Environmental Science

Unit 1 - Environment, Ecosystems and Biodiversity

- **Environment** - encompasses everything that is around us or the surroundings of an object.

  From the French word environ, meaning to encircle

- It involves relationships that exist between living organisms and non-living things like air, land and water.

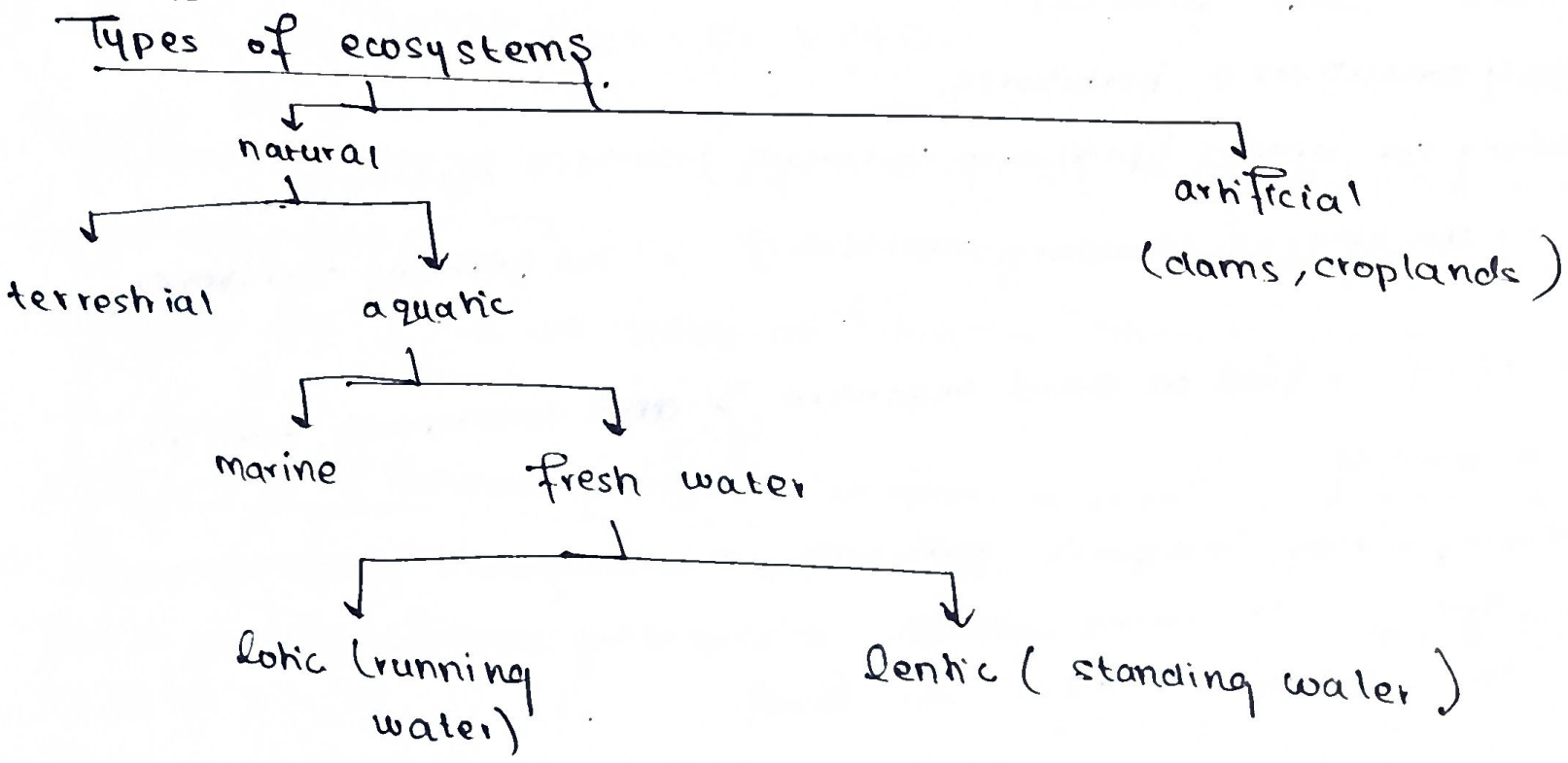
- **Causes for key environmental problems**

(i) increase in population
(ii) overexploitation of natural resources
(iii) lack of environmental awareness
(iv) luxurious lifestyle

- **Ecology** - the study of the interactions between organisms in an environment, with both biotic and abiotic components.
  (study of an ecosystem)

- **Ecosystem**: The basic functional unit of ecology. A group of organisms interacting among themselves and with the environment is known as an ecosystem.

Types of ecosystems



- Structure or components of an ecosystem

(A) Abiotic components: non living components
climate, soil, water, air, energy, nutrients

Physical components: energy, climate, raw materials that the biological community need

Chemical components: source of essential nutrients

organic substances: proteins, lipids, carbohydrates
inorganic substances: micro (Al, Co), macro (C, H, O) elements

(B) Biotic components: living members in an ecosystem, classified on the basis of their nutritional relationship

1. Autotrophic components: producers, make their own food, derive energy from sunlight. eg. green plants, algae

2. Heterotrophic components: consumers and decomposers, which depend on others for food., they consume the autotrophs. The heterotrophs are classified as:

(i) macro consumers: primary herbivores, carnivores & omnivores
(ii) saprotrophs (micro consumers): decomposers like bacteria, fungi.

Classification of consumers

primary consumers = herbivores
secondary consumers (primary carnivores) = eat herbivores
tertiary consumers (secondary carnivores) = eat primary carnivores

Decomposers: • feed on dead organism, and decompose them into simpler compounds
• during decomposition, inorganic nutrients are released. Those inorganic nutrients, along with same organic substances are utilized by producers to synthesize their own food.

Functions of an Ecosystem

1. Primary function: manufacturing starch (photosynthesis)
2. Secondary function: distributing energy in the form of food to all consumers
3. Tertiary function: All living organisms die at a particular stage. These dead systems are decomposed to initiate the third function of ecosystems, i.e cycling.

Energy flow in ecosystems

- Solar energy transformed into chemical energy, by the process of photosynthesis. The atmosphere absorbs about 50% of the energy.
- Though a lot of sunlight falls on the green plants, only 1% is utilized for photosynthesis.
- Some of the chemical energy is used by the plants for their growth, and the remaining is transferred to the consumers by the process of eating.
- Thus, energy enters the ecosystem through photosynthesis and passes through different tropic levels.

Photosynthesis Equation

$$CO_2 + H_2O \xrightarrow{\text{sunlight}} CH_2O + O_2 + H_2O$$

- The law of ~~conserv~~ conversion of solar energy is governed by the first law of thermodynamics. It says that energy can neither be created or destroyed, but it can be converted from one form to another.

~~i.e Solar~~

2nd Law of Thermodynamics: Whenever energy is transformed, there is a loss of energy through the form of heat.
This occurs when energy is transferred through tropic levels. (around 80-90%)
There is a loss of energy during respiration as well.

Respiration equation

$C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$

Food chains, food webs and ecological pyramids

Food chains: The transfer of energy within the ecosystem by a sequence of eating and being eaten is called a food chain. It flows from producers to herbivores to carnivores.

For eg. Grass → grasshopper → frog → snake → hawk

(grassland ecosystem)

Features of food chains

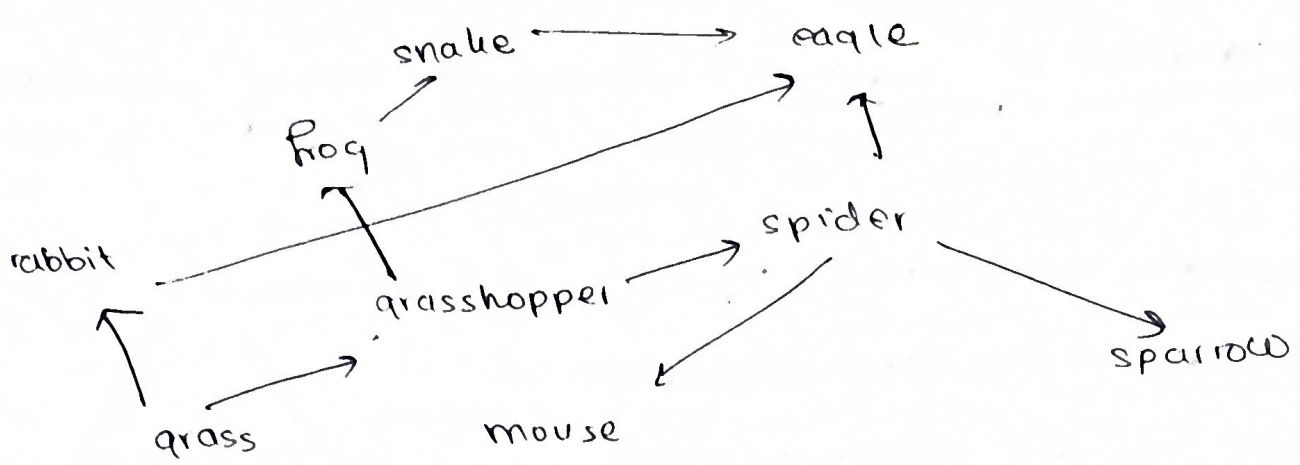
- A food chain is always straight.
- Usually 80-90% of the energy is lost as heat when energy is transferred from one level to another.
- Shorter food chains provide greater available energy.
- Most food chains do not have more than 4 or 5 links.

Types of food chain

1. Grazing food chain: found in a grassland ecosystem
2. Detritus food chain: starts with organic dead matter, organic nutrients is broken down into simple nutrients by bacteria and fungi.

   leaf litter → algae → crabs → small carnivorous fish
3. Parasitic food chain: either the producer or consumer has parasites. The parasites extract food from them. Energy transfer is not significant.

Food webs: Most consumers feed on more than 1 type of organism and most organisms are eaten by more than 1 consumer. A network of food chains is called a food web. Also called 'web of life'.



Significance of food webs

- To understand the feeding relationships between organisms.
- To understand the energy flow mechanism and matter circulation
- To track the movement of toxic substances, and the problem of biological magnification

Differences between food chain and food web

Food chain	Food web
1. simple structure	complex structure
2. unidirectional	multidirectional
3. less number of organisms	large number of organisms
4. a single strand of different levels of energy transfers	shows many chains in a particular ecosystem

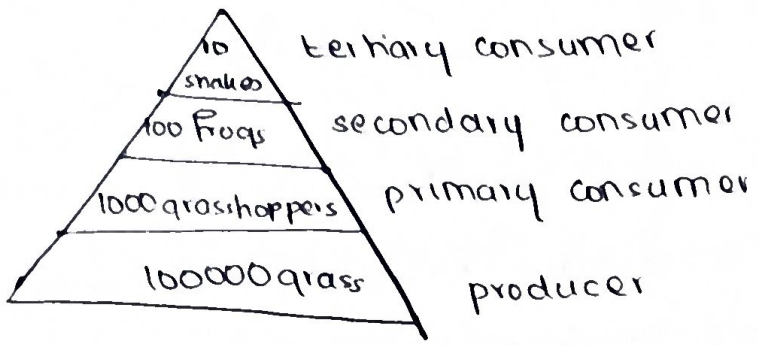
Ecological Pyramids : a graphic representation of trophic levels and functions of an ecosystem.

Types: (i) pyramid of numbers : no. of organisms at each level
(ii) pyramid of energy : rate of flow of energy at different trophic levels
(iii) pyramid of biomass : shows total biomass present at each tropic level.

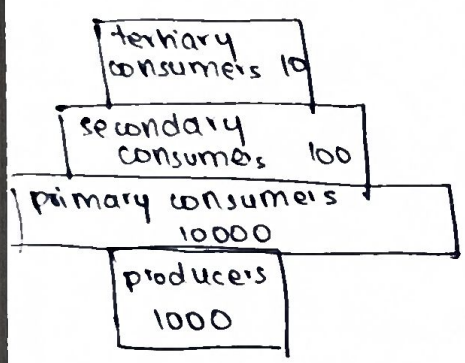
(1) Pyramid of numbers: shows the no. of organisms at each level.

- can be upright, ~~certi~~ partially upright and inverted

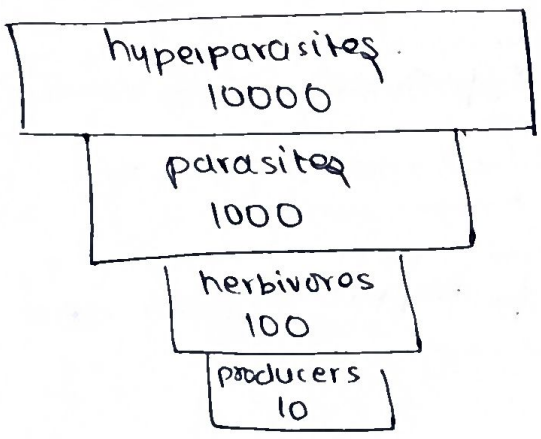
upright pyramid = grassland ecosystem



- partially upright = forest ecosystem

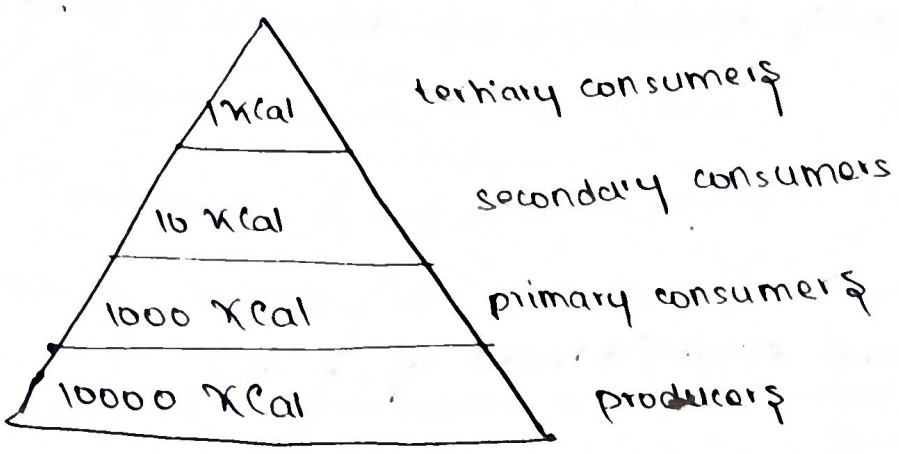


- inverted pyramid : parasitic food chains (one primary parasitic producer supports numerous parasites, which support even more hyperparasites)

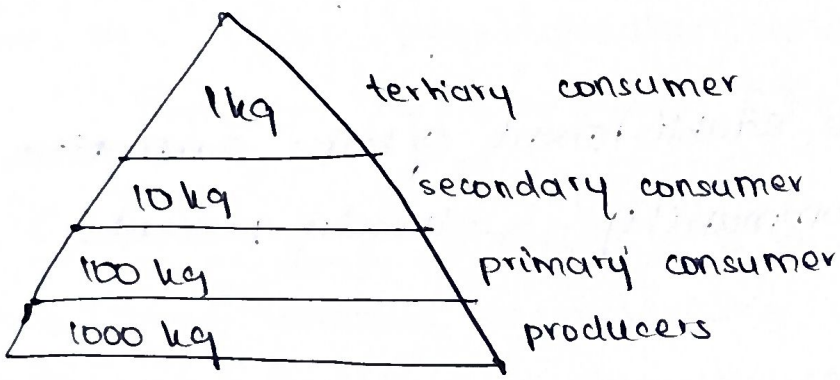


(2) Pyramid of energy: graphically represents the amount of energy consumed at each level, Note: IS ALWAYS UPRIGHT

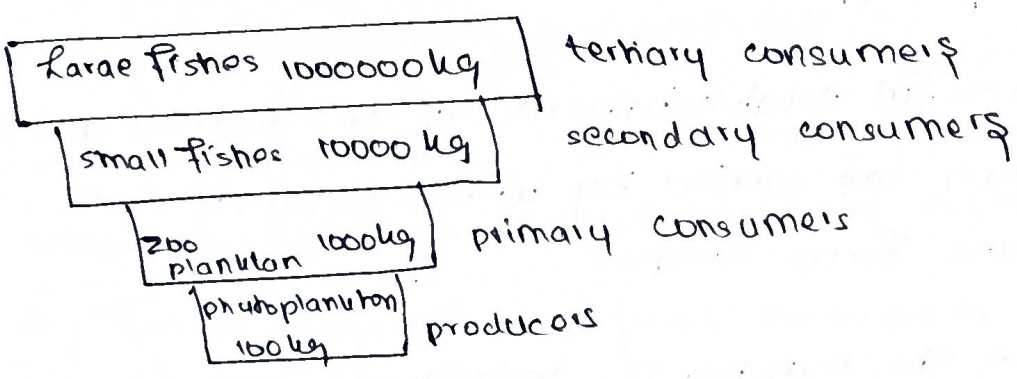
- Energy is lost in the form of heat and respiration between energy levels
- Total energy is minimum at the highest trophic level and minimum at the lowest trophic level.



(3) Pyramid of biomass: represents the amount of biomass at different trophic levels, it is measured in grams per meter^2 or calories per meter^2. can be upright or inverted. An upright pyramid is one where the combined weight of the producers is greater than the combined weight of the consumers. eg - forest ecosystem.



Inverted pyramid: combined wt. of producers is smaller than the combined weight of consumers. eg. an aquatic ecosystem



Ecological Succession: It is defined as the orderly changes that happens in a community structure and function over a period of time.

- The community which established first is called the pioneer community
- The communities which are transitory and are undergoing changes are known as the seral stages or seres.

• The final and mature community established at the end is known as the climax community.

Types of ecological succession

Primary succession: involves the gradual establishment of biotic communities on a lifeless ground.

(a) Hydrarch : establishment starts in a water body like a pond or a lake, begins with the formation of colonies of photoplankton.

(b) Xerarch: establishment starts in an area that is devoid of water and minerals, begins with the formation of lichens on the surface of rocks

Secondary succession : This involves the establishment of biotic communities in an area where some sort of biotic community is already present.

Process of Succession

(i) Nudation: Formation of a bare area without any life form, may be due to landslides, volcanic eruptions.

(ii) Invasion: It is the successful establishment of one or more species in a bare area. Seeds and spores are carried by wind, water, birds etc. Pioneer species begin to increase and form groups.

(iii) Competition: It results when the number of individuals increases, can be among species / different species. There is competition for water, space and nutrition. Survival of the fittest takes place.

(iv) Reaction: Due to the influence of the environment, there may be some modification of the existing species. The available resources may be suitable for some species and unsuitable for some another. This results in the replacement of species, leading to several seral communities

(v) Stabilization: Also called the climax, where the final stable community is formed.

Importance of ecological succession: (i) provides info on how a smaller community develops into a climax community.

(ii) helps in afforestation and forest management plans

Biodiversity: a measure of the variety of the flora and fauna present in various ecosystems.

Types of biodiversity:

1. Genetic diversity: refers to the variation of genes within a species. Genes are responsible for the similarities and differences between species

For eg. Dog: pug, dalmation, bulldog

Elephant: Indian elephant, African elephant

2. Species diversity: Species is a group or class of animals and plants that have some common characteristics which distinguish them from other groups or species. Species diversity refers to the variation among species in a community.

Plant species: apple, mango, orange

animal species: lion, cow, deer, cat

3. Ecosystem diversity: refers to the variation of biological communities in an ecosystem. Different ecosystems have different structure and functions

eg. forest ecosystem and pond ecosystem

Values of Biodiversity: classified into direct values and indirect values

Direct values:

(a) Consumptive use values - products are directly consumed, eg. fuel, food, drugs etc.

(b) Productive use values - products which are commercially harvested and sold in a market. They may be from plants or animals. eg, wood, musk, honey, silk

Indirect values

(a) Social values - include holy plants, animals and river.

(b) ethical values - coexistence of humans and nature

(c) aesthetic values - eco-tourism to enjoy nature

(d) optional value - biodiversity that is unknown and needs to be explored, could possibly be useful.

(e) ecosystem service value - ecosystems serve living beings, aid in water purification, soil formation, nutrition cycling, climate control

(f) genetic value : some ecosystems have a large variety of flora and fauna, can act as a genetic reservoir from which seeds and other material can be obtained, can also be used as a gene pool for producing disease resistant, high yielding varieties.

Classification of species

1. Extinct species : said to be extinct, when a species is not seen in the wild for 50 years at a stretch. eg. dodo, passenger pigeon

2. Endangered species : when the no. has been reduced to a critical level or whose habitats have been drastically destroyed / reduced ; they are at risk of becoming extinct if not protected and conserved. eg. Giant panda, Indian elephant

3. Critically endangered species : face an extremely high risk of extinction in the immediate future. eg. asiatic cheetah

4. Endemic species : species that are restricted to a particular area

eg. Nilgiri Tahr

endemic flora : sapria himalayane
uvaria lurida.

endemic fauna : nilgiri tahr
lion tailed macaque

Keystone species : a species / set of species whose impact on its community or ecosystem is much larger & influential.

Extinction of keystone species may lead to the extinction of other forms of life.

For eg. in the African savannah, keystone species = elephant. They destroy trees making room for the grass species.

Indicator Species : Species that serve as early warnings of damage to a community or ecosystem. They are very sensitive and respond quickly to environmental change, and they are called biological indicators. Indicator species are the first to react under external influences such as water pollution, air pollution or climate change.

eg. presence / absence of trout indicates the quality of water

presence of stone flies = high dissolved oxygen

Native species - species that are normally seen in a particular ecosystem

Exotic / alien species - species that migrate or are accidentally introduced into an ecosystem by human beings.

Classification of the species by the ICUN

Extinct (EX)

Extinct in the wild (EW) : only found in captivity

Critically endangered (CR)

Endangered (EN) : high risk of extinction in the wild

Vulnerable : high risk of endangerment in the wild

Near threatened (NT) : can become endangered in the near future

Least concern (LC)

Data deficient (DD)

Not evaluated (NE)

India as a mega diversity nation

- India is one of the 12 mega biodiversity countries in the world.
- Diverse physical features and climatic conditions have resulted in the formation of forests, grasslands, deserts, wetlands, coastal and marine ecosystem
- **Stats** 7-8% of all species
  45K plants
  91K animals

Reasons why India is a mega-diversity nation

(1) **Endemism** : • species that are restricted only to a particular area
- unique climatic and geographic features ⇒ many endemic species
- western ghats have the most endemism

(2) **Centre of origin** : many species have originated in India.
for eg. 500 plant species originated in India

(3) **Marine diversity**: 7500 km of coastline
- mangroves, coral reefs, back waters found
- have different types of fish, amphibians, molluscs and crustaceans

(4) **Hotspots of biodiversity** : high species richness, high species endemism.
- the world has 35 hotspots - in India, Eastern Himalayas and Western Ghats

Himalayas - in India as well as parts in Pakistan, Tibet, Nepal, Bhutan
Indo-Burma - NE India as well as Andaman Islands, Myanmar, Thailand
Sundalands - Nicobar group of islands (Indonesia, Singapore)
Western Ghats and Sri Lanka

Biogeographical Classification

1. Trans- Himalayan region : ranges directly above the Great Himalayas
- has sparse vegetation
- pine, deodar, snow leopard, goat

2. Himalayan : youngest, high altitude, steep mountains
- Rich temperate flora
- dense tall trees
- oak, chestnut, pandas, wild sheep

3. Indian Desert: Rajasthan, Gujarat
- hot in summer, cold in winter.
- annual rainfall < 70cm
- palm, dates, cactus, camels, asses, snakes

4. Semi-arid region : between denser forests of Western Ghats and desert
- thorn vegetation
- discontinuous
- Thorny shrubs, scrubs, grass
- Jackal, lion, snake

5. The Western Ghats : 1600 km long mountain range

Kerala, Tamil Nadu, Karnataka, Goa

rubber, tea, coffee, pepper

monkey, elephant, deer

6. Deccan peninsula : part of the Deccan plateau

different types of forests are found.

teak, neem banyan

monkey, elephant, tiger

7. Gangetic plane : plane extending up to the foothills of the Himalayas.

has the river Ganga

Banyan, teak, sal

8. Coastal Region : 5500 km

Fertile soil - crops are grocon.

coconut trees, banana

turtles, dolphins

9. North-east : seven north-eastern states

Largest no. of flora

elephant, rhinoceros

10. Islands : Lakshadweep

Andaman & Nicobar

coconut, dolphin.

Threats to biodiversity

Factors

(1) Destruction of habitats - animals deprived of food and shelter

(2) Habitat Fragmentation - loss of habitats happen in installments

Some big animals like bears and large cats need large areas to live and flourish. Habitat fragmentation affects their population

(3) Disturbances and pollution : air, water pollution

acid rain

forest fire

soil pollution

(4) Introduction of exotic species : when new species enter a geographical region kill native species to the point of extinction.

For eg. water hyacinth from south america, excessive growth has led to clogging of rivers and lakes, threatens survival of fish and aquatic species

(5) Hunting and over exploiting : hunting for pleasure
dodo, marine animals

(6) Poaching : killing of wild animals for illegal trading of parts
fur, horn, tusks

(7) Man-wildlife conflict : wild animals causing damage to life and property of man.

reasons: diseased animals
females protecting their babies
settlements too close to forests
loss of habitat
electric fencing

remedies: • ensure that wild animals have adequate food and resources
• avoid construction/ settlements too close to the forest
• more space to be given for protected areas like national parks

Conservation of Biodiversity : In-situ and ex-situ conservation

In-situ Conservation : conservation of plants and animals in their own natural habitat.

In-situ conservation aims to maintain biodiversity within the natural habitat where it is found. Protection can be in:

(a) National parks : (i) dedicated for the conservation of wildlife
(ii) tourism
(iii) cultivation & grazing not allow
(iv) private ownership not allowed

Examples: Kaziranga National park (one-horned rhino)
Jim Corbett National Park (Bengal Tiger)

(ii) Wildlife Sanctuaries : protection of wildlife

Private ownership permissible

forestry operations also permitted, so long as it doesn't affect wildlife

examples : Vedanthangal Wildlife Sanctuary (water birds)
Pulicat lake Bird Sanctuary

(iii) Biosphere Reserves : people are an integrated part of the environment for long-term conservation

- area is much larger when compared to national parks and wildlife sanctuaries
- promotes sustainable dev, support for logistics
- there may be one or more ~~biospheres~~ national parks within biosphere

eg. Nilgiri Biosphere Reserve, Sundarbans Biosphere Reserve

Advantages of In-Situ conservation

(i) cheap and convenient

(ii) species conserved within their own habitat, unmonitored

Disadvantages

(i) requires large areas

(ii) difficult to maintain, less funding, shortage of staff

Ex-Situ Conservation : conservation of species outside their habitat, habitat provided artificially

Methods : (i) long term captive breeding : in zoos and botanical gardens, special care given to offspring

(ii) short term propagation and release. : rare species bred in captivity, then released into the wild, helps increase no. of species in the wild.

(iii) cryo-preservation : seeds, pollen, gametes stored at -196°C

(iv) Tissue culture : growth of tissues & cells outside org., collected then transferred to a broth /agar

(v) Artificial Insemination : healthy semen collected from male, injected into female

(vi) Cloning : creating exact genetic replicas . Dolly the sheep

gene cloning - copies of genes / DNA segments

reproductive cloning - clone entire org

therapeutic cloning - create embryonic stem cells, replace injured / diseased tissues

(vii) Seed & gene banks : seed and genetic resource stored in seed bank

Advantages

(i) ensure survival of endangered species, would not survive in the wild

(ii) animals assured of food, water, shelter and security) longer lifespan

Disadvantages

(i) expensive

(ii) freedom lost

(iii) can only be done for a few species

(iv) captive animals struggle when released into the wild.

Environmental Science - Unit 2.

Mineral Resources :

Minerals - naturally occurring inorganic, crystalline solids having a definite chemical composition & characteristic physical properties

Classification

non metallic → graphite, diamond

metallic → bauxite, haematite

Uses of minerals

Generation of energy : coal, lignite and uranium

Development of industrial plants & machinery

Construction, housing

Defence equipment

Communication

Alloys

Agriculture – fertilizers & fungicides

Jewellery - gold, silver, platinum, diamond

Minerals in India

Gold : Kolar gold field, Hutti gold field

Diamond : Panna belt

Iron : Bihar, Orissa, MP

Mica : leading producer

Coal & lignite : Neyveli, Bihar, Orissa, MP

Bauxite : Bihar, AP, MP

Mining : process of extraction of minerals = mining

Phases:

(i) prospecting = searching

(ii) exploration = assessing, size, shape, location economic value

(iii) development = preparing access to the deposit

(iv) exploitation = extracting minerals

Impacts of mining

(1) Deforestation : leads to loss of biodiversity
loss of genetic & species diversity
loss of habitat
species may become extinct

(2) Land subsidence : caused by underground mining
causes cracking of roads, bending of railway tracks

(3) Ground water & surface water contamination : leads to acid mine drainage
heavy metal contamination

(4) Air pollution : processing like smelting and roasting introduces a lot of pollutants & particulate matter into the air

SPM, SO_x, soot, arsenic particles, cadmium, lead causes health problems.

(5) Soil erosion : erosion of fertile top soil, carried off as sediment into streams, rivers, lakes

(6) Occupational health hazards : respiratory and skin diseases due to constant exposure to chemicals & toxic substances

diseases = asbestosis, silicosis, black lung disease.

Food Resources

Food: anything that is able to satisfy appetite / hunger
should meet physiological needs, supply energy
components of food: carbohydrates, proteins & fats, vitamins and minerals

- < 90% of recommended intake = undernourished
  < 80% = seriously undernourished

Food Problems: food production not able to meet population demands
- 25% destroyed by pests
- undernourishment > malnutrition.

Environmental Impacts Related to Food Resources

(1) **Overgrazing** = rapid consumption of grass and other small plants without enough time to regenerate

Impacts: (i) land degradation & desertification
(ii) soil erosion
(iii) loss of useful species: replacement by thorny bushes, weeds

(2) **Impacts of Traditional Agriculture**

Traditional agriculture: use of animals for ploughing
minimal pesticides & fertilizers
moderate production

Impacts: Deforestation
Soil erosion
depletion of nutrients

(3) Impacts of modern agriculture

A. Fertilizer Related problems

Fertilizer : a substance applied to soil to supply plant nutrients that are essential for plant growth. Indiscriminate usage can lead to :

(a) micronutrient imbalance :

NPK = macronutrients

zinc, iron, selenium = micronutrients

macro-nutrients added in large quantities ⇒ deficiency of micro-nutrients.

(b) nitrate pollution – nitrate based fertilizers reach water bodies, groundwater, can cause harmful biological effects.

- high concentrations lead to methaemoglobinemia.
- haemoglobin is oxidized to methomoglobin, which has a decreased affinity for oxygen
- Infants may develop "Blue baby syndrome" or "Infantile methaemoglobinemia", skin turns blue
- happens when conc. of nitrates > 25 mg/l
- can cause gastric cancer
- affect CNS

(c) Eutrophication : water body enriched in dissolved nutrients, like phosphates, causes excessive aquatic plant growth, depletes dissolved oxygen, algae grows faster.

(d) Consequences : increased biomass of photoplankton
decreased water turbidity
loss of fish, aquatic orgs
decreases aesthetic value

(d) alteration of soil properties - changes pH

B. Pesticide Related Problems

Pesticide : chemical to retard / kill growth of pests

The ideal pesticide should:

(a) kill only target pest

(b) should not cause genetic resistance

(c) be biodegradable

(d) cost effect

Problems :

(i) super pests : pests that are immune to pesticides

20 super pests

housefly resistant to DDT

fruit flies resistant to Malathion

(b) death of non target organism : earthworms, bees

(c) Biomagnification : chemicals conc. in the body of higher orgs of the food chain.

(d) induce cancers

Post control method

(i) biological predators

(ii) provide homes to pests

(iii) bring natural enemies

(iv) pheromones

(v) use hormones to disrupt life cycle

④ Water logging

Causes: over irrigation

excessive rainfall

lack of proper drainage

raised water table

incorrect cultivation method

nature of the soil (black soil = poor permeability)

Consequences

increase in salinity

destroys crops

destroys microorganisms

damages soil

reduces nitrogen fixation by legumes

Control measures

proper drainage

prevent excessive irrigation

choose the right crops

⑤ Salinity : salt content

most crops don't grow well in salty soil

if ~~potassium~~ sodium content is high = sodic salt

causes over irrigation

salt water infiltration

consequences : low productivity

changing pH

death of microorgs

control : flush w/ fresh water

plants tolerant to salinity

Soil erosion

causes : deforestation

floods and heavy winds

agricultural practices (traditional practices like tilling & ploughing)

Control measures

(1) no-till farming : seeds directly inserted into untilled soil

slits made by machines

seeds, fertilizers, herbicides placed in slits

(2) contour farming : slope is tilled along lines of consistent elevation

each row planted horizontally

acts as a dam

increases water infiltration.

(3) Terracing : done in hilly / mountainous regions

step terraces made

decreases erosion

rice cultivation

(4) Strip cropping : diff. crops grown on alternative strips

eg. wheat on 1 strip

corn, soybeans cotton etc on another strip

(5) Alley cropping : crops cultivated between trees / shrubs

agro forestry

trees hold top soil

walnut oak

(6) Shelter belts : where wind is the major cause

trees block wind

Land degradation : temporary / permanent reduction of productive capacity

causes : overgrazing, deforestation, waterlogging

consequences : migration of animals, no crop o/p, may become d.sat

Desertification : natural & anthropogenic reasons

Deforestation

Man Induced Land Slides

landslides : sudden movement of large amounts of earth, sand or mud.

destabilize soil, leads to landslides

causes : deforestation, mining, rainfall, earthquakes

consequences : loss of life & property
loss of transport & comm
avalanche

Energy Resources

Non- Renewable Resources

1. Natural gas
2. coal - anthracite, bituminous & lignite
3. petroleum : crude oil, fractional distillation, refinery (a01.)
4. nuclear energy : involves a change in the no. of protons & neutrons

heavy nucleus splitting = fission
for eg. U into Ba, Kr

nuclear reactors : Kalpakkam
Tarapur

Advantages

(i) Low emissions
(ii) high amount of electrical energy

Disadvantages

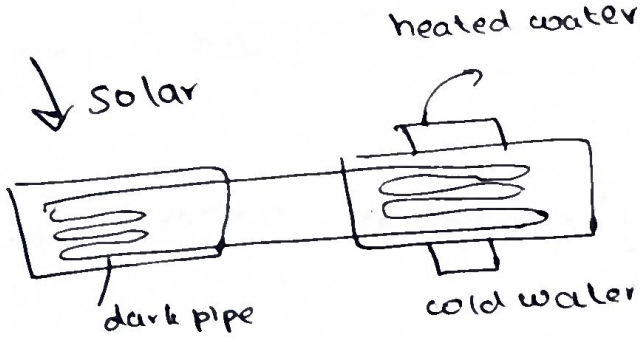
(i) dangerous by-products
(ii) accidents
(iii) limited ∪

Renewable Energy Resources

(1) Solar Energy : by thermal conversion
photovoltaic conversion

Thermal conversion

sunlight is directly used for energy conversion



Solar water heater

- supplies hot water using only solar energy
- installed on terrace
- heated water stored in an insulated tank

Components : solar collector (sensor)
insulated hot water storage tank
cold water tank.

Working : • collectors get solar energy
• dark insulated pipe warms up under sunlight
• inside the pipe, there is heat transfer liquid called the primary liquid
• pipe goes into cold water tank, heats up water
• hot water has low density ⇒ moves ↑, cold water ↓

Solar cooker

· construction : insulated box
glass cover
mirror on the inside

working : mirror reflects sunlight into box
reflected radiation trapped inside box
temp increases
cooks rice in 1–3 hrs

Advantages : preserves nutritional value
safe, simple, economic

Disadvantages : only possible on sunny days
· longer cooking time

Photovoltaic conversion : p-n junction diode – photocell

Advantages of solar energy harvesting devices
(i) renewable
(ii) no emission
(iii) quick installation
(iv) govt.

Disadvantages (i) expensive
(ii) cannot be used all the time
(iii) low efficiency

Wind Energy — Windmills

Wind energy (kinetic energy) → electrical energy

15 km/hr

windmills in Kanyakumari.

Merits: renewable

no pollution

area underneath windmill for cultivation, grazing

demerits: min 15 km/hr

wind farms disturb TV, radio signals

direction of wind not predictable

seasonal variation

Biogas :- decomposition of biological matter by anerobic bacteria.

components : digester - below ground level

steel gas holder

pipes

working : cowdung - anaerobic fermentation - absence of free air - closed tank - slurry - form methane & CO_2 - 34-38°C

Advantages : renewable

no pollution

cheap

Disadvantages : difficult to transport

initial high investment

no continuous supply of biomass

Geothermal energy : energy from inside thoar

cold water injected - water absorbs heat - becomes shoam - produces electricity

advantages : cheap
clean

disadvantages : only select locations

Ocean Thermal Energy : temp. diff between cooler deep & warmer shallow water - 20° C temp diff - heat diff ~~to~~ boils low boiling liquid like ammonia — vapor turns turbines - electricity cold water as a by product

Advantages - renewable
cheap

disadvantages : inefficient
need large temp diff

Classification of pollutants

1. Primary pollutants: emitted directly from some source - remain in that form eg. SO_2, CO, NO_2

2. Secondary pollutants: produced from primary pollutants - primary pollutants undergo chem rxn ⟶ 2° pollutant

eg. smoke + fog = smog
SO_3 from SO_2

Air pollution

Sources: 1. natural - forest fires + volcanic eruptions

2. anthropogenic : (i) burning of fossil fuels
(ii) automobile emissions
(iii) industrial emissions
(iv) agricultural activities - insecticides & pesticides

Common Air Pollutants

(i) CO_2 : · displace O_2 in lungs
· rapid breathing fatigue
· green house effect

(ii) CO : · poisonous
· incomplete combustion
· strong ligand binds with Fe in haemoglobin
· interferes w/ O_2 carrying capacity

$$HbCO_2 + CO \longrightarrow HbCO + O_2$$

(iii) Oxides of nitrogen: automobile & chemical ind.
· lower O_2 carrying capacity
· irritate lungs - chronic bronchitis
· acid rain

(iv) Oxides of sulphur: chlorosis (yellowing of leaves)
acid rain

(v) hydrocarbons : incomplete combustion

(vi) particulate matter

Effects

On plants : chlorosis
decrease in crop productivity
smoke + dust — ↓ photosynthesis capacity
damage to leafy vegs

On man : Ozone: asthma, bronchitis
SO_2 : coughing, wheezing
Hydrocarbons : carcinogens

On aquatic animals : change of pH
fish die

On materials : accelerate corrosion
fabric, leather, paint, paper

Smog : smoke + fog

Types:

London Smog

early morning

soot, fly ash, SO_2 react

might produce H_2SO_4

high reducing impurities,
∴ reducing smog

LA smog (Photochemical smog)

noon

smog triggered by 

has ozone, volatile hydrocarbons, peroxy acetyl nitrate NO_2

has oxidizing impurities
called oxidizing fog

Acid Rain : acidic - pH < 5.6

causes : oxides of nitrogen : automobile exhaust, factory emissions

$$NO_2 + H_2O \longrightarrow HNO_2 + HNO_3$$

oxides of sulphur : automobile oxides, crude oil

$$SO_2 + H_2O \longrightarrow H_2SO_4$$

$$SO_2 + O_2 \longrightarrow SO_3$$

Effects: plants: loss of waxy coating
root damage
loss of nutrients

on animals : leaching of heavy metals into the H2O
- damages aquatic life
fertility loss

humans : respiratory issues, eye, nose irritation

buildings & monuments : deterioration of marble objects, leather, rubber

Control : (i) low SO_2 coal
(ii) coal → CH_4
(iii) ↓ SO_2 NO_2 emission
(iv) renewable sources

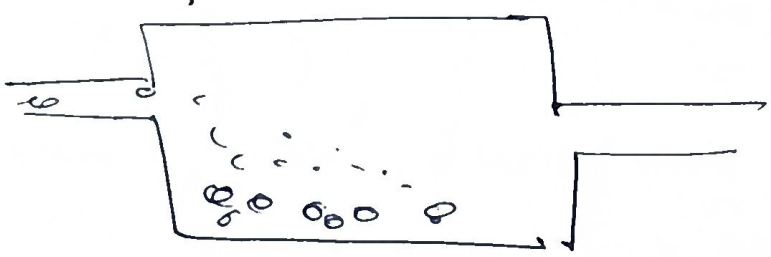
Particulate pollution : particle suspended in air

cause : forest fires, volcanoes, automobiles

consequences : premature death
irregular heartbeats
nonfatal heart attack

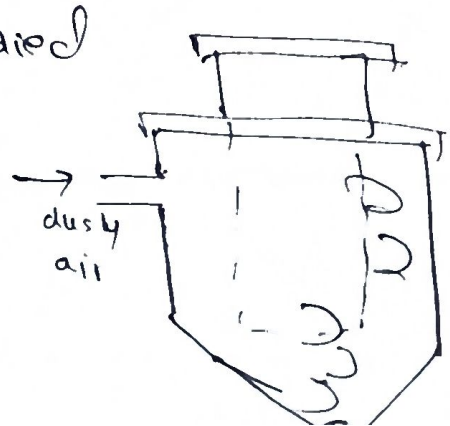
Air pollution control devices

(1) Gravity settling chamber.



- particles removed - influence of gravity
- for only large particles
- settle at bottom

(2) cyclone collector : • centrifugal force is applied
- centrifugal > gravitational force
- particles thrown along tgt / settles down
- for smaller particles
- expensive



(3) wet scrubbers : · polluted gas brought in contact of scrubbing liquid

· removes SO_2, small particulate matter

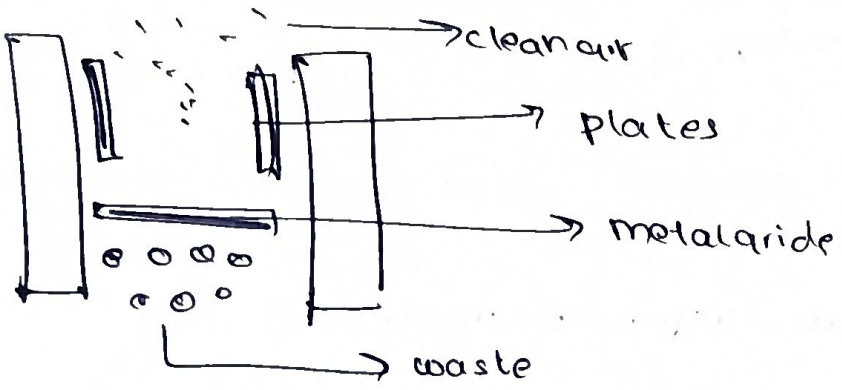
· can handle high temp & moisture

· can neutralize corrosive gases

(4) Electrostatic precipitators : · non-uniform, high voltage fields

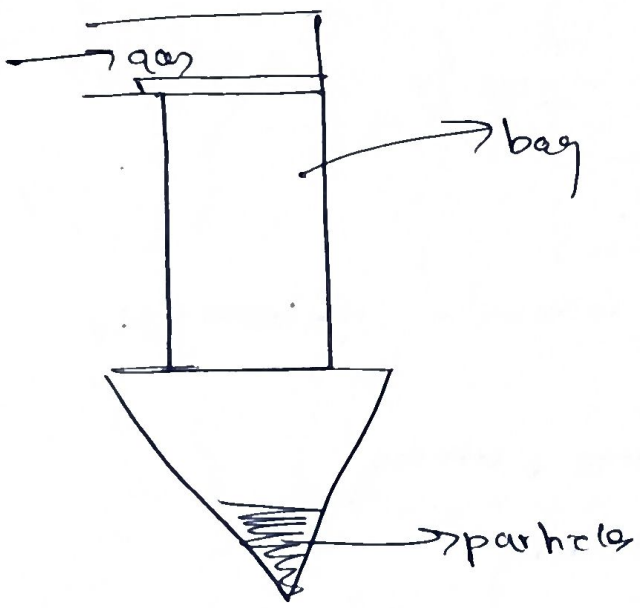
· charge polluted gas particles

· move to opp. charged plate



(5) Fabric filters : · pass gas through

· particles get stuck



Catalytic converters

- 3 simultaneous tasks
  - (i) reduction of nitrogen oxides to nitrogen & water
  - (ii) oxidize carbon monoxide to CO_2
  - (iii) oxidize unburnt HC to CO_2 & water

construction : platinum, palladium & rhodium

coat a ceramic honeycomb - connect to exhaust pipe

honeycomb = max surface area ⇒ less catalyst

Case Study : Bhopal Gas Tragedy

Place : MP, Bhopal

Time : Night of 2nd & morning of 3rd 1984

Company : Union Carbide India Limited

Gas : methyl isocyanate

Toxic effects of MIC : → a volatile fluid
→ irritation of mucous membrane
→ difficulties in breathing
→ causes injury to the cornea

reason : water entered tank
human error + lack of safety

Tragedy :
- water enters tank
- chem rxn starts - accelerated by contaminants, high temp, catalyst = iron
- exothermic rxn
- 30 tons of MIC leaked

- people coughing, thousands dead

death count = 1430
loss of vision

after effects: legal battle w/ Dow chemicals
no compensation yet

Water pollution

water quality parameters

Temp, pH, turbidity, conductivity (minerals)

DO = dissolved oxygen
If DO < 3 ppm fish die

high DO = corrosion

Biochemical Oxygen demand (BOD) = amt of O_2 needed by microorganisms to oxidize decomposable org matter

high BOD = less O_2
low BOD poor water quality

Chemical Oxygen demand: capacity of H_2O to consume oxygen during the decomposition of org. matter & inorganic chemicals

sample strong oxidizing agent under acidic conditions

COD much faster than BOD

COD oxidizes more chem

easily standardized

Water pollution

(i) causes : industrial eff.
thermal waste
dom waste
aq. waste
pathogen

(ii) consequences

on ecosystem : eutropication
destruction
death of species
bio mag

on humans : heavy metal (brain & liver)
blue baby syndrome (too much nitrate)

on animals : reduced reproduction rate
secondary food chains are shorter.

Waste water treatment

(1) Primary Treatment - remove suspended & floating waste
(i) screening - coarse particles
(ii) silt and grit removal - grit chamber
(iii) remove oil & grease - skimming tank
(iv) sedimentation : coagulating agent, alum, $FeSO_4$

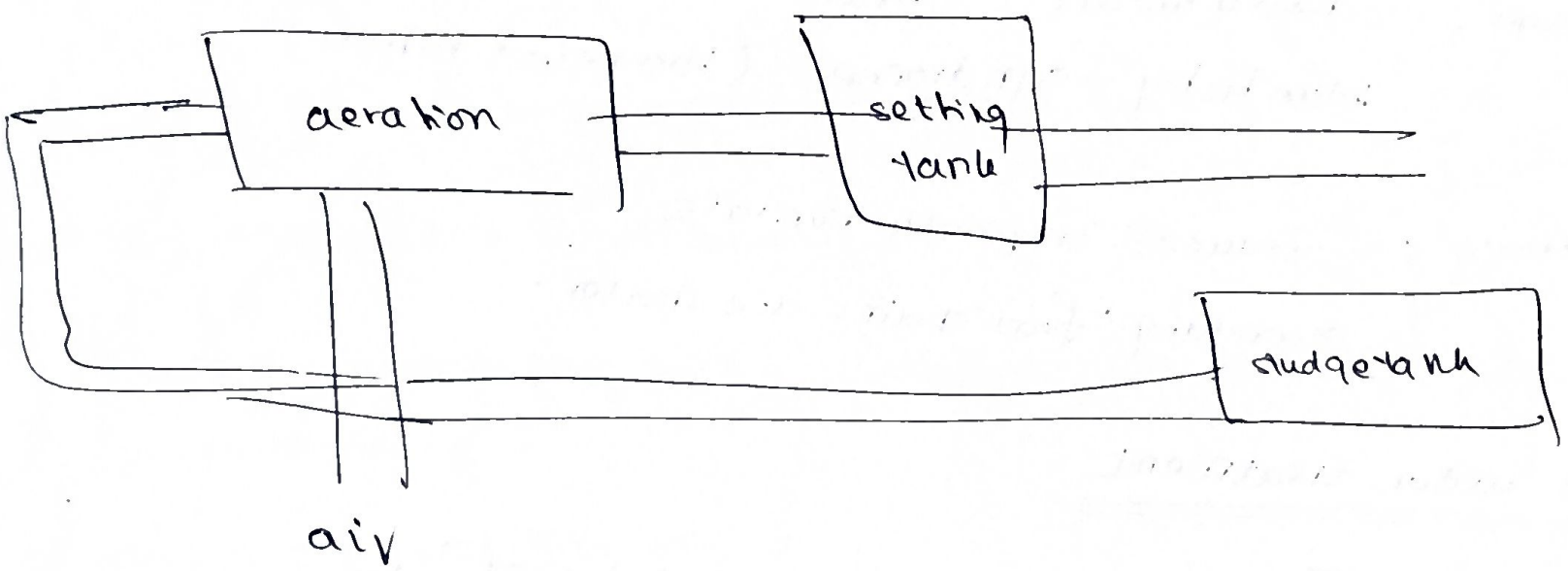
(2) Secondary Treatment - done by microbes that consumes organic matter.

methods: activated sludge method
trickling filter method

(a) Activated sludge method

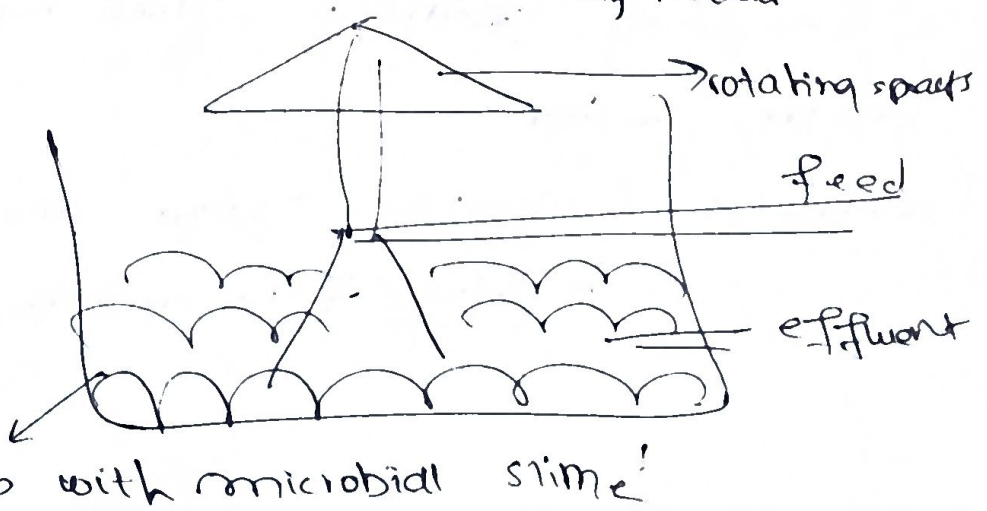
- Activated sludge - biologically active - aerobic bacteria - oxidize organic matter

- wastewater mixed w/ sludge
- air passed for hours
- moved to settling tanks
- purified water pumped out
- part of sludge used for purification of a fresh batch of sewage



(b) Tracking filter method :

- rock bed 1-3 m deep
- covered with microbial slime - bacteria, protozoa, mold & algae
- sewage slowly sprinkled onto it
- microorganisms present in sewage grow on filtering media
- aerobic oxidation
- sewage to settling tank
- ease of op, low cost



Tertiary treatment

(i) remove phosphate - add lime

(ii) coagulation : alum, $FeSO_4$ neutralize charge

(iii) filtration : water passed through bed with gravel

(iv) disinfection, Cl_2 gas, air, ozone

Case studies

(1) Minimatha Disaster

Place: minimatha bay, Japan

Date : 1956

Company: Chisso corporation's chemical factory

chemical responsible : mercury compounds

- inorganic mercury salts = catalyst for the prep. of acetaldehyde
- waste dumped into bay
- mercury converted into toxic compounds - methyl mercury
  dimethyl mercury
- weeds → fish → man (biomagnification)

Consequences: numbness in limbs
narrow vision
difficult in hearing
madness
dead cats
birds fell dead

(2) Itai - itai disease

- ouch - ouch sickness
- cadmium poisoning
- 1912
- softening of bones, kidney failure

↓

frail & weak

joint & spine pain

mining companies sued.

Rainwater harvesting - collecting & storing rainwater

recharge groundwater

obj: meet H_2O requirements

raise H_2O table

reduce groundwater contamination

(1) Storage on surface for later use

(2) Recharge groundwater - recharging bore wells; dug wells

can also be from roof, use pipe to send to borewell

Watershed management

watershed - a geographic area through which water is allowed to flow

drains into a common body of water

size from a few sq. to a few thousand sq. km

obj: dom supply
↓ soil erosion
↓ floods, droughts

soil conservation: trenches
rainwater harvesting
agroforestry
scientific mining, public awareness

Ozone layer: relatively high conc. of O_3 layer

stratosphere

umbrella of life

Dobson unit — 1 dU = no. of molecules of ozone required to create a layer of pure ozone 0.01 mm thick at 0°C at 1atm pressure

Ozone formation: $O_2 + h\nu \longrightarrow 2O$ $(\lambda < 240nm)$

$O + O_2 + M(N_2 \text{ or } O_2) \longrightarrow O_3 + M$

M absorbs excess energy, stabilizes the ozone.

Decomposition

$O_3 + h\nu \longrightarrow O_2 + O$

process of ozone destruction is iniated by ultraviolet radiation.

Chapman rxns.

Thinning of ozone layer = ozone layer depletion

Ozone layer depletion

1. chlorofluorocarbons

Effects humans: DNA change → mutation

skin cancer

calaract

plants: photoplankton, foodchain

decrease crop product

contributes to global coarmity