runoff into the waters due to rain, and
- pollutants that are released from the atmosphere.

Direct discharge: Pollutants enter rivers and the sea directly from urban sewerage and industrial waste discharges, sometimes in the form of hazardous and toxic wastes

Land runoff: Surface runoff from farming, as well as urban runoff and runoff from the construction of roads, buildings, ports, channels, and harbors, can carry soil and particles laden with carbon, nitrogen, phosphorus, and minerals. This nutrient-rich water can cause fleshy algae and phytoplankton to thrive in coastal areas; known as algal blooms, which have the potential to create hypoxic conditions by using all available oxygen.

Ship pollution: Ships can pollute waterways and oceans in many ways. Oil spills can have devastating effects. While being toxic to marine life, polycyclic aromatic hydrocarbons (PAHs), the components in crude oil, are very difficult to clean up, and last for years in the sediment and marine environment.

Discharge of cargo residues from bulk carriers can pollute ports, waterways and oceans. In many instances vessels intentionally discharge illegal wastes despite foreign and domestic regulation prohibiting such actions. Ballast water taken up at sea and released in port is a major source of unwanted exotic marine life.

Control

In order to control marine pollution it is important for humans, individually, to pollute less. That requires social and political will, together with a shift in awareness so more people respect the environment and are less disposed to abuse it. At an operational level, regulations, and international government participation is needed. It is often very difficult to regulate marine pollution because pollution spreads over international barriers, thus making regulations hard to create as well as enforce

4.7 Radioactive pollution can be defined as the emission of high energy particles or radioactive substance into air, water or land due to human activities in the form of radioactive waste. **Radioactive waste** is usually the product of a nuclear process such as nuclear fission, which is extensively used in nuclear reactors, nuclear weapons and other nuclear fuel-cycles.

Radioactive pollution that is spread through the earth's atmosphere is called "**Fallout**". The atmospheric nuclear pollution become prominent during the world war 2 period when United States, Britain and Soviet Union started conducting nuclear tests in the atmosphere. The best example of fallout is the nuclear bomb attack on **Hiroshima and Nagasaki, Japan** in 1945 by United States of America during world war 2. As a result of nuclear bomb attack, nearly 2,25,000 people had died as a result of long-term exposure to radiation from the bomb blast within 5 years of attack due to radiation effect and cancer.

Sources

- nuclear power plants
- nuclear weapon
- transportation
- disposal of nuclear waste
- uranium mining

Effects of Radioactive Pollution on human beings:

Radioactive particles forms ions when it reacts with biological molecules. These ions then form free radicals which slowly and steadily start destroying proteins, membranes, and nucleic acids. A longer exposure to radioactive radiations can damage the **DNA** cells that results in cancer, genetic defects for the generations to come and even death. There are many effects of the radioactive pollution which is broadly classified as short and long range. The first effects were noted in the early 20th century. The people who were working in the uranium mines suffer from skin burn and cancer. These occur due to the radiations from the radioactive material. The different organisms show different sensitivity to the radiations. There are certain conditions in which the oak trees can survive but the pine trees are not able to do so. The plants which

are present at the high altitudes have a multiple set of chromosomes which is referred as a polyploidy. It helps in the protection from radiations. The southern part of our country has a large number of radiations which are harmful and are background in nature and occur in the coastal areas. The cells which divide rapidly are also damaged easily. It includes the skin cells, intestinal cells, bone marrow and gonads. The cells which do not divide rapidly are also not damaged easily. It includes the bone, muscle and nervous cells. The short range effects are known as the immediate effects and occur within the few days. It includes the loss of hair, nails, subcutaneous bleeding, and change in the number of cells and metabolism, change in the proportion of cells. The long range effects are known as the delayed effects and do not occur within the few days. It takes few months to some years to occur. They cause genetic changes, mutations, decrease the life span and form tumors. The human race possesses mutations. The radiation affects all the organisms. In some animals the radioactive materials aggregate and are transferred via food chain. It includes the zinc, iron and strontium.

Control

- Protection from radiation exposure and radiation contamination.
- Exposure to radiation in an area which is restricted.
- As radiations are threat to life so radioactive waste should be changed into harmless form or stored in deep layers of lithosphere so that it can decay..

4.8 Solid Waste and Its Management

Solid waste means any garbage, refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage.

In Simple Words – ‘Solid wastes are any discarded (abandoned or considered waste-like) materials. Solid wastes can be solid, liquid, semi-solid or containerized gaseous material’. Examples of solid wastes: scrap metal, paints,

furniture and toys, domestic refuse (garbage), discarded appliances and vehicles, uncontaminated used oil, construction and demolition debris, asbestos

Solid Waste Management

Waste management is the collection, transport, processing or disposal, managing and monitoring of waste materials. The term usually relates to materials produced by human activity, and is generally undertaken to reduce their effect on health, the environment or aesthetics. Waste management practices differ for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Management for non-hazardous waste residential and institutional waste in metropolitan areas is usually the responsibility of local government authorities, while management for non-hazardous commercial and industrial waste is usually the responsibility of the generator.

Solid waste management can be broadly classified into three headings as:

- *Collection*
- *Waste handling and separation, storage and processing at the source.*
- *Transfer and transport:*
- *Disposal*
- *Recovery*

A. Collection: The 3 basic methods of Solid waste collection are:

- a. **Curbside collection:** In it waste in containers is brought and placed on footway from where it is collected by waste collectors (or collection agency responsible for waste collection).
- b. **Community Collection:** Waste storage bins are placed in fixed places in a community where the generated waste is deposited by households and waste collection agencies collects it.
- c. **Block collection:** In it the individual brings the waste and delivers it to waste collector who empties the waste in waste collection vehicles.

B. Waste handling and separation, storage and processing at the source: Waste handling and separation involves activities associated with waste management until the waste is placed in storage containers for collection.

Handling also encompasses the movement of loaded containers to the point of collection. Separating different types of waste components is an important step in the handling and storage of solid waste at the source.

C. Transfer and transport: This element involves two main steps. First, the waste is transferred from a smaller collection vehicle to larger transport equipment. The waste is then transported, usually over long distances, to a processing or disposal site.

D. Disposal: Methods of disposal include:

a. Incineration: Incineration is a disposal method in which solid organic wastes are subjected to combustion so as to convert them into residue and gaseous products. This method is useful for disposal of residue of both solid waste management and solid residue from waste water management. This process reduces the volumes of solid waste to 20 to 30 percent of the original volume. Incineration and other high temperature waste treatment systems are sometimes described as "thermal treatment". Incinerators convert waste materials into heat, gas, steam and ash. Incineration is carried out both on a small scale by individuals and on a large scale by industry. It is used to dispose of solid, liquid and gaseous waste. It is recognized as a practical method of disposing of certain hazardous waste materials (such as biological medical waste). Incineration is a controversial method of waste disposal, due to issues such as emission of gaseous pollutants.

b. Landfill: Disposing of waste in a landfill involves burying the waste, and this remains a common practice in most countries. Landfills were often established in abandoned or unused quarries, mining voids or borrow pits. A properly designed and well-managed landfill can be a hygienic and relatively inexpensive method of disposing of waste materials. Older, poorly designed or poorly managed landfills can create a number of adverse environmental impacts such as wind-blown litter, attraction of vermin, and generation of liquid leachate. Another common byproduct of landfills is gas (mostly composed of methane and carbon dioxide), which is produced as organic waste breaks down anaerobically. This gas can create odor problems, kill surface vegetation, and is a greenhouse gas.

c. Sanitary landfill: Design characteristics of a modern landfill include methods to contain leachate such as clay or plastic lining material. Deposited waste is normally compacted to increase its density and stability, and covered to prevent attracting vermin (such as mice or rats). Many landfills also have landfill gas extraction systems installed to extract the landfill gas. Gas is pumped out of the landfill using perforated pipes and flared off or burnt in a gas engine to generate electricity.

d. Composting: In it the organic components of solid waste are subjected to bacterial decomposition and results in the formation of humus or compost.

e. Pyrolysis: Solid wastes are heated under anaerobic conditions (burning without oxygen) thereby the organic components of solid waste are fractioned in to liquid and gaseous fractions (CO, CO₂, CH₄, etc).

E. Waste management concepts

There are a number of concepts about waste management which vary in their usage between countries or regions. Some of the most general, widely used concepts include:

- **Waste hierarchy** - The waste hierarchy refers to the "3 Rs" reduce, reuse and recycle, which classify waste management strategies according to their desirability in terms of waste minimization. The waste hierarchy remains the cornerstone of most waste minimization strategies. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste see: resource recovery.
- **Polluter pays principle** - the Polluter Pays Principle is a principle where the polluting party pays for the impact caused to the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the waste.

CHAPTER 5:- GLOBAL ENVIRONMENTAL PHENOMENON AND ITS MANAGEMENT

5.1 Climate Change-What is it?

Climate change is a significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions or the distribution of events around that average (e.g., more or fewer extreme weather events). Climate change may be limited to a specific region or may occur across the whole Earth.

The most general definition of climate change is '*a change in the statistical properties of the climate system when considered over long periods of time, regardless of cause*'. (Education Center – Arctic Climatology and Meteorology. NSIDC National Snow and Ice Data Center. Houghton, John Theodore, ed (2001). http://nsidc.org/arcticmet/glossary/climate_change.html.) Accordingly, fluctuations over periods shorter than a few decades, such as El Niño, do not represent climate change.

Global Environmental Phenomenon

5.2 Acid rain

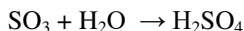
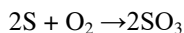
The term "acid rain" was coined in 1872 by Robert Angus Smith. It can be defined as 'the presence of excessive acids in rain water'. It is in fact described as a cocktail containing H_2S , HNO_3 and HCl and the ratio of the three can vary. ". Distilled water, once carbon dioxide is removed, has a neutral pH of 7. Liquids with a pH less than 7 are acidic, and those with a pH greater than 7 are alkaline.

“Clean” or unpolluted rain has a slightly acidic pH of over 5.7, because carbon dioxide and water in the air react together to form carbonic acid, but unpolluted rain also contains other chemicals. Therefore, rain water with pH values lower than 5.7 is called acid rain.

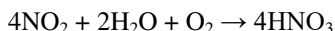
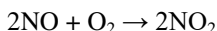
Formation of Acid rain

The principal cause of acid rain formation is the release of Oxides of Sulphur and Nitrogen from earth's surface onto atmosphere by various man-made activities.

i. Oxides of Sulphur: These are emitted to atmosphere by the burning of fossil fuels and by automobile exhausts. The gaseous sulphur is emitted to earth's surface and eventually it is converted to gas. The chemical reactions involved in this reaction are as follows:



ii. Oxides of Nitrogen: These are emitted from power plants and automobiles. The various chemical reactions are as follows:



Effect of Acid Rain on:

Living biota

- Acid rain has been shown to have adverse impacts on forests, freshwaters and soils, killing insect and aquatic life-forms as well as causing damage to buildings and having impacts on human health.
- Both the lower pH and higher aluminum concentrations in surface water that occur as a result of acid rain can cause damage to fish and other aquatic animals. At pH lower than 5 most fish eggs will not hatch and lower pHs can kill adult fish.
- As lakes and rivers become more acidic biodiversity is reduced.
- Acid rain has eliminated insect life and some fish species, including the brook trout in some lakes, streams, and creeks in geographically sensitive areas, such as the Adirondack Mountains of the United States.

Soil

- Soil biology and chemistry can be seriously damaged by acid rain. Some microbes are unable to tolerate changes to low pHs and are killed.
- Base cations, such as calcium and magnesium, are leached by acid rain thereby affecting sensitive species, such as sugar maple (*Acer saccharum*).

Forests and other vegetation

Plants can also be damaged by acid rain, but the effect on food crops is minimized by the application of lime and fertilizers to replace lost nutrients. In cultivated areas, limestone may also be added to increase the ability of the soil to keep the pH stable, but this tactic is largely unusable in the case of wilderness lands. When calcium is leached from the needles of red spruce, these trees become less cold tolerant and exhibit winter injury and even death.

On materials

Acid rain can also damage buildings and historic monuments, especially those made of rocks such as limestone and marble containing large amounts of calcium carbonate. Acids in the rain react with the calcium compounds in the stones to create gypsum, which then flakes off.



The effects of this are commonly seen on old gravestones, where acid rain can cause the inscriptions to become completely illegible. Acid rain also increases the oxidation rate of metals, in particular copper and bronze.

5.3 Green House effect: *Green house effect is a phenomenon due to which earth retains heat. The greenhouse effect heats the earth because greenhouse gases absorb outgoing radiative energy and re-emit some of it back towards earth. It was proposed by Joseph Fourier in 1824 and was first investigated quantitatively by Svante Arrhenius in 1896.*

Phenomenon

The incoming radiation from the Sun is mostly in the form of visible light and nearby wavelengths, largely in the range 0.2–4 μm . About 50% of the Sun's energy is absorbed at the Earth's surface and the rest is reflected or absorbed by the atmosphere. The absorbed energy warms the surface. The surface of the Earth, warmed to a temperature around 255 K, radiates long-wavelength, infrared heat in the range 4–100 μm . At these wavelengths, greenhouse gases that were largely transparent to incoming solar radiation are more absorbent. Each layer of atmosphere with greenhouse gases absorbs some of the heat being radiated upwards from lower layers. To maintain its own equilibrium, it re-radiates the absorbed heat in all directions, both upwards and downwards. This results in more warmth below thereby causing the phenomenon of greenhouse effect.

Green house gases

Naturally occurring greenhouse gases have a mean warming effect of about 33 °C (59 °F). The major greenhouse gases are water vapor, which causes about 36–70 percent of the greenhouse effect; carbon dioxide (CO_2), which causes 9–26 percent; methane (CH_4), which causes 4–9 percent; and ozone (O_3), which causes 3–7 percent. Clouds also affect the radiation balance, but they are composed of liquid water or ice and so have different effects on radiation from water vapor.

Global warming is the current rise in the average temperature of Earth's oceans and atmosphere. It is occurring and was initiated by human activities, especially those that increase concentrations of greenhouse gases in the atmosphere, such as deforestation and burning of fossil fuels. This increase in the CO_2 concentration in the atmosphere results in warming of atmosphere. According to the 2007 report of the Intergovernmental Panel on Climate Change (IPCC), the "best estimate" of future warming is 3.4°C (6.1°F) by 2100, with a likely range from 2.0–5.4°C (3.6–9.7°F). This exceeds the 2°C threshold for dangerous climate change recognized by the United Nations Framework Convention on Climate Change, and warming from this century's emissions will extend well beyond 2100 due to the longevity of some greenhouse gases in the atmosphere.

Global warming can be defined as “Blanketing effect of carbon dioxide and other similar gaseous molecules just over the earth's surface that allows the shorter incoming solar radiations (eg, visible radiations) to come through in but does not allow the longer outgoing terrestrial radiations (infrared radiations) to escape from the atmosphere thereby increasing the earth's temperature”.

Effects of global warming

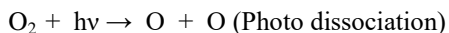
- Sea level will rise and decrease in snow and ice content.
- In terrestrial ecosystems, the earlier timing of spring events, and pole ward and upward shifts in plant and animal ranges, has been linked with warming.
- It is expected that most ecosystems will be affected by higher atmospheric CO₂ levels, combined with higher global temperatures. Overall, it is expected that climate change will result in the extinction of many species and reduced diversity of ecosystems.

5.4 Ozone layer and its depletion

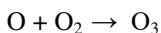
Ozone is a O₃ molecule found in stratosphere. It acts as a shield against the harmful Ultra violet radiations and thus, prevents from reaching on the surface of earth.

Formation and destruction reactions of ozone

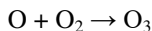
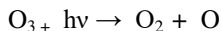
Ozone is formed in the stratosphere by photodissociation of oxygen molecules after absorbing an ultraviolet photon whose wavelength is shorter than 240nm. A single oxygen molecule is converted into two atomic oxygen ions as:



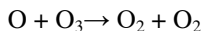
These atomic oxygen ions then combine with separate oxygen molecules to form O₃ molecules as follows:



These O₃ molecules absorb ultraviolet radiations between 310 and 200 nm range and O₃ split into a molecule of O₂ and an oxygen atom as follows:



It is a continuous process which terminates when an oxygen atom recombines with ozone molecule to make two oxygen molecules:



These reactions are known as Chapman Reactions.

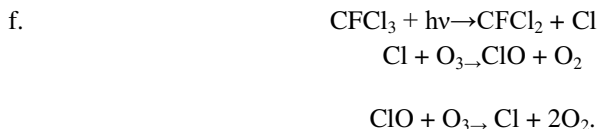
Units of measurement of ozone thickness: The thickness of ozone layer is measured in terms of Dobson Unit (DU) where 1DU= 0.01mm of compressed gas at 0°C and 760mm Hg Pr.

Ozone Depletion Process

The Antarctic ozone hole is an area of the Antarctic stratosphere in which the recent ozone levels have dropped to as low as 33% of their pre-1975 values.. Most of the ozone layer depletion process occurs in the lower stratosphere compared to much smaller depletion primarily through gas-phase reactions in upper stratosphere.

- a. **Formation of polar vortex:** During Antarctic spring (September to early December) strong westerly winds starts to circulate around the continent and creates an atmospheric container (Polar vortex). Within this polar vortex over 50% of stratospheric ozone gets destroyed.
- b. **Decrease in temperature:** Polar Regions during winter remain dark without sunlight. Lack of sunlight further decreases the temperature (about and below - 800C). These low temperatures favor the formation of cloud particles known as Polar Stratospheric Clouds (PSC's). These PSC's provides surfaces for the chemical reactions that lead to the ozone destruction.
- c. **Role of CFC'S and Hydrocarbons:** The primary cause of ozone depletion is the presence of chlorine containing source gases (Chloroflouro carbons and hydrocarbons). Most of the chlorine in the stratosphere resides in the stable reservoir compounds primarily hydrochloric acid (HCl)and chlorine nitrate (ClONO₂). PSC's covert HCl and ClONO₂ into reactive free radicals as Cl and ClO. PSC's also remove NO₂ from atmosphere by converting it into HNO₃ which prevents ClO from being converted back into ClONO₂.

- d. **Arrival of Spring season:** With the onset of the spring season, the sun comes out and provides energy to drive photochemical reactions, melts PSC's and releases the trapped compounds.
- e. **Destruction of Ozone.:** In the presence of Ultraviolet radiation the Ozone destruction starts as follows:



A single chlorine atom would keep on destroying ozone (thus a catalyst) for up to two years (the time scale for transport back down to the troposphere) were it not for reactions that remove them from this cycle by forming reservoir species such as hydrogen chloride (HCl) and chlorine nitrate (ClONO₂). On a per atom basis, bromine is even more efficient than chlorine at destroying ozone, but there is much less bromine in the atmosphere at present. As a result, both chlorine and bromine contribute significantly to the overall ozone depletion. Laboratory studies have shown that fluorine and iodine atoms participate in analogous catalytic cycles.

Effects of Ozone layer depletion

- The most common forms of skin cancer in humans, basal and squamous cell carcinomas, have been strongly linked to UVB exposure.
- Another form of skin cancer, malignant melanoma, is much less common but far more dangerous, being lethal in about 15–20% of the cases diagnosed.
- An increase of UV radiation would be expected to affect crops. A number of economically important species of plants, such as rice, depend on cyanobacteria residing on their roots for the retention of nitrogen. Cyanobacteria are sensitive to UV light and they would be affected by its increase.

CHAPTER 6:-DISASTER MANAGEMENT

6.1 Definition

Disaster: *“Is a natural or human-caused event which causes intensive negative impacts on people, goods, services and/or the environment, exceeding the affected community’s capability to respond”.*

Disaster management can be defined as *‘the organization and management of resources and responsibilities for dealing with all humanitarian aspects of emergencies, in particular preparedness, response and recovery in order to lessen the impact of disasters’.*

Disaster management is a systematic process (i.e., is based on the key management principles of *planning, organizing, and leading* which includes *coordinating* and *controlling*) Aims to reduce the negative impact or consequences of adverse events (i.e., disasters cannot always be prevented, but the adverse effects can be minimized).

6.2 Types of Disasters

There is no country that is immune from disaster, though vulnerability to disaster varies. **There are four main types of disaster.**

- **Natural disasters.** These disasters include floods, hurricanes, earthquakes and volcano eruptions that can have immediate impacts on human health, as well as secondary impacts causing further death and suffering from floods causing landslides, earthquakes resulting in fires, tsunamis causing widespread flooding and typhoons sinking ferries
- **Environmental emergencies.** These emergencies include technological or industrial accidents, usually involving hazardous material, and occur where these materials are produced, used or transported. Large forest fires are generally included in this definition because they tend to be caused by humans.
- **Complex emergencies.** These emergencies involve a break-down of authority, looting and attacks on strategic installations. Complex emergencies include conflict situations and war.

- **Pandemic emergencies.** These emergencies involve a sudden onset of a contagious disease that affects health but also disrupts services and businesses, bringing economic and social costs.

Classification of disasters according to their:

a causes – natural vs. human

b speed of onset – sudden vs. slow

A. Causes

Natural Disasters

These types of disaster naturally occur in proximity to, and pose a threat to, people, structures or economic assets. They are caused by biological, geological, seismic, hydrologic, or meteorological conditions or processes in the natural environment (e.g., cyclones, earthquakes, tsunamis, floods, landslides, and volcanic eruptions).

Human-Made Disasters

These are disasters or emergency situations of which the principal, direct causes are identifiable human actions, deliberate or otherwise. Apart from “technological disasters” this mainly involves situations in which civilian populations suffer casualties, losses of property, basic services and means of livelihood as a result of war, civil strife or other conflicts, or policy implementation. In many cases, people are forced to leave their homes, giving rise to congregations of refugees or externally and/or internally displaced persons as a result of civil strife, an airplane crash, a major fire, oil spill, epidemic, terrorism, etc.

Speed of onset

Sudden onset: little or no warning, minimal time to prepare. For example, an earthquake, tsunami, cyclone, volcano, etc.

Slow onset: adverse event slow to develop; first the situation develops; the second level is an emergency; the third level is a disaster. For example, drought, civil strife, epidemic, etc. The main hazards a region is, or may be vulnerable to, will depend on the geographic location of the country. In Samoa, for example, the main hazards which may turn into disasters are:

- Cyclones
- Earthquakes
- Tsunami
- Flooding
- Landslides
- Epidemics

Disaster management is linked with sustainable development, particularly in relation to vulnerable people such as those with disabilities, elderly people, children and other marginalized groups.

Difference between an emergency and a disaster situation

An **emergency** is a situation in which the community is capable of coping. It is a situation generated by the real or imminent occurrence of an event that requires immediate attention and that requires immediate attention of emergency resources.

A **disaster** is a situation in which the community is incapable of coping. It is a natural or human-caused event which causes intense negative impacts on people, goods, services and/or the environment, exceeding the affected community's capability to respond; therefore the community seeks the assistance of government and international agencies.

6.3 Disaster Management Cycle

Disaster management is a cyclical process; the end of one phase is the beginning of another (see diagram below), although one phase of the cycle does not necessarily have to be completed in order for the next to take place. Often several phases are taking place concurrently. The diagram below shows the Disaster Management Cycle.



Fig. Disaster Management Cycle

Phase -I

Disaster Mitigation: Mitigation refers to all actions taken before a disaster to reduce its impacts, including preparedness and long-term risk reduction measures. Measures put in place to minimize the results from a disaster. Examples: building codes and zoning; vulnerability analyses; public education.

Mitigation activities fall broadly into two categories:

1 Structural mitigation – construction projects which reduce economic and social impacts

2 Non-structural activities – policies and practices which raise awareness of hazards or encourage developments to reduce the impact of disasters.

Mitigation strategies

Two aspects of mitigation include:

- 1 Hazard identification and vulnerability analysis and
- 2 Various mitigation strategies or measures.

Phase-II

Preparedness: Planning how to respond. Actions taken before the onset of a disaster so that a government can successfully discharge its emergency management responsibilities, such as establishing authorities and

responsibilities for emergency actions and garnering the resources to support them.

Examples: preparedness plans; emergency exercises/training; warning systems.

Disaster Preparedness

Disaster preparedness is defined as a **continuous and integrated process involving a wide range of activities and resources from multi-sectoral sources**. (*Disaster Preparedness Training Programme; International Federation of Red Cross and Red Crescent Societies, IFRCRC, 2005*). The goal of emergency preparedness programmes is to achieve a satisfactory level of readiness to respond to any emergency situation through programmes that strengthen the technical and managerial capacity of governments, organizations, and communities. These measures can be described as logistical readiness to deal with disasters and can be enhanced by having response mechanisms and procedures, rehearsals, developing long-term and short-term strategies, public education and building early warning systems. Preparedness can also take the form of ensuring that strategic reserves of food, equipment, water, medicines and other essentials are maintained in cases of national or local catastrophes. During the preparedness phase, governments, organizations, and individuals develop plans to save lives, minimize disaster damage, and enhance disaster response operations. Preparedness measures include:

- Preparedness plans
- Emergency exercises/training
- Warning systems
- Emergency communications systems
- Evacuations plans and training
- Resource inventories
- Emergency personnel/contact lists
- Mutual aid agreements
- Public information/education

As with mitigation efforts, preparedness actions depend on the incorporation of appropriate measures in national and regional development plans.

Phases III and IV: Response and Recovery

Response: Initial actions taken as the event takes place. It involves efforts to minimize the hazards created by a disaster. Examples: evacuation; search and rescue; emergency relief. Disaster response is the sum total of actions taken by people and institutions in the face of disaster. These actions commence with the warning of an oncoming threatening event or with the event itself if it occurs without warning. The focus in the response and recovery phases of the disaster management cycle is on meeting the basic needs of the people until more permanent and sustainable solutions can be found.

Aims of disaster response

The overall aims of disaster response are:

- To ensure the survival of the maximum possible number of victims, keeping them in the best possible health in the circumstances.
- To re-establish self-sufficiency and essential services as quickly as possible for all population groups, with special attention to those whose needs are greatest: the most vulnerable and underprivileged.
- To repair or replace damaged infrastructure and regenerate viable economic activities. To do this in a manner that contributes to long-term development goals and reduces vulnerability to any future recurrence of potentially damaging hazards.
- In situations of civil or international conflict, the aim is to protect and assist the civilian population, in close collaboration with the International Committee of the Red Cross (ICRC) and in compliance with international conventions.
- In cases involving population displacements (due to any type of disaster) the aim is to find durable solutions as quickly as possible, while ensuring protection and assistance as necessary in the meantime.

Recovery: Returning the community to normal. Ideally, the affected area should be put in a condition equal to or better than it was before the disaster took place. Examples: temporary housing; grants; medical care.

Recovery activities are classified as **short-term** and **long-term**.

a Short-term recovery is immediate and tends to overlap with response. The authorities restore interrupted utility services, clear roads, and either fix or demolish severely damaged buildings. Additionally, there may be a need to provide food and shelter for those displaced by the disaster. Although called short-term, some of these activities may last for weeks

b Long-term recovery may involve some of the same activities, but it may continue for a number of months, sometimes years, depending on the severity and extent of the damage sustained. For example, it may include the complete redevelopment of damaged areas. The goal is for the community to return to a state that is even better than before the emergency.

Recovery activities continue until all systems return to normal or better. Recovery measures, both short and long term, include returning vital life-support systems to minimum operating standards; temporary housing; public information; health and safety education; reconstruction; counseling programmes; and economic impact studies. Information resources and services include data collection related to rebuilding, and documentation of lessons learned. Additionally, there may be a need to provide food and shelter for those displaced by the disaster.

CHAPTER 7:-B



ASIC CONCEPT OF ENVIRONMENTAL IMPACT ASSESSMENT

7.1 What is EIA?

EIA can be defined as *“a systematic process to identify, predict and evaluate the environmental effects of proposed actions and projects.* The EIA process is applied prior to major decisions and commitments being made and ideally is integrated into the project design process.

The role of EIA is to inform the decision maker of the significant environmental impacts that are likely to occur if the development proposal is granted consent.

7.2 Environmental Impact Assessment Principles

There are eight guiding principles that govern the entire process of EIA and they are as follows:

Participation: An appropriate and timely access to the process for all interested parties.

Transparency: All assessment decisions and their basis should be open and accessible.

Certainty: The process and timing of the assessment should be agreed in advanced and followed by all participants.

Accountability: The decision-makers are responsible to all parties for their action and decisions under the assessment process.

Credibility: Assessment is undertaken with professionalism and objectivity.

Cost-effectiveness: The assessment process and its outcomes will ensure environmental protection at the least cost to the society.

Flexibility: The assessment process should be able to adapt to deal efficiently with any proposal and decision making situation.

Practicality: The information and outputs provided by the assessment process are readily usable in decision making and planning.

The EIA Process

The EIA process is an iterative one containing many feedback loops to allow the development proposal to be continually refined. So whilst the process of EIA follows a number of commonly accepted steps, it does not observe a linear pattern. The EIA process is summarized in the figure below.

Generalised EIA Process Flow chart

