Chapter 1

Introduction to Environment and Environmental Pollution

1.1 Introduction

1.1.1 Earth-Blue Planet

Earth our home planet is the third planet from the sun and only place we know of so far that's inhabited by living things. Earth is only the fifth largest planet in the solar system; it is the only world in our solar system with liquid water on the surface. Just slightly larger than nearby Venus, Earth is the biggest of the four planets closest to the sun all of which are made of rock and metal.

Why Earth is called 'Blue Planet'? The name Earth is at least thousand years old. All the planets except for earth where are named after Greek and Roman Gods and Goddesses. However the name Earth come from German word which simply means the ground. Earth is known as the blue planet because of the vast oceans that cover two-thirds of its surface. When seen from space our world looks like a pale Blue Dot.

1.2 Environment

The word environment literally means surroundings. It includes the surrounding objects,regions conditions and especially circumstances of life of all living beings. **Environmental Chemistry** deals with study of chemical phenomena in the environment. It is in fact multidisciplinary in the sense that it embraces Chemistry, Physics, Life sciences, Agricultural science, public health and a lot of other disciplines. It includes study of the sources reactions and fates of the chemical species in the air water and soil environment. It is an important part of the general environmental studies and studies on the effects of human activities upon environmental segments. Study of the interactions between the different types of living organisms as well as that between the living organisms and the non living components of the environment is called **ecology or environmental biology.** The environmental conditions that can direct regulate and influence the life processes and activities of living organisms are called environmental factors or ecological factors. The major ecological factors which affect the environment are the following.

1. Topographic factors :-these include factors related to attitude mountain ranges plateaus valleys plains seas rivers lakes etc.

2. Climatic factors these include temperature humidity light heat wind snow rain etc. iii. Edaphic factors these include media such as air water soil etc.

3. Chemical factors these include media sorry atmospheric gases salinity pH biogenic compounds (essential for life) etc.

4. Biotic factors these include all types of interactions between different living organisms.

In his attempt to modify environment and improve the quality of his life, man has interfered constantly with environment and this has raised very many environmental issues which threaten

the very sustenance of life on earth. It is in this context that environmental education assumes importance. It aims at enlightening the public about the grave environmental issues the importance of protection and conservation of our environment and the need for restrained in all activities which would have the environment.

Environment Environment can be defined as the sum total of all social economical, biological physical and chemical factors which constitutes the surroundings and influence the life of a living organism in its habitat.

Environment consists of the following three components.

1. Abiotic or non living component:- this consists of the lithosphere (sold earth), hydrosphere (water component) and atmosphere (gaseous envelope)
2. Biotic or living components:- this consists of all living organisms.
3. Energy commodity this includes solar energy, geo chemical energy, thermo electric energy, hydroelectric energy, nuclear energy etc..

1.2.1 Segments of environment

Environment consists of four segments namely

I. Atmosphere

II. Hydrosphere

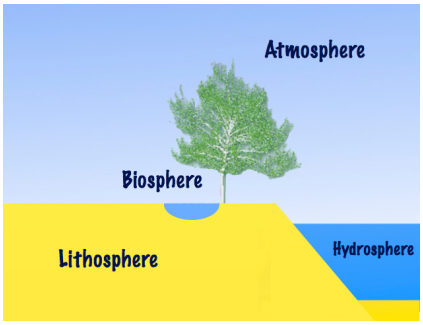
III. Lithosphere and

IV. Biosphere.

1.3 Atmosphere

Atmosphere is the protective cover of gases surrounding the earth which sustains life on earth and saves it from hostile environment of outer space. On account of gravitational force, this this envelope has the maximum density at the sea level, but things rapidly towards the upper regions. Its major components are nitrogen and oxygen. It also contains some carbon dioxide Argon and ozone as well as traces of helium neon methane etc.

The atmosphere serves several functions



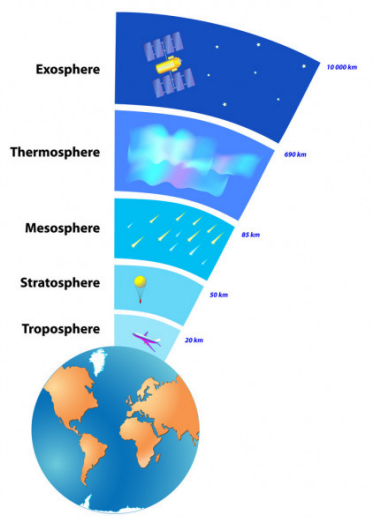
1. It absorbs most of the cosmic rays and all the harmful solar radiation. It allows only the near ultraviolet near-infrared and radio frequency waves to pass through it towards earth.
2. It absorbs part of infrared radiation emitted by the sun and also that re emitted by earth. If thereby maintains the thermal balance of the earth.
3. It acts as a source of oxygen for living organisms, carbon dioxide for plants and nitrogen for plants, nitrogen fixing bacteria etc.
4. It acts as the vital carrier of water from the oceans to land as the part of the hydrological cycle.

1.3.1 Layers of Atmosphere

The atmosphere is divided into several layers as follows:

1.3.2 Troposphere

Troposphere starts at the Earth's surface and extends 8 to 14.5 kilometre height(5 to 9 miles).



This part of the atmosphere is the most dense. Almost all weather is in this region. It is the lowest layer of atmosphere of the Earth and the layers to which changes can greatly influence the floral and faunal environments. The troposphere extends from the surface of the earth to a height of approximately 30,000 feet at the polar regions to approximately 56,000 feet at the equator with some variations due to whether. The troposphere is bounded above by Tropopause, a boundary marked in most places by a temperature inversion (a layer of relatively warm air above a colder one) and in others by a zone which is isothermal with height.

1.3.3 Stratosphere

The next layer up is called the stratosphere. It extends from the top of the Troposphere to about 50 km (31) miles above the ground. The infamous Ozone layer is found within the stratosphere. Ozone molecules in this layer absorb high energy ultraviolet light(UV) from the sun, converting the UV energy into heat. Unlike the troposphere the stratosphere actually gets warmer, the higher you go. That trend of rising temperatures with altitude means that air in the stratosphere lacks the turbulence and updrafts of the troposphere beneath. Commercial passenger jets fly in the lower stratosphere, partly because this less turbulent layer provides a smoother ride. The jet stream flows near the border between the troposphere and the stratosphere.

1.3.4 Mesosphere

Mesosphere lies just above Stratosphere. It extends to a height of 85 km(53 miles)above earth. Most meteors burn up in this layer. Unlike stratosphere temperatures once again grow colder as you rise up through the mesosphere. The coldest temperatures in Earth's atmosphere is about -90^{0}C or -130^{0}F are found near the top of this layer. The air in the mesosphere is far too thin to breath; The air pressure at the bottom of the layer is well below 1% of the pressure at the sea level and continues dropping as you go higher.

1.3.5 Thermosphere

The layer of very rare air above the mesosphere is called the Thermosphere. High energy X-rays and UV radiation from the sun are absorbed in thermosphere raising is temperature to hundreds or thousands of degrees. However the air in this layer is so thin that it would feel freezing cold to us! In many ways the thermosphere is more like outer space than a part of the atmosphere. Many satellites actually orbit earth within the thermosphere. Variations in the amount of energy coming from the sun exert a powerful influence on both the height of the top of this layer and the temperature within it. Because of these the top of thermosphere can be found anywhere between 500 and 1000 kilometres (311 to 621 miles) above the ground. Temperature in the upper atmosphere can range from about 500^{0}C (or 932^{0}F) 2000^{0}C (or 3632^{0}F) or higher. The aurora, the northern lights and southern lights occur in the thermosphere.

1.4 Hydrosphere

The history of human civilization reveals that water supply and civilization are almost synonymous. Several cities and civilisations have disappeared due to water shortages originating from climatic changes. Millions of people all over the world, particularly in the developing countries, are losing their lives every year from water-borne diseases. Water chemistry includes multi-dimensional aspects of aquatic environmental chemistry which involve te sources, composition, reactions and transport of water.

About 97% of the earth's water supply is in the ocean, which is unfit tor human consumption and other uses because of its high salt content. Of the remaining 3, 2% is locked in the polar ice caps and only 1% is available as fresh water in rivers, lakes, streams, reservoirs and ground water which is suitable for human consumption.

Ground water and surface water used by man are of different characteristics. Ground water

contains dissolved minerals from the soil layers through which it passes. In the process of seepage through the ground, the water gets depleted of most of the micro-organism originally present in the surface water. Though the salt content may be excessively high on occasions, it is generally superior as a domestic water source. Surface water contains a lot of organic matter and mineral nutrients which feed algae and large bacteria populations.

The mass balance of annual rainfall shows that about 70% is lost by direct evaporation and transpiration by plants, while the remaining 30% goes into the streamflow. The approximate breakup of this streamflow, as consumed by man, is 8% for irrigation, 2% for domestic use, 4% for industries and 12% for electrical utilities. Irrigation for agricultural purposes and electric power plants are the major consumers of water. The surface water resources continue to be contaminated with run-off water from agricultural fields, containing pesticides, fertilisers, soil particles, waste chemicals from industries and sewage from cities and rural areas. If the water is to be reused, it must be purified. World Health Organization (WHO) has estimated that water consumption will have to be cut by 50% by 2025, if nations fail to address imbalances in global water supply and demand. Some European companies have ventured into water business by supplying water to water thirsty countries across the oceans. Nordic water supply (Norwegian company) has been transporting fresh water (clean drinking water) in giant floating bags across the oceans. These floating bags sausage-shaped bags, about 200-m long and containing 35,000 tonnes of water each. The floating water bags are made ot a poyester fabric coated with plastic and are 2.0-mm (0.08 inch) thick: In future, the company plans to build new bags of the size of supertanker, 300-m long and a capaciy of 60,000 tonnes.

1.4.1 Water Resources

Water resources are sources of water that are useful or potentially useful to humans. Uses of water include agricultural, industrial, household, recreational and environmental activities. Virtually all of these human uses require fresh water. Fresh water is a renewable resource, yet the world's supply of clean, fresh water is steadily decreasing. Water demand already exceeds supply in many parts of the world and as the world population continues to rise, so too does the water demand. Awareness of the global importance of preserving water for ecosystem services has only recently emerged as, during the 20th century, more than half the world's wetlands have been lost along with their valuable environmental services. Biodiversity-rich freshwater ecosystems are currently declining faster than marine or land ecosystems. The framework for allocating water resources to water users (where such a framework exists) is known as water rights.

Fresh Water Resources

Water resources are divisible into two distinct categories : the surface-water resources and the ground-water resources. Each of these categories is a part of the earth's water circulatory system, called the hydrologic cycle, and is derived from precipitation, which is rainfall plus snow.

Surface Water Surface water is water in a river, lake or fresh water wetland. Surface water is naturally replenished by precipitation and naturally lost through discharge to the oceans, evaporation, and sub-surface seepage. Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system at any given time is also dependent on many other factors. These factors include storage capacity in lakes, wetlands and artificial reservoirs, the permeability of the soil beneath these storage bodies, the run-off characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors also affect the proportions of water lost.

Ground Water Sub-surface water, or groundwater, is fresh water located in the pore space of soil and rocks. It is also water that is flowing within aquifers below the water table. Sometimes it is useful to make a distinction between sub-surface water that is closely associated with surface water and deep sub-surface water in an aquifer (sometimes called "fossil water"). The natural input to sub-surface water is seepage from surface water. The natural outputs from sub-surface water are springs and seepage to the oceans.

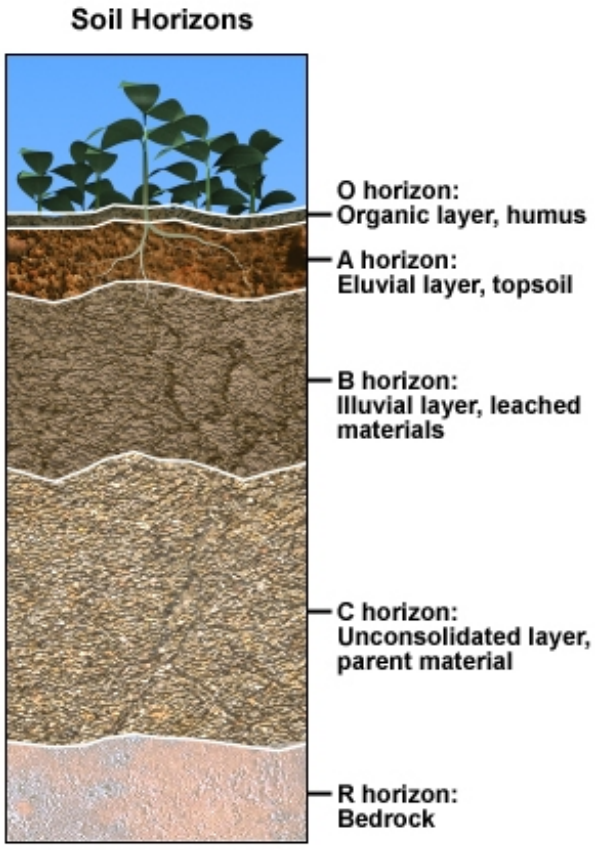
Desalination Desalination is an artificial process by which saline water (generally sea water) is converted to fresh water. The most common desalination processes are distillation and reverse osmosis. Desalination is currently expensive compared to most alternative sources of water, and only a very small fraction of total human use is satisfied by desalination. It is only economically practical for high-valued uses (such as household and industrial uses) in arid areas. The most extensive use is in the Persian Gulf.

Frozen Water Several schemes have been proposed to make use of icebergs as a water source, however to date this has only been done for novelty purposes. Glacier run-off is considered to be surface water. The Himalayas, which are often called "The Roof of the World", contain some of the most extensive and rough high altitude areas on Earth as well as the greatest area of glaciers and permafrost outside of the poles. Ten of Asia's largest rivers flow from there, and more than a billion people's livelihoods depend on them.

1.5 Lithosphere

Lithosphere is the outer mantle of solid Earth consisting of minerals occurring in the earth's crust in the form of soil rocks etc. Soil, in fact, comprises of a mixture of minerals, organic matter weathered rocks, air and water. Rocks consists of various minerals like asbestos, gypsum, clay, haematite, calcite, quarts, etc. Rocks are subjected to continuous processes of physical, chemical, and biological (attack by lichens) weathering. The resulting primitive soil is colonized by higher plants and, in course of time, plant debris return to the soil as plants die and leaves fall to the ground. The organic matter in soil is decomposed by a host of micro-organisms and the biomass is mixed by the soil fauna.

Soil plays a very important role as it produces food for human beings and animals. Good soil and a congenial climate for productivity are valuable assets for any nation. But, due to human activities, soil is the receptor of many pollutants including pesticides, fertilisers, particulate matter for power-plant smoke stacks, etc. Hence soil is an important component of environmental chemical cycles.



Soil, in general, has a loose texture consisting of solid mineral and organic matter, air and spaces.

The figure shows distinctive layers with increasing depth. These layers are called horizons. The top layer, several inches in thickness, is known as the top soil or A horizon. Hence it is of maximum biological activity in the soil and contains bulk of the organic matter. Hence it is of considerable importance for vegetation cover and agricultural crops. A horizon is subject to considerable leaching due to reckless deforestation.

Next is the B horizon subsoil. It receives materials-organic matter, salts, or clay particles leached from the top soil. The next layer, C horizon is composed of weathered parent rocks from which the soil originated. The mineral component of soil originates from the parent rocks by weathering processes, while the organic component is due lo plant biomass in various types of decay as well as high populations of bacteria, fungi, and animals such as earthworms. A typical productive soil consists of approximately 5% organic matter and 95% inorganic matter.

Plants require large quantities of water for their sustenance and growth. Water is a part of this solid-liquid-gas system making up soil. Due to the splenial size of soil particles and presence of small

capillaries and pores in the soil, the water phase depends on the soil solid matter. Water present in larger spaces in soil is relatively more available to plants and readily drains away. But water held in smaller pores or between the unit layers of clay particles is bound more strongly. Soil rich in organic mater may hold relatively large amount of water compared to other soils but it is relatively less available to plants due to physical and chemical sorption of water by organic matter. There is strong affinity between clays and water in soil. Colloidal clay particles have high surface/volume ratio so that a large amount of water remains adsorbed on the surfaces of clay particles. About 35% of the volume of a typical soil consists of air filled pores. The percent of CO_2 and O_2 are 0.25 to 20% and 15 to 20% respectively and are different from atmosphere. In addition soil contain minerals known as micronutrients and macronutrients.

Inorganic and Organic components in Soil

The soil is essentially silicate mineral. 74.3% of which consists of silicon and oxygen. The common elements in soil are Oxygen46.6%, silicon 27.7% aluminium 8.1% iron 5.0% calcium 3.6%, sodium 2.8%, potassium 2.6% and magnesium, 2.1%. The clay minerals are secondary minerals, essentially hydrated aluminium and iron silicates, which serve to bind cations such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, and NH_4^{+} which do not leach by water and are available as plant nutrients.

The organic matter constitutes less than 5% of the soil. The organic matter provides food for micro-organisms, takes part in chemical reactions, such as ion exchange, governs the physical properties of soil, and some times contributes to the weathering of mineral matter. The biologically active components of organic matter consists of polysaccharides, amino sugars, nucleotides, organic sulphur and phosphorous compounds.

Micronutrients and Macronutrients

For plants, the essential micronutrients are boron, chlorine, sodium, copper, iron, manganese, zinc, vanadium, and molybdenum. These elements are required at trace levels and if present in higher levels have toxic effect. Most of these serve as components of essential enzymes. Some of them such as chlorine, magnesium, iron, zinc and vanadium are likely to take part in photosynthesis. The essential macronutrients are carbon, hydrogen, oxygen, nitrogen, phosphorous, sulphur, potassium, calcium, and magnesium. These minerals constitute separate pathways like nitrogen cycle, carbon cycle, sulphur cycle, etc.

Wastes and Pollutants in Soil

Soil is the receptor of large quantities of waste products- domestic, human, animal, industrial and agricultural. Combustion of sulphur containing fuels emits SO_2 and leaves sulphates in the soil.Particulate lead from auto mobile exhausts settles on soil, especially along both sides of highways with heavy traffic.Fertilisers and pesticides applied to crops are largely retained by the soil.

1.6 Biosphere

Biosphere denotes the realm of living organism and their interactions with the environment, namely, lithosphere, hydrosphere and atmosphere. Thus in the biosphere living organisms like plants and animals live together being dependent on each other and also interact with other segments of the environment.

The biosphere is the global sum of all ecosystems. It can also be termed the zone of life on Earth, a closed system (apart from solar and cosmic radiation and heat from the interior of the Earth), and largely self-regulating. Biosphere has a geological origin, it is an indication of the effect of both Charles Darwin and Matthew F. Maury on the Earth sciences. It is an interdisciplinary concept for integrating astronomy, geophysics, meteorology, biogeography, evolution, geology, geochemistry, hydrology and generally speaking, all life and Earth sciences.

The Geologist Eduard Suess in 1875, defined Biosphere as "The place on Earth's surface where life dwells". The physical properties of the biosphere in terms of its surface reflectance (albedo) and exchange of heat and moisture with the atmosphere are also critical for understanding global circulation of heat and moisture and therefore climate. Alterations in both the physics (albedo, heat exchange) and chemistry (carbon dioxide, methane, etc.) of earth systems by the biosphere

are fundamental in understanding anthropogenic global warming.

Factors Affecting Biosphere Distance between the earth and the sun is a major factor. Seasons and seasonal climate changes are direct results of the tilt of the Earth towards or away from the Sun. Summer months allow half of the planet to warm while the other half cools. Six months later, the temperatures shift in the opposite direction. Chemical erosion is a great example of a landscape changing one molecule at a time. Oxidation and reduction reactions change the composition of rocks and organic materials. There is also biological erosion. Tiny organisms, such as bacteria and fungi, are constantly working to break down organic and inorganic materials.

1.6.1 Ecosystems

Ecosystem is a self-supporting functional unit of mutually depending and regularly interacting (living) and abiotic (non living components) of a definite zone of the biosphere. In other words an ecosystem consists of the living organisms(plants animals fungi and microorganisms) and the non living environment (soil water air etc. of a given area or habitat which are mutually dependent and interact upon each other. it is thus in much smaller unit of the biosphere.

Natural ecosystems are divided into two:

1. Aquatic ecosystems :- These include marine ecosystems.(estuaries, seas, sea shore etc.) and freshwater ecosystems(rivers, streams, ponds, lakes, Wells etc.)

2. Terrestrial ecosystems :- These include desert, forest, grassland, etc.

In addition to the natural ecosystems there are artificial or man made ecosystems also. These includes, aquaria, agricultural fields, orchards, etc. The interrelationship between the biotic community and the abiotic environment in an ecosystem is dynamic in nature. This is manifested in the form of natural cycles which provide a continuous circulation of the nutrients necessary for life. Living organisms require a regular supply of chemical elements. These nutrients are recycled in ecosystems through pathways commonly known as bio geo chemical cycles.

1.7 Pollutants

Pollution can be defined as the introduction of substances or energy by man into the environment liable to cause:

i. Hazards to human health.

ii. Harm to living resources and ecological systems.

iii. Damage to structures or immunity.

iv. interference with legitimate use of the environment.

The term environment in the above definition includes air, water, land, and biota. (eg. vehicles, buildings, landscapes, oceans etc.)

Pollutant A pollutant is a substance present in greater than natural concentration as a result of human activity that has a net detrimental effect upon its environment or upon something of value in that environment.

When assessing the problems of the pollutant may pause, it is desirable to evaluate its:

1. Tendency for bioaccumulation.

2. Short and long term toxicity.

3. Persistence.

4. Dispersion properties and

5. Chemical reactions and breakdown or interaction products.

Pollutants are classified in several ways. Pollutants are classified into

i. Persistent and

ii. Non persistent pollutants.

Persistent pollutants are those pollutants that tend to enter in the environment for years after they are released into it. It takes longer to remove them from the environment. examples of persistent chemicals are chlorinated hydrocarbons such as Aldrin and Lindane. Non persistent chemicals are those chemicals that longer only for a brief period after the release in the environment. Eg. endosulfan.

On the basis of disposal, pollutants are classified into two.

1. Biodegradable pollutants :- Pollutants that are decomposed by natural processes. eg. domestic sewage.

2. Non biodegradable pollutants :- Pollutants which do not decompose naturally or decompose very slowly. eg. DDT, Aluminium cans, etc.

In a second way of classification, pollutants are classified into:

i. Primary Pollutants :- Pollutants directly emitted into the atmosphere (eg. SO_2, NO_x, CO, PM)

ii. Secondary Pollutants :- Pollutants that form in the air as a result of chemical reactions with the other pollutants & gases (eg. O_3, NO_2,PAN, Smog).

According to another classification, pollutants are classified into

i. Gaseous pollutants are those in the form of gas in the atmosphere. eg. NO_2, SO_2, CO, CO_2, etc.

Main gaseous pollutants are mainly oxides of carbon, nitrogen, sulphur, etc.

Sources of Carbon Monoxide

- Auto mobile exhausts.
- Furnaces or boilers
- Gas stoves and ovens

Effects It causes respiratory problems since it combines with haemoglobin. If exceeds a certain limit it causes death while in lower concentrations causes anaemia.

Sources of Carbon Dioxide

- Fossil fuel combustion/use.
- Industrial Processes.
- Volcanic eruptions.

Effects Acid rain, human health problems, global warming and green house effect are the major effects.

ii. Particulate pollutants are in the form of tiny particles. Based on size, particulate matter is often divided into two main groups:

The coarse fraction contains the larger particles with a size ranging from 2.5 to 10 μm (PM_{10} - $PM_{2.5}$). The fine fraction contains the smaller ones with a size up to 2.5 μm ($PM_{2.5}$). The particles in the fine fraction which are smaller than 0.1 μm are called ultrafine particles. Their size and composition may vary. Most dangerous particulate pollutants for man are PM_{10} and $PM_{2.5}$.

In some other classification, pollutants are classified into

i. Global pollutants are those pollutants whose emission are controlled or regulated by certain international agreement or arrangement.eg. NO_x, CO_2, CFCs etc.

ii. Local Pollutants are subject to domestic environmental regulations. Localized pollutions are smaller scale environmental incidents that cause pollution. eg. Minamata disaster caused by release of methylmercury into water body(Minamata bay) by Chisso corporation, in Minamata, Japan(1956).

Contaminants, which are not classified as pollutants unless they have some detrimental effect, cause deviations from the normal composition of an environment.

Every pollutant originates from a source. Source is the material or activity(the system) which releases the pollutant.

The source is particularly important because it is generally the logical place to eliminate pollution. After a pollutant is released from a source, it may act upon a receptor.

The receptor is anything that is affected by the pollutant. It is the store where the pollutant is received and stored for long time. Humans whose eyes smart from oxidants in the atmosphere are receptors. Trout fingerlings that may die after exposure to dieldrin in water are also receptors.

Eventually, if the pollutant is long-lived, it may be deposited in a sink, a long-time repository of the pollutant. Here it will remain for a long time, though not necessarily permanently. For example, a limestone wall may be a sink for atmospheric sulphuric acid through the reaction,

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

which fixes the sulfate as part of the wall composition.

Cycle pathways in which elements required to sustain life are constantly transferred from the environment to the living system and back to the environment are called biogeochemical cycles. The major natural biogeochemical cycles include carbon cycle, nitrogen cycle, for phosphorous cycle, sulphur cycle, etc.

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