S5 BIOLOGY(MR.LUBEGA)

EFFECTS OF HUMAN ACTIVITIES ON ECOSYSTEMS

How human activities affect ecosystems

- Interruption of biogeochemical cycles.
- Natural resources imbalances and exhaustion.
- Population imbalances.
- Decline in Biodiversity/species diversity.
- Soil erosion/soil exhaustion/loss in soil fertility.
- Extinction of species.
- Environmental pollution.
- Drought/Desertification.
- Green house effects/Global warming.
- Disease out breaks.
- Famine.
- Loss of habitats.
- Speciation.

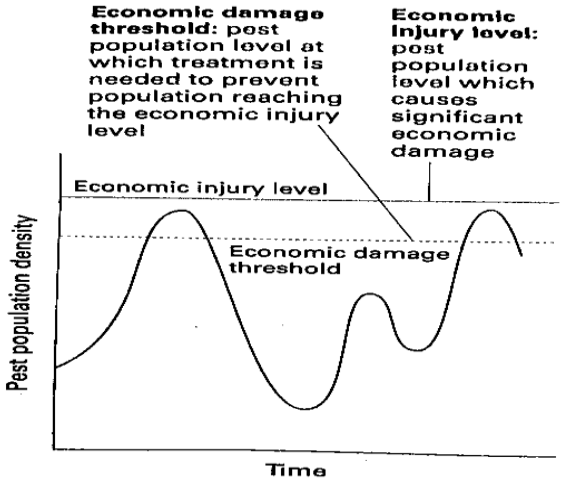
Human activities affecting an ecosystem.

- Pesticide use to control pests.
- Pollution.
- Deforestation.
- Agricultural practices such as use of fertilizers, mulching, crop rotation, weeding, harvesting of standing crops.
- Over fishing.
- Urban development. These include activities such as construction of dams, bridges, houses, roads, recreation centers and reclamation of swamps and wet lands for urban development.
- Hunting and poaching.
- Use of fire to burn forests and grasslands.
- Mining activities.
- Nuclear plants.
- Industrialization.

(i) PEST CONTROL AND USE OF PESTICIDES.

A pest is any organism that people find undesirable. It may cause harm economically or affect someone's health. Agricultural pests cause economic damage to crops and farm animals. Most pests cause significant damage when their populations reach a certain level called ***economic injury level*** which is the pest population level which -causes significant economic damage. And therefore a pest control measures must be started at a lower pest population level called ***economic damage threshold.*** This is the pest population level at which treatment is needed to prevent population of pests reaching the economic injury level.

A graph distinguishing the economic injury level and economic damage threshold of pest populations



METHODS OF PEST CONTROL.

Pests can be controlled by any one of the following methods,

- Cultural control methods.
- Chemical control.
- Biological control.
- Integrated pest management/Combination of the control methods.

A. CULTURAL CONTROL METHODS.

Cultural methods such as weeding, tillage and crop rotation are among the most common methods of pest control. Weeding and tillage remove weeds and overturning the soil that may expose insect pests to predatory birds. Crop rotation often prevents the buildup of pests that occur in monoculture but it is only effective if when a pest cannot attack successive crops.

Other cultural methods of pest control include the following,

- ❖ Removing the remains of crops and badly damaged plants which might harbour pests.
- ❖ Creating physical barriers for example apple trees are protected from their potential pests coding moth caterpillars by putting sticky bands on their trunks.
- ❖ Covering the soil with organic material (mulching) which prevents light from reaching weeds.
- ❖ Growing crops or harvesting crops at a particular time in the life cycle of the pest when the pests can do least damage. For example in maize.
- ❖ Intercropping. Planting two different crops in the same field, for example under sowing cereal crops with rye grass provides suitable conditions for ladybirds which control aphids on the cereals.

B. **CHEMICAL CONTROL.**

This method involves the application of toxic chemicals that control pest population called ***pesticides***.

Pesticides are defined as chemical substances used by humans to control pests. Different types of pesticides are classified according.

(a) to the pest organisms that they treat

- ***Herbicides:*** These are pesticides that kill plant species.
- ***Insecticides*****:** Are pesticides that kill insects.
- ***Fungicides*****:** Are pesticides that kill fungi.

(b) How they exert their effects on to the pest

- ***Contact pesticides:*** kill pests without being eaten for example penetrating cuticles of insects.
- ***Systematic pesticides:*** are taken into a plant and translocated within the plant and enter the pest when it eats the plant or its sap.
- ***Broad-spectrum pesticides*****:** Designed to control a wide range of pests, may also kill harmless or beneficial ones such as the predators of the pest.

Most pesticides are poisons and aim to kill the target pest species. But others can cause sterility such as chemosterilants or inhibit growth such as growth inhibitors.

ECOLOGICAL CHARACTERISTICS OF PESTICIDES.

The important ecological characteristics of pesticides are toxicity, persistence and specificity.

(i) ***Toxicity.***

For a particular species, toxicity is defined by the **lethal dose 50 (LD_{50}).** This is a single dose which kills half an experimental laboratory population. When organisms are subjected in addition to environmental stresses a higher proportion die in field. The survivors form the basis for a resistant pest population and in organisms such as insects with a rapid life cycle, resistance and pest resurgence are common problems.

(ii) ***Persistence.***

This is the length of time that pesticide remains in the environment and within organisms without being broken down. An example of a persistent insecticide is DichloroDiphenyl Trichloroethane (DDT). Persistence is undesirable quality of a pesticide particularly on food crops. However, in the control of animal parasites and soil-borne diseases, persistence makes the pesticides effective and efficient, but persistence for too long is very damaging to organisms.

Certain persistent toxic chemicals e.g. DDT progressively accumulate in the body of organisms at a particular trophic levels and are availed in even much higher concentrations to the organisms in the next trophic levels.

This is because DDT is not easily broken down and it is stored rather than metabolized or excreted in living organisms and it remains active for many years i.e. 10-15 years. It is mainly stored in fatty tissues; as it is more soluble in fats than in water. During times of food shortage, fat is mobilized and used so that the DDT pesticide accumulated over a long period of time is released into the blood stream in relatively high concentrations.

Examples of other toxic pesticides that can accumulate in food chain include, Dieldrin and aldrin.

Disadvantages of DDT pesticide in an ecosystem

- High mortality rate (death) among vertebrates especially predatory birds e.g. peregrine falcons, sparrow hawks, golden eagles
- Leads to extinction of some species of organisms especially birds from an ecosystem due rampant deaths.
- It reduces resistance to diseases in some organisms.
- Reduction in fertility (low fertility) among organisms especially carnivorous vertebrates.
- Leads to reduction in calcium metabolism in birds, resulting to production of thinner egg shells which easily break when female sits on them during incubation.
- It kills species of some insects, pests and other organisms.
- Can alter the behavior of birds, sometimes preventing them building proper nests

Advantages of DDT pesticide.

- Easily affordable and relatively cheap to produce.
- It effectively kills mosquitoes and their larvae, therefore very efficient in control of malaria, which is the biggest killer disease in sub-Saharan Africa.
- It is quite persistent and have a long lasting effects and more efficient in eliminating pests, important in controlling animal parasites and soil- borne diseases.

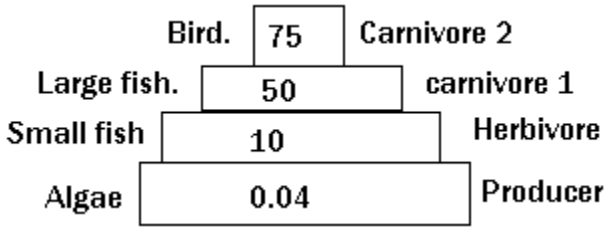
NOTE: Pesticide poisoning has devastating effects on carnivores occupying higher trophic levels. This is because the concentration builds up in high enough concentrations to kill top consumers in food chains.

Qn. ***Why DDT can be widely spread in an ecosystem?***

- ✓ It can be carried at very low concentrations in water. If it is washed off agriculture land and carried into the rivers, some of it reaches the sea and becomes concentrated in marine food chains i.e. fish and other aquatic organisms will have DDT stored in their body tissues.
- ✓ DDT pesticide can be carried in the atmosphere because it is volatile and is spread as dust, which is carried by wind over a long distances.

EXAMPLE

The figure below shows the amount of DDT at different levels in a food chain. Study it carefully and answer the questions that follow.



(a) If the concentration of DDT in the water surrounding the algae was 0.02ppm. Determine the final concentration factor for DDT in passing from water into,
(i) Primary producers. (ii) Small fish. (iii) Large fish. (iv) the top carnivores

SOLUTION.

(i) $\frac{0.04}{0.02}$ = 2 times. (ii) $\frac{10}{0.02}$ = 500 times (iii) $\frac{50}{0.02}$ = 2500 times

(iv) $\frac{75}{0.02}$ = 3750 times.

(b) what conclusions can you draw from your answers in (a) above

DDT is subjected to progressive concentration as it passes along the food chain. This suggests that it is a persistent chemical, not easily broken down, and that it is stored rather than metabolized in living organisms.

(c**) At which trophic level**

(i**) would DDT be most easily detected**

Top carnivore (4^{th} trophic level)

(ii) is likely to have the most marked effect

Top carnivore(4^{th} trophic level)

(iii) Are insect pests of crops found (a typical target for DDT)

2^{nd} trophic level (herbivore)

(iv) ***Specificity.***

This is the range of organisms the pesticide can affect. DDT is an example of a broad spectrum pesticide, it seriously affects many different kinds of animals. Narrow-spectrum pesticides only affect a restricted range of organisms.

Use of broad-spectrum pesticides can lead to ***pest resurgence.*** This is when numbers of the pests after treatment increase to more than before the treatment. This is because the pesticide kills both the pest and predator of the pest.

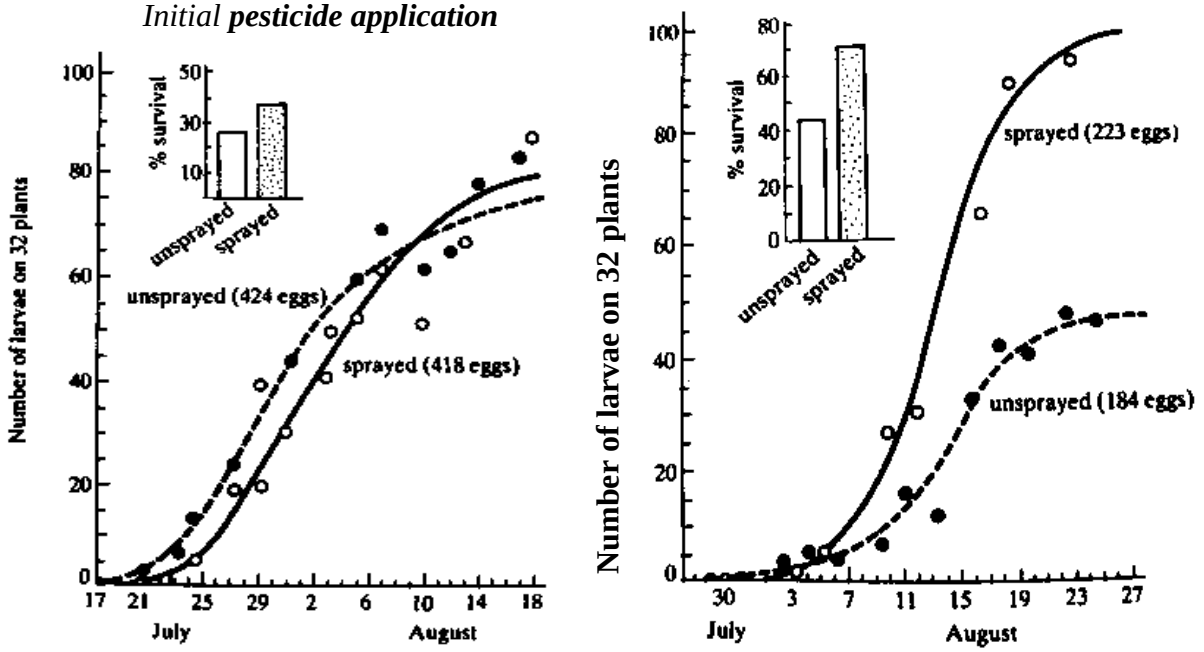
Example

The study of use of DDT to control cabbage white butterfly, *Pieris rapae*.

Initial ***pesticide application*** gave good control but subsequently numbers of butterfly larvae exceeded those in unsprayed control area

Repeated ***pesticide application***

Initial ***pesticide application***



The effect was more pronounced on repeated application of the pesticide

Reason

The pesticide concentration decreased on the leaves due to subsequent growth of existing and new leaves but levels in the soil increased, since crop residues with the a persistent pesticide were ploughed into the soil; thus eggs deposited by adults entering the crop from surrounding areas after spraying were less affected by the pesticide, but instead larval predators which are soil dwelling were greatly affected and their survivors fed less frequently on the larvae, significantly reducing larval predation, thus leading to larval numbers exceeding the pre spraying levels.

Note: Further application of the pesticide has greater effects on predator species than the pest species, since they occur in smaller number than their prey, thus their population is more vulnerable and recovers more slowly once affected.

PROPERTIES FOR IDEAL/GOOD PESTICIDES.

(i) Specificity. It must be specific so that it has minimal effects on the species other than the pests. The pesticide should have a narrow range of organisms it affects otherwise, if it has a broad spectrum, it may kill the pest and its natural predators leading to resurgence when a few pests survive.

(ii) Toxicity should be adequate to kill most of the targeted pests within a short period of time without damaging crops. The lethal dose should be sufficient enough to kill the pests.

(iii) It should be cheap to produce and manufacture.

(iv) Non-persistent. Relatively non-persistent in the eco-system, the pesticide should not remain in the environment including within organisms without being broken down as long term persistence may lead to accumulation along the food chain, thereby affecting the untargeted organisms.

(v) It should be bio-degradable. It can gradually be broken down to simpler and less harmless substances once it has accomplished the purpose for which it was applied.

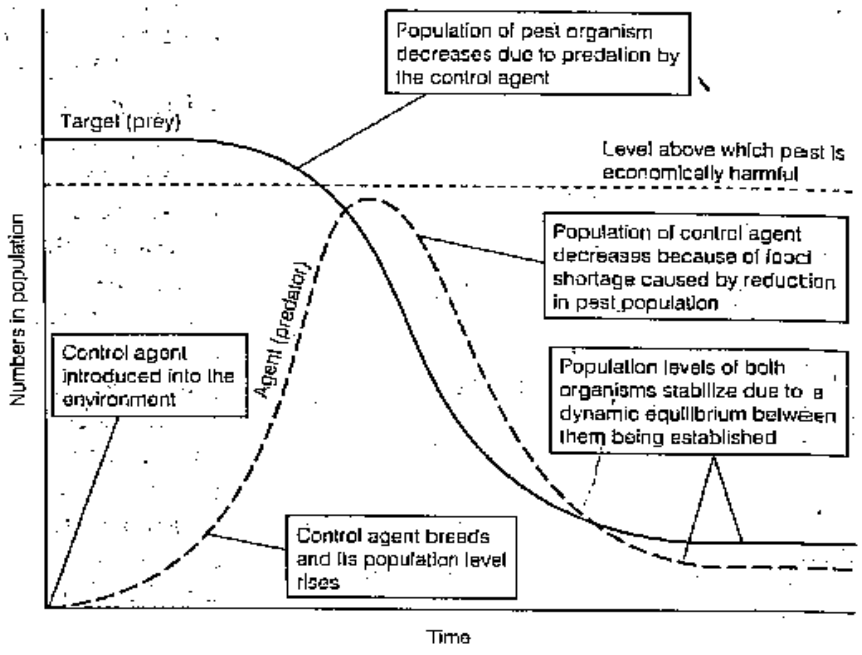
(vi) Non-volatile so that it cannot be carried in the atmosphere by wind.

C. BIOLOGICAL CONTROL.

Biological control is the control of the population of pests and weeds by using other living organisms that are their natural enemies such as predators, parasites and pathogens to the target pests.

A beneficial organism, the **agent** is deployed against an undesirable one, the **target**, the control organisms are used to keep the pest or weed population below the economic injury level and not to eradicate the pest, as tis could be counter-productive if the pest (target) was reduced to such an extent that it no longer provide adequate food source for the predator (agent), then the agent in its turn would be eradicated and the few remaining targets would increase their population rapidly, in absence of the controlling agent. Therefore it is necessary for the controlling agent and the pest to exist in balance with one another but at a level where the pest has no major detrimental effect.

A graph showing the relationship between pest and control agent populations in biological control



Examples of biological Pest control

- ❖ Cane toads introduced into Australia to control beetle infestations of sugar cane.
- ❖ In green houses, parasitic wasps are introduced to control whitefly and lady birds to control aphids.
- ❖ In natural environments, caterpillars of the moth control the population of prickly pear population successfully and bacillus bacteria (*Bacillus thuringiensis*) applied as sprays to cabbage plants infected with caterpillars. The bacteria infects and kills the caterpillars without harming other insects.
- ❖ Myxomatosis is a viral disease introduced deliberately in Australia to control rabbit populations. However, this virus infected other non-targeted domestic rabbits and lost its effectiveness as the pests evolve resistance.
- ❖ Irradiation is another method of biological control. It involves breeding the pest species, separating the males and sterilizing them by exposure to x-rays. Sterile males are released into the population to mate with females which produce infertile eggs.
- ❖ Hydra(chlorohydra) introduced to reduce malaria as they feed on the anopheles mosquito larvae

Advantages of biological pest control.

- ♣ Control agents are specific to their target organisms. So, they cannot destroy other useful organisms in the environment.
- ♣ No danger of polluting or harming the environment.
- ♣ Control agents may become useful food materials for other organisms.
- ♣ It does not lead into extinction of the target organisms.
- ♣ Have few incidences of pest resurgence.
- ♣ They are very effective and efficient; they can control population of pests within the shortest time possible.

Precautions taken in using biological control methods.

(i) Careful matching of climatic conditions to ensure that they favour the natural enemy of the pests especially when the population of the pest is at peak.

(ii) Monitoring of interactions with native species to ensure that the natural enemy of the pest is not preyed on by other unsuspected organisms, prey organisms which may be preferred instead of the targeted pest can be identified.

(iii) The predator must be released at a time when the pest population has reached large numbers to provide sufficient food for the natural enemies otherwise, it may get wiped out prematurely resulting into pest resurgence.

D. INTEGRATED PEST CONTROL/MANAGEMENT.

Is pest population management which combines and integrates biological and chemical controls in a sensitive way, to maintain the pest population at a level below the economic injury level or even prevent their development. As in practice no one type of pest control is ideal. Pest population densities are monitored and pesticides used only when the pest reaches the economic damage threshold. This method must ensure minimum harm and disruption to a crop, natural ecosystem and the natural enemies of the pest species.

However this method may not be cost effective as it involves research and development costs with the market for selective chemical being smaller therefore targeted use of broad spectrum chemicals can be applied. By developing pheromones used to lure pests into traps laced with an insecticide to aid spatial targeting and also to aggregate a population in an area to be treated with the pesticide

2. DEFORESTATION.

This is the permanent destruction of forests in order to make the land available for other uses. Many forests have been destroyed by burning and felling of trees. Many forests have been converted to agricultural lands, grass lands and shrubs.

Reasons for deforestation.

- ♣ To open land for agricultural practices.
- ♣ Supplying firewood as fuel and making charcoal.
- ♣ To make room for houses, industrial buildings, roads and dams.
- ♣ To obtain trees for manufacture of pulp and paper.
- ♣ Cutting trees for timber used in the construction industry and getting poles for construction of houses.
- ♣ Destruction of some trees by atmospheric pollution such acid rains.
- ♣ Replacement of native trees with fast growing species such as conifers, eucalyptus and rubber trees.

Effects of deforestation.

- ♣ There is a loss of traditionally harvested products such as timber, poles, fire wood, honey, fruit, game animals and herbs that are one time supply local people with their needs.
- ♣ More rapid run-off of rain water results in soil erosion, resulting into loss of soil structure and soil fertility, crop production and yields is lowered. This may cause famine and great economic losses.
- ♣ Leads to floods in low lying plain lands.
- ♣ Increases global carbon dioxide which causes global warming.
- ♣ Rain fall regimes are interrupted, leads to reduction in the amount and frequency of rain fall and supply of water from spring waters is lost, resulting into change in climatic conditions, water shortage, drought and desertification.
- ♣ Leads to loss of genetic variety and reduction in biodiversity.

- ♣ Habitat loss of many organisms, leads to extinction of some plant and animal species since forest has the most species-rich and diverse wild life.
- ♣ Leads to loss of some important medicinal plants. For example, tropical rain forest tree species have great human value, rosy periwinkle used for anti-cancer drug, others tropical rain forest trees are used as antibiotics and anti-malarial drugs.
- ♣ **Destructs Water cycle,** Trees are important to the water cycle as they absorb rain fall and produce water vapor that is released into the atmosphere. Trees also lessen the pollution in water,
- ♣ **Reduces quality of life,** Soil erosion can also lead to silt entering the lakes, streams and other water sources. This can decrease local water quality and contribute to poor health in populations in the area.

3. AGRICULTURE.

Is the production of crops and animals. It is a human activity that affects greatly the lives of organism in an ecosystem.

EFFECTS OF AGRICULTURE ON ECOSYSTEM.

(a) Positive effects.

- ➢ Increase productivity in an ecosystem. This is achieved through, appropriate use of fertilizers, crop rotation, mulching to improve plant growth and crop yields.
- ➢ Increase population density of many organisms in an ecosystem since agriculture increases food production.
- ➢ Improve soil conditions for the survival of soil micro-organisms.
- ➢ Proper tillage improves soil structure, texture and aeration for survival of soil micro-organisms.
- ➢ Terracing method of farming also prevent soil erosion and maintaining mineral nutrients in the soil.
- ➢ Mixed farming where both plants and animals are reared leads to nutrient recycling.
- ➢ Preserves valuable ecosystems e.g. extensive farming of increasingly rare permanent grasslands that provide habitat to a great number of animals and native plants.
- ➢ Sets back ecological succession as some species need early successional habitats e.g. prairies to thrive
- ➢ Sequesters carbon as with any other plants, growing crops, especially in agroforestry, add oxygen to the atmosphere, as plants photosynthesize and remove carbon dioxide from the atmosphere.
- ➢ Plants and trees in agricultural systems retain and add water to underground aquifers. This process is most effective when the crops being grown are perennials that continue to grow every year and have deep, well-established root systems.

(b) Negative effects.

- ➢ Leads to pollution of the environment.

Over use of artificial fertilizers can cause leakage of soluble nutrients into the water bodies resulting into Eutrophication and hence fresh water pollution. It can also change soil pH and structure that kills some soil micro-organisms.

Use of pesticides. Is the main cause of land pollution. Pesticide is persistent in an ecosystem, kills other organisms at higher trophic levels.

- Leads to habitat destruction.

Use of fire, deforestation to open land for agricultural purposes destroy habitat for organisms and may cause extinction of species of some organisms.

- Deforestation, weeding, harvesting of standing crops reduce primary productivity of ecosystem.
- Use of fire to open land for agriculture leads to many negative effects which include destruction and death of slow moving animals and destruction of many plant species.

4. ENVIRONMENTAL POLLUTION.

Pollution is defined as the release into the environment of substances or energy in such quantities and for such a duration that they cause harm to the people or other organism or their environment.

A pollutant is a natural or artificial substance which enters the ecosystem in excess amounts that it becomes harmful to the ecosystem.

COMMON POLLUTANTS.

These include the following,

- Physical pollutants such as noise/sound, heat, radioactive substances from nuclear power stations,
- Chemical pollutants such as, industrial waste products like nitrogen oxide, hydro-carbons, mercury or any other heavy metals.
- Biological pollutants such as the sewage.
- Gaseous emissions like carbon monoxide, carbondioxide, sulphur dioxide.
- Oil leakages.
- Agricultural drugs like pesticides and herbicides.
- Smog or fog.

TYPES OF POLLUTION.

- Air pollution.
- Water pollution.
- Sound pollution.
- Radio-active pollution.
- Terrestrial pollution.

1. AIR POLLUTION.

All air pollutants are gases added to the mixture of air which supports life. All air pollutants is a result of burning fossil fuels either in the homes, in industries or internal combustion engine. Examples of the air pollutants are,

- Smoke.
- Sulphur dioxide.
- Lead.
- Nitrogen oxide.
- Carbon monoxide from car exhaust.
- Aerosols which may be solid or liquid particles suspended in the atmosphere
- Carbon dioxide.
- Chlorofluorocarbons (CFCs)
- Hydrocarbons

(i) SMOKE.

Smoke is tiny particles of soot (carbon) suspended in the air which are produced as a result of burning fossil fuels such as coal and oil.

Effects of smoke

- When breathed in, it blackens the alveoli causing damage to their epithelial lining. It also increases the risks of bronchitis.
- It reduces light intensity at the ground level. This lowers overall rate of photosynthesis and hence productivity.
- Deposits of soot and ash coats plant leaves, blocking the stomata thus reducing rate of photosynthesis in green plants.
- Smoke, soot and ash dirtens or blackens clothes, ears and building, these are costly to clean.

(ii) CARBONMONOXIDE (CO)

Carbon monoxide is released from the car exhausts.

Effects

- When inhaled, it combines irreversibly with haemoglobin to form carboxyhaemoglobin reducing the capacity of red blood cells to transport oxygen. the vital areas like the brain are deprived of oxygen resulting into fainting and low metabolic reactions and finally culminating into death.
- Carbon monoxide may also lead to global warming and many other effects of carbon monoxide since it is quickly converted into carbon dioxide.
- Carbon monoxide also leads to irritated eyes.

NB: Cigarette smoking increases the carbon dioxide concentration in blood.

(iii) SULPHUR DIOXIDE (SO_2).

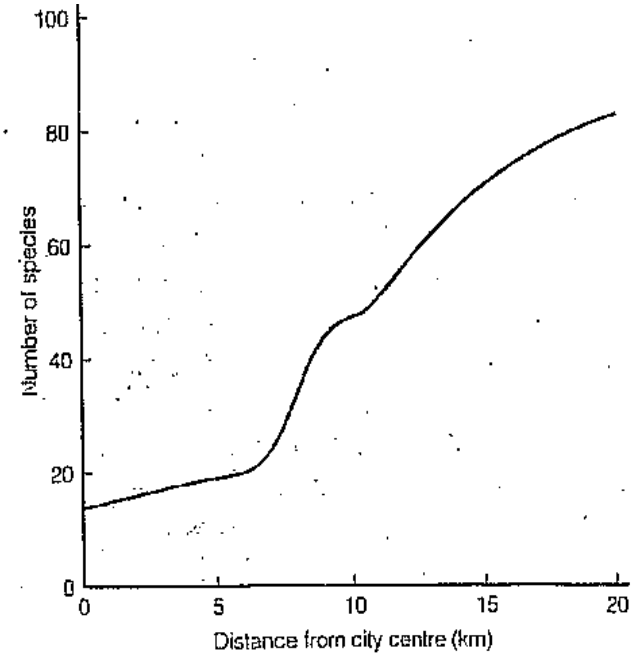
Burning of fossil fuels at home or from industries, emit some amount of sulphur dioxide. It may also be produced from smelting of ores such as copper, zinc, and iron ores. It may combine with

water and ammonia and form harmful compounds, especially when released in higher concentrations.

Effects of sulphur dioxide

- It causes irritations of the respiratory systems and damages the lining of the alveoli of the lungs.
- It can damage the eyes by causing irritations of the conjuctiva of the eye.
- Sulphur dioxide dissolve in rain water and falls down as acid rain that enters lakes and oceans, causing death of aquatic plants. Acid rains also cause great destruction and damages of forests. For example coniferous trees.
- It reduces the growth of many plants e.g. lettuce wheat, while others like the lichens on the surfaces of trees and on rocks are killed. This reduces photosynthetic activities of the blue-green algae, reducing primary productivity of the ecosystem. Absence of lichens may expose certain insects like the peppered moths to their predators.

  The tolerance of lichen and moss species to sulphur dioxide is very variable and makes them useful indicator species for measuring sulphur dioxide pollution. For example as one moves from the centre of major industrial city, the number of species of lichen and mosses increase due to rapid decrease concentration of sulphur dioxide, in the centre only the most tolerant species are present while the less tolerant ones are found on the outskirts of the city as shown on the graph below



Advantages of sulphur dioxide

- When sulphur dioxide combines with other chemicals like ammonia and water, it forms compounds that are deposited into the soil, increasing soil fertility or adding sulphate in areas where they are deficient.
- The compounds containing sulphur when applied or deposited into some plants, they work as fungicides. For example black spot on roses are treated when acid rain falls on them.

- The concentration of the sulphur dioxide in the environment can be used to provide the measure of the level of environmental pollution by industrial wastes.

(iv) NITROGEN OXIDES (NOx) e.g. NO_2.

They are produced by burning of fuel in car engines and emitted as exhaust. They are poisonous and also results into the formation of photo-chemical smog. The action of sun light on this chemical converts Nitrogen oxide to perox-acyl nitrate (PAN). This compound formed is dangerous, causing damage to vegetation and eye and lung irritations in man.
The acid gases sulphur dioxide and oxides of nitrogen are washed out of the atmosphere to produce acid precipitation in rain and snow.

Effects of acid rain

- Causes major changes in ecosystems
- causes damage to buildings
- Leaches magnesium and calcium from soils and from damaged leaves
- Dissolves aluminum, manganese and heavy metals such as iron and cadmium which upon reaching toxic concentrations, damage tree roots and lead to breakdown of mycorrhizas. Decreasing capacity of trees to take up water and nutrients.

Note: The effects of acid rain are common in areas bordering those which are major sources of the pollutants.

(v) LEAD (Pb).

Lead can be emitted into the air through car exhausts. Tetra-ethyl lead (TEL) is added to petrol as an anti-knock agent to help it burn more evenly in car engines. If breathed into the lungs and then into the general body, it will have the following effects,

- Digestive problems. For example Intestinal colic.
- Impairing the functioning of the kidney.
- Nervous problems including convulsions.
- Brain damage and mental retardation in children.

(vi) CARBONDIOXIDE (CO_2)

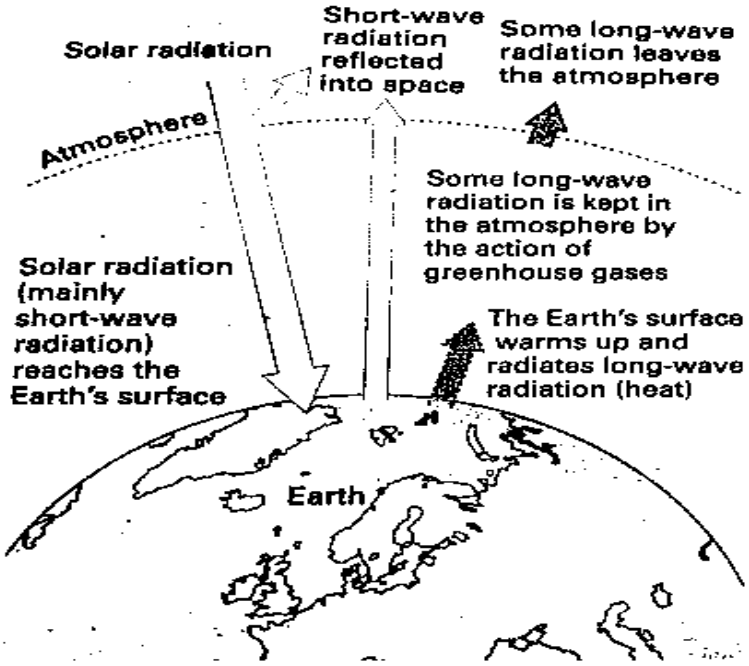
Carbon dioxide is formed through respiration by aerobic organisms, volcanic activities, decomposition of organic matter and burning of the fossil fuels. It is used by plants for photosynthesis to ensure that it does not accumulate. Deforestation and increased burning of fossil fuels have resulted into excess release of carbon dioxide into the atmosphere. This has caused an increase in concentration of atmospheric carbon dioxide, causing occurrence of the three world problems, ***ozone depletion***, ***greenhouse effect*** and ***Global warming.***

GREEN HOUSE EFFECT.

Solar energy from the sun passes through lower atmosphere (troposphere) reaches the Earth in form of short wave radiation. When the radiation strikes a surface, much of its energy is converted

into heat (a long wave radiation) carbon dioxide, water vapour and other gases present in the atmosphere absorb and retain long-wave radiation gases of the lower atmosphere are warmed up. Some of this heat energy escapes into space but much is radiated back towards the surface of the earth warming the planet further. In this case these gases, including carbon dioxide act like panes of glass in a greenhouse, letting light in but retaining some of the heat before it escapes into space, hence the term "greenhouse effect".

The retention of heat by the greenhouse effect is a natural process, essential for the evolution of life on earth. It maintains optimum average temperatures of the earth at about 15^{o}C rather than -18^{o}C which would be the case in absence of greenhouse gases, at such freezing temperatures many species of organisms would die.



However, the greenhouse effect appears to be increased by the emission of certain industrial gases collectively called **greenhouse gases**, the most important of which are carbon dioxide, chlorofluorocarbons, methane and ozone.

Carbon dioxide.

It is produced naturally from respiration, decomposition and volcanic activities. Burning of fossil fuels is another source of carbon dioxide. It contributes the largest percentage of the green house, about 50%.

Chlorofluorocarbons (CFCs)

Are organic molecules that are not natural but manufactured artificially by humans, for use as refrigerator coolants, in air conditioning units, as aerosol propellants, and in the manufacture of foam plastics. They have advantages of being cheap, non-flammable and non-toxic chemicals but are relatively stable. When released into the atmosphere, tends to last for long time (up to 60 years). Its effect is many times greater than that of carbon dioxide.

CFCS dissociate when exposed to ultraviolet light, releasing highly reactive free chlorine atoms, by series of chemical reactions the chlorine released reduce the ozone concentration.

Methane.

It is produced by anaerobic bacteria living in the mud of boggy habitats, landfill sites, rice paddies, and in guts of certain insects such as termites and in the stomachs of the ruminants such as cattle, sheep, and camel. So, the human activity such as cattle ranching has increased the release of methane.

Ozone.

Ozone is a triatomic form of oxygen. It occurs naturally in the atmosphere where it is formed by the action of solar energy (ultra-violet radiation) on oxygen gas. Ozone forms a layer called ozone layer at high altitudes 20 – 50 Km above the earth surface. Ozone is a greenhouse gas but at high altitudes it absorbs harmful ultra-violet radiations and prevents it reaching the earth. At low altitudes, its concentrations are low but boosted by the action of sunlight on nitrogen oxides in car exhaust fumes. Ozone forms part of the photochemical smog seen in large cities during bad weather.

As a low altitude pollutant, ozone is harmful. It is chemically very reactive, irritating eyes and respiratory tissues and it can damage plants. A higher concentration of ozone is toxic.

OZONE DEPLETION

This is constant damage and destruction of the ozone layer by the greenhouse gases, especially the chlorofluorocarbons to the point that holes are created into it. This will allow harmful ultra-violet radiations to directly reach the earth. Ultra-violet radiation causes skin cancer to humans.

GLOBAL WARMING.

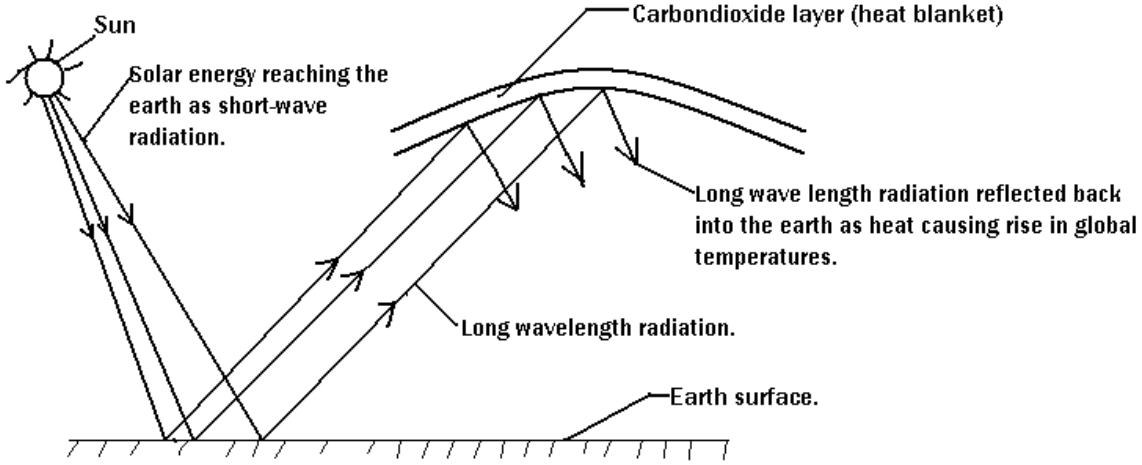
Increase in carbon dioxide or greenhouse gases in the atmosphere absorbs and retains heat or reflects the long wave-radiation back into the earth. This causes unnecessary rise or increase in the global temperatures above the usual, a phenomenon called global warming. This could cause change in the climate. The effect of global warming is detected in rising sea levels, an increase in the melting of ice caps at arctic and Antarctic regions, changes in the vegetation and unusual weather patterns.

EFFECTS OF THE GLOBAL WARMING.

- It leads to melting of the ice caps in the polar regions of the earth. This result into increased volume of water bodies, causing floods in low lying areas displacing a number of plants and animal communities living at the shores of the rivers, lakes and oceans.
- The increased atmospheric temperatures increase evaporation of water from the surfaces of the water bodies causing rampant heavy convectional rain fall seasons known as Elninos. Elnino rain causes destruction of crops and leads to famine, outbreak of water borne diseases like cholera, causing mass death of people.

- It leads to extinction of species of organisms which cannot adapt to extremely high temperatures. This causes changes in the Bio-diversity of plants and animals.
- High temperatures increase primary productivities. Demand for essential nutrients increase, resulting in competition among plant species for such nutrients.

DIAGRAM SHOWING PROCESS OF GLOBAL WARMING IN AN ECOSYSTEM.



WATER POLLUTION.

Water Pollution is defined as the release of substances or energy the water bodies or aquatic environment in such quantities and for such a duration that they cause harm to the people using the water or to the aquatic organisms living in the aquatic environment.

Uses of water in an ecosystem

- For drinking.
- For bathing, washing clothes, utensils, cars etc.
- For removing sewage.
- To irrigate crops.
- Used as a coolant in industries.
- Habitat and breeding sites for fish and other aquatic organisms that provide source of food.
- Used to generate electric hydro-power
- For recreational uses, sailing, fishing and diving.

COMMON CAUSES OF WATER POLLUTION.

These include;

- Discharge untreated sewage into the aquatic ecosystem.
- Eutrophication due to agricultural wastes from factory farms and organic industrial wastes from food and drink industry.
- Eutrophication due to nitrate and phosphorus fertilizers that enter nutrient cycle.
- Oil spills mainly from accidental spillage and cleaning storage tanks.

- Hot water from power stations resulting into the thermal pollution.
- Heavy metals such as mercury, cadmium from industrial effluent.
- Persistent pesticides such as DDT.
- Radioactive materials from nuclear power stations.
- Mining wastes such as china clay waste.
- Medical waste such as hypodermic needle, blooded bandages, etc.
- Soil erosion on the land surface, increasing silt load of rivers and coastal waters

SEWAGE DISCHARGE AND ITS EFFECTS ON THE AQUATIC ECOSYSTEM.

Sewage is liquid waste which can be either industrial waste from abattoirs, factories, hospitals or domestic waste including human faeces, urine and detergents. Sewage is carried through pipes called **sewers**.

Sewage is made up of 99.9% water and dissolved substances and only 0.1% solids, of the solids approximately 70% are organic and 30% inorganic e.g. metals and grit.

Raw sewage also contains a large number of bacteria, some of which can cause disease (they are pathogenic)

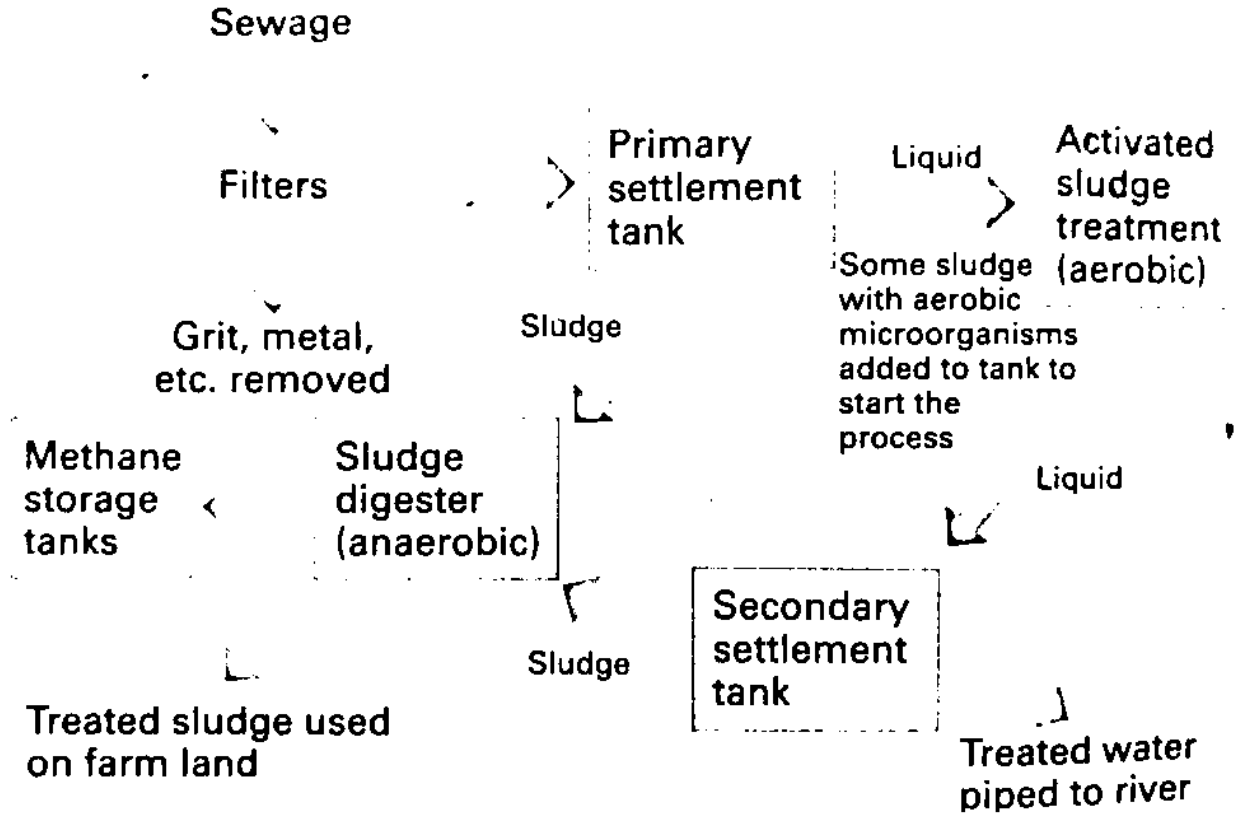
SEWAGE TREATMENT

This removes organic material and potentially dangerous pathogenic organisms such as those causing cholera and typhoid. The stages in sewage treatment include,

Sewage first passes through filters, which remove solid inorganic matter e.g. grot and metals and then into primary settlement tanks where organic solids are separated as sludge from the liquid part.

The thick sludge is pumped into sludge digestion tanks where for a period of upto a month, it is digested by anaerobic microorganisms. Sludge digestion produces large amount of methane gas which can be used as fuel and solid sludge, which can be used as organic fertilizer on farmland.

The liquid sewage is pumped into special tanks called activation sludge tanks, where compressed air is pumped into the sludge to activate the aerobic microorganisms e.g. protoctists and bacteria in the tank, these feed on the organic material in the liquid and the harmful anaerobic bacteria it contains, the aerobic microorganisms also produce a thick mucus causing most of the remaining organic matter to flocculate (clump together), then the mixture is transferred into a secondary settlement tank where the flocculated material settles as sludge, this can be piped to the sludge digester, leaving behind clean water piped to the swamps or rivers.



However, raw sewage is sometimes discharged into water bodies without being fully treated, giving rise to pollution.

EFFECTS ON THE ECOSYSTEM DUE TO DISCHARGE OF UNTREATED SEWAGE.

- Increases Biological Oxygen Demand (BOD).
- Eutrophication of the water bodies.
- Sewage may contain potentially dangerous pathogenic organisms such as those causing cholera and typhoid. So, may lead to outbreak of diseases.
- The organic matter in the sewage makes water to have unpleasant smell, turbid and therefore unsafe for domestic use like drinking, washing etc.
- Prevents penetration of the light intensity, stopping photosynthesis by the aquatic plants.
- Buildup of ammonia and hydrogen sulphide from anaerobic decomposition occurs. These chemicals are toxic and result in death of many aquatic organisms and almost lifeless river.

BIOLOGICAL OXYGEN DEMAND (BOD).

Adding organic materials to water stimulates the growth of microorganisms which feed on the organic materials. As the density of the micro-organisms increases, their demand for oxygen also rises. This demand is called the ***Biological Oxygen Demand (BOD)***.

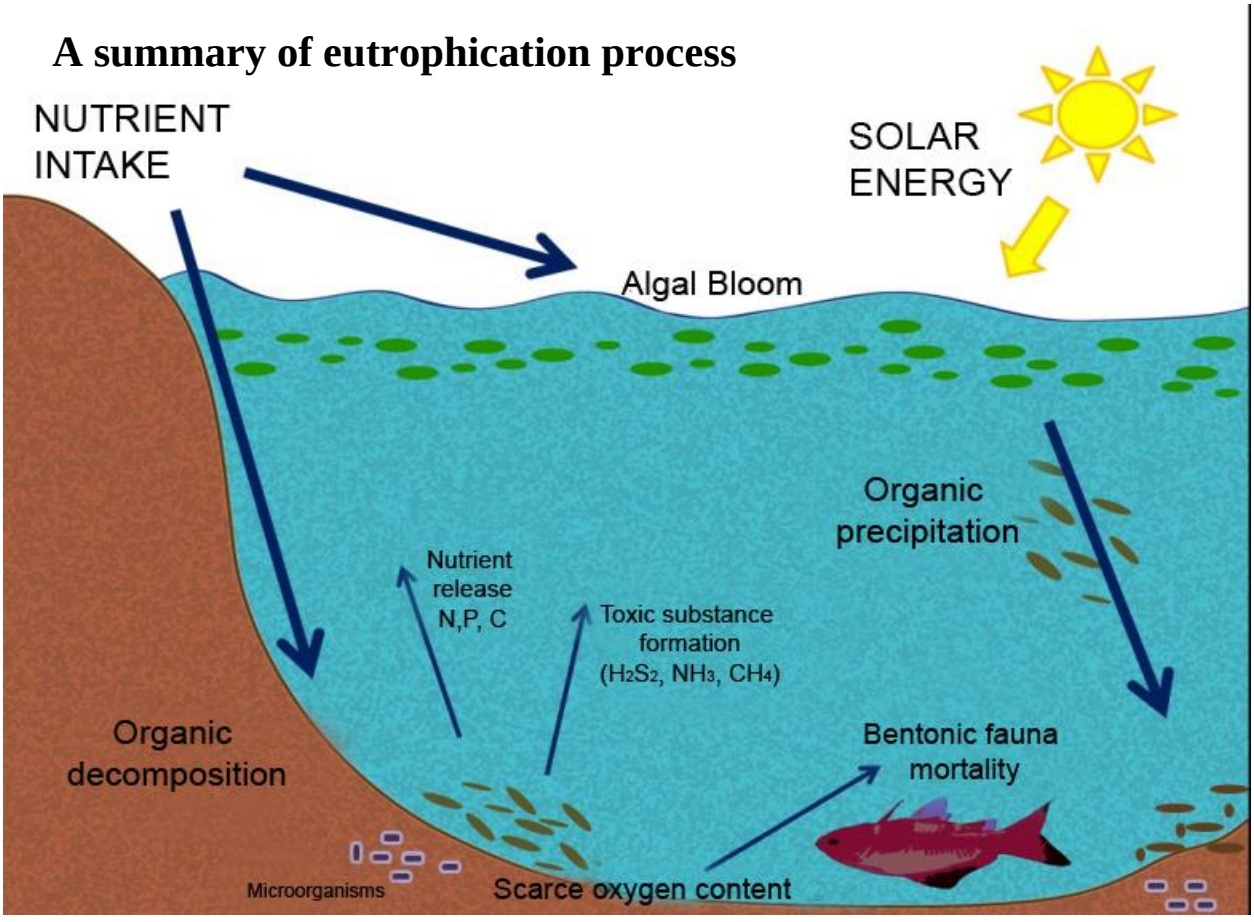
BOD *is the minimum amount of dissolved* ***oxygen*** *needed (i.e. demanded) by aerobic* ***biological*** *organisms to break down organic material present in a given water sample at certain temperature over a specific time period.*

Water that is very heavily polluted with raw sewage may become deoxygenated, Oxygen deficiency occurs downstream the water bodies, the water may also become anaerobic for much of its length, resulting into aerobic aquatic animals and zooplanktons to suffocate to death.

EUTROPHICATION.

Is the enrichment of water by nutrient salts e.g. phosphates and nitrates that causes structural changes to the ecosystem such as increased production of algae and aquatic plants, depletion of fish species, general deterioration of water quality and other effects that reduce and preclude use.

The immediate effect of Eutrophication is the dramatic fast growth of algae called algal blooms due to the greater availability of one or more growth factors necessary for photosynthesis, such as sunlight, carbon dioxide and nutrients (nitrogen and phosphorus). Algal blooms produce toxins that cause mass death of fish species and also prevent light penetration to any depth. The alga, phytoplanktons and other aquatic photosynthetic plants in deeper regions of the lake are unable to photosynthesize and die. Rapid decomposition of these dead organisms by aerobic saprophytic bacteria creates a considerable biochemical oxygen debt/demand (BOD) resulting in deoxygenation of lower regions of the water, The microorganisms, decomposing the organic substance in the absence of oxygen, free compounds that are toxic, such as ammonia and hydrogen sulphide (H_2S) as a consequence most aerobic organisms in this region die.



A useful chemical indicator of Eutrophication is Biochemical oxygen demand.

Causes of Eutrophication

- Discharge of untreated sewage into lakes and rivers. Sewage contains high concentration of phosphate and nitrate ions, resulting from decomposition of detergents and washing powders.
- Use of fertilisers: Agricultural practices and the use of fertilisers in the soil contribute to the accumulation of nutrients. When these nutrients reach high concentration levels and the ground is no longer able to assimilate them, they are carried by rain into rivers and groundwater that flow into lakes or seas.
- Leaching from the surrounding land but it is a slow process and sometimes offset by the removal of the salts as water drains from lakes and rivers.

Effects of eutrophication on the ecosystem.

- Increase in Biochemical oxygen demand causes death of aerobic organisms.
- Algae produce toxins that cause fish to die.
- Species diversity decreases and the dominant biota change.
- Plant, algal and animal biomass increase.
- Turbidity of the water increases reducing light penetration.
- Rate of sedimentation increases, shortening the life span of the lake.
- Anoxic conditions may develop.
- The water becomes unsafe for drinking due to unpleasant taste and odour.
- The water may be harmful to humans and other animals.
- Increased vegetation may impede water flow and navigation.
- Important species of fish may become instinct.

Lakes and rivers with low salt concentrations are termed as ***Oligotrophic lakes*** while those with waters with high concentration of the nitrate and phosphate salts are termed as ***Eutrophic or dystrophic***.

Differences between oligotrophic and eutrophic lakes.

OLIGOTROPHIC LAKE	***EUTROPHIC LAKE***
▪ Deeper in depth. ▪ Relatively higher oxygen concentration in lower regions. ▪ High species diversity with low productivity. ▪ Green algae dominant. ▪ Algal bloom are absent or rare due to low salt content of the water. ▪ Concentration of nitrate and phosphate salts are low. ▪ Animal production is low.	▪ Shallower in depth. ▪ Relatively lower oxygen concentration in lower regions. ▪ Low species diversity with high productivity. ▪ Blue-green bacteria dominant. ▪ Algal blooms very frequent due to high salt content. ▪ Concentration of nitrate and phosphate salts are high. ▪ Animal production is high.

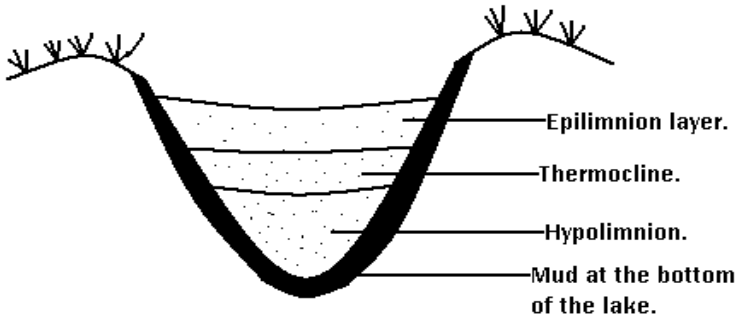
In Lake Ecosystem, the problem of Eutrophic oxygen depletion may be worsened by seasonal **water thermal stratification**. This is where water forms layers with different temperatures. This occurs for two reasons,

(i) The sun heats the surface water, it becomes warm and less dense so it remains in the top layer of the lake called the ***epilimnion***.

(ii) Rivers and streams are shallower compared to lakes and seas and when sun heats their waters, the river and the stream waters become warm through out their depth. And when the warm waters from the rivers and streams are fed into lakes, the warm waters mix only with the surface waters of the lake, and since the waters entering the lakes are light and less dense, they remain on top while raising the temperatures of the waters at the surface forming a layer of warm water at the surface of the lake called epilimnion. The deeper layers remain cool called hypolimnion.

The thermal stratification of mid-latitude lake in summer is in such a way that, a warm oxygen rich circulating layer of water called **epilimnion** at the top is separated from cold oxygen poor layer called hypolimnion waters at the bottom by a broad zone of rapid temperature change layer called the **thermocline** existing in the middle.

DIAGRAM SHOWING THERMAL STRATIFICATION IN SUMMER.



Thermal stratification affect supply of oxygen to the deep waters. Oxygen supplies in the lake waters come from three main sources and these are,

- Photosynthesis which requires light and is therefore most rapid in the surface waters.
- Atmospheric air that mixes with the surface waters and oxygen diffuses and dissolve in the water.
- Dissolved oxygen in stream and river waters draining into the lake.

The above sources of oxygen enrich mainly surface waters. Oxygen in deeper water depends on effective diffusion from upper layer and extreme turbulence linked with storm events. This occurs quite well in winter season. In summer thermal stratification occurs, preventing dissolved oxygen reaching the deeper layers (hypolimnion). The deeper layers will depend on the oxygen that had dissolved in the previous season.

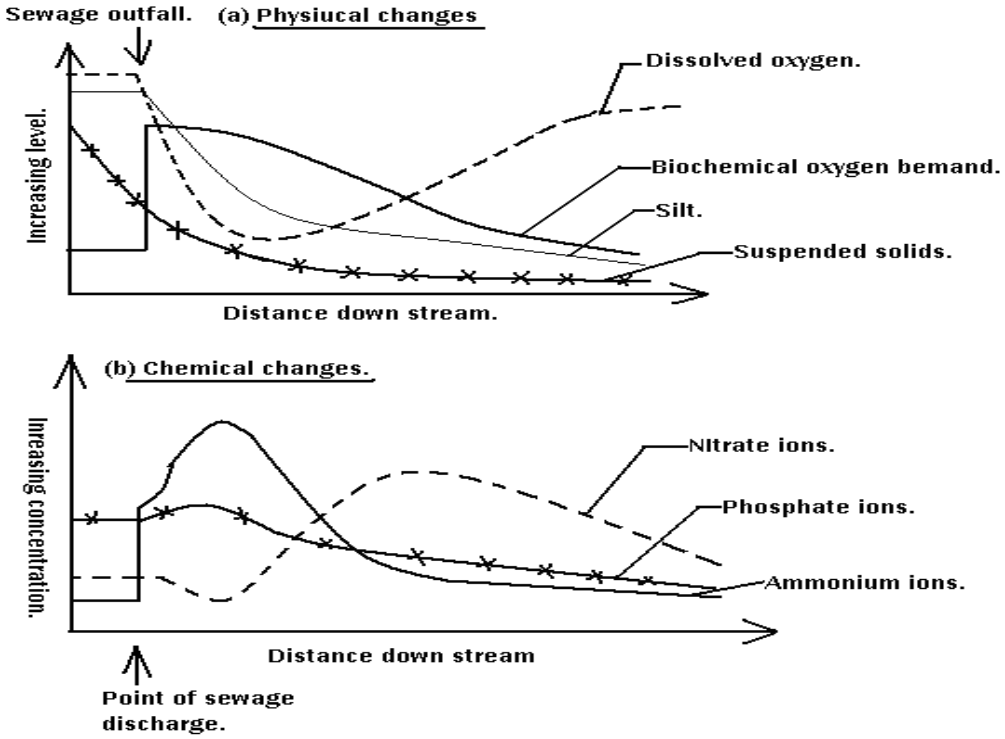
In a healthy lake ecosystem, most primary producers are eaten, few die and form food for detritivores and decomposers. However increased phytoplankton production may occur at the

surface layer of the water due to warmth and increased nutrient status of this epilimnion or due to Eutrophication, excess primary producers not eaten by herbivores will fall into the hypolimnion, when they die there decomposition will create an additional oxygen demand and when oxygen supply is sufficient like in seasons where oxygen from the surface diffuse to the deeper layers, no major problem will arise but if there is no sufficient oxygen diffusing from top to the deeper layers like in summer, sudden fish kill occurs in late summer when biochemical oxygen demand is maximum (oxygen supply approach exhaustion).

PHYSICAL AND CHEMICAL CHANGES IN A RIVER DUE TO DISCHARGE OF UNTREATED SEWAGE IN AQUATIC ECOSYSTEM.

Sewage contains mainly water and organic materials, other in-organic substances such as nitrogen compounds like urea and uric acids, ammonium ions, nitrate and phosphate ions may be present in low concentrations.

Organic matter acts as food source for saprophytic aerobic bacteria. The bacteria carry out decomposition of the organic material, using oxygen dissolved in the water in a process called putrefaction, causing a BOD. Initially the decomposition activity utilizes little oxygen, but as the distance downstream increases, the decomposition processes increases. In this case, the aerobic bacteria successfully decompose the existing organic matter, urea into ammonium ions and there concentration increase rapidly. The ammonium ions are converted to nitrates. The concentration of the ammonium ions decrease while those of the nitrates increase rapidly. Some ammonium and nitrate ions are absorbed by the aquatic plants, reducing their concentrations. The rapid decomposition by aerobic bacteria uses up dissolved oxygen, reducing the concentration of the dissolved oxygen to minimum levels, this creates a Biochemical oxygen Demand (BOD) that will cause the death of most aerobic species, including fish leaving only anaerobic ones. When all organic matter has been broken down further downstream, little or no decomposition activities occur and less dissolved oxygen is used up and its levels rises rapidly again. The increased photosynthetic activities by the phytoplanktons, turbulent, fast moving streams, new dissolved oxygen from the atmosphere may all increase the levels of dissolved oxygen further downstream.



BIOLOGICAL CHANGES IN A RIVER DUE TO DISCHARGE OF UNTREATED SEWAGE IN AQUATIC ECOSYSTEM.

The changes in the physical and chemical conditions in the rivers are accompanied by changes in the flora and fauna of the water body. When the level of organic material is high, saprophytic bacteria survive e.g. the sewage fungus which increases because they feed on sewage. Algal populations lower initially due to the sewage reducing the amounts of light that penetrate the water body.

Further downstream, the algal levels rise above normal because the bacteria break down sewage releasing many minerals including nitrates. As the minerals are used up, the algal levels return to normal.

The population levels of animal species vary according to the level of oxygen in the water. Most tolerant species of organisms to low oxygen levels are the worms of the genus *Tubifex* whose haemoglobin has a particularly high affinity for oxygen which it obtains even at very low concentration. These worms survive in regions close the point of sewage discharge. *Tubifex* population grows high in this region due to lack of competition from other species and absence of predators since they are unable to survive in this region with low oxygen.

Further downstream, there exists other species such as the larvae of the midge *Chironomus* which are also able to tolerate low oxygen levels. They begin to compete with *Tubifex* for small amount of available oxygen and the population of the worm *Tubifex* reduces.

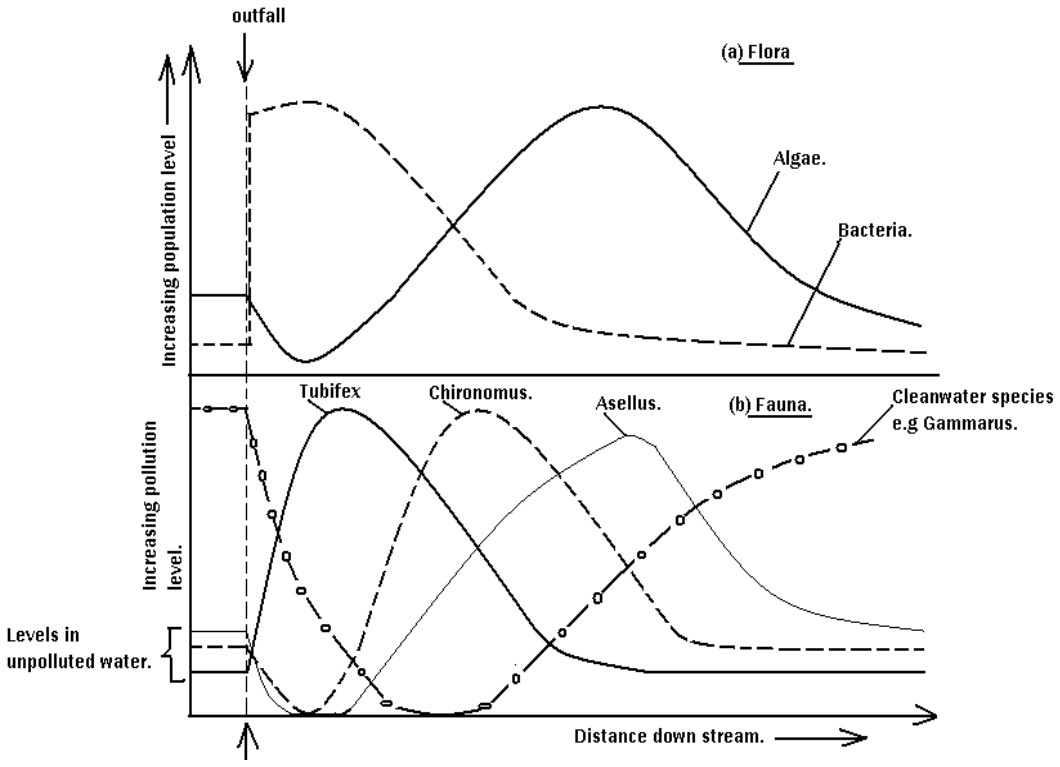
A continuing rise in oxygen further downstream from the outfall results in the appearance of the species like the water louse, *Asellus*. Its presence adds on the intraspecific competition, causing reduction in the populations of the Tubifex and the *Chironomus*.

Finally, as the sewage is completely decomposed, oxygen levels in the water returns normal high and clean water species like Chrimp, *Gammarus* appear again. The ecological equilibrium is restored again and the population levels of the species of organisms return to those found above the outfall. These changes in the fauna and flora are illustrated in the graphs below.

Note: The above organisms act as indicator species;

Indicator species is a species that needs a particular environmental condition or set of conditions in order to survive. Such species are used to monitor water and air quality.

Graphs showing changes in the fauna (animal community) and flora (plant community) due to sewage discharge/effluent.



THERMAL POLLUTION OF WATER.

It arises from the use of water as a coolant in industrial processes like in electricity generation plants. Excess heat is discharged into a nearby waterway causing thermal pollution. Warm water has less dissolved oxygen than cool water, warm water also increases the metabolic rate of aquatic organisms increasing their oxygen demand contributing to increased BOD

Effects of thermal pollution on the aquatic ecosystem

- Kill fish by depriving them of oxygen since increase in water temperatures lowers the amount of oxygen that will dissolve in water.
- It may also cause indirect death of fish and other aquatic animals by encouraging the increased growth of parasites.

- Increased warmth raises the metabolic rate of organisms in the water and therefore increases their oxygen demands.
- Some animals may migrate away from regions of the water with high temperatures to where water temperatures are cool e.g. salmon and trout
- When temperature differences are large in the waters, it may prevent migratory fishes like salmon from returning to spawning sites or from moving down stream.
- It increases growth rate of some shellfish and allows some warm water organisms to be cultured in temperate regions.
- In rivers or lakes polluted with sewage or other organic effluents, addition of warm water may lead to restoration of good water quality. The coolant water may become more oxygenated during use upon addition to polluted water with low oxygen concentration promotes increased microbial activity within the polluted water.

OIL POLLUTION OF WATER.

The main sources of fresh water or marine oil pollution are,

- ✓ Damage to oil tankers due to accidents.
- ✓ Seepage from offshore installations.
- ✓ Illegal washing at lakes, rivers or seas of storage tanks of oil tankers.

Effects of oil pollution

- ♣ The oil coats the feathers of sea birds preventing them from flying, their insulatory ability are reduced causing their death by hypothermia.
- ♣ Oil coats seaweed, preventing photosynthesis.
- ♣ Oil covers the gills of shellfish interfering with their feeding and respiration.

Methods for treating and preventing oil pollution.

- ♣ Burning heavy oil residues.
- ♣ Collection of oil and pumping back into special collection ships.
- ♣ Spraying onto oil slicks naturally occurring bacteria such as Pseudomonas that can digest oil.
- ♣ Routine checkups of supertankers to avoid such hazardous accidents in ecologically sensitive areas.
- ♣ Introduction of double tanker hulls and new ballast systems.
- ♣ Use of floating booms to prevent slicks from reaching sensitive lines.

WATER POLLUTION BY TOXIC CHEMICALS.

These include heavy metals such as copper, zinc, lead, mercury and cyanide that may enter the water bodies. Fish and algae are killed by low concentrations of copper. Mercury denatures most enzymes and may cause many organs to stop functioning, such organs include, kidney, liver and brain. These may lead to loss of sensation, paralysis and eventually death.

The sources of such heavy metals include,

- ♣ Natural weathering of rocks, mercury enters oceans in this way.

- ♣ Discharge of toxic industrial wastes into water bodies.
- ♣ Microbial/bacterial activities may convert less toxic chemicals to toxic ones in the water. For example conversion of less toxic mercury into the toxic dimethyl mercury by anaerobic bacteria.

TERRESTRIAL POLLUTION.

This is the pollution of the land. It is divided into two,

(i) The dumping of wastes and deposits.
(ii) The use of pesticides.

(i) Dumping of wastes and deposits.

Waste materials are dumped into pits or heaps.

Large volumes of solid waste materials accumulating on land from many commercial activities.
Spoil heaps consist of waste material from various mining activities like gravel digging.
Slag heaps are wastes from ore-digging and metal refining activities especially mining of coal.
Domestic waste or rubbish. This contains a high proportion of ash, organic matter, solid non-combustible materials, combustible materials like papers, plastic materials. Domestic rubbish are damped in old quarries, pits and on low lying land.

EFFECTS OF TERRESTRIAL POLLUTION ON ECOSYSTEM.

(i) Heaps of domestic wastes can cause air pollution as unpleasant odour/smell is produced.
(ii) Leads to destruction of habitats for living organisms.
(iii) Some domestic wastes include accumulation of sewage that may end up in water bodies causing Eutrophication. Some toxic chemicals from the heaps and pits of the waste materials may run off into the water bodies after rain, causing death of aquatic organisms or causing Eutrophication.
(iv) Decay of rubbish in absence of air produces methane which is a green house gas. This will lead to global warming.
(v) Toxic substances in the slag heaps may cause death of some organisms.
(vi) They prevent growth of vegetation, this increases the incidences of soil erosion, and removal of vegetation also lowers primary productivity.
(vii) Leads to development of new species of plants tolerant to heavy metals and growing on mine heaps.
(viii) Combustible material in the domestic rubbish may cause uncontrolled fire outbreak.
(ix) When properly covered in soil, can form organic manure for agricultural practices, increasing plant growth and overall yields.
(x) May lead to out break of diseases.

METHODS TO CONTROL DUMPING OF WASTES/DOMESTIC WASTES.

(i) Digging deep and large pits to burry the waste materials.
(ii) Recycling of the materials in domestic wastes.
(iii) Use of organic waste to generate power. For example Biogas production.
(iv) The use of organic waste to produce fertilizers.
(v) Burning rubbish or treating with chemicals to reduce bulk.

USE OF PESTICIDES.

Pesticides are poisonous chemicals which kill pests.

EFFECTS OF PESTICIDES ON THE ECOSYSTEM.

(i) They are used to kill unwanted organisms, weeds and pests in a given area so as to increase crop yields. They can also be used to control spread of diseases by killing vectors of diseases. For example DDT kill fleas and mosquitoes.
(ii) Pesticides are often not specific so they may kill even beneficial organisms thus destroying food webs. Organic pesticides like malathion and parathion may kill useful insects such as bees, some Herbicides like paraguate kill all vegetation.
(iii) Pesticides may get concentrated along food chains killing animals at higher trophic levels.

RADIOACTIVE POLLUTION.

There are two main forms of radiation.

(i) electromagnetic waves.
(ii) Sub-atomic particles.

Electromagnetic waves of short wave lengths have high energy content, they include X-rays and gama rays, both rays are harmful and hazardous.

Sub-atomic particles include α-particles and ß-particles which are naturally radioactive. There are other man made sources of radiations. These include testing of nuclear weapons and wastes from the nuclear power industry.

EFFECTS OF RADIOACTIVE POLLUTION.

(i) Causes gene mutation due to breakage of hydrogen bonds in the DNA molecule.. Mutations in the gonads may lead to production of defective gametes and hence resulting into deformed offsprings.
(ii) Early somatic effects of radiations that include damage to the gut, damage blood cells, bone tissues, skin burns, loss of hair and infertility, all these effects are collectively referred as radiation sickness. While delayed effects include an increased risk of cancer and possible hereditary defects.
(iii) Radioactive materials can also become persistent and accumulate along the food chains, this also affects animals at higher trophic levels especially birds, the normal embryonic development is impaired
(iv) Causes genetic diseases like leukamia.

NOISE POLLUTION.

• Extreme noise causes hearing damage.
• Loud noises can cause anger, discomfort; the loud noise is irritating and stressful
• Loud and sudden noise causes adrenalin to be secreted into blood, causing rise in blood pressure.

INDICATOR SPECIES.

Is a species of organisms that needs a particular environmental condition or set of conditions in order to survive. Presence, absence or population sizes of such species of organisms provide information about the state of the environment. Indicator species are used in a wide range of ecological investigations which include,

- ♣ Present and past Edaphic (soil) conditions.
- ♣ Present and past climatic conditions.
- ♣ Biological monitoring of water and air quality. This involves detection of level of fresh water pollution, BOD of water, Eutrophication and pollution due to sulphur dioxide.
- ♣ Detection of concentration of Carbon monoxide in mines.

Examples of applications of indicator species or biological monitoring of water, air and soil quality using indicator species.

- ❖ Many rivers show that there are characteristic communities of organisms associated with different levels of organic pollution in rivers, lakes and seas. Clean water organisms include stonefly nymphs (larvae), *chrimp*, *Gammarus,* may fly larvae and caddisfly larvae. They indicate unpolluted, well oxygenated water, As pollution increases and oxygen content falls, those organisms tolerant to this conditions appear, these include worms of the genus *Tubifex, Chironomus, Asellus,* rat tailed maggots. These organisms are indicator species of high levels of organic pollution, low dissolved oxygen content of the water called Biochemical oxygen Demand (BOD).
- ❖ Lichens are commonly used to indicate levels of air pollution by sulphur dioxide. Most lichens are very sensitive to levels atmospheric sulphur dioxide. Air pollution levels by sulphur dioxide are indicated by Biotic Index based on lichen species diversity in which lichen species abundance/number of individual lichens, extent of area covered by the lichens and lichens growth forms are considered. On heavily polluted surfaces with sulphur dioxide, species of lichens are absent but only algae are present. Many species of lichen are only present on surfaces less polluted or not polluted at all by sulphur dioxide. Species of lichen such as *Leconora cornizoides*, *L. dispora* and moss species *Ceretodon purpureus* and *Funaria hygrometrica* are most tolerant to high levels of sulphur dioxide pollution. While Lichen species like *Permelia scivatilis* and *P. fulginosa* inhabit areas with low levels of sulphur dioxide such as areas far distance away from industrial cities or towns.

- ❖ Indicator species can also be used to asses levels of in-organic pollutants. For example chemicals contained within individual indicator species may be analysed to assess levels of in-organic pollutants such as pesticide organochloride.
- ❖ Some years ago, coal miners used a canary in a cage to detect levels of air polluted by Carbon monoxide and the canaries used as indicator species to determine whether the conditions in the mine were suitable for health of the miners. Canaries are very sensitive to small amounts of Carbon monoxide and Carbon monoxide poisoning. So, a canary falling off its perch was taken as an alarm signal to accumulating levels of Carbon monoxide and the miners quickly get out of the mines.
- ❖ Eutrophication can be monitored biologically. Changes in phytoplankton species present may help to indicate Eutrophication for example Blue-green bacterial blooms are common in eutrophied water. Eutrophied water also show high abundance and low species diversity of phytoplankton.

Advantages of biological monitoring over physiochemical monitoring.

- ▪ Abundance of organisms depend on the sum of all factors affecting environmental quality, physicochemical factors are usually measured individually.
- ▪ The abundance of organisms reflects the effect of continuous exposure to all environmental factors, physicochemical measurements are usually taken at intervals and are often spot checks.
- ▪ A brief and damaging pollution incident would continue to affect the abundance of organisms for some time even after the event, physicochemical measurements could miss this when they are not continuous.

Disadvantages.

- ▪ Biological indicators do not reliably identify the precise cause of a pollution incidence, physicochemical measurements can identify the precise cause allowing specific actions to be taken.
- ▪ The abundance of the indicator species may vary naturally, so absence of an organism may not reflect a particular environmental condition, carefully conducted physicochemical measurements do not suffer from this problem.

NOTE:

In most situations, environmental quality is monitored both biologically and physicochemically.

Biotic indices are used for routine, continuous monitoring of the environment and when they indicate a problem, physicochemical tests are conducted to identify the precise cause.