The Carbon Cycle

⇒ CO_2 enters the waters of the ocean through diffusion → after dissolving gets converted to carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) → forms of sea life biologically fix bicarbonate with Ca^{2+} to produce calcium carbonate ($CaCO_3$)

⇒ $CaCO_3$ is used to produce shells and other body parts by organisms such as corals, clams, oysters, some protozoa and some algae.

⇒ When these organisms die, their shells and body parts sink to the ocean floor where they accumulate as carbonate rich deposits. After long time these deposits are physically and chemically altered into sedimentary rocks

⇒ Ocean deposits are the biggest sink of carbon on this planet about 93% of CO_2 is stored in algae, vegetation and coral under the sea

Carbon Cycle

① Respiration

$$\underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2} \longrightarrow \underset{\text{carbon dioxide}}{6CO_2} + 6H_2O$$

② Burning fossil fuels

$$\underset{\text{methane}}{CH_4} + 2O_2 \longrightarrow CO_2 + 2H_2O$$

③ Roasting limestone

$$CaCO_3 \longrightarrow CaO + CO_2$$

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CO_2 is removed from atmosphere by:

1. Photosynthesis

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

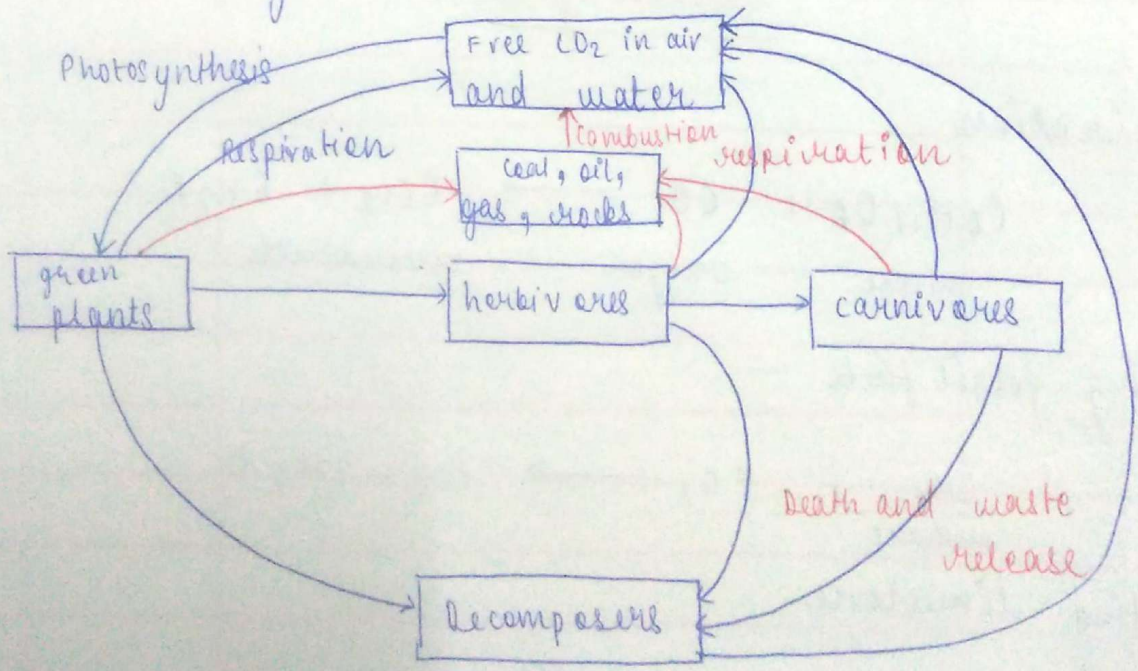
2. Dissolving in water

$$CO_2 + H_2O \longrightarrow H_2CO_3$$

Humus: Humus is formed during the decomposition of plant and animal remains by microorganisms under aerobic and anaerobic conditions, usually in soils and water basins

⇒ Rise of CO_2 in atmosphere after Industrial Revolution mainly through the burning of fossil fuels

⇒ Atmospheric levels have increased by over 30% from about 275 parts per million (ppm) in early 1700s to just over 365 ppm today. can reach upto 450 to 600ppm by 2100



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Oxygen Cycle

⇒ It makes about 65% of total mass of body

⇒ It makes around 30% of the earth and 21% of the atmosphere

⇒ Found in carbonates, sulphates and nitrates

⇒ Important component of biological molecules like proteins, nucleic acids etc.

⇒ Phytoplankton is one of the biggest sources of oxygen that live near the ocean.

→ perform half of the world's photosynthetic activity

→ micro-algae single celled organism

→ rich in trace minerals, chlorophyll, amino acids, DHA, EPA, carotenoids, antioxidants, nucleic acids and necessary vitamins

→ responsible for creating 70% of earth's oxygen supply

Kinds → cyanobacteria, silica encased diatoms, dinoflagellates green algae, chalk coated coccolithophores

→ sensitive to climate change

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Importance of oxygen

① Burning of fossil fuels

$$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$$

② Utilized by aerobic organisms in degradation of organic matter

$$[CH_2O] + O_2 \xrightarrow{\text{organism}} CO_2 + H_2O$$

③ Oxidative weathering processes of minerals

$$4FeO + O_2 \longrightarrow 2Fe_2O_3$$

④ Photosynthesis returns the oxygen

$$CO_2 + H_2O \xrightarrow[h\nu]{\text{plants}} CH_2O + O_2$$

Ozone (O_3) a form of oxygen containing species occurring in stratosphere absorbs harmful UV radiation and serves as radiation shield

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

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

$$O + O_2 + M \longrightarrow O_3 + M$$

Absorption of ultraviolet radiation from 220 nm to 330 nm

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Solid Wastes Management

→ Types of wastes

1. Municipal solid waste
2. Industrial waste
3. Agricultural waste
4. Hazardous waste (toxic, chemically active, corrosive, flammable)
5. Nuclear waste
6. Biomedical Waste

① MSW (Municipal solid waste)

→ generated from households, offices, shops, schools, hotels
→ major components are food waste, plastic, rags, metal, glass
→ hazardous waste → electric light bulbs, batteries, discarded medicines, chemicals

② Industrial Solid Waste

③ Agricultural Wastes : livestock waste, agricultural crop residue, agro industrial by-products

④ Waste from Automobiles

→ Poisonous gases due to incomplete combustion of petrol
→ old not working vehicles are dumped

⑤ Hazardous Waste : waste that poses substantial or potential threats to public health or environment. Depends on 4 factors :

(a) ignitability
(b) reactivity
(c) corrosivity
(d) Toxicity

Hazardous waste can be incinerated in cement industry

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(6) Biomedical waste

→ waste from different health care units like hospitals, nursing homes
→ expired medicines
→ operational ingredients
→ used needle and syringes
→ used bandage
→ blood
→ pharmaceuticals

Electronic Waste

(7) Electronic waste, e-waste, e-scrap or waste Electrical and Electronic Equipment (WEEE) describes loosely discarded, surplus, obsolete or broken electrical and electronic devices

→ Some electronic scrap components like CRTs contain contaminants such as lead, cadmium, beryllium, mercury and brominated flame retardants
→ Europe has outlawed using landfills for computer components

Plastic Pollution

→ Plastics are macromolecules formed by polymerization
→ They can be reshaped by reasonable amount of heat and pressure
→ Polyethylene, polyvinyl chloride, polystyrene is largely used in manufacturing plastics

Advantages
→ inexpensive to produce
→ Resistant to chemicals and water; biologically inert
→ Good safety and hygiene properties for food packaging
→ Excellent thermal and electrical insulation properties
→ Less brittle than glass; can be made equally transparent and smooth

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Disadvantages:

a) Non-Biodegradable
b) Hard to reuse, recycle
c) Harmful to wildlife and marine life and human health
d) Plastic releases pollutants
   → Bisphenol A (plasticizer)
   → Phthalates

⇒ Absorbs Hydrophobic Pollutants
   → Polychlorinated Biphenyls (PCBs)
   → Dichloro diphenyl trichloro ethane (DDT)

→ Threat to animals
   → Biggest dumping ground for plastics → Pacific Ocean
   → Plastic toxins end up in fish, which end up on our plates, which end up inside our bodies

Treatment of Solid Waste

Open Dumping

→ most widespread method
→ open burning of waste is practiced at dumpsites
→ waste is dumped along the shoreline and into the sea

Drawbacks

① scarcity of available land
② build up of landfill gas (mostly methane) which can lead to outbreaks of fire
③ adverse effects on workers and adjacent residents
④ Fire can spread accidentally
⑤ Flammable industrial wastes increase the danger of fire and can convert old tyres into toxic gases (dioxins and furans)

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Landfills

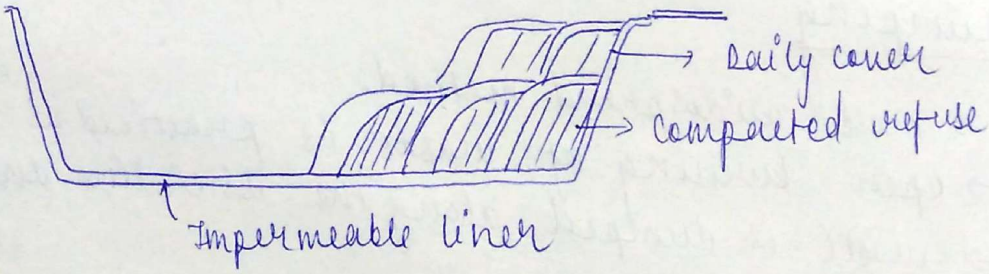
→ The sanitary landfilling operation involves numerous stages including siting, design, operation and closing

→ The liner is made of plastic (PVC) and a layer of clay that reduces the chance of leakage into groundwater of the liquid

→ Refuse in unloaded, compacted with bulldozers and covered with compacted soil

→ Landfilling is compaction of refuse in a lined pit and covering the compacted refuse with an earthen cover

→ Landfill is built in units called cells. The daily cover is between 6 and 12 inches thick depending on soil composition and final cover at least 2 feet thick is used to close the landfill.



→ Closed landfills have potential uses as golf courses, playgrounds, tennis courts, parks, green belts

Disadvantages

⇒ Requires more costly hauls than other methods

⇒ Requires more land

⇒ Operational problems may occur due to inclement weather

⇒ It causes health hazards as insects and rodents may breed.

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Numerical Estimate the required landfill area for a community with a population of 260,000

Solid waste generation = 7.6 lb/capita · day

Compacted specific weight of solid wastes in landfills = 830 lb/yd³

Average depth of compacted solid wastes = 60 ft

Calculate area required per day for each cell

Daily solid waste generation waste in tons per day:

$$\frac{260{,}000 \times 7.6}{2000 \text{ lb/ton}} = 988 \text{ ton/day}$$

$$\text{Volume} = \frac{\text{Mass of SW}}{\text{Sp wt of SW}}$$

$$\text{Area} = \frac{\text{Volume}}{\text{depth}}$$

Energy from Landfill

→ MSW contains 150-250 kg of organic carbon per ton which microorganisms convert to landfill gas via anaerobic processes

→ Landfill gas production starts 1 or 2 years after the waste is deposited in landfill and lasts for 15-25 years

→ 1 million tonnes of MSW generate 1.7-2.5 million m³ of collectable methane

→ landfill gas used for power generation

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Composting

→ treating solid waste in which organic material is broke down by microorganisms in the presence of oxygen to a point where it can be safely stored, handled and applied to environment

→ can act as a natural fertilizer for farming and gardenin

→ It is a process where microorganisms break down complex organic matter into basic elements

Biomass + O_2 (Aerobic / bacteria) ⟶ $CO_2 + H_2O$ + organic mat

→ The carbon released as CO_2 is made available to plants for photosynthesis

→ Can include anything except meat

Benefits

→ keeps organic wastes out of landfills
→ can be used as organic fertilizer
→ Reduces need of fertilizers and pesticides
→ Increases beneficial soil and organisms
→ Protects soil from erosion

For composting proper ratio of carbon rich materials → browns and nitrogen rich materials → greens is mined

→ Among brown materials are dried leaves, straw and wood chips
Green materials are grass clippings and kitchen refuse

→ Microorganisms require carbon as energy source and nitrogen for synthesis of some proteins

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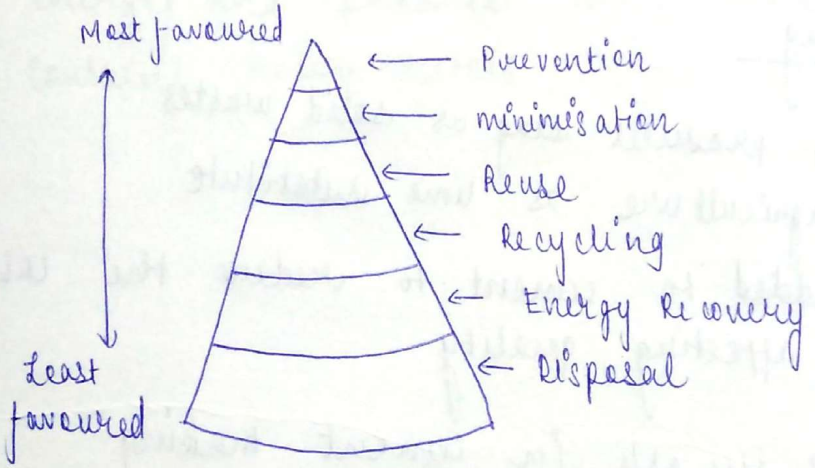
→ Raw materials should normally be blended to approximately 35:50 (by weight) carbon to nitrogen ratio by weight.

→ optimal water content should be 40% to 60%.

→ A high C/N ratio can be corrected by dehydrated mud
" low " " " " " " cellulose

Waste Hierarchy

The waste hierarchy is a guide when determining the Best Practicable Environmental Option and represents a chain of priority for waste management, extending from the ideal of prevention and reduction to the last resort of disposal.



Waste Reduction and Reuse

Measures to control

① Efforts to minimize generation of waste
② Waste exchanges
③ Resource optimization
④ Reuse of scrap material
⑤ Durability

Waste Exchange

IIT Madras students → Glass Fibre Reinforced Gypsum (GFRG) panels
→ Glass fibre is combined with gypsum plaster hydrated calcium sulphate

Scanned by CamScanner

Production of Bio Fuel from agricultural waste

→ Bio fuels are alternative renewable energy

→ Bio ethanol (used in replacement of gasoline) is made from crop grains or sugarcane

→ Bio diesel - made from vegetable oils and animal fats. By products of oil refining industry are suitable for production of bio diesel

$$\text{Oil of fat} + \text{Alcohol} \xrightarrow[H^+]{\text{Catalyst}} \text{Biodiesel} + \text{Glycerin}$$

Utilization of slag

→ steel plants produces slag as solid wastes

→ Used in agriculture as lime substitute

→ Can be added to cement to reduce the cost without affecting quality

Utilization of fly ash in cement making

→ coal based thermal power stations → fly ash is formed

→ heterogeneous material. SiO_2, Al_2O_3, Fe_2O_3 and occasionally CaO - are the main chemical components present in fly ashes

→ Use of fly ash can be used in cement manufacturing process

→ Use of fly ash eliminates the need to mine virgin materials and conserves limited land and material resources

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Reduce, Reuse, Recycle

↓

buy less
use less
turn off lights
rain barrels
carpools

↳ gold, lead, nickel, steel, copper, silver, zinc and aluminium are recyclable

glass is virtually infinitely recyclable

tires are usually allowed if they are quatered or shredded

Problems

→ uses energy and generates pollution

→ de-inking process in paper recycling requires energy and produces toxic sludge that contains heavy metals

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Ecology

Ecology is the study of the interconnections and interdependencies of plants, animals and their environment.

Ecosystems: Ecosystem is a community of organisms involved in a dynamic network of biological, chemical and physical interactions between themselves and with the non-living components. Such interactions sustain the system and allow it to respond to changing conditions.

→ The sum total of all the ecosystems on planet Earth is called the Biosphere which includes all the earth's living organisms interacting with physical environment as a whole to maintain a steady state ecosystem

→ ecosystem is the combination of an area's abiotic and biotic factors

Abiotic Features: air, water, rainfall, temperature, soil, rocks, elevation, humidity

Biotic: Anything living

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Definitions

Biomass → Refers to the total mass of living plants, animals, fungi and bacteria in a given area

Energy flow → Flow of energy from an ecosystem to an organism and from organism to organism

Producers → Produce food in the form of carbs during photosynthesis

Consumers → Eat food produced by ~~consumers~~ producers.

Decomposition → Breaking down of organic waste and dead organisms

Biodegradation → Action of living organisms such as bacteria to break down dead organism

Decomposers → Changes waste and dead organisms into usable nutrients

Autotrophs → (self feeding) or producer is an organism that produces complex organic compounds from simple substances present in its surroundings

Detrivores → Feed on plant and animal remains and other dead material

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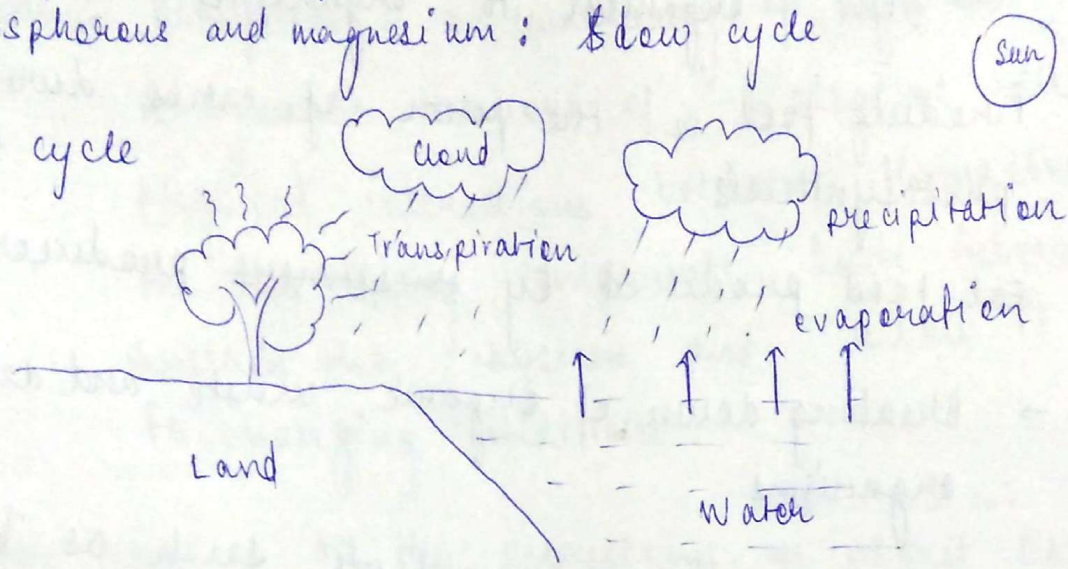
→ The cyclic movement of minerals from their reservoirs to living components and back to their reservoirs is called nutrient cycling or biogeochemical cycles.

→ Oxygen and nitrogen: Fast cycle
Phosphorous and magnesium: Slow cycle

→ Water cycle



→ Carbon cycle

CO_2 addition to atmosphere

1. Respiration

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

2. Burning fossil fuels

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

3. Heating limestone

$CaCO_3 \rightarrow CaO + CO_2$

CO_2 removal from atmosphere

1. Photosynthesis

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$

2. Dissolving in water

$CO_2 + H_2O \rightarrow H_2CO_3$

→ Oceans play a major role in regulating level of CO_2

→ Carbon plays a key role in temperature regulation mechanism of our earth (GHG)

Scanned by CamScanner

→ Nitrogen cycle

Addition of nitrogen into the soil from atmosphere:

① lightning

② nitrogen fixing bacteria. Example alfalfa or soyabeans

$$\text{Org N} \rightarrow NH_3 \xrightarrow{O_2} NO_2^- \xrightarrow{O_2} NO_3^-$$

Plants take up NH_3, NO_3 dissolve in soil pore water and convert them into proteins, DNA

Animals get their nitrogen by eating plants

Nitrogen Fixation : cyanobacteria or rhizobium

Nitrification : Autotrophic bacteria : Nitrosomonas and nitrobacter

Ammonification / mineralization : Ammonifying bacteria

Denitrification : Facultative heterotrophic bacteria like:

Bacterium denitrificans:

Pseudomonas anchromobacter

Nitrogen Fixation → conversion of atmospheric nitrogen into other forms through:

$N_2 \rightarrow NH_4$

① Lightning

Energy from lightning causes nitrogen (N_2) and water (H_2O) to combine to form NH_3 and NO_3. Precipitation carries the ammonia and nitrates to ground.

② Biological Fixation by bacteria in soil and root nodules of legumes alfalfa

Performed by selected bacteria and actinomycetes

$$N_2 + 8H^+ + 8e^- + 16ATP = 2NH_3 + H_2 + 16ADP + 16Pi$$

$$N_2 + 3H_2 \rightarrow 2NH_3$$

Ammonia can be used by plants directly

Scanned by CamScanner

Nitrification

Optimal pH level is 6.6 – 8.0

Two step reactions that occur together

if pH < 6 → slow rate
if pH < 4.5 → reac is inhibited

- 1st step catalyzed by Nitrosomonas : $2NH_4^+ + 3O_2 \longrightarrow 2NO_2^- + 2H_2O + 4H^+$
- 2nd step catalyzed by Nitrobacter : $2NO_2^- + O_2 \longrightarrow 2NO_3^-$

$NH_4 \longrightarrow NO_2 \longrightarrow NO_3$

Ammonification

Decomposers : earthworms, termites, slugs, snails, bacteria, fungi

Plants die or bacteria cells lyse → release of organic nitrogen

Organic nitrogen ~~is converted~~ to inorganic nitrogen (NH_3)

Proteases, lysozymes, nucleases → degrade nitrogen containing molecules

Denitrification

$NO_3 \rightarrow NO_2 \rightarrow NO \rightarrow N_2O \rightarrow N_2$

- Removes a limiting nutrient from the environment
- $4NO_3^- + C_6H_{12}O_6 \longrightarrow 2N_2 + 6H_2O$

Through denitrification, oxide forms of nitrogen such as nitrate and nitrite are converted to dinitrogen (N_2) and to a lesser extent nitrous oxide (N_2O)

↳ Important greenhouse gas

→ Phosphorous Cycle

→ second most abundant mineral in human body surpassed only by calcium

→ 20% of mineral ash of body, 1% of body weight

→ 80% of it found in bones and teeth

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→ sedimentary cycle in which Earth's crust is major reservoir

→ On earth phosphate rocks are primary source

→ Plant roots absorb phosphate from soil → thus it is carried through food chain eventually returning to soil via animal waste and decay

However these returns are small as compared to the amount of phosphate which is continually being eroded from land to sea.

Biogeographic Regions

Factors which determine growth and type of ecosystem

→ temperature, rainfall, soil type, location

Himalayas, desert, North east, Western ghats

→ 21 wetlands have been declared as National Wetlands

→ Keoladeo Ghana National Park → human-made wetland
Bharatpur
Rajasthan

→ Chilika → Orissa
↳ brackish water lake

Wetlands: Areas where water is the primary factor controlling the environment and associated plant and animal life. They occur where water table is at or near the surface of land or where land is covered by shallow water

→ water quality protection → Important function
→ Flood control
→ Erosion control
→ Fish and wildlife habitat

good water filters

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Ecology (18 Pages)

Ecology derived from greek word 'oikos' meaning household and logos meaning study

→ Producers

→ Sun provides most of the energy that is stored in food
→ Producer is an organism that captures energy and stores it in food as chemical energy
→ Most energy enters as photosynthesis
In absence of light organisms can use chemical energy to produce carbohydrates which is called chemosynthesis

→ Seaweed, Phytoplankton, Plants

producers

→ Consumers

Scavengers → feed on dead animals eg: Vulture

⇒ Models help explain feeding relationships

→ Food chains

• Every organism in an ecosystem can be assigned a feeding level referred to as trophic level.

Green plants → First trophic level
Herbivores → second trophic level
carnivores → third " "

Bacteria feed at every trophic level

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Types of food chain

→ grazing food chain : Green plants → herbivores → carnivores
→ detritus food chain : Dead organic matter → scavengers → insects / microorganisms

Food Web

Model of feeding relationships between many different consumers and producers in an ecosystem. Many overlapping and interconnected food chains.

⇒ Nutrient cycles are the link b/w biotic and abiotic components

Energy Flow

⇒ Laws of thermodynamics
⇒ Energy can neither be created nor destroyed
⇒ No energy conversion is 100% efficient
⇒ Energy flows from high level to low level

⇒ Rule of 10 : This is the concept that only 10% of the available energy at any trophic level gets transferred to next higher level

→ India has seventh largest coastline (7500 km)

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Water Cycle

→ Distribution of earth's water supply

2% → locked up in polar ice caps
1% → Fresh water → 77% frozen in ice caps and glaciers ~~→ 3% usable~~
97% → High salt content unusable for human consumption

Man → Oceans 95.96%.

→ 71% of earth's surface is covered with water

→ 3% usable fresh water

→ Major use of Freshwater

- 50% → Thermal power plants
- 30% → Irrigation
- 13% → Idustrial water
- 7% → Domestic uses

→ 60% of human adult body is water
80% of body weight

→ Hydrologic Cycle

water enters the atmosphere through evaporation, transpiration, excretion and sublimation

⇒ some groundwater gets collected in reservoirs underground called aquifers.

→ Due to its high specific heat, water vapour is a major factor in greenhouse effect
Major role in temperature maintenance

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Atmosphere and Air Pollution

→ Major Constituents

Nitrogen → 78.08% (by volume)

Oxygen → 20.95%.

Water Vapour → 0-3 or 4%.

Argon → 0.934%.

CO_2 → 0.035%.

→ Major regions of atmosphere

	(km)	Significant chemical species
Troposhere	0-11	N_2, O_2, CO_2, H_2O
Stratosphere	11-50	O_3
Mesosphere	50-85	O_2^+, NO^+
Thermosphere	85-1000	O_2^+, NO^+, O^+

→ Troposhere :

⇒ Temperature generally decreases with altitude

⇒ Reason : gases in troposhere absorb very little of incoming solar radiation. Instead the ground absorbs this radiation and then heats the tropospheric air by conduction and convection

⇒ 6 °C per kilometer → rate at which temp decreases

⇒ The very cold layer at top of troposphere is tropopause

↙ Its low temperature and resulting condensation of water to ice particles prevents water from reaching higher altitudes at which it would photodissociate through action of intense UV light. If this happens, hydrogen produced would escape earth's atmosphere

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Stratosphere

⇒ In this layer temperature increases with increase in altitude with a max of -2°C at upper limit of stratosphere

⇒ The heating effect is caused by absorption of ultraviolet radiation energy by ozone. It absorbs ultraviolet radiation with wavelengths as long as 290 nm. This radiation causes ozone to decompose into O_2 and O atoms.

Air pollution

Primary Pollutants: CO, CO_2, SO_2, NO, NO_2

Secondary Pollutants: SO_3, HNO_3, H_2SO_4, H_2O_2, O_3, PANs

Most NO_3 and SO_4^{2-} salts

Sources: Stationary vs Mobile sources

Natural sources (volcanoes, dust, fires, pollen, salt, etc)

Primary vs secondary pollutants

Carbon Monoxide

⇒ Formed by incomplete combustion of carbon containing materials (fossil fuels)

⇒ Odourless, Colourless

⇒ Hampers transportation of O_2 in blood

⇒ Sources: Motor vehicle exhaust, burning of forests/grasslands, tobacco smoke, open fires, inefficient stoves

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Carbon Dioxide

⇒ Formed by complete combustion of carbon containing materials

Greenhouse gases and its effect

⇒ It is because of green house effect that the average global temperature of the earth is 15°C (59°F)

⇒ Without the atmosphere the temperature would be a frigid -18°C (0°F)

⇒ greenhouse gases : water vapour, carbon dioxide, methane, ozone and nitrous oxide

greenhouse effect (Adverse Impacts)

⇒ Polar ice disappearing, polar bears having trouble finding food

⇒ many low lying countries like Bangladesh will submerge if sea level rises by 5-12 ft

⇒ doubling the atmospheric CO_2 conc is likely to lead to a 3 ± 1.5 °C rise in atmospheric temperature

Major Air Pollutants

⇒ Ozone

Photochemical smog → visible as a brown haze Los Angeles, Sydney Mexico city, Beijing

$N_2 + O_2 \xrightarrow{\text{+high temp}} 2NO$ (engines)

$2NO + O_2 \longrightarrow 2NO_2$

$NO_2 + h\nu \longrightarrow NO + O$ (photodissociation by sunlight of wavelength 393 nm)

$O + O_2 \longrightarrow O_3$

Ozone + hydro carbone → product gas (condenses) visible cloud

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Health Impact of Ozone (Not to memorize)

⇒ Acts as a powerful respiratory irritant

⇒ Long term, repeated exposure to high levels may lead to reductions in lung function, inflammation of lung lining and increased respiratory discomfort

MAJOR AIR POLLUTANTS

- Nitrogen oxides and nitric acid

NO (Nitrogen oxide)

Forms when nitrogen and oxygen gas react at high combustion temperatures in automobile engines and coal burning plants. NO can also form from lightning and certain soil bacteria

→ NO reacts with air to form NO_2

→ NO_2 reacts with water vapour in the air to form nitric acid (HNO_3) and nitrate salts (NO_3^-) which are components of acid deposition

- Sulphur dioxide (SO_2)

→ comes from human sources, from sulfur containing coal and from oil refining and smelting of sulfide ores.

→ SO_2 —(can be converted)→ H_2SO_4 (sulphuric acid) and SO_4^{2-} (sulphate salts) → falls to ground as acid rain

→ causes classical smog

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Effects of Acid Rain

→ upset the ecology in lakes and streams. Fishes can't live in water with ph < 4.5

→ Attacks plant foliage and roots: Removes protective coating on leaves. Plants become susceptible to pests, disease and other pollutants like ozone

→ Dissolves and carries away nutrients in the soil

→ Damages materials especially monuments and buildings

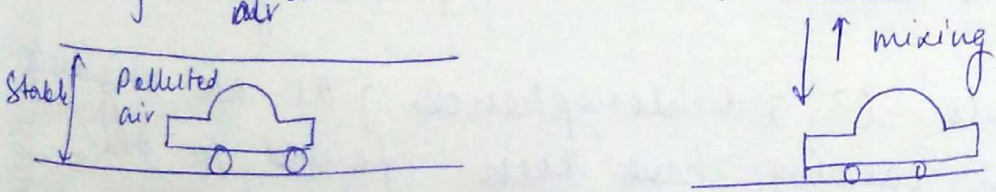
$$CaCO_3 + H_2SO_4 \longrightarrow \underset{\text{gypsum}}{CaSO_4} + H_2O + CO_2$$

slowly dissolved by rainwater

LONDON SMOG

⇒ Most deaths caused by hypoxia (deficiency in amt of O_2 reaching the tissues)

⇒ SO_2 gets stuck in the layer near surface.



Major air pollutants

Suspended particulate matter (SPM)

⇒ small and light enough to remain suspended in air

→ causes bronchitis, mutations, reproductive problems

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Water Pollution

Inorganic industrial wastewater

Wastewater produced mainly from
- → coal and steel industries
- → commercial enterprises
- → Industries for surface processing

Acid Mine Drainage

coal washing

⇒ coal mines release substantial quantities of sulphuric acid and iron hydroxide into local streams

⇒ The first step in the process is the oxidation of pyrite (FeS_2) which is common in underground coal streams

⇒ Thiobacillus ferrooxidans is a highly acidophilic (ph 1.5 to 2) autophtrophic bacterium that obtains its energy through oxidation of ferrous ion

Tanneries

→ Tanning industry is known to be very polluting

→ Chlorinated phenols (3,5 dichlorophenol) as an organic pollutant used for tanning have been found to be highly toxic and affect cellular compounds of organisms

Pollution → 2 types → groundwater
→ surface water

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→ Ground water

Natural purification is limited

↳ through flushing & biological decomposition

→ eg benzene which comes from petroleum waste of which aerobic degradation is well known but in anaerobic condition it can be decomposed only in the presence of nitrates

$$C_6H_6 + 9O_2 \longrightarrow 6CO_2 + 3H_2O$$

$$C_6H_6 + 6NO_3^- + 6H^+ \longrightarrow 6CO_2 + 3N_2 + 6H_2O$$

Inorganic Pollutants:

Cyanide : Naturally occurring chemical

... electroplating

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Ammonia

→ normal constituent of ground water
→ most of it present in water is present as NH_4^+ rather than NH_3
→ excess ammoniacal nitrogen cause water quality problems → used as fertilizer ammonium sulphate
→ manufacture of phenolics and polyurethanes " nitrate
→ In alkaline cleaners " hydrogen phosphate
→ pulp and paper industry → synthetic textile fibres nylon, rayon, acrylics

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Hydrogen sulphide (H_2S)

characteristic rotten egg smell

→ occurs naturally in crude petroleum, natural gas, sewer gases, volcanic gases, hot sulfur springs

Major use of H_2S

→ production of elemental sulphur and sulfuric acid
→ in metallurgy to precipitate copper, nickel and cobalt sulfides from ores

Toxic effect of Nitrites

→ Added to industrial process water as corrosion inhibitor
→ 'Blue Baby Syndrome'

Non biodegradable organic Pollutants : Refractory organics

1. Volatile Organic Compounds (VOCs)
2. Persistent Organic Pollutants (POPs)

VOCs

→ Low molecular weight, high vapour pressure
→ can be natural or synthetic

Examples: Methane, chlorofluorocarbons, Trichloroethylene, formaldehyde, Acetone, Ethylene glycol, 1-3 butadiene, vinyl chloride, tetrachloroethylene benzene toluene xylene CCl_4

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Uses 1. In Laboratories as solvents

Sources

→ Released from burning fuel (gasoline, oil, wood, coal, natural gas)

→ Found at airports and automobile service stations, machine print and paint shops, electronics and chemical plants

VOCs are produced naturally through metabolism

Plants synthesize many organic molecules and release some VOCs (terpenes, isoprene which give them characteristic smell)

Trees emit VOCs for variety of reasons
→ repel harmful insects and animals
→ to attract pollinators

Toxic effects

→ Most VOCs are suspected carcinogens
→ Vinyl chloride (chloroethylene) is known human carcinogen

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Biodiversity.

Bio → means Life Diversity → variety

→ 1.7 million species of living organisms have been described to date

→ overall richness is concentrated in equatorial regions and tends to decrease as one moves to polar region

→ In marine ecosystems, species richness tends to be much higher in continental shelves.

3 components of Biodiversity.

- Genetic Diversity
- Species Diversity
- Ecosystem diversity

① Genetic diversity: Variety of genes or inheritable characteristics present in population

Chihuahua, beagles, Rottweiler → all dogs but diff genes.

② Species diversity: Number of different species and relative abundance of each species

③ Ecosystem Diversity: Variety of ecosystem that are present in biosphere. grasslands, deserts, mountains

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According to Whittaker

α Diversity
tells species diversity in a community
→ Refers to no. of species
→ Better called species Richness
→ Used to compare no. of species in diff communities

β Diversity
describes range of communities due to replacement of species
→ Degree of change in species composition along an environment gradient

γ Diversity
describes diversity of habitat over total landscape or geographical area
→ Species turnover rate with distance between sites of similar habitat

→ Plants produce primary metabolites and secondary metabolites
→ Primary metabolites include carbohydrate, lipids, proteins
→ Secondary metabolites are major source of pharmaceuticals, food additives and pesticides

→ Alkaloids are found mainly in plants. Alkaloid based drugs are:
  → Atrophine
  → Scopalamine
  → Morphine

→ Tropical regions are rich in biodiversity than temperate regions

→ Threats to Biodiversity
Natural Causes: Narrow geographical area
Low population
Low Breeding Rate
Natural Disasters

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Anthropogenic Causes

Habitat Destruction ⟶ primary causes of species extinction

→ Overexploitation of species ⟶ Poaching
→ Pollution
→ Hunting
→ Global warming & Climate Change
→ Agriculture
→ Domino Effect

Endangered species : plant or animal that is in danger of becoming extinct

Threatened species : plant or animal that may become endangered in near future

Conservation Measures

Ex situ conservation : (Captive conservation)
⇒ Refers to conservation outside their natural habitats eg zoos, museums, gene banks, botanic gardens

Insitu Conservation : Refers to conservation of ecosystems and natural habitat.

→ National Parks → under jurisdiction of Central Government
Game reserves → managed by local country council

Insitu Conservation : In these areas hunting, firewood collection, timber harvesting are prohibited so that the wild plants and animals can grow and multiply freely without hindrance.
Cold desert (Ladakh and Spiti)
Hot Desert (Thar)
Saline swampy area (Sunderban & Rann of Kutch)

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→ About 89 national parks in India

→ Kaziranga, Gir, Periyar, Corbett

Sanctuaries : Areas where only wild animals are present

→ Ghavial Project

→ Chilika Sanctuary

Hot Spots Norman Myers developed this concept to designate priority areas for insitu conservation

25 hot spots have been identified in the world

→ They are characterized by exceptionally high biodiversity

→ Most of them located in tropical areas

→ 2 of them located in India

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