5.0 EFFECTS OF HUMAN ACTIVITIES ON ECOSYSTEMS

POLLUTION

It is the release of substances or energy into the external environment in such quantities and for such duration that they cause harm to living organisms or their environment.
Pollutants include noise, heat and radiation as different forms of energy, many chemical compounds and elements and excretory products.
The parts of the external environment affected include air, water and land.

Harm caused by pollutants

- Disruption of life support systems for living organisms
- Damage to wildlife, human health and property.
- Nuisances such as noise and unpleasant smales, tastes and sights

Categorization of pollutants basing on their persistence in the environment

a) Degradable (non-persistent) pollutants:
These are pollutants that are broken down completely or reduced to acceptable levels by natural physical, chemical and biological processes.
Biodegradation is the breakdown of complex chemical pollutants into simpler chemicals by living organisms (usually specialised bacteria) e.g. sewage is a biodegradable pollutant.
b) Slowly degradable (persistent pollutants):
Are those that take a longer time to degrade e.g. DDT - an insecticide, and plastics.
c) Non-degradable pollutants:
These cannot be broken down by natural processes e.g. the toxic elements lead, mercury, arsenic, selenium

AIR POLLUTION

Pollutant and its sources	Effects on living organisms	Control measures
Carbon monoxide [CO] • Motor vehicle exhausts • Incomplete combustion of fossil fuels • tobacco smocking	i) Prevents oxygen usage by blood by forming carboxy-haemoglobin, which may cause death. ii) Small concentrations cause dizziness and headache	i) Efficient combustion of fuels in industry and homes ii) Avoid smocking. iii) Vehicle exhausts gas control e.g. in USA.
Sulphur dioxide [SO_2] Combustion of Sulphur containing fuels, oil, coal gas	i) Causes lung diseases, irritation of eye surface, and asthma resulting into death if in high concentrations. ii) Forms acid rain which increases soil PH. iii) Reduces growth of plants and kills lichens. Lichens are indicator species for SO_2 pollution. The presence of many lichen species indicates low level of SO_2 pollution in that area.	i) Use of Sulphur free fuel e.g. natural gas. ii) Installation of SO_2 extraction units in industrial flues and chimneys.
Ozone, O_3 • Motor vehicle exhausts	<u>Low level</u> (tropospheric) ozone causes i) Internal damage to leaves hence reducing photosynthesis.	

• combustion of fossil fuels to form nitrogen dioxide which decomposes to form oxygen atoms that combine with oxygen molecules to form ozone	ii) Eye, throat and lung irritation which may result into death. iii) Greenhouse effect by absorbing and radiating heat which raises the temperature at the earth's surface. High level (stratospheric) ozone offers protection against excessive solar heat by absorbing solar ultraviolet radiation which would reach the earth's surface	Vehicle exhausts gas control e.g. in USA.
Smoke i) House coal, smoke, soot ii) Motor vehicle exhausts iii) Tobacco smocking iv) Incomplete combustion of refuse in incinerators and bonfires	i) Causes lung diseases when inhaled ii) Sunlight barrier, hence reducing photosynthesis. iii) Stunted growth of plants iv) Stomatal blockage hence reducing photosynthesis.	i) Usage of smokeless fuels ii) Efficient combustion iii) No smoking iv) Vehicle exhausts gas control
Dust Solid fuel ash, soil, quarrying, mining, e.t.c.	i) Lung diseases ii) stomatal blockage iii) Stunted growth of plants. iv) Smog – forms when temperature inversion occurs (layer of warm air traps cool air containing dust and smoke close to the earth' surface)	i) Installation of dust precipitators in industrial chimneys. ii) Efficient combustion. iii) Wearing of face masks by factory workers.
Carbondioxide [CO_2] i) Motor vehicle exhausts ii) combustion of fossil fuels	i) Causes **Greenhouse effect**; warming up of the earth's atmosphere as a result of the blanket of some atmospheric gases e.g. CO_2 preventing escape of solar radiation higher into space. ii) Increased atmospheric CO_2 levels results in global warming – the observed average global temperature rise of 0.8^0C since 1900	Planting more green plants, reduction in combustion of fossil fuels by relying on alternative sources of energy e.g. solar energy
Nitrogen oxides Car exhaust emissions and industrial flue gases	Acid rain formation, contribute to greenhouse effect.	Car exhaust control
Chlorofluorocarbons [CFCs] Aerosol propellants, refrigerator and air conditioner coolants, expanded plastics. E.g. bubbles in plastic foam used for insulation and packaging	Enters stratosphere, the chlorine reacts with ozone hence reducing the ozone layer and permitting greater penetration of UV light to cause global warming.	Ban on the use of CFCs
Noise Discos, road traffic, engines, machines, aeroplanes, firearms	Hearing impairment, total deafness, and nervous disorders.	Effect laws against excessive noise, put on ear muffs and plugs while in industry.
Radioactive fallout from explosion	Ionizing radiation causes cancer	Nuclear power controls

Nuclear weapons and nuclear power fuels		

GREEN HOUSE EFFECT AND GLOBAL WARMING

Greenhouse effect

This is a description of the condition which results when greenhouse gases i.e. gases in the troposphere (atmosphere's inner most layer extending about 17km above sea level) like **carbon dioxide**, water vapour**, methane** and nitrous oxide allow mostly visible light, some infrared radiation and ultraviolet radiation from the sun to pass through the troposphere to the earth, which transforms this solar energy to longer-wavelengths - infrared radiation (heat), which then rises into the troposphere. Molecules of greenhouse gases absorb and emit this heat into the troposphere as even longer-wave length infrared radiation, which causes a warming effect of the earth's surface and air. The tropospheric gases act like a glass of large green house surrounding the earth.

Global warming

This is the observed average global temperature rise of 0.8^0C since 1900 as a result of the enhanced natural greenhouse effect.

Origins/sources of greenhouse gases

i) combustion of fossil fuels by motor engines and industries releases carbon dioxide and methane into the troposphere
ii) deforestation and clearing of grasslands reduces the uptake of carbon dioxide in photosynthesis
iii) ruminant fermentation produces methane, which is released into the troposphere
iv) use of aerosol propellants, which contain CFCs that are 105 times worse than carbon dioxide as greenhouse gases
v) cultivation of rice in swamps and paddy fields causes anaerobic fermentation , which produces methane
vi) use of inorganic fertilisers causes the release of nitrous oxide

Effects of global warming

i) Rise in sea level due to melting of polar ice and thermal expansion of seas.
ii) Altered temperature gradients cause cyclones and heavy rains as water evaporates quicker.
iii) Species migrations which are likely to cause pests/diseases to extend their ranges.
iv) Reduced crop yields due to drier weather.
v) Increased crop yields because of more rainfall and longer growing seasons in some regions.
vi) Flooding low-lying islands and coastal cities.
vii) Extinction of some animal and plant species.
viii) Increased death of the human population.
ix) Greatly increased wild fires in areas where the climate becomes drier.

ACID RAIN

Formation

Combustion of fossil fuels releases **sulphur dioxide** and **nitrogen oxides** into the atmosphere. Catalysed by ammonia and unburnt hydrocarbons, these oxides react with water in the clouds to form solutions of sulphuric acid and nitric acid, which make up acid rain.

Effects

i) Hydrogen ions bound to soil particles are displaced into runoff water by the SO_4^{2-} ions from sulphuric acid, causing formation of soft exoskeletons, which results into death of invertebrates
ii) Aluminium ions are displaced from soil by SO_4^{2-}ions into water where it interferes with gill functioning in fish causing their death.
iii) Aluminium ions displaced from soil by SO_4^{2-} ions into water are toxic when absorbed by plants

iv) The leaching action of acid rain removes calcium and magnesium ions from soil causing poor formation of middle lamella and chlorophyll in leaves.
v) Contributes to human respiratory diseases such as bronchitis and asthma.
vi) Can leach toxic metals such as lead and copper from water pipes into drinking water.
vii) Damages statues and buildings
viii) Decreases atmospheric visibility, mostly because of sulphate particles
ix) Promotes the growth of acid-loving mosses that can kill trees.
x) Loss of fish populations when the PH lowers blow 4.5

Prevention

i) Installation of SO_2 extraction units (wet scrubbers) in chimneys of industries.
ii) Cleaning up exhaust emissions by encouraging several pollutants to react with one another to give less harmful products in catalytic converters.
iii) Reduce coal use.
iv) Increase use of renewable resources.
v) Tax emissions of Sulphur dioxide i.e. "Polluter pays principle" should be adopted everywhere

Why high-altitude lakes quickly become acidic than low-altitude lakes?

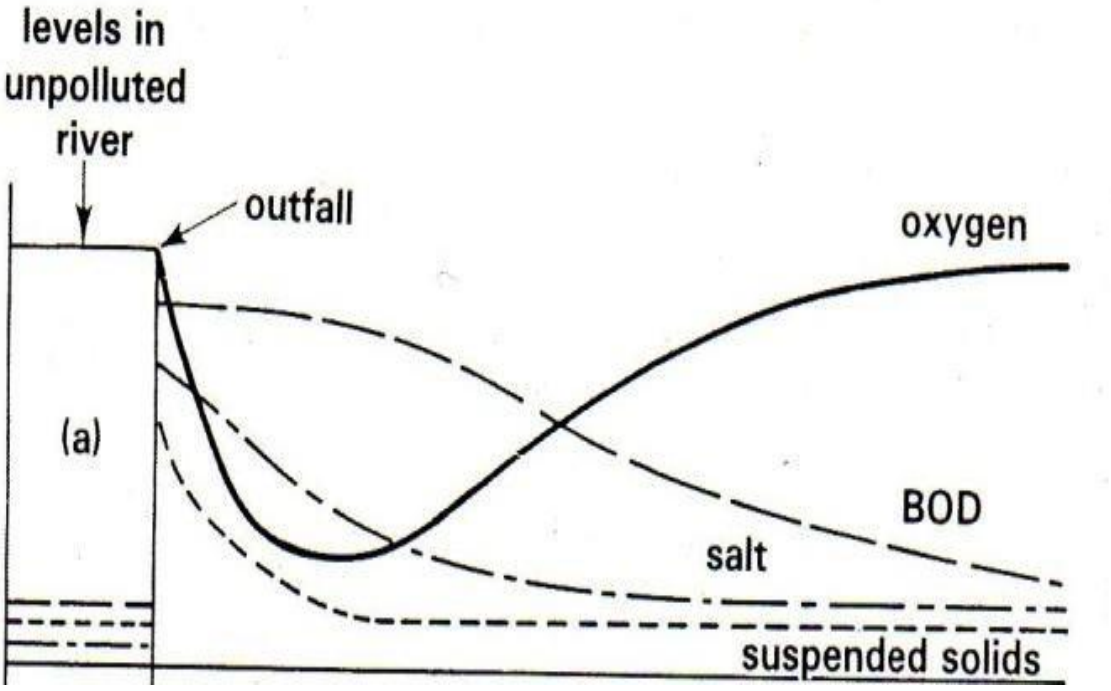
Low-altitude lakes are richer than high-altitude lakes in limestone which buffers against the effects of acid rain, and also the surrounding soils to low-altitude lakes are deeper.

MAJOR CATEGORIES OF WATER POLLUTION

A) Sewage discharge into rivers

Sewage is liquid waste (composed of faeces, urine, water, detergents and other substances) from industries and or homes carried through pipes called sewers.

Effects of sewage discharge into rivers - changes in abiotic (a and b) and biotic (c and d) conditions



Component description from the point of discharge and explanation

Part a

Dissolved oxygen and **B.O.D (Biological oxygen demand)**

BOD is the mass of oxygen consumed by microorganisms in a sample of water in a given time - usually measured as the mass (in mg) of oxygen used by $1dm^3$ of water stored in darkness at 20^0C for 5 days.

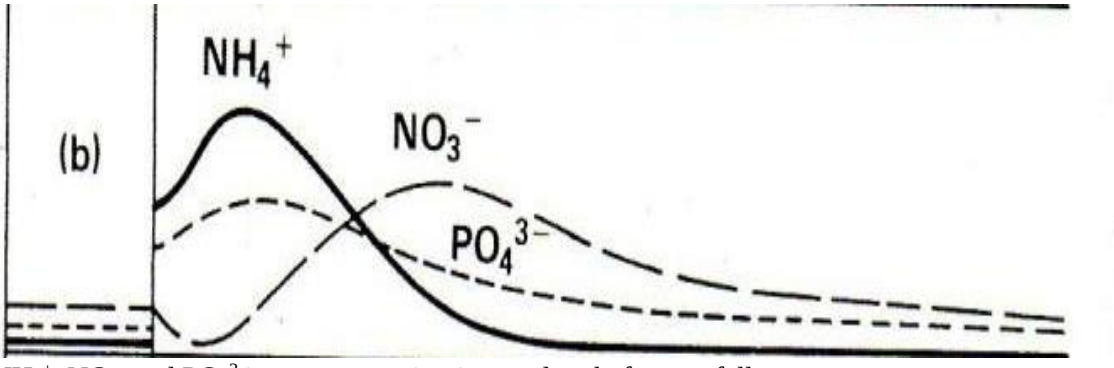
B.O.D indicates the oxygen not available to more advanced organisms. Therefore a high B.O.D indicates anaerobic conditions (low oxygen availability).
Dissolved oxygen level is high in unpolluted water but decreases rapidly at sewage outfall (discharge) to the minimum and then increases gradually downstream, returning to a normal level further downstream

- B.O.D is very low in unpolluted water, increases rapidly at outfall then decreases gradually downstream.
- Decomposition of organic components of sewage by aerobic bacteria coupled with reduced photosynthesis because of low illumination caused by suspended solids in sewage rapidly reduce oxygen (cause oxygen sag) and create a high BOD at outfall.
- The gradual increase of oxygen downstream is because of increased photosynthesis and dissolution from atmosphere.
- The death of aerobic bacteria due to reduction in organic substances decreases BOD down stream

Suspended solids

- Suspended solids are very few before outfall, increase rapidly at the sewage discharge but progressively decrease downstream
- Sewage discharge adds decomposable organic matter into the water at the point of discharge, the progressive decrease downstream is due to bacterial consumption and dilution by water.

NH_4^+, NO_3^- and PO_4^{3-}(Ammonium, nitrate and phosphate ions)



- NH_4^+, NO_3^- and PO_4^{3-}ion concentration is very low before outfall
- NH_4^+ions increase rapidly at discharge, then very rapidly to a maximum just after outfall, then decreases first rapidly and later gradually to a very low level downstream.
- NO_3^- ions first decrease gradually to a minimum concentration after outfall, gradually increase to a maximum a short distance downstream, then decreases gradually further downstream.
- PO_4^{3-} ion concentration increases **(1)** rapidly at discharge, **(2)** gradually just after outfall to a maximum, then decreases gradually to a very low level downstream.

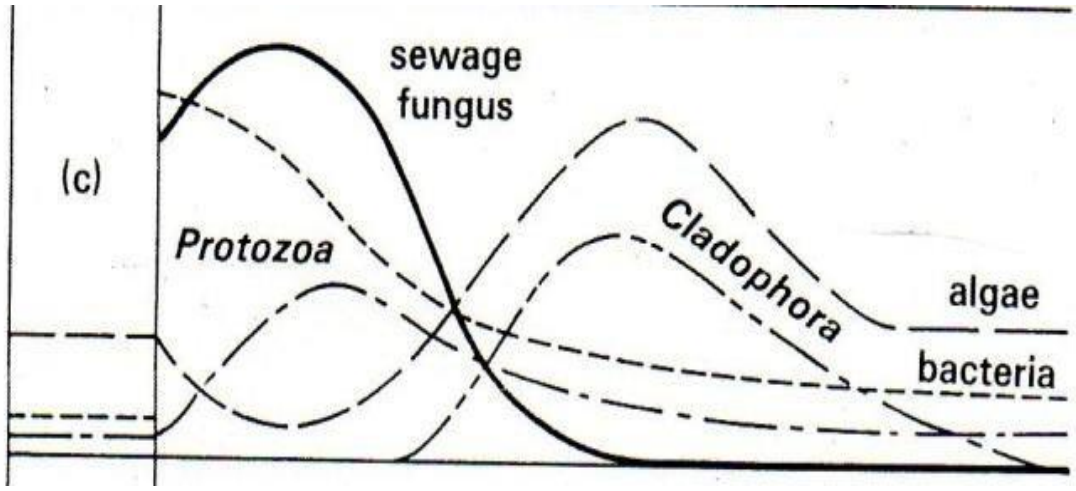
❖ Sewage contains NH_4^+ions. Putrefying (ammonifying) bacteria convert organic nitrogen-containing compounds in sewage to NH_4^+ just after outfall. Downstream, NH4+ions are converted to NO_3^- by nitrifying bacteria and further downstream there is dilution by water.

❖ NO_3^- ions first decrease due to consumption by sewage fungus abundant at outfall, then gradually increase because NH_4^+ions are converted to NO_3^- by nitrifying bacteria, then decrease gradually due to consumption by plants and algae.

❖ Sewage contains PO_4^{3-} ions from **(1)** detergents and **(2)** decomposition of organic matter, yet the consumption by autotrophs is very low at outfall, accounting for the high PO_4^{3-} ion concentration.

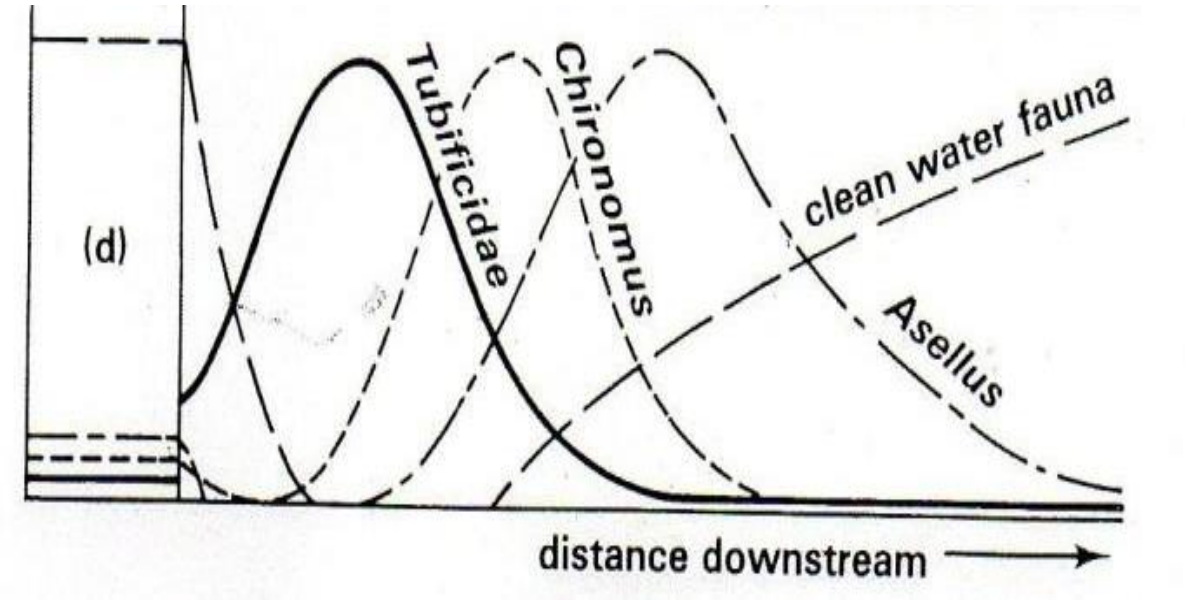
❖ PO_4^{3-} ion gradual decline downstream is caused by **(1)** absorption by the progressively increasing populations of autotrophs **(2)** storage in sediments.

Aerobic bacteria, sewage fungus, algae and higher plants



- Aerobic bacteria are very few before, but very many at outfall, then their population decreases rapidly immediately and gradually after out fall downstream.
- Sewage fungus is contained in sewage population, increases to a maximum immediately after outfall, but decreases rapidly downstream to very low level.
- Algae and higher plant populations decrease rapidly to a minimum at outfall but increase rapidly a short distance downstream and return to normal further downstream.
- Sewage contains aerobic bacteria that feed on organic substances, but population falls as availability of oxygen and nutrients diminishes.
- Population increases at outfall because the sewage fungus thrives in anaerobic conditions and is very tolerant of high ammonia concentrations.
- The rapid decrease in populations results from reduced photosynthesis because of the turbidity caused by suspended solids, the rapid increase is because of the high concentrations of NO_3^- (nitrate) ions and increased illumination because suspended solids reduce and water becomes clearer

Clean water fauna (e.g. stonefly nymphs, may fly larvae, perch, trout), Asellus (fresh water louse), Chironomus (bloodworm), rat tailed maggot and Tubifex



- The populations of clean water fauna are high before outfall, decrease rapidly to zero at outfall only appearing and increasing to normal with distance downstream.
- Asellus population decreases rapidly to zero at outfall, only appearing and increasing rapidly to a maximum a short distance downstream after which it decreases rapidly.
- Tubifex population increases rapidly to a maximum at outfall and then decreases rapidly downstream. Rat tailed maggots' population increases rapidly to a maximum a short distance after outfall and then decreases rapidly downstream and
- Chironomus population increases rapidly to a maximum at a slightly longer distance from outfall and then decreases rapidly downstream.
- Clean water species cannot tolerate anaerobic conditions at outfall, populations increase downstream because oxygen and food become available.
- Asellus cannot tolerate anaerobic conditions at outfall and therefore dies and/or migrates to the relatively less polluted water downstream where it shrives. The decrease thereafter is due to consumption.
- Tubifex, rat tailed maggots and Chironomus are **(i)** relatively inactive to reduce oxygen demand and **(ii)** have respiratory pigments with very high affinity for oxygen enabling them to be tolerant to anaerobic conditions. The increase in their population downstream indicates the level of pollution in the water. Tubifex, is the most tolerant to anaerobic conditions, followed by rat tailed maggots and Chironomus. The decrease in population downstream is partly due to predation.

Note:

Flowing rivers naturally undergo self-purification to recover from pollution through a combination of dilution and biodegradation, but the recovery time and distance depend on;

i) volume of incoming degradable wastes in sewage
ii) flow rate of the river
iii) temperature of the water
iv) PH level of the water

Addition of inorganic chemicals, plant nutrients and sediments into lakes

Pollutant	**Examples**	**Main human sources**	**Harmful effects**
Plant nutrients	Nitrate (NO_3^-), phosphate (PO_4^{3-}) and ammonium (NH_4^+) ions. The nutrient enrichment of water bodies is termed **eutrophication**	Raw sewage discharge, detergents and other chemical release from industries, leaching of inorganic fertilizers e.g. NPK from farmland.	**(1)** Rapid growth of algae and green protists (algal blooming) **(2)** reduces light penetration in water leading to **(3)** Death and decay of algae, which depletes water of dissolved oxygen, killing fish and other aerobic animals. **(4)** Excessive levels of NO_3^- if drank in water lowers the oxygen carrying capacity of blood and kills unborn children and infants ("blue baby syndrome")
Sediment	(1) soil (2) silt	Land erosion	**(1)** cause turbidity / cloudiness in water and reduce photosynthesis, **(2)** settle and destroy feeding and spawning grounds of fish, **(3)** clog and fill water bodies, shortening their lifespan **(4)** disrupt aquatic ecosystems **(5)** carry pesticides, bacteria and other harmful substances into water.

Inorganic chemicals	Acids, compounds of toxic metals like lead (Pb), mercury (Hg), arsenic (As) and selenium (Se) and (3) salts e.g. NaCl in ocean water	Surface runoff, industrial effluents and household cleaners.	**(1)** Drinking water becomes unusable for drinking and irrigation **(2)** Lead and Arsenic damage the nervous system, liver and kidneys **(3)** they harm fish and other aquatic life **(4)** they lower crop yields **(5)** they accelerate corrosion of metals exposed to such water.

Heat (thermal) pollution:

Main human sources

Water cooling of electric power plants and some types of industrial plants

Harmful effects

1) Lowers dissolved oxygen levels since solubility of most gases reduces with temperature.
2) Makes aquatic organisms more vulnerable to disease, parasites, and toxic chemicals
3) When a power plant shuts down for repair or opens, fish and other aquatic organisms adapted to a particular temperature range can be killed by the abrupt change in water temperature. This is known as **thermal shock**.
4) Some aquatic animals may migrate to waters with favourable temperature.

Note:

Effects of eutrophication are more severe in water bodies where thermal pollution occurs because of **(1)** increased decomposition of organic matter and metabolism, which raises the demand for oxygen by higher organisms, **(2)** reduced dissolved oxygen levels in water.

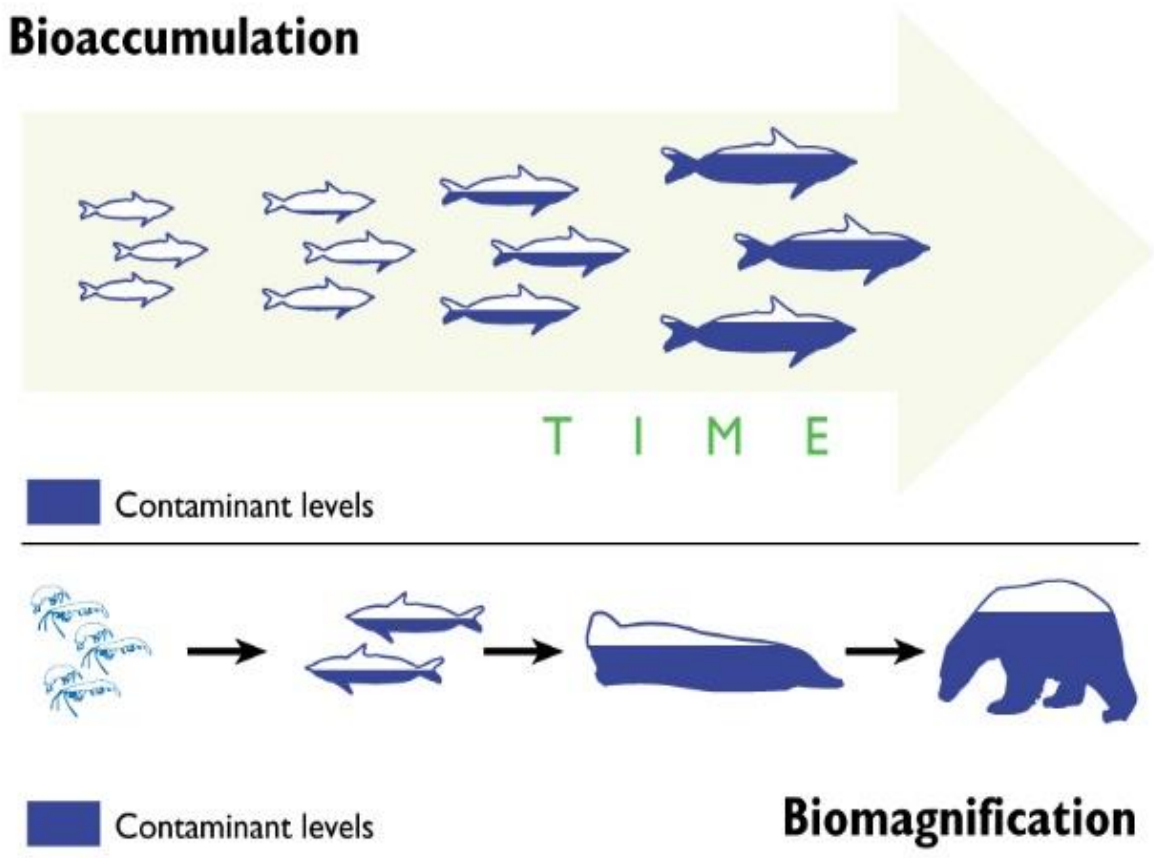
Chemical pest control

Properties of an **ideal pesticide**, **s**hould;

i) be biodegradable / non-persistent so that toxic products are not left in or on crop plants
ii) be specific so that only pest species is killed.
iii) not accumulate either in specific parts of an organism or as it passes along food chains.
iv) effectively control the pest under field growing conditions.
v) be easy to apply at the correct dosage.

Problems of using insecticides

1. Bioaccumulation (some molecules of the pesticide may be stored in specific organs or tissues at levels higher than would be expected) and biological magnification (the pesticide may get more concentrated as it passes along the food chains and webs) may occur. See the figure on the right: (Soper page 336 fig 10.32)



2. Many are non-specific, killing non-target species, particularly natural predators of the pest species i.e. by killing pests, the natural enemies of the pests will lack food hence they too will die.
3. Accidental misuse of toxic chemicals results in death of humans and domestic animal.
4. Effect on the cycling of materials
5. Pest resistance occurs i.e. genetic variation enables a few individuals in the pest population to survive and may quickly reproduce.
6. Effect on the cycling of materials
7. There is pest replacement i.e. since most crop are susceptible to attack by more than one pest species, and the pesticide may be more deadly to one species than another, elimination of one species may simply allow another species to assume major pest proportions.
8. Pest resurgence may occur i.e. non-specific pesticides may kill natural predators as well as pests, and so a small residual pest population may multiply quickly without being checked.

Dichlorodiphenyltrichloroethane (DDT)
Concentration of DDT in water = 0.000003 parts per million (ppm)
Concentration of DDT in ospreys = 75ppm
DDT concentration in osprey compared to water = 75/0.000003
DDT therefore was magnified by magnified by a factor of 2.5 million times

Effects of DDT

i) Inhibits cytochrome oxidase enzyme.
ii) Limits reproductive success, especially by causing formation of thin eggshells in birds of prey.
iii) Kills organisms.

Effects of other pesticides in general

i) Inhibition of enzyme activity
ii) Kill organisms.
iii Reduce species diversity
iv) It increase productivity at lower levels of the ecosystem
v) It increase productivity at higher levels of the ecosystem

Fig 32.18 page 540 Roberts

Biological pest control

Control of a pest population using its natural predator, parasite or pathogens

Steps involved in biological control:

a) Identifying the pest and tracing its origins, i.e. where it came from.
b) Investigating the original site of the pest and identifying natural predators, parasites or pathogens of the pest.
c) Testing the potential control agent under careful quarantine to ensure its specificity.
d) Mass culturing of the control agent.
e) Development of the most effective distribution / release method for the control agent.
f) Use procedures which make it impossible for the pest to complete its life cycle

Several human activities which directly destroy the environments are:

1. **Deforestation;** forests are important for:

Have most species and diverse wild life communities. Their destruction will lead to extinction of numerous species and less of genetic variety and potential resources.

Forests protect the soil. Deforestation leads to soil erosion, clear water supply are destroyed and silting of reservoirs.

Timber harvest, poles, food, fuel, honey, fruits and herbs

Forests catch large amounts of rain and release the water slowly into streams and rivers. Their destruction cause floods in areas down-hill.

Forests release large amounts of oxygen and absorb carbon dioxide (lock it up) during photosynthesis. Deforestation has led to increased global carbon dioxide hence causing global warming.

Forests influence the amount and frequency of rain fall received in an area.

2. **Poor agricultural methods:**

These include Monoculture, shifting cultivation, use of artificial fertilizers and pesticides. Excess fertilizers and pesticides leads to eutrophication of water bodies giving rise to build up of toxic by-products by leaching and draining. Pesticides/herbicides/fungicides draining away from fields enter water ways are connected through the food chain. This leads to poisoning of top carnivores.

3. **Poor methods of mining;** such as open cast mining destroy habitats. Mineral elements mined cause destruction of the environment around the mine. Heavy metals like lead and mercury drain into water bodies causing severe destruction of aquatic fauna, poison water for human consumption; sulphides destroy vegetation altering the structure of plant and animal communities.
4. **Urbanization/human settlement;** e.g. aggregation of people, food and water supply, garbage disposal.
5. **Fires;** burning of fossil fuel
6. Cement manufacture

NATURAL RESOURCES

From a human stand point, a resource is anything obtained from the environment to meet human needs and wants. Natural resources are those not made by man.
While some resources are directly available for use e.g. solar energy, fresh air, wind, fresh surface water, fertile soil, wild edible plants others become available after processing has been done e.g. petroleum, metallic elements like iron, ground water, modern crops.

CLASSIFICATION OF NATURAL RESOURCES

Type of resource	Example
Perpetual resources Resources that are replaced (renewed) continuously on human time scale	Solar energy, wind, tides.
Renewable resources Resources that are replenished (replaced) fairly rapidly (hours to decades) through natural processes as long as the usage is not faster than the replacement	Fresh water, fresh air, fertile soil, animals and plants (Forests, grasslands)
Nonrenewable resources Resources that exist in a fixed quantity or stock in the earth's crust. On the shorter human time scale, they depleted much faster than they are formed i.e. the energy crisis	Fossil fuels (e.g. coal, oil, natural gas), metallic minerals (e.g. copper, iron, aluminium), non-metallic minerals (e.g. salt, clay, sand, phosphates)

Further terms associated with natural resources
Sustainable yield
The highest rate at which a renewable resource can be used indefinitely without reducing its availability supply.
In spite of the renewability, renewable resources can be depleted or degraded.

Environmental degradation
The process when the resource's natural replacement rate is exceeded resulting into a decline in its availability.
Urbanization of productive land, excessive soil erosion, deforestation, ground water depletion, overgrazing of grasslands by livestock, reduction in the earth's forms of wildlife by elimination of habitats and species, pollution, water logging and salt buildup in soil.

Sustainable yield

The highest rate at which a renewable resource can be used indefinitely without reducing its availability supply.
In spite of the renewability, renewable resources can be depleted or degraded.

Reusing of resources
Using of resources over and over in the same form.
Glass bottles of alcoholic and soft drinks can be collected, washed and refilled many times.

Wildlife
This is includes plants and animals that occur in their natural environment such as forests and wild animals

WHAT IS BIODIVERSITY (BIOLOGICAL DIVERSITY)?

The different life forms and life-sustaining processes that can best survive the variety of conditions currently on earth.

Kinds of biodiversity

a) **Genetic diversity** – variety in the genetic makeup among individuals within a species.
b) **Species diversity** (species richness) – number of species present in a habitat.
c) **Ecological diversity** – the different biological communities e.g. forests, deserts, lakes etc.
d) **Functional diversity** – biological and chemical processes or functions such as energy flow and matter cycling needed for the survival of species and biological communities.

Species abundance refers to the number of individuals of each species

Term	Definition/ explanation
Immigration	Movement of individuals into a population from neighbhouring populations.
Emigration	Departure of individuals from a population.
Rare species	Species with small populations either restricted geographically with localized habitats or with widely scattered individuals.
Endangered species	Species with low population numbers that are in considerable danger of becoming extinct.
Extinct species	Species, which cannot be found in areas they previously inhabited nor in other likely habitats.

Factors that affect species diversity on land and in water

a) **Latitude** (distance from equator) **in terrestrial communities**; species diversity decrease steadily with distance from the equator toward either pole, resulting in the highest species diversity in tropical areas e.g. tropical rain forests and lowest in polar areas such as arctic tundra. The main effect of latitude is on temperature, which later affects life.
b) **Depth in aquatic systems;** in marine communities, species diversity increases from the surface to a depth of 2,000 metres and then begins to decline with depth until the deep-sea bottom is reached. This change is attributed to light penetration which affects photosynthesis, availability of oxygen and availability of dead organisms at the sea bottom.
c) **Pollution in aquatic systems**; increased pollution kills off or impairs the reproductivity of various aquatic species hence reducing species diversity and abundance.
d) **Increased solar radiation** increases species diversity in terrestrial communities.
e) **Increased precipitation** in terrestrial communities increases species diversity.
f) **Increased elevation** decreases species diversity.

g) **Pronounced seasonal changes** increase species diversity.

FACTORS THAT AFFECT SPECIES DIVERSITY IN AN ISLAND ECOSYSTEM

Robert MacArthur and Edward O Wilson (1960s) studied communities on islands after which they proposed the species equilibrium model or the theory of **island biogeography**.

- According to this model, the number of species found on an island is determined by a balance between two factors:
  - **a) The rate at which new species immigrate to the island and**
  - **b) The rate at which species become extinct on the island.**
- The model predicts that at some point the rates of immigration and extinction will reach an equilibrium point that determines the island's average number of different species (species diversity)
- The model also predicts that immigration and extinction rates (and thus species diversity) are affected by two important features of the island;
  - **a) Size of the island.**
  - **b) Distance of the island from the nearest main land.**

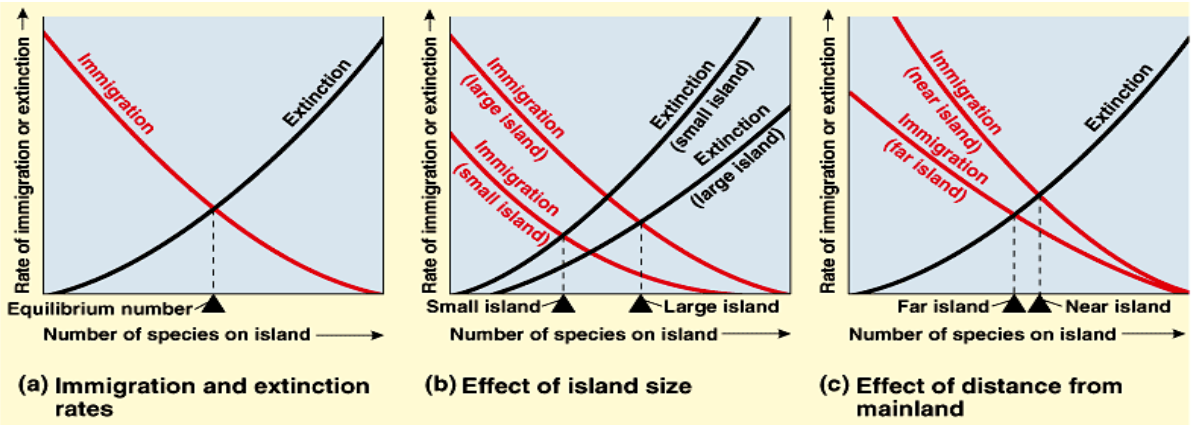
Size of the island

Larger islands tend to have higher species diversity than Small islands because of two reasons:

i. Small islands generally have lower immigration rates since they are a smaller target for potential colonizers
ii. Smaller islands should have a higher extinction rate because they generally have fewer resources and less diverse habitats for colonizing species.

Distance of the island from the nearest main land:

For two islands of about equal size and other factors remaining constant, the island closest to the main land source of immigration species will have the higher immigration rate and thus a higher species diversity (assuming that extinction rates on both islands are about the same)

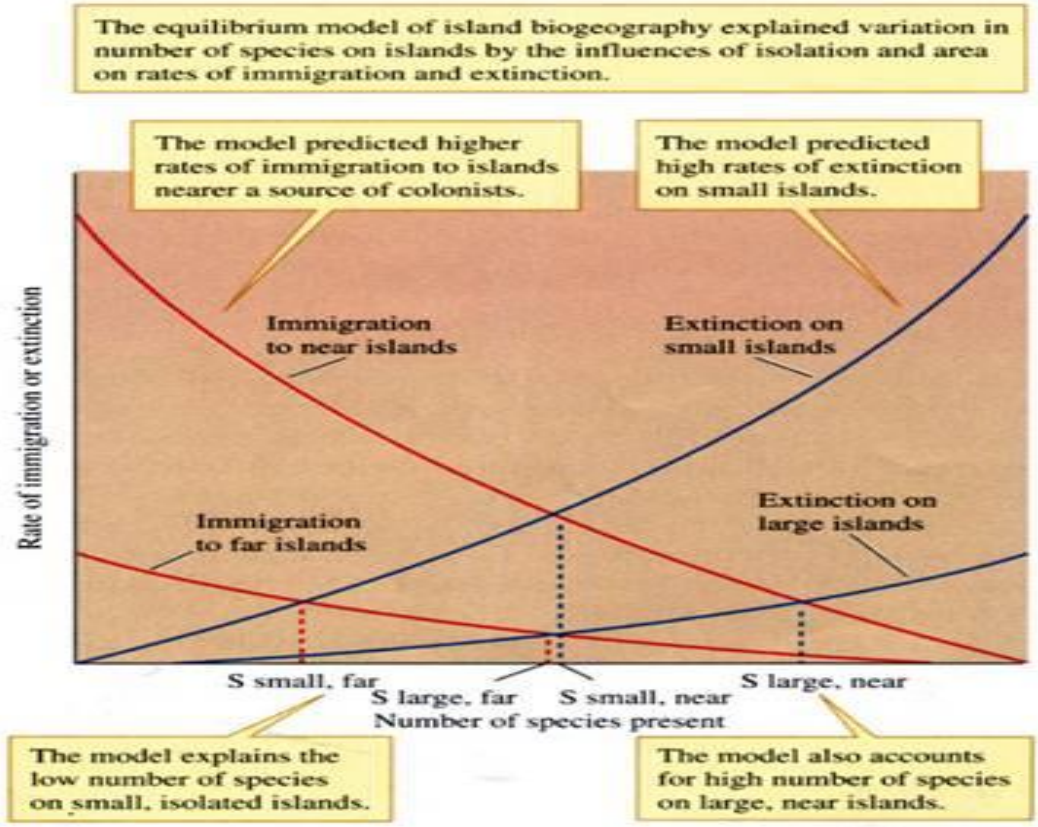


Explanations from the observations made from the graphs

a) Immigration and extinction rates

- The rate of immigration decreases with increase in species number, while the extinction rate increases with increase in species number on the island.
- The equilibrium number of species on the island is reached when immigration rate and extinction rate equal.

- Extinction rate increases with increasing species number because of interspecific and intraspecific competition.



b) Effect of island size on immigration and extinction rates

- The rate of extinction increases with increase in species number on the island on both small and large islands, but it is higher on small islands than on large islands. The higher extinction rate on small islands is because of the fewer resources and less diverse habitats for colonizing species.
- The rate of immigration decreases with increase in species number on both small and large islands, but with a large island having a higher immigration rate than a small island. Small islands have lower immigration rates because they are a smaller target for potential colonizers.

c) Effect of distance from mainland on immigration and extinction rates

- For both near and far islands, immigration rate decreases with increase in species number, but immigration rate is higher on near island than on the distant island. The higher immigration rate on near island is because of the easy reach by organisms enabled by its proximity to the main land.
- Since extinction rate increases with increasing species number that exert interspecific and intraspecific competition, extinction rate is far higher on small islands due to the fierce competition caused by the higher immigration rate because of easy reach by organisms enabled by its proximity to the main land.

Conservation of natural resource

Ecosystems contain natural biological resources which are useful for (**1**) food (**2**) medicine (**3**) raw materials for industries (**4**) biological control of pests and diseases (**5**) biogeochemical cycling (**6**) pleasure i.e. ecotourism.

Some of the conservation methods employed include;

(a) restricting urban and industrial development
(b) implementing recycling programs
(c) legislating the protection of endangered and keystone species, and enforcement of the law
(d) carrying out breeding programs and establishing sperm/seed banks to maintain high biodiversity
(e) implementing sustainable development programs
(f) establishing conservation areas such as national parks, zoos, botanical gardens, nature reserves and sanctuaries
(g) effective pollution control methods, especially when wildlife species are vulnerable to pollutants
(h) creating corridors that connect habitat fragments
(i) bioremediation i.e. using organisms e.g. fungi and prokaryotes to detoxify polluted ecosystems

SAMPLE QUESTIONS