S.K.

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1) Hydrosphere. ✓[8]
2) Mutalism [8]
3) pond ecosystem ✓[8]
4) population density ✓[8]
5) Natality. ✓[8]
6) oxygen cycle. ✓[8]
7) producer. ✓[8]
8) Aim & Nessisity of wild life ✓[8]

Zoology Solunke sir — Unit I.

Ecology

* Introduction :-

- An ecosystem is basic & functional eco logical unit. It consist of living orga- nisms (biotic factor) & non-living org (abiotic factors).
- It is an interacting system where bio- tic & abiotic factors interact to produce an exchange of material betn living & non-living factors.
- An ecosystem is sum of total of living oeg, environmem & process of interact betn & within all parts of system.
- Accoeding to odum, an ecosystem is the basic fundamental unit of ecology whi- ch include both organism & non-living environmen each influencing peopeties of other & each is necessary for main- tenance of life.

eg- pond ecosystem, fofest., eivee, ocea sea forms marine ecosystem. othee eg. are estuary, grassland, town etc.

- The word ecosystem was coined by A. G. Tansley.
- Term deeived from 2 woeds - eco & syste Eco = environment & system = complex co-ordinated unit.

componant of ecosystem :-

- The structure of any ecosystem is formed of 2 componants i.e Abiotic & biotic.

Abiotic :- The abiotic factors of an ecosystem include non-living sub. of the environment

eg- Water, soil, air, light, temp, mineral, climate etc.

Temp :- Temp is physio-chemical, ecological, abiotic factor. It defined as the intensity aspects of heat.
It is formed of energy called thermal energy. It penetrate into every reagion of biosphere. It affect all forms of life.
- It affect various stages of life activity such as growth, metabolism, reprod? movement, distribution, behaviour, death etc.
- Temp is variable factor, it varies from place to place & time to time.
- In day it is high & in night is low.

* effect of temp :-

① Tolerance to temp -

- The lowest temp at which org can live in definitely in an active state called min effective temp & lowest temp at survival is possible called as min survival temp.
- The highest temp org can live called max effective temp & highest temp at survial → max survival temp.

② Eurythermal org - org which can tolerate wide ranges of temp fluctuation called E.O.
- They have adaptn to adjust themselves in fluctn of temp.
eg- man, lizard, amphibian etc.

③ stenothermal - can not tolerate wide range of temp called stenothermal.
- They have no adaptations.
eg- corals, snails etc.

④ poikilothermic - In some animals bod temp changes according to fluctuation of environmental temp, these animals called as P.A
+ Also called as cold blooded animals.
+ And ectothermic animal.
eg- All animals except bird & mammales

(5) Homeothermic :-

- In some animals, body temp. remain constant & it is independent of environmental temp. called Homeothermic animals.
- These are also called warm blooded & eridotheemic animals.

eg- Birds & mammales.

(6) Heterotheemic -

- Group of animals shows behaviour like both ecto & endotheemic animals.

eg- Many flying insect, camels etc.

(b) Water -

- Water is described as mother of life.
- It is liquid - gold. It is universal solvent.
- It is largest medium of life.
- It is abiotic factor & occupies 71% of earth surface.
- Water is inorganic comp. formed by the combin^n of H & O.
- Water exist in 3 forms namely, liquid solid & vapours.
- on the basis of & type of salt in water classified into, Hard water & soft water.

- Depending upon requirment of water ecologically animals are classified into following groups.

① Hydrocoles :-

These are aquatic animals which require large amount of water.

- They have aquatic adaptations.

② xerocoles -

These are terrestrial animals which can tolerate dry condⁿ & surevive long time without water.

- They have adaptation for desert life.

③ Mesocoles -

These animals require moderate amount of water.

- They exhibit amphibian mode of life.

eg- Amphibians.

(ii) Biotic factors :-
Biotic factors include living organism of environment
eg- plants, animals, bacteria, viruses etc.
- Biotic factor depend on abiotic factors for their survival.
- The biotic factors of an ecosystem are classified into 3 main groups, namely producers, consumers & Reducers / decomposers.

(a) producers :-
The organism which carry about one photosynthesis constitute producers of an ecosystem.
eg- plants, algae & bacteria.
- producers depend on abiotic factors of ecosystem for producing energy.
- They contain chlorophyll.
- chlorophyll is used for synthesis of food with utilization of abiotic factors like light, CO_2, waters & minerals.
- This process is called photosynthesis.
- producers are inorganic sub. of abiotic factors & convert them into organic food material.
- A portion of food synthesized by produces is used for their growth & survival.
& remaining food is stored for future use.

(2) consumers -
consumers are organism which eat or devour other organism. All animals are consumers, devided into 3 types.
i) primary - They eat producers like plants, algae & bacteria.
- primary consumers are also called as Herbivores.
eg - Rabbit, deer, cow, goat etc.
ii) Secondary - They kill & eat herbivores. They are also called carnivores.
- As carnivores directly depend on herbivores, they are called pri. carnivores.
eg - fox, wolf, etc.
iii) Teriary - They kill & eat sec. consumers. They are also called sec. carnivores
eg - Lion, tiger etc.

(3) Reducers / Decomposers -
- These are the org. that break up the bodies (dead) of plant & their waste products.

eg - ifungi & bacteria.
- They secrete enzyme.
- Enzyme digest dead organism & the debris into smaller bits or molecule.
- These molecules are absorbed by the reducers.
- After taking energy, reducers release molecule to environment as chemical to be used again by producers.

2 Pond Ecosystem :-

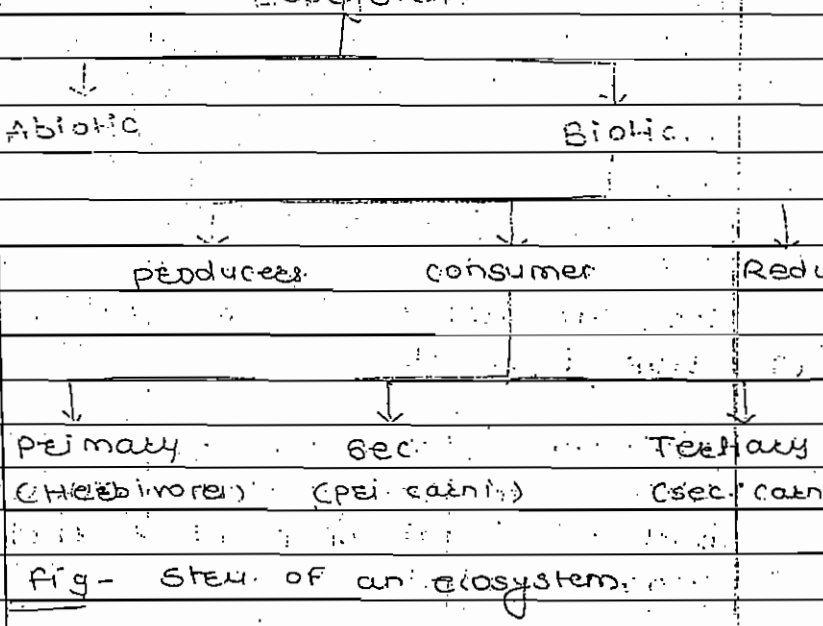


fig- Stem of an ecosystem.

pond ecosystem -
- A pond is suitable eg for aquatic ecosystem
- It is containing a shallow ~~&~~ standing water. The pond ecosystem is formed of abiotic & biotic factor.

i) Abiotic - Abiotic factors of pond ecosystm are water, CO_2, O_2, inorganic comp, org. comp. light, temp, pressure, pH etc.

ii) Biotic - Biotic factors of pond ecosystem are plants & animals. They are producers consumers & reducers or decomposers.

a) producers - producers synthesize food from abiotic substances. They carry out photosynthesis.
- producers of pond include phytoplankton like BGA, green algae, rooted plants submerged plants & floating plants.

b) consumers - they eat other organism. org. which depend on other producer are called pri. consumers or herbivores.
eg. zooplankton., insects, snails.
- The pri. consumers are eaten by sec consumers or carnivores.
These carnivores are called primary carnivores. 'Coz they are 1st carnivores

in food chain.

eg. small fishes, frogs etc.

- The sec. consumers are eaten by tertiary consumers or sec. carnivores.

eg. large fishes, snakes.

c) Reducers - Reducers / decomposer are org. that break up dead bodies of other org. & their waste products.

- They include microbes like bacteria & fungi. They secret enzyme.
- Enzyme digest dead organism & debries into smaller bits of molecules.
- These molecules absorbed by reducers.
- After taking energy, reducers release mol. to environment as chemical to be used again by producers.

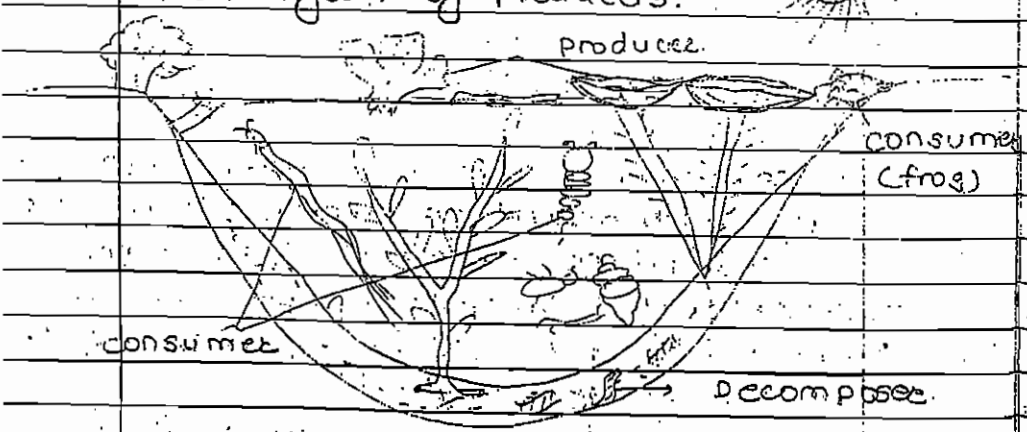


fig. pond ecosystem.

(5) Desert ecosystem :-

- An ecosystem is basic functional ecological unit. It consist of living org & non-living substance.
- In desert, rainfall is less than 10 cm
- Temp. is very high.
- Air movment & storms are common in deserts. Desert occupies 1/5th of earths surface.
- The Thar desert covers an area of 15,00,000 sq. km.
- The desert is a biome
- It is terrestrial ecosystem. It is a self sustaining ecological system.
- A desert ecosystem is made up of 2 componant i.e Abiotic & biotic.

① Abiotic - Abiotic componant include non-living things such as water, air, light & temp. etc.

② Biotic - The biotic componant includes living thing such as plants & animals.

- plants of desert include succulent plants, ~~thro~~ thorn bushes, shrubs, & some trees.

eg - Yuccas, Agaves, cacti etc.

- The animals include camel, kangaroo, rat, owl, Rattle snake, insects, etc.

- The biotic componant of desert consist of peoducers, consumers & decomposes
- The producers are desert plants.
- The consumers are animals, herbivores & carnivores.
- The decomposers are bacteria & fungi They break dead bodies of plants & animals.
- The producers are eaten by herbivores The herbivores are eaten by carnivores This process of eating being eaten is called food chain.

producers → Herbivores → Carnivores

- The energy flows in ecosystem from producers to consumers.
- The minerals circulate bet living & non-living componant of ecosystem.
- It is called biogeochemical cycle.

* Sphere of earth →
- Environment made up of 4 parts i.e
  Atmosphere → Air
  Hydrosphere → water
  Lithosphere → Land
  Biosphere → plants & animals.

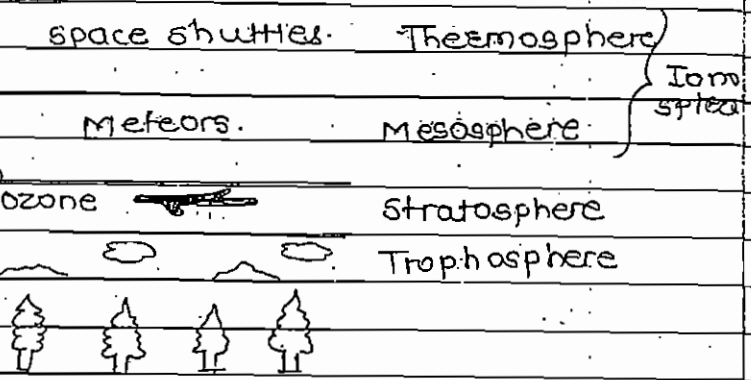
(1) Atmosphere → It is gaseous envelope of earth. It is present around the earth. It extend upto 20,000 km.
- It consist of gases & some solid & liquid particles suspended in it.
- The gases include N, O_2, NH_3, Neon, keypton, xenon etc. of theses N_2 makes upto 78%, O_2 → 21% & Ar → 0.9
- other gases found in trace amounts.
- Atmosphere devided into 5 layers, on basis of vertical distribution of temp.

(a) Teophosphere →
The lowest layer of atmosphere, in which temp. ↓ with ↑ altitude is called teophosphere.
- clouds are formed & carried by winds in this layer. It extends from 8 to 8 km at poles & to about 17 km at equator
- It contains 90% of air of atmosphere.
- seasonal variation are so common.

② Stratosphere –

The layer of atomsphere above tropho sph in which temp ↑ with ↑ altitude is called stratosphere.

- It extends to height of 50 km.
- Here, air is much thinner: Long distn aircrafting fly in lower part of stratosphere.
- The top of this layer contain ozone.



③ Mesosphere – It lies above 50 km upto 100 km.

- It is characterised by ↓ in temp.

④ Thermosphere – It lies beyond ~~400~~ mesosphere. Here temp. rises sharply attaining 1000°c.

- It extends to height of 400 km.

⑤ Exosphere – It lies above thermosphere beyond 400 km. The ↑ in temp. ceases at this layer.

- The density of atmosphere is very low.

* Ozone layer –

In atm, about 30 km above surface of earth, ozone mol. of are concentrated in stratosphere.

- The concentrated layer of ozone is called as ozone layer.
- It screens off ☹ UV light of sun.
- It protects life of earth from damaging effect of UV light.
- It is now feared that there is dangers of appearing holes on ozone layer.
- This is caused by freon & chloro-fluoro-carbons (CFC)
- The appearance of skin cancer will be result of ozone depletion.
- The ozone prevent damaging effect of UV radiation coming from sun.
- Atm. support life on earth. It supplies
  ① ~~☹~~ O_2 for respn.
  ② CO_2 for photosynthesis
  ③ Rain ④ Temp.
- The atmosphere prevent entry of UV rays of sun into earth.

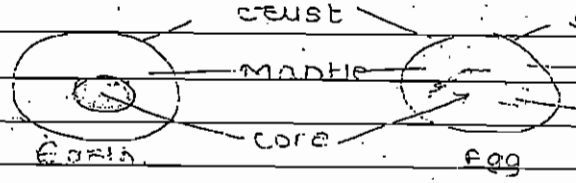
(2) Hydrosphere -

The layer of water on surface of earth is called Hydrosphere.

- It include all liquid & frozen surface waters, groundwater held in rock & soil & atmospheric water vapours.
- It is estimated that world has 1,46,000 cubic kilometer of water.
- The ocean & seas constitute about 97% of water.
- The polar ice caps & glaciers constitute 2%.
- The freshwater bodies, groundwater & atmospheric vapour constitute 1%.
- All these waters of hydrosphere are in constant circulation through hydrologic cycle.
- Three fourth of Earth's surface is covered by water. It include oceans, seas, ponds, lakes, rivers, dams etc.

(3) Lithosphere -

- The solid componant of earth is called lithosphere.
- The lithosphere is made up of three layers, an outer crust, middle mantle & an inner core.
- The crust is outer most solid ozone of Earth & its thickness varies from 12 to 60 km.
- The mantle is middle layer is in a molten state. The thickness of mantle is estimated to be 2,900 km.
- The inner core is about 2,500 km thick. It is in a solid or molten state.
- It is composed of Ni & Fe.



- The lithosphere can be compared to a hen's egg. It is elliptical.
- The shell of egg represent crust, white of egg is compared to mantle & yellow yolk compared to core.
- The lithosphere is made up of rocks & soil. The rock is formed of minerals.

(4) Biosphere -

- Biosphere is sphere of life. It consist of plant, animal & human being of earth. It is also called Earth sphere.
- Biosphere found in lithosphere, hydrosphere & atmosphere.
- Total mass of biosphere is 5×10^{18} tonnes.

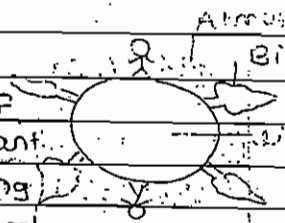


Fig. Biosphere

- The biosphere consist of organism, pop. watr, community & ecosystem.
- organism include plants & animals.
- popuⁿ is group of similar plants or animals living in an area.

eg - All teaks trees in forest.

- A community refers to all plants & animals living in an area.
- An ecosystem refers to all non-living things, plants & animals of an area & their interactions.

5) Green House Effect :-

- Green house effect is ↑d warming of earth caused by else in CO_2 content of air.
- It is case of air pollution.
- In Green house effect, temp of Earth ↑ causing global warming.
- Green house is glass house, where green plants are reared.
- In glass house temp. will be slightly highee than that of outside.
- The glass allows sunlight to pass into glass house. The sunlight heats floor of green house & floor reflects infrared radiation.
- The glass does not allow infrared radⁿ to go out. A part of radⁿ is absorbed by glass & another part is reflected back into green house.

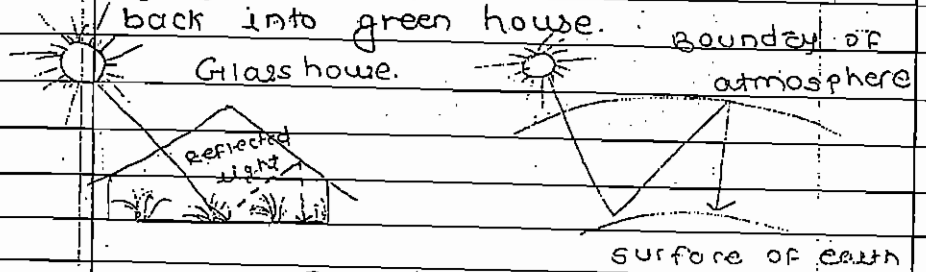


fig- Green House Effect.

- Hence glass house gets heated.
- certain gases such as CO_2, Methane, Nitrous oxide, CFC, water vapours etc. funⁿ as glasses in glass house. These gases are called as green house gases.
- They form a layer about 20 km above Earth's surface.
- The Green house gases allow sunlight to pass through them. The sunlight heats Earth & Earth reflects infrared radiation back to Earth. This process warms up the Earth.
- The warming ↑ proportionally to ↑ in conc^n of green house gases.
- The industries, auto mobiles, deforestn, burning of fuels, decomposition of organic materials etc release large amount of green house gases.

* Harmful effects -

– Green house ↑ global temp. The ↑ in global temp. or global warming produces following effects.

① polar ice caps will melt causing an ↑ in sea level. When sea level ↑, low lying coastal town & cities will be swallowed by sea.

② The drastic change in global climate.

③ Melting of ice leads to floods in rivers.

④ Rainfall will be affected.

⑤ food prodn will be ↓d.

⑥ High temp. may be harmful to life of man.

* protective measures -

① The fuels such as petrol, coal, diesel etc. can be replaced by non-pollutant agent such as electric current, sunlight etc

② Forest fire should be prevented.

③ More & more trees must be grown. Trees consume CO_2 during photosynthesis

④ The use chloro-fluoro carbon in refrigerators & air conditioners may be substituted by hydro-fluoro carbons.

* Bio-Geo-chemical cycle -

– The cyclic path of element from abiotic system to biotic system & back is called as biogeochemical cycle.
(Bio= living org., Geo= water, air, earth)

– Organism are built upon chemical substances. They require certain chemicals like N_2, O_2, H_2, P, C etc. continuously for their survival.

– These chemicals enter into org. from environment & come out after undergoing changes or without changes.

– Thus these element tend to circulate in characteristic path from environment to organism & back to environment.

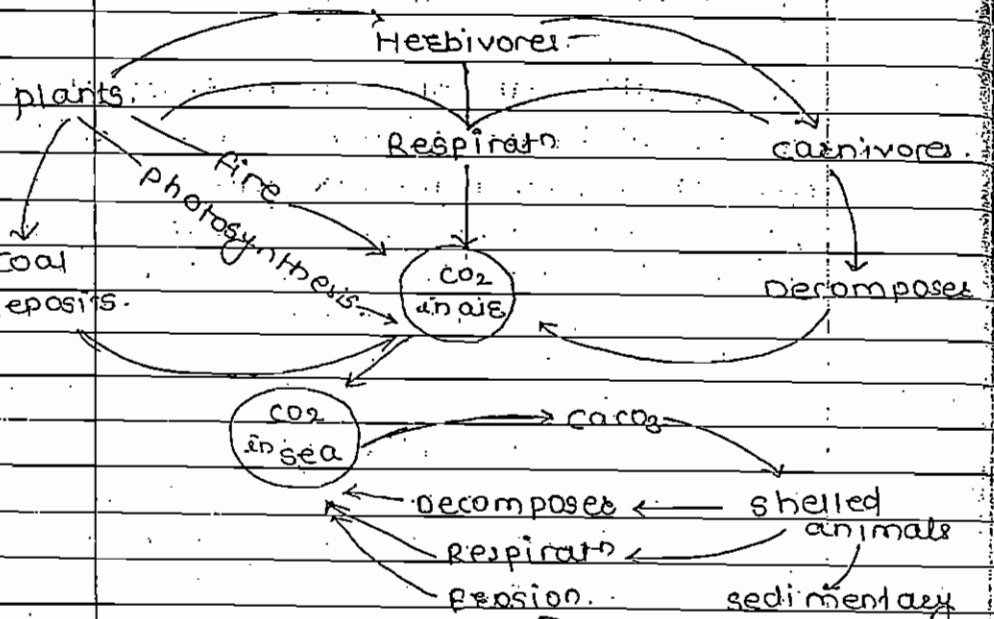
① Carbon cycle-

The cycling of carbon betn biotic & abiotic systems is called carbon cycle.

– It is gaseous cycle. The main source of C is CO_2. CO_2 present in water & air. CO_2 content of air is 0.03 %

* Flow of C in Biotic System-

– C flows into Biotic system in 2 ways,
① photosynthesis &
② Formn of shells.



i) photosynthesis.

- C enters biotic system through photosyn.
- In photosynthesis, green plants utilize CO_2 & incorporate the C of CO_2 in glucose. Glucose is used for synthesis of other type of carbohydrate, proteins, & lipids.
- These comp. containing C, are stored up in plant tissues.
- When plants are eaten up by herbivore C flows into body of herbivores animals through food chain.
- When herbivores are eaten by carnivores carbon enters body of carnivores animals.

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

ii) formation of shell.-

CO_2 dissolved in sea water is utilised by marine animals like protozoan, coral, molluscs, algae etc. for construction of shells. In these animals CO_2 is converted into $CaCO_3$ which is used for construction of shells.

$$CO_2 + H_2O \rightarrow H_2CO_3 \text{ (carbonic acid)}$$
$$H_2CO_3 \rightarrow H^+ + HCO_3^- \text{ (Bicarbonate)}$$
$$HCO_3^- + Ca^+ \rightarrow H^+ + CaCO_3 \text{ (calcium carbon.)}$$

* flow of C in abiotic system-

Into 5 ways-

i) Respn- plants & animals release CO_2 by respn.

$$C_6H_{12}O_6 \rightarrow CO_2 + H_2O + \text{Energy}$$

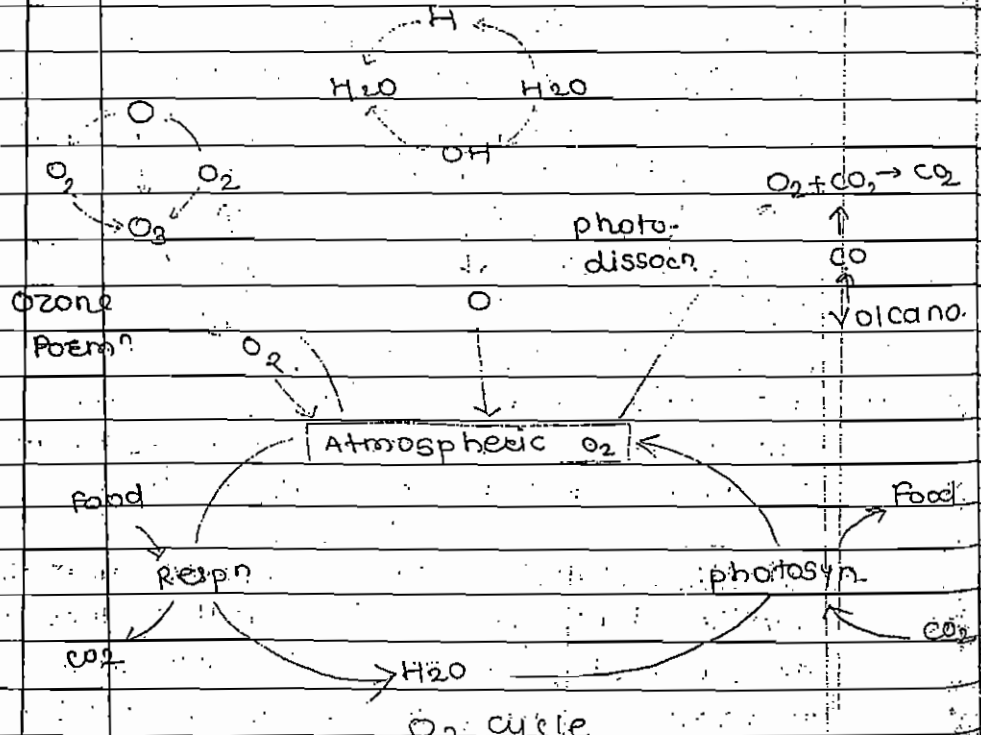
ii) decompos^n- when plants & animals die dead bodies, decomposer into CO_2 by decomposers like Bacteria, algae etc.

iii) Shells - After death of marine animals $CaCO_3$ stored in shells is either deposited as sedimentary rocks or dissolved in water to release CO_2 by reversion of above said

④ coal - A certain proportion of C from plants is deposited as coal. C from coal returns to air in form of CO_2 through combustion & weathering.

⑤ forest fire - combustion of wood in the forest, releases C from plants in form of CO_2.

2 Oxygen Cycle :-



The cycling of O_2 between biotic & abiotic systems is called O_2 cycle. It is gaseous cycle. Air is reservoir for O_2. O_2 enters the biosphere through respiration.

- The O_2 taken in body is used for oxid? of carbohydrate, proteins & fats.
- Certain amount of O_2 in atmospheric air is converted into ozone (O_3). The ozone forms an umbrella like layer in outer atmosphere.
- This layer prevents UV. radiation from reaching earth's surface.

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

$$O_2 + O \longrightarrow O_3$$

- Carbon monoxide is released from volcanos. This CO is unstable. It combines with O_2 to form CO_2.
- O_2 combines with variety of element to form comp. eg - it forms CO_2 with C, H_2O with H_2, nitrates with N_2, ferric oxide with iron etc. O_2 returns to air by 2 main methods.

① photosynthesis - Green plant synth. Carbo. by photosy. During photo. H_2O mol. break up into H & O_2 is released into atmo. & H_2 is trapped & turned into carbohydrate.

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

② photodissociation - Water vapour is dissociated in presence H & O.

A] Population Ecology- A group of organism of same sp. living in particular area at a particular time.

* characteristics -

① All individual of popuⁿ belongs to the one species.

② The individuals are morphologically & anatomically similar

③ The individuals are genetically related.

④ There is free gene flow betⁿ individual of population.

⑤ The individuals are reproductively isolated from other species.

- Each popuⁿ has following characteristick

① Natality :- (Birth rate)

- Birth rate refers to average nu. of new individuals produced by popuⁿ in given time.
- Natality is due to birth, hatching, germination or fission.
- Size of popuⁿ ↑ because of natality.
- It is of 2 types - potential natality and realised natality

Natality = Nu. of births per unit time / Average population

Natality → the [illegible] per 1000 individuals of a population per year

Natality = Total nu. of births in a year / Average population during mid year

① potential or max. natality :- The max. possible rate of repⁿ for popuⁿ under optical condⁿ is called potential natality.

eg- salmon produce 2,80,00,000 egg in season. So potential natality of salmon is 2,80,00,000 eggs in season.

But all egg do not hatch & reach adulthood becoz of environmental resistance. Hence potential natality is not attained in nature.

② Realized / Ecological - It refers to actual nu. of new individual added to population in given time. Realized natality is consideeably lesser than potential natality.

② Mortality :- (Death rate)

- Mortality refers to nu. of individual dying in popuⁿ at given time. The size of popuⁿ ↓ becoz of mortality.
- There are 2 aspects of mortality: they are potential mortality or min. & realized / actual mortality.
- potential mortality refers to nu. of death due to old age.
- Realized - nu. of death that occure at all ages from gamets to adults due to

environmental factors like predation, disease & other hazards.

– Realised is higher than potential.

Mortality = $\frac{\text{Nu. of death per unit time}}{\text{Average population.}}$

iii) Population Density :–

population density refers to total nu. of individuals in unit area or unit volume. at given time.

– It may be expressed in diffn parameters.

eg. Nu. of bacteria in litre of water,
Nu. of plants per acre of land.
Nu. of peoples per square km. & so on.–

– The density of any population can be expressed by foll. formula.

$D = \frac{n/a}{t}$

Where D = Density
n = nu. of individu
t = Time
a = Area.

– several method are followed to measure population density. They are as follows.

① Total count
② Sampling method
③ Tagging method
④ pellet counting method

④ Age distribution :–

– A population is formed of individuals in diffn age groups.

– The individuals in an popuⁿ can be classified into 3 groups according to their age. They are

① The pre-reproductive group - It includes immature animals.

② The reproductive group - It includes comprising sexually mature individuals.

③ The post - reproductive groups - comprising old animals where reproductive ability has been stopped.

– The birth rate, death rate, growth rate of popuⁿ are determined by age group of population.

– In growing popuⁿ birth rate is high.

– When populatn is formed predominantly of pre-reproductive age group, it is in state of growth.

– When popuⁿ formed predominantly of post-reproductive age group, it is said to be declining.

– When popuⁿ formed predominantly pre-reproductive & reproductive age group. it is to be in stable condition.

B) Biotic interactions :-

- The interaction include

* Neutralism → none of partner is affect
* competition → both partners inhibited
  eg - paramecium
* predation → predator is benifited & prey is harmed. eg - Lion & deer.
* parasitism → parasite is benifited & host is harmed eg - Ascaris & man.
* commensalism → 1 partner is benifited & other is neither benifited / harmed.
  eg - shark & sucker fish.
* Mutualism - Both partners are benifited
  eg - Hermit crab & sea anemone.

① positive interaction :-

i) commensalism (+, 0)

It is symbiotic interspecific relationship where 1 partner is benifited & other is not harmed.

- The partners are called commensals.

eg - Eating at same table as guest.

- commensalism classified into 4 groups.

a) Temperary → Here assocn is temporary. sometimes partner may seprate & go away.

eg - crab living in tube of chaetopterus, sucker fish & shark.

b) permanant - Here assocn is permanant. partner remain together permanantly.
eg - Lichens.

c) Ectocommensals - These lives on outer surface of other partners.
eg - suckee fish & shark.

d) Endo commensals - lives inside body of other partner

eg

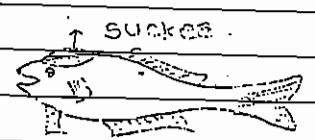


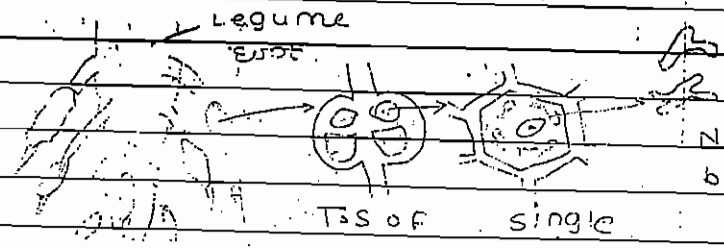
fig - commensalism

ii) Mutalism :- (+, +)

Mutualism is an interspecific symbiotic relationship where both partners are benifited

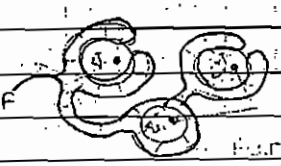
- This term literally means 'living togethr & was coined by De-bary. (1877).
- following are eg -

a) Rhizobium & leguminous plants.



- The bacterium rhizobium produce nodule on root of leguminous plants.
- The bacteria fixes atm. N_2 in nodules in form of nitrates.
- The plant utilise these nitrates.
- The bacteria, in turn, obtain carbohydrate & other sub. from plants.

② Lichens -



Lichens are formed of algal & fungus.
- The fungus provide protein. Lichens moisture & minerals for algal cells.
- The algal cells prepare carbohydrate for both partners by photosynthesis.

② Birds & Grazing animals -

The cow bird oxpecker & white heron are found alighting on the back of grazing animals.
- The birds pick off ticks & other external parasites. These forms food for birds.
- Grazing animals gets 2 benifits
① They get rid off external parasites.
② They get early warning about approaching enemies by activity of birds as "watch men"

② Negative interaction -

i) competition (-, -)

Competition is rivalry betn 2 animals for common resource.
- It is an animal interaction.
- Here 2 individuals are involved. They are called partners.
- The two partners may be harmed or only one partner will be harmed as a result of competition.
- Idea of compn. was proposed by Darwin in form of struggle of existance
eg- A deer competes with tiger. A tiger needs food. It chases deer. The deer wants to live. It run away. It is a competition in animals.
- man stores food grains. Rats steal them Thus there is compn in man & rat.
- There are 2 types of competition -

④ Intraspecific → competition betn members of same sp. is called intraspecific co
The members of same sp. are similar in all respects. They have same type of requirments such as food, shelter, mate etc.
eg many male dog compete among themselve

to mate with female dog.

② Many speems compete among themselves to fertilize the egg.

ⓑ Interspecific compⁿ → compⁿ betⁿ members of diffⁿ sp. is called interspecific compⁿ.

eg- A tigeᴇ & deeᴇ compete with leach otheᴇ. The tiger chaseᴇ deeᴇ foᴇ food. The deeᴇ tieᴇ to escape.

② There is compⁿ betⁿ man & mosquito. A mosquito bites a man. & man kills mosquito.

ii) predation :- (+, -)

predation is an animals relationship wheᴇe one animal kills & deveaᴇ otheᴇ animals foᴇ food.

- The animal which kills otheᴇ animal is called predatoᴇ. & animal which is killed - called as prey.
- All animals & insectivoᴇᴇ plants are predatoᴇy.
- The predatoᴇy are of 2 types -
① Heᴇbivores ② carnivores.
- The predators which eat plant called heᴇbivores.

eg- Rabbit.

- The predatoᴇ which kills & eat animal are called carnivores.

eg- Lion, fox, tigeᴇ etc.

* characterstick of predation -
A succeᴇs full predation has foll. chara.
- The predator has high hunting ability
- searching image of predator muᴇt be high.
- predators hunt only, when it is necessaᴇy foᴇ them to peocure food.
- predatoᴇ select food on basis of size.
- The predatoᴇ-prey interaction causes a redⁿ in population. But co-evolution of sp. has led to dynamine balance betⁿ population in community i.e sizes of popuⁿ of predatoᴇ & prey sp. are inteᴇ-regulated by feedback mechanism which effectively contᴇol the popuⁿ of both.
- The evolutionaᴇy relationship of predatoᴇ & peey may occure betⁿ group of speciᴇ It is called diffuᴇe co-evolution.
- The diffuᴇe coevolution has leᴇs specific evolutionaᴇy relationship.
- Diffuᴇe co-evolution can be explained undeᴇ following eg.

eg-① Evoln of tolerance in predators-

– In community, most plants sp. are eaten by variety of herbivores. In response to activity of these various herbivores most plants produce a variety of protective mechanism such as thorns, tough leaves, toxins & distasteful chemicals.

(ii) predation :- paracitism :- (+,-)

– parasitism is one-sided relationship where one partner is benifited at expense of other.

– The other partner is harmed.

– The partner which is benifited is called parasite. The other partener is called as host.

* parasite -

The paracite lives inside or on the body of host. Hence paracite is usually smaller than host. The parasite

eg- ploits resources of the host.

– But it does not kill host.

– The death of host, if any, is due to after effects of parasitism.

* Host - Host is an animal which provide shelter & food for parasite. It is usually largest than parasite. certain parasites require more than 1 host to complete their life cycle.

– When there are 2 hosts, they are named primary host (definitive hosts) & sec. host (intermediate hosts).

– In pri. host, parasite complete its sexual cycle. In sec. host, parasite complete its asexual cycle.

* Effect of parasite on host-

- Parasite do not kill the host, because the death of host leads to death of parasite itself. But—host is affected in many ways due to enormous multiplication of parasite in host & also due to after effect of parasitism.

eg- plasmodium causes malarial fever.

* Effect of Host on parasite.

- parasitism causes changes on parasite also. They are following-

① Host provide food in digested form. Hence parasite loses gut & digestive glands.

② parasite loses locomotory organ.

Unit III

pollution

* Introduction :-

- pollution is an undesirable change in physical, chemical or biological characteristics of our air, land & water that will harmfully affect human life & desirable sp. or that may waste or deteriorate our raw material resources

- pollution is accidental contamination of environment with man's waste.
- pollution → matter in wrong place.
- continued economic growth, mismanagment of resources & population explosion have an explosive impact on environment

1. Air pollution :-

It refers to undesirable change occuring in air causing harmful effect on man & domesticated species.

* sources -

1) Agriculture - Hydrocarbon released by plants, pollen grain, insectiside etc. causes air pollution.

2) Dust - Dust in air is ↑d by dust storms, wind, volcanoes, automobiles etc, causes air pollution.

3) Industries - combustion of fossils fuel like coal, petroleum etc. in industries is main resources of air pollution.

4) Automobiles - The combustion of petrol & diesel in automobiles releases harmful gases into air. They also produce dust.

5) freons - Use of freons & other CFC as refrigerants, co-olants & as filling agents in aerosol packages cause pollutions.

* Effects :-

1) Death - When air is polluted with poisonous gases, death comes as result immidiatly eg - Bhopal Episode on 2nd Decem 1984 about 8000 human being died.

2) chlorosis - The disappearance of chlorophyll is called chlorosis. It is caused by SO_2 & fluoride present in air.

3) Necrosis - Breakdown of cell is called necrosis. It is caused by SO_2, nitrogen dioxide, ozone & fluoride.

4) Vomating - SO_2 causes vomating

5) Jaundice - Arsines induce RBC breakdown & jaundice.

* control -

⊕ Electrostatic precipitators can reduce smoke & dust from industries.

② Gaseous pollutant arising from industri can be removed by differential solubility of gases in water.

⑧ Certain gases can be removed by filtra or absorp through activated carbon.

④ Certain gases can be made chemicaly inert by chemical conversion.

⑤ At gov. level poln can be controlled by framing legislations.

② Water pollution :-

It refers to undesirable change occuring in water which may harmfully affect the life activities of man & domesticated species.

* Sources :-

① Domestic sewage - The city sewage is released into rivers.
- Domestic sewage contain human faeces, urine & dirty used-up waters in houses.
- It contains a large no. of pathogenic bacteria & virus.

② Industrial effluent -
The industrial wastes includes heavy meta (Hg, Cu, lead, Zn etc.) detergents, acids

carbonates, alcohol, chlorine etc.
- Those non-usable chemicals are dumped in water as means of getting rid of them

③ Thermal pollution :-
Many industries use water for cooling & resultant warm water is discharged into rivers. This brings about thermal pollution.

④ Fertilizers - The fertilizers used for crop are washed into ponds & rivers.

⑤ Pesticides - pesticides are used to control pest in field & house. They include DDT, BHC, endrin etc. This leads to water po.

⑥ Oil poln - Oil poln is due to ship accident loading & discharging of oil at harbour oil refineries. Oil is source of pollution in sea water.

* Effects :-

① Minamata disease → This disease is caused by mercury poisoning which came as by-product from the factories. The accumulation of mercury leads to crippling & death.

② Diarrhoea -
It is due to Hg, cadmium & cobalt pre sent in the water.

⑥ mortality of plankton & fish :-
chlorine which is added to water to control growth of algae & bacteria, may persist in streams to cause mortality of plankton & fishes.

④ Siltation :- siltation is phenomenon by which gills of fishes are deposited with silt. This causes heavy mortality among fishes.

⑤ Water born diseases :- Diseases like jaundice, cholera, typhoid, diarrhoea etc. are transmitted through water contaminated with sewage.

* Control :-

① Sewage treatment :- Water pollⁿ can be controlled by sewage treatment by ① sedimentation ② dilution ③ storage

② Waste stabilizⁿ pond :- Domestic & industrial waste are stored in dilⁿ condⁿ in pond called waste stabᶻⁿ pond. After few days micro-org & algae flourish. The micro-org decomposes org. waste by oxdⁿ & water is purified.

③ Recycling :- pollⁿ can be prevented by certain extent by reutilizing waste i.e called recycling certain pollutants from industrial effluents can be removed by filtⁿ & selective absorption.

③ Noise pollⁿ :- Noise pollⁿ is unwanted sound dumped into environment.
- Noise measured by unit decibel (dB)

* causes :-
Scooters, motor bikes, cars, Aircraft, ships, social gathering, factories, mills, kitchen appliances, fire crackers, Generators, workshops, Loud music, speakers.

* Effect :-
① Noise diminishes power of hearing
② It gives pain to ear.
③ It interferes with communicn systems.
④ causes stress ⑤ It ↑ rate of heart beat
⑥ ↑ blood press. ⑦ causes headache.
⑧ cause emotional upset ⑧ causes deafness

* control :-
① Legislation should be framed.
② Sources that generate unwanted sound should be reduced.
③ Wheels of automobile should be oild properly.
④ Loudspeekes should be set at low sound.
⑤ Noise producing machines should be placed in closed rooms.
⑥ Residental houses should be constructed far away from industry, factory & airports.

(2) – Energy Resources * *

– Energy resources may be renewable or non-renewable.

– Non-renewable energy resources cannot be ~~replaced~~ reproduced after their use. eg- coal, petrol etc.

– Renewable sources are available continuously. They are also called sustainable energy sources.

eg- Sunlight, wind etc.

① conventional →

i) Fossil fuels -

Fossils fuel are coal, oil, & natural gas formed over geological time under the Earth. They are organic compounds.

– They are non-renewable energy resources.

– They are formed from dead bodies of plant & animals. They are used as energy resources.

a) coal - Coal is fossil fuel. It is non-renewable natural resources. It is found under earth.

– It is organic comp. It is black product formed from org. decomp^n of plant material millions of years ago.

b) – oil :- Oil is non-renewable resource. Oil is most abundant fluid in Earth's crust, next to water. It is hydrocarbon. It is mineral oil. It is fossil fuel.

– The crude oil is petroleum.

– It is formed by decomposition of buried plants million of years ago.

– The chemicals present in oil are isolated & used for prod^n of plastics, medicines etc.

c) Natural gas - Natural gas is fossil fuel. It is hydrocarbon. It is found together with oil. It accumulates above oil. It is formed by decompos^n of buried plants.

– methane is natural gas. It is used for domestic & industrial purposes.

ii) Nuclear Energy :-

The nuclear energy is obtained from fission of atoms of radioactive elements.

– It is a nonrenewable energy.

– A very small amount of radioactive element can produce an enormous amount of energy.

– Radioactive elements are used in atomic power station to produce electricity.

– It is used as fuels in marine vessels, space crafts, heat generators & chemicals & food processing plants.

- There are more than 434 nuclear power stations in world.
- In India, atomic power stations are located in Tarapur, Kota, & Tamil nadu.
- The nuclear power plants produces the following impacts on environments.

① Disposal of nuclear waste.
② very hot waste waters which damages, aquatic ecosystem.
③ Nuclear accidents cause many death & ill effects for many generations.
④ High cost is needed for decommissioning old plants.

iii) Hydroelectric Energy :-

- The flowing of water produces electricity so water is hydro power.
- It is renewable energy resource.
- In olden days, water wheels were used to generate, mechanical energy to run some mills & machineries.
- The water stored in dam is used to rotate the wheels of power generators.
- Hydroelectric power prodn creates following problems

① construction of dams leads to submergence of forest & agriculture land.
② silting reduces life of turbines.
③ water transport is prevented when dams are constructed across rivers.
④ fishing is a problem.
⑤ The dwelling place of tribal people is disturbed
⑥ The tribal people must be resetted in some other places.

② Nonconventional Energy :-

① Solar energy :-

- Sunlight is solar energy. It forms major energy source for plants. plants synthesize steach with help of sunlight.
- All animals in world depend on the ere energy stored by plants.
- The solar energy is also used for solar cookers, solar light, solar calculator etc.
- The solar energy contain tremendous electric energy.
- Technologies must be developed to exploit sunlight.
- solar cells generate electricity using sunlight. They are pollution free.
- In solar cells, 2 layers of silica are used.

- Solar cells are used for calculators, Electric appliance, Radio, water pumping, Electric lights, weather stations, street lights, cars etc.
- Soon, man is going to fly in air without any air crafts.
- A day will come on which men fly individually in air.
- man can fly in air by 2 methods
  1. By attaching a solar cell on his body
  2. By neutralizing gravitational force around him.
- When gravitational force is neutralised man can fly in air like H_2 balloon.

ii) Wind Energy :-

- Wind is renewable natural energy resou
- Wind is an inexhaustible source of energy. It is perrennial source & and is available day & night.
- It is used to generate electric currents.
- The blow of wind is allowed to rotate the blades of windmill.
- The windmill is coupled to turbine.
- This generate electricity.
- Windmills are most abundant in Gujrat, Tamilnadu, & A.P.

- Muppandal (Tamilnadu) has highest conc of windmills in Asia & it ranks third in world.
- The windmill has vertical pillar with 3 blades. The force of wind rotates blades.
- The blades rotate a wheel. The wheel is connected to generator to generate electricity
- The speed of wind should be 10 to 20 km/hour.
- In rural areas, small windmills are us for pumping water, threshing, winnowing, cutting woolen logs, battery charging etc.

iii) Tidal power -

Tides & waves are used to rotate whe ls of turbines to generate hydroelectric power.

- Tidal power is trapped by constructing a dam across an estuary.
- The tidal flow is used to rotate turbines.

Unit IV

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A] Wild life conseervn & Endangered sp.

Aims of wild life consn -

Wild life conseervn has foll: aims -

① To protect & preseerve the rare species of plants & animals.
② To preseerve breeding stock
③ To prevent deforestation.
④ To maintain balance of nature
⑤ To study ecological relationship of plants & animals in natural habitats.

Neccesity of wild life conseervn -

The conseervn of wild life peovide the following advantages & benifits.

ⓐ Balance of Nature :-

conseervn of life maintain a balance of nature.

eg ① When all herbivores animals in forest are killed, the tigee & lions enter human settlements & attack human beings & domesticated species.

② The killing of snakes foe their skin allows rat populations to ↑ enoemously.

ⓑ Genetic resources :-

The wild flora & faunna are rich resources of genes which can be used in breeding new foems of plants & animals with desirable characters like disease resistance variety & high productivity, higher ecologically amplitude etc.

This calls foe preseervation of wild life as an imp. genetic resource.

ⓒ Economic value:

Wild life is wealth of countey & it is a good source of income. Wild life yield timbee, firewood, hides, ivoey, hoens etc. Live & dead animals can be stored in zoos & museums foe exhibition.

ⓓ Recreation -

Wild life foems a source of enjoyment & recreation to human being

ⓔ Education -

visits to sancturies give education to student of schools & colleges.

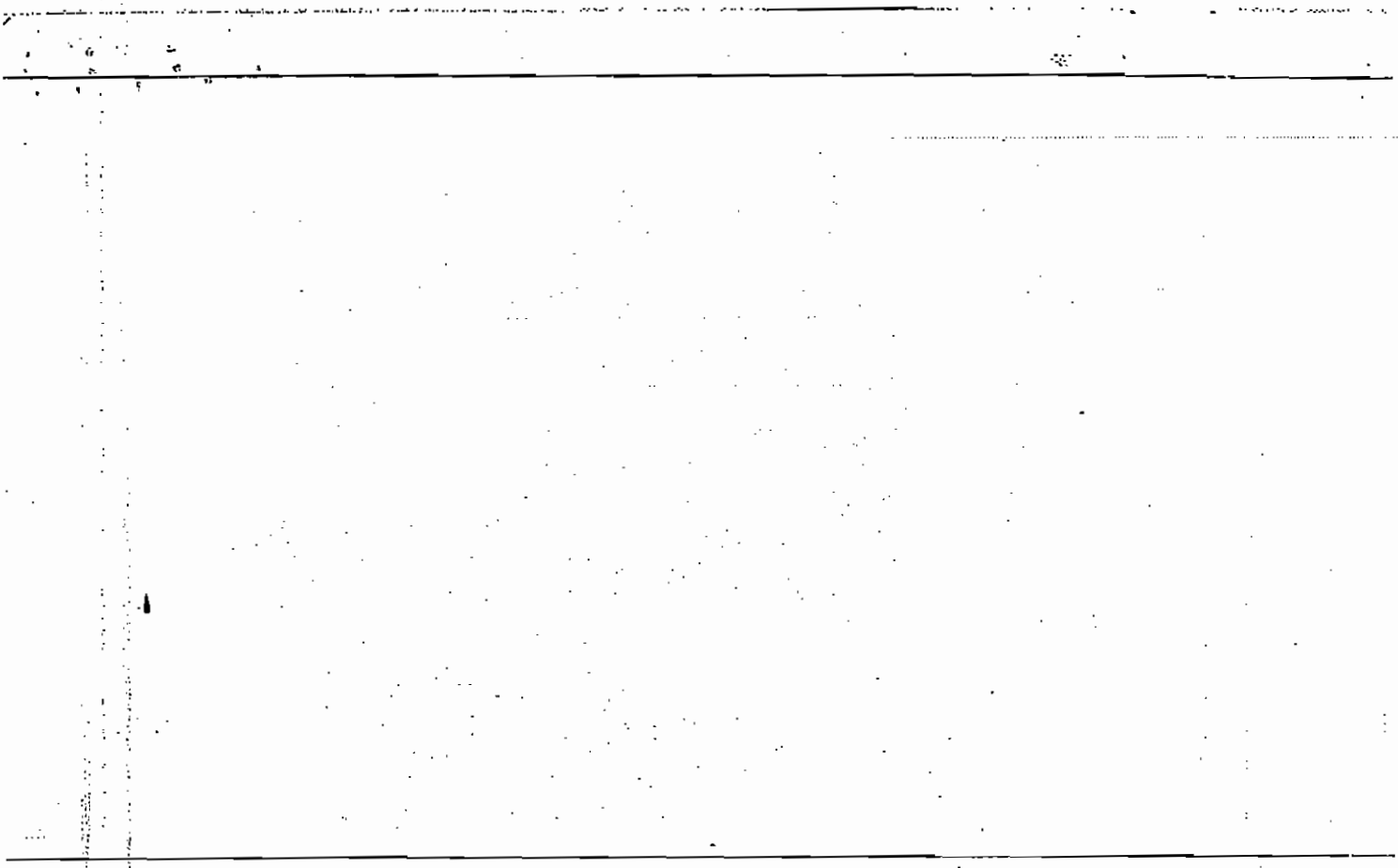
(iii) Endangered sp. of India :-

- Many sp. of plants & animals are facing the problems of extinctions & becoming lesser in nu. every year. These sp. are called endangered species.
- Endangered ~~ing~~ ing of sp. may be caused ① Habitat loss ② Feeling of trees ③ cleaning of forest areas ④ deforestration ⑤ Quarrying in forest area ⑥ poaching & hunting ⑦ Export to other countries
- The western Ghats is natural & only habitat for lion tailed macaque.
- once this sp. was seen in large nu. in forests : but now because of habitat loss only a few animals are seen.
- but now becoz of habitat loss only a few animals are seen.
- Now this animal is more or less at stages of extinction.
- ∴, it is considered to be an endangered species.
- In India, about 450 sp. of plants are ~~forme~~ found to be endangered sp. by Botonical survey of India (BSI) in 1998.

eg- camellia caduca.
piper barberi.

Many Indian sp. of animals are also found to be endangered ~~sp~~ by zoological survey of India in 2000. The foll. eg. of endangered ~~sp~~ animals in India.

① Primates :- Lion-tailed macaque.
② Carnivora :- Indian fox, Jungle cat
③ Logomorpha :- Aassam rabbit.
④ Birds - Eagles, peacock,
⑤ Reptiles - Monitor lizard.
⑥ Amphibia - vivipacous toad.
⑦ Crustacae - Coconut crab.
⑧ Insecta - 55 sp. of butterflies and moths.



I) Aims of Wildlife Conservation

Wildlife means those are untamed & uncultivated species of plants & animals, living in their natural habitate.

The concept of wildlife conservation means protection, preservation of rare species of plants & animals in their natural habitat.

AIMS of Wildlife Conservation

Wildlife conservation has following aim.

1) To protect & preserve the rare species of plants & animals from extinction (Wildlife & Environment)
2) To preserve the breeding stock (Adult male & female)
3) To prevent deforestation.
4) To maintain the balance of nature.
5) To study the ecological relations of the plants & animals in natural habitat.

II) Necessity of conservation.

It is necessary to conserve the wildlife beacuse to keep

1) Balance of Order Nature

Due to conservation of plants & animals & their respective habitats is maintaining a balance of nature. This balance sometimes disturbs.

e.g. when all the herbivorous animals in the forest are killed then tiger & lions enter into the human dwellings & attack human & domesticated species or

Due to the killing of snakes for their snake allows the rat population to increase enormously.

2) To keep Genetic Resource

The wild flora & fauna are rich resource of genes, which can be used in breeding new forms of plants & animals, with desirable characters like Disease resistance, high productivity, higher ecological aptitude etc.

3) For economic Value

Wildlife is a wealth of the country. It is a good source of income. The wildlife gives timber, firewood, bidis, ivory, horns, fur & live & dead animals can be kept in zoos & museums, for exhibition.

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III] Management & Conservation of Wildlife.

It involves following major steps

1) The restoration of the habitat.
2) Enforcement of the law to stop poaching activity completely.
3) Prevention of competition from domestic livestock - regarding the grazing activity also prevention of transmission of diseases i.e zoonosis
4)

Methods of Conservation & Management (no. of organisations)

1) Knowledge of wildlife is essential to know the ecology of wild animals.
2) Appointment of officials. The officials should have inborn love for wildlife (training)
3) Protective laws - By govt. level:
India was the first country who made the Wildlife Protection Act.
The no. of act are as follows:
1) The Wild Birds & animals Protection Act of 1887.
2) Forest Act 16 XVI 1927 for the protection of Games
3) Indian Board for wildlife 1952.
4) The Wildlife protection Act of 1972.

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In this act, the hunting of female is inhibited. Chief Wildlife Warden & officers are appointed to watch

1) The possession, trapping & shooting of animals alive or dead.
2) Prevention on beef eating, transportation & export.
3) Restriction of hunting
4) Poaching
5) Habitat Improvement - & construction of water hole & salt licks
6) Restoration of the habitats - poll^{n} free zone

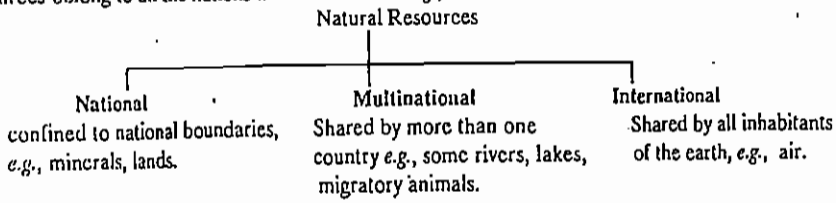
Clonal Bank: cells of rare species of plants are collected, preserved & stored. Lastly if the rare plants become extinct then it will can be cultured & grown into plants. This concept is called clonal bank.

Provision for shelter & covers:
Due to deforestation & exploitation of natural resources there are no shelters & covers for wild animals. So, to provide them shelter & cover leasing herbs & shrubs is done.

Artificial stocking:
In this case certain species can be introduced into a new area by importing them for another area

zoology- Solunke sir

3. Distribution. On the basis of their distribution, natural resources are of three types : national, multinational and international. (*i*) National Resources. The resources are property of a nation as they occur within its boundary, *e.g.*, minerals, land. (*ii*) Multinational Resources. They are shared by two or more adjacent countries, *e.g.*, some lakes, rivers, migratory animals. (*iii*) International Resources. The resources belong to all the nations and their citizens *e.g.*, air.



For Competitive Exams

- Life Time of Resource. Period of time upto which availability for human use is estimated.
- Depletion Time of Resource. Period of time when the resource will deplete to such an extent as to become incapable of meeting human requirements.

ENERGY RESOURCES

Per capita daily consumption of energy was only 2000—4000 kcal in case of hunter and food gatherer human beings. Food was the only source of energy. Work was carried out by muscle power. As the fire was discovered, wood and litter became an energy resource for warmth and cooking. In agricultural society, animal power was added to carry out various processes of agriculture and for transport. In nineteenth century human society turned out into industrial society. Fossil fuels were discovered to provide energy for running machines and subsequently transport, etc. In industrial society per capita consumption of energy was 70,000 kcal per day. Developed countries have only 30% of world population. They consume 80% of the global energy. In developing countries the per capita consumption of energy is hardly 10,000 kcal per day. In India, the value is 20,000 kcal per day. Even in India 80% of all energy is consumed by 20% of the population.

There are two types of energy resources, conventional and non-conventional.

Conventional Energy Resources

They are energy resources commonly in use, *e.g.*, animal power, wood, fossil fuels, hydroelectric, etc.

1. Animal Energy. It is a renewable conventional source of energy which is obtained from draught animals like bullock, horse, buffalo and camel. Animal energy is used both in agriculture and transport by developing countries of Africa and Asia. In India, the population of the draught animals is 84 million. They provide energy equal to 30% of total electricity generation. Limitations : (*i*) Animals consume more energy than they provide. (*ii*) They have low efficiency. (*iii*) Their speed is slow. (*iv*) There is increase in dirt and filth.

2. Fuel or Fire Wood. It is renewable conventional energy resource that is obtained by burning of wood. The energy source is used in cooking and heating. It is an important resource in poor countries and remote villages. Poor persons all over the world collect dried twigs and litter for using as fuel wood. About two billion persons consume about 1·8 billion cubic metres of wood annually. In India wood consumption is 300 million cubic metres but the availability from forests is hardly 58 million cubic metres. Limitations : (*i*) It can not be used for running transport vehicles and machines. (*ii*) Excessive consumption of wood is resulting in deforestation and desertification. The availability can be augmented through social forestry and agroforestry.

3. Dung. The energy resources is renewable and is used at many places in villages, small towns and way side 'dhabas'. Poor persons collect dung from passing cattle, dry it and use it. Dung cakes are also sold. Dried dung cakes are used for cooking, heating, drying of earthen wares by potters, etc. Limitations : (*i*) Dung gives low heat. (*ii*) It burns quickly. (*iii*) Burning of dung causes pollution. (*iv*) The resource should be used for manure formation and biogas generation.

4. Fossil Fuels. They are non-renewable conventional energy resources. They are of three types—coal, petroleum and natural gas. Fossil fuels yield a number of chemicals like fertilisers, pesticides and dyes. They provide for 70% of all energy consumption and 87·4% of all commercial energy. In India coal meets 58% of the requirement of commercial energy while petroleum and natural gas for 38% of the commercial energy. LPG is liquefied petroleum gas. India has abundant coal. However, its use is more polluting. Availability of natural gas is limited and is not being fully exploited. 24% of it goes waste in India. Indigenous availability of petroleum is only 50% of the requirement. The remaining 50% is imported. Demand for fossil fuels is rising everywhere. It is 6% for the whole world and 15% for India. Limitations. Use of fossil fuel is a major cause of air pollution. Delhi is the most polluted city of India due to it. (*ii*) Water and soil pollutions occur in the areas of coal washeries and oil refineries. (*iii*) The resource is exhaustible. Petroleum is on the verge of depletion. (*iv*) Many countries including India have to spend large amount of foreign exchange on import of petroleum and other fossil fuels.

5. Hydroelectric Energy. It is a conventional but nearly inexhaustible source of energy which is obtained by allowing the water to fall over turbines with a force. Therefore, water has to be stored at a height in dams. Microhydroelectric projects use minor falls but the energy availability is low. The force of flowing water can also be harnessed with the help of minihydel sets. India obtains 6·8% of electricity requirements from hydroelectric projects. Limitations. (*i*) Impounding of water in dams submerges a lot of land; (*ii*) It destroyes forests and wild life. (*iii*) Salt content of water increases. (*iv*) The incidence of water borne diseases rises. (*v*) Fish cycle is disturbed. (*vi*) Possibility of earthquakes increases. (*vii*) Silt collects at the bottom of dams and reduces the amount of water and generation of electricity.

6. Thermal Power Plants. They provide conventional, non-renewable source of energy. Thermal power plants use coal, gas and gasoline. They generate 17% of commercial energy in India. Limitations. (*i*) Thermal power plants produce a lot of soot and fly-ash. (*ii*) Many toxic chemicals are liberated during combustion. (*iii*) Combustion produces a lot of CO_2, CO, SO_2 and nitrogen oxides. They cause air pollution. (*iv*) The coolant water used in thermal plants causes thermal pollution.

Non Conventional Energy Resources

They are either new or those resources which have not been in common use, *e.g.*, wind energy, solar energy, biogas energy, nuclear energy.

7. Nuclear Energy. It is a non-conventional non-renewable energy source which uses fission (fusion also possible) of radioactive materials like Uranium-235. The energy released by fission is passed on to a coolant. The coolant is heavy water in heavy water reactors, ordinary water in light water reactors and liquid sodium in fast breeder reactors. The heat of the coolant is used for generation of electricity.

For Competitive Exams

- First Nuclear Reactor. It was built in U.S.A. and started functioning on 2·20 pm on 2.12.1942.

France has exploited nuclear energy to the maximum, constituting 73% of its total commercial energy. In India it produces only 1% of the total commercial energy. Some nuclear reactors of India are at Kota, Tarapur, Narora and Kalpakkan. Limitations. (*i*) The chances of core melting and hence bursting of nuclear reactor are always there. This has happened with Chernobyl reactor in Ukraine (1986). (*ii*) There is a small amount of leakage of radioactivity into coolant. (*iii*) The coolant causes thermal pollution. (*iv*) Disposal of nuclear waste is a big problem as it remains radioactive for thousands of years. (*v*) There is a limited availability of fissionable radioactive materials. (*vi*) decommissioning of old reactors may cause a big leakage of radioactivity.

8. Solar Energy. It is an inexhaustible pollution free non-conventional source of energy. Solar

energy can be harvested by three methods – (*i*) Direct heating, *e.g.*, solar cookers, solar driers, solar heaters, solar desalination plants. (*ii*) Thermoelectric conversion by heating salt water or producing steam to generate electricity. (*iii*) Photovoltaic conversions by using tiny cells of silicon, gallium arsinide or cadmium telluride. A photovoltaic cell produces only 0·5 volt of energy. Therefore, a large number of them are prepared in ribbons or films to obtain the required energy. They are used in calculators, lanterns, T.V. sets, satellites, water pumps and other machines. Limitations. (*i*) The energy content of photovoltaic cell is very low (*ii*) It is not available on cloudy days. (*iii*) The cost of instruments trapping solar energy is vey high.

9. Wind Energy. It is an inexhaustible and non-conventional source of energy which had been in use in old times for grinding mills, lifting water and moving boats. Wind power is used to rotate wheels which generate energy with the help of turbine or generator. The instrument used for producing wind energy is called wind mill. A number of wind mills can be installed wherever wind speed of 25 km/hr or more is available, *e.g.*, mountains, coast, some valleys and plains. Lamba in Gujarat has the largest wind mill complex. Netherland is known as land of wind mills because of their extensive use. Limitations (*i*) wind speed of 25 km/hr is not available everywhere. (*ii*) Even in windy areas the air may remain calm for days together.

10. Tidal Energy. It is an inexhaustible non-conventional source of energy. The tidal water is allowed to move into narrow areas where dual flow turbines are installed to generate energy. Tidal energy is being harnessed in certain coastal regions of India, *e.g.*, Gulf of Kutch.

11. Geothermal Energy. It is a non-conventional source of energy. Heat from hot rocks or hot water is converted into electrical energy. One such plant has been installed at Manikaran in H.P.

12. Biogas. Wet dung mixed with other organic wastes and water weeds is dumped in pits having overlying gas storage tanks. Organic matter is decomposed and fermented partially with the help of decomposers, fermentative microbes and methane bacteria to produce biogas. Biogas is 50–70% methane, 30–40% CO_2 with traces of hydrogen and hydrogen sulphide. It is used in cooking, heating, lighting and generation of electricity. The remaining organic matter is changed into manure. Biogas plants are cleaner, producing both biogas and manure. They eliminate the spread of pests and pathogens. Already 1·5 million biogas plants are in operation in India.

13. Hydrogen Energy. It is non-conventional future source of commercial energy. Use of this energy is pollution free. The only drawback is that hydrogen is highly combustible.

Energy Crisis

The world is in the grip of energy shortage and impeding energy crisis due to the following reasons: (*i*) The demand for energy is increasing rapidly due to rising standards even in developing countries and further technological advancements in deveoped countries. (*ii*) Increasing requirement of energy for expanding industrialisation and transport, housing and agriculture. (*iii*) Increasing population. (*iv*) use of fossil fuels for mechanisation of farm operations. (*iv*) Reduced availability of fire wood in comparison to demand. (*v*) Rapid depletion of fossil fuels. Petroleum reserves are going to be exhausted by the year 2040. Already international prices of fossil fuels have doubled in the last decade.

Conservation of Energy

This can be done through the following steps. (*i*) Continuous improvement in fuel efficiency of automobiles. (*ii*) Developing solar powered machines and vehicles. (*iii*) Promoting use of alternate sources of energy: (*iv*) Increase in generation of hydroelectric energy. (v) Searching for newer areas having fossil fuels. (*vi*) Developing technology to extract fuel from poor and depleting resources. (*vii*) Protecting coal mines and oil installations from accidental fires. (*viii*) Reducing wastage during purification. (*ix*) Avoiding use of dung cakes and promoting biogas generation. (*x*) Switching off lights and appliances not required. (*xi*) Developing fuel efficient and smokeless wood stoves (*chulhahs*). (*xii*) Extensive development of social forestry and agroforestry to reduce demand of wood from forests.

ATMOSPHERE

Atmosphere is transparent gaseous envelope around the earth. It is a mixture of many gases and particles. Near the earth the composition of atmosphere is as follows.

1. Nitrogen – 78·08%
2. Oxygen – 20·94%
3. Carbon Dioxide – 0·03%
4. Hydrogen – 0·00005%
5. Ozone – 0·0006%
6. Nitrogen oxides, SO_2, CO , NH_3 – traces
7. Argon – 0·93%
8. Neon – 0·0018%
9. Helium – 0·0005%
10. Krypton – traces
11. Xenon – traces

Atmosphere shows variations in density, temperature, composition and other properties with change in altitude. There is a vertical profile with several concentric layers forming strata – troposphere, stratosphere, mesosphere, thermosphere and exosphere.

1. Troposphere. It is the lowermost stratum of atmosphere which is in contact with the surface of earth. It extends to a height of 8 km over poles and 18 km over equator. 80% of the atmospheric mass occurs in troposphere. 50% of the atmospheric mass extends to the height of 5·5 km. Dust particles, spores pollen, water vapours, cloud formation, movement of air masses and other weather phenomenon are manifested in troposphere. Temperature decreases with height from 15°C near equator to -55°–-60°C at the upper end. Cooling with height is due to thinning of the atmosphere. It is known as adiabatic cooling. Troposphere is the source of metabolic gases and medium of flight for animals. Upper part of the troposphere and lower part of the stratosphere form a transitional region called tropopause.

2. Stratosphere. It extends for a distance of 35–40 km above troposphere. The concentration of gases is only 5–10% of troposphere. Dust particles, spores, pollen, clouds, etc. are absent. Stratosphere contains ozone which is formed *in situ* from oxygen through high intensity solar radiations ($3O_2 \longrightarrow 2O_3$). Maximum concentration of ozone is at about the height of 23–25 km from earth. However, it is not more than 0·3–1·0 ppm. The total ozone if compressed will not form more than 3 mm thick stratum. Part of the stratosphere which is rich in ozone is called ozonosphere. Ozone has a warming effect. It results in rise of temperature of stratosphere from about –60°C to about 0°C. Ozonosphere is highly protective as it filters out harmful short wave ultra-violet radiations (100–300 nm). However, high speed jets flying in stratosphere are causing depletion of ozone due to release of chlorofluorocarbons (now banned) and nitrogen oxides. Already a variable big hole has appeared over Antarctica and a smaller one over the Arctic region. Upper part of the stratosphere forms a transitional zone with the lower part of mesosphere. It is called stratopause.

3. Mesosphere. It is about 40 km in thickness. Mesosphere lies between stratosphere and thermosphere. Its temperature decreases with height from about 0°C in stratopause to –92°C in the upper part of mesosphere. Upper part of mesosphere forms transition zone with thermosphere called mesopause.

Atmosphere upto mesopause, roughly about 100 km. in height, has a system of circulation which keeps it well mixed and somewhat homogeneous. It is called homosphere. Of course, thinning with height does occur throughout. The part of atmosphere above homosphere is called heterosphere. It does not show homogeneity. Lower atmosphere is atmosphere upto stratopause. The one above it is called upper atmosphere.

4. Thermosphere. The stratum has a thickness of 400 km. It lies above the mesosphere from about 100 km–500 km altitude. Atmosphere is rarefied. Ultraviolet and other high energy radiations knock out electrons from gas molecules producing electrons and ions. Part of the thermosphere having ions and electrons is called ionosphere. It is multilayered. Ionosphere filters out X-rays, gamma rays and cosmic rays. Different regions of ionosphere reflect radiowaves of different wavelengths. Ionosphere is, therefore, highly important for telecommunications. In thermosphere there is rise of temperature with height. Day time temperature may touch 1200°–1500°C.

Automobile Pollution

Pollution from automobile emissions can be reduced by the following methods.

1. Non-Leaded Gasoline. Leaded petrol should be replaced by non-leaded petrol. It will reduce lead pollution and spare the metal from over-consumption.

2. Low Sulphur Diesel. Diesel often has high sulphur content. The same should be reduced to nearly zero percent through desulphurification processes.

3. Two Wheelers. They are often fitted with two stroke engines which are less efficient and emit 20–30% of unburnt hydrocarbons. The same should be replaced with four stroke engines where the emission of unburnt hydrocarbon is 10–15%.

4. Tune-Ups. All automobiles should be fitted with tune ups that increase air-fuel ratio and help in better combustion. Multiple point fuel injection system further helps in increasing efficiency of combustion.

5. Catalytic Convertors. They are devices which oxidise CO ($CO \rightarrow CO_2$) and reduce nitrogen oxides ($NO \rightarrow N_2$)

Agricultural Burning

It should be stopped as it not only reduces an important resource but also pollutes the air. Begasse and other crop wastes can be used to prepare industrial paper and cardboard. Paddy husk is a raw material for poultry feed. If it is to be used for generation of energy, the same should be changed to briquettes. Remaining farm refuse should be used in producing manure or biogas and manure.

Acid Rain

Normal rain has a *p*H of 5·6–6·0. Acid rain is rainfall with a *p*H of less than 5, generally 3–4·5. The minimum *p*H recorded for acid rain is 1·5 over West Virginia, USA. The term acid rain was coined by Robert Augus (1872). It is due to excessive release of SO_2 and nitrogen oxides into the atmosphere during combustion of fossil fuels and coal processing. In air nitrogen oxides are oxidised to N_2O_5 while SO_2 is changed to SO_3. The gases dissolve in water producing nitric acid and sulphuric acid. 65% of acid rain is due to sulphur dioxide emission, 30% due to nitrogen oxides and 5% by release of hydrogen chloride from chemical industries. The various effects of acid rain are as follows.

1. Destruction of Vegetation. Acid rain has killed more than 50% of forests in Switzerland, Germany, Romania, Czechoslovakia, Poland and N.E. U.S.A. The destruction is due to three reasons. (*i*) Direct Effect. Acid rain causes chlorosis, necrosis, defoliation and dieback. (*ii*) Leaching. Acidic rain water dissolves away a number of essential minerals of the soil. The dissolved minerals leach down along with percolating rain water. This makes the soil deficient in minerals. (*iii*) Dissolution of Toxic Minerals. Change in *p*H caused by acid rain dissolves normally insoluble toxic minerals like aluminium, nickel, lead, etc. The minerals kill the plants.

2. Killing of Lakes. Acid rain has killed lakes in several places—20% in USA, 25% in Sweden, 80% in Norway. Killing of lakes means destruction of plant and animal life of lakes. It occurs due to change in *p*H. The acidic *p*H dissolves heavy metals present over the lake bed like aluminium, manganese, lead, zinc, mercury, etc. The dissolved minerals kill both plants and animals of the aquatic habitat. Dissolved aluminium is known to clog gills of fish. Birds dependent on aquatic animals are also killed. Such lakes come to have only some algae and fungi.

3. Spoilage of Human Assets. Marble structures, limestone structures, metallic articles, jewellery, textiles and paintings are spoiled by acid rain. This happens due to corroding effect of acids on metals through formation of sulphates, nitrates and chlorides. Paintings are decolourised. Jewellery is similarly affected. Marble and limestone are made of $CaCO_3$. It is insoluble in water. Acid rain changes $CaCO_3$ into $CaSO_4$ and $CaNO_3$. The chemicals are soluble and are washed away or peeled off. This results in pitting and corrosion of these structures.

WATER POLLUTION

Water pollution is degradation of quality of water due to addition of substances (*e.g.*, silt), chemicals (*e.g.*, metals, inorganic and organic chemicals) or factors (*e.g.*, heat) and deprivation that makes it a health hazard, unfit for human use, use by animals and industries as well as growth of aquatic biota. Water pollution is both natural and anthropogenic. (*a*) Natural Water Pollution. It is water pollution caused by natural processes of soil erosion and addition of clay or silt, run off and leaching. (*b*) Anthropogenic or Man-Made Pollutinn. It is water pollution caused by human activities like industrial effluents, domestic sewage, waste from animal sheds and slaughter houses, detergents, pesticides and fertilisers, oil spills, etc.

1. Community Waste Waters. They are waste waters carried by sewerage system. The latter drains sewage from homes, animals sheds, slaughter houses, canning industries, tanneries, food residues, detergents, discharges from industrial and commercial establishments. The water contains a number a pathogens, their spores, cysts or eggs, coliforms and enterococci. The sewage is mostly organic and gets decomposed by microbial activity. The property of decomposibility is known as putrescibility. It requires oxygen. The amount of oxygen required for microbial breakdown of organic matter indicates degree of water pollution. BOD or biochemical oxygen demand is the amount of oxygen in milligrams required in 5 days for complete degradation of organic matter in one litre of water at 20°C. Requirement of less than 1500 mg/lt indicates low pollution, 1500–4000 mg/lt medium pollution and above 4000 mg/lt indicates high organic pollution.

Decomposer organisms involved in breakdown of organic matter are collectively called sewage fungus. It consists of bacteria (*e.g.*, *Escherichia coli*, *Beggiatoa*), cyanobacteria (*e.g.*, *Oscillatoria*, *Microcystis*), fungi (*e.g.*, *Mucor*, *Fusarium*) and green algae (*e.g.*, diatoms, *Chlamydomonas*, *Chlorella*, *Scenedesmus*). Sewage contaminated water also has blood worms and sludge worms at the bottom. A number of bacteria eating pollution tolerant protozoan protists (*e.g.*, *Colpidium*, *Paramecium*) and some protozoan eating animals occur in such waters. Some plants can also tolerate a good degree of sewage pollution, *e.g.*, moss *Fontinalis antipyretica* and angiosperm *Potamogeton pectinatus*.

Sewage contamination makes water brownish and oily. It has a bad taste and foul smell. The water contains scum and sludge, metallic sulphides, organic sulphides, ammonia, hydrogen sulphide, methane, etc. At times algae blooms occur due to increased availability of nitrate and phospbate. It reduces oxygen content.

2. Industrial Wastes. Their nature and concentration depend upon the type of industry and the treatment of waste water (Table 21·2). (*i*) Liquid Effluents. If passed directly into water, they will kill aquatic life due to toxic chemicals, acids and alkalies. (*ii*) Mercury. It is released by paper and paint industries, combustion of coal and smelters. In water, it is changed to soluble dimethyl state, $Hg(CH_3)_2$. The latter enters food chains and gets concentrated with the rise in trophic level. It poisons aquatic animals. Regular intake of meat from such poisoned animals causes minamata disease (minimata disease), first reported in Japan in 1952. The disorder is characterised by impairment of various senses (tactile, vision, speech and hearing), numbness of lips and limbs, repeated diarrhoea, haemolysis and meningitis. It ultimately leads to death. (*iii*) Cadmium. The metal is released by welding, electroplating, pesticide and metallurgical industries. In human beings it accumulates in liver, kidneys and thyroid. The pollutant causes nausea, vomiting, diarrhoea, cramps, hypertension, testicular atrophy, skeletal deformities due to softening of bones and multiple fractures. The disease is called itai-itai (ouch-ouch, I cannot-I cannot). (*iv*) Lead. The contaminant is released by battery, pesticide, paint and chemical industries. The disorder produced by use of lead polluted water is called as plumbism. It is characterised by colic, bluish lines around gums, anaemia, loss of appetite, convulsions, irreparable demage to kidneys, liver and brain.

Table 21.2. Some Industries and Their Pollutants

S.No.	Type of Industry	Inorganic pollutants	Organic pollutant
1.	Mining	Mine Wastes: Chlorides, various metals, ferrous sulph-ate, sulphuric acid, hydrogen sulphide, ferric hydroxide, surface wash offs, suspe-nded solids, chlorides and heavy metals.	–
2.	Iron and Steel	Suspended solids, iron cyanide, thiocy-anate, sulphides, oxides of copper, chrom-ium, cadmium, and mercury.	Oil, phenol and naptha.
3.	Chemical Plants	Various acids and alkalies, chlorides, sulphates, nitrates of metals, phosphorus, fluorine, silica and suspended particles.	Aromatic compounds, solvents, organic acids, nitro compound dyes, etc.
4.	Pharmaceutical	–	Proteins, carbohydrates, organic solvent intermediate products, drugs and antibio-tics.
5.	Soap and Detergent	Tertiary ammonium compounds, alkalies.	Fats and fatty acids, glycerol, polyphos-phates, sulphonated hydrocarbons.
6.	Food processing	–	Highly putrescible organic matter and pathogens.
7.	Paper and Pulp	Sulphides, bleaching liquors.	Cellulose fibres, bark, wood sugars, org-anic acids.

3. Run off from Agricultural Fields. It is of three types – animal wastes, fertilisers and pesticides. (*i*) Animal Wastes. Animal excreta from cattle sheds, piggeries and poultry farms, is often dumped in pits. The same is washed down during rains into water bodies. Decomposer activity is increased. Eutrophication is common. (*ii*) Fertilisers. Part of fertilisers added to crop fields are passed down into water bodies. They enrich them and bring about eutrophication. (*iii*) Pesticides. Pesticides include insecticides, fungicides, nematicides, rodenticides, herbicides, algicides and soil fumigants. They are chemically chlorinated hydrocarbons, organophosphates, metallic salts, carbamates, thiocarbamates and acetic acid derivatives. Many of them are nondegradable, specially chlorinated hydrocarbons (organochlorine compounds). They enter food chains, accumulate in adipose tissues and show biomagnification with rise in trophic level.

Biomugnification (Bioconcentration). Biomagnification or biological magnification is increase in concentration of persistent pollutant or other substance per unit weight of the organism with the rise in trophic level. It is caused by non-utilisation of the substance in metabolism, accumulation in fat and non-breakdown by decomposers. In one study concentration of DDT in water was found to be 0·05 ppb (parts per billion), 10 ppb in phytoplankton (concentration of 200 times), 40 ppb in zooplankton (4 times concentration), 420 ppb in clams, 1240 ppb in minow and 7550 ppb in sea gull. There is a total biomagnification of 151,000 times. Due to the phenomenon of biomagnification, the entry of non-biodegradable metals, toxins, pesticides and chemicals in food chains is highly dangerous. Extensive use of DDT after World War-II resulted in several disorders in higher trophic levels like thinning of egg shells, liver cirrhosis, softening of brain, hypertension, cerebral haemorrhage, defective sex hormones, etc. Population of many predator birds declined, *e.g.*, Bald Eagle. Ultimately use of DDT was stopped. However, several other persistent pesticides continue to be in use.

4. Thermal Pollution. Hot water is produced by thermal power plants, nuclear reactors and many industries. It is poured into water bodies resulting in increase in temperature. Higher temperature reduces oxygen content of water, *e.g.*, 14 ppm at 0°C and 6·5 ppm at 14°C. There is increased BOD. Aerobic decomposition of organic matter is stopped while anaerobic decomposition takes over. As a result there is increased organic loading which gives rise to offensive odours, scum and sludge. Many fish are killed. Trouts eggs do not hatch while Salmon does not spawn at temperature of 30°C and above. Green algae are replaced by cyanobacteria.

For Competitive Exams

- ElNino. It is a hot water current that appears after every 5 to 8 years in the east Pacific Coast off Peru and Ecuador. It kills fish and other biota over thousands of kilometres. ElNino is somehow connected with monsoon in India.

5. Ground Water. Though a lot of filtration occurs before water reaches the underground water table, ground water does become polluted due to following reasons: (*i*) Underground sewage disposal pits. (*ii*) Septic tanks. (*iii*) Refuse dumps. (*iv*) Industrial effluent dumps. (*v*) Leaching of pesticides and fertilisers. In many industrial belts, underground water has been found to contain nickel, chromium, dyes, fluorides etc. even upto a depth of 30 m. Presence of excess nitrate and phosphate is quite common in underground water of crop-lands. Similarly, seepage of sewage is found in the areas of sewage dumps outside towns and cities.

6. Oil Pollution. Spills from oil wells and refineries and washing of tankers during loading and unloading cause a lot of pollution. Oil spills spread over the surface of water killing plankton and smearing others which happen to come on the surface. There is reduced oxygenation of underlying water. As a result many animals are killed due to asphyxiation. The oil spills are always in danger of catching fire.

7. Marine Pollution. A lot of pollutants are poured into sea from coastal areas. They include sewage, detergents, garbage and industrial wastes. Toxic wastes, radioactive wastes and navigational discharges are other sources of marine pollution. Sea has very little dispersal and decomposing capacity. Therefore, a lot of pollution remains localised in coastal areas. The state of pollution is so bad in Mumbai that no beach is worth taking a bath.

8. Non-Availability of Potable Drinking Water. Several areas in India as well as other countries do not have potable drinking water. The deficiency of water further results in non-hygenic habits and poor waste disposal. At places human beings and animals share the same source of water. In India water pollution causes 60% of all diseases and 40% of all deaths.

Effects of Water Pollution

1. Chemical Pollutants. (*i*) Many chemicals present in industrial effluents are poisonous causing various types of deformities, *e.g.*, mercury (minamata disease), lead (plumbism), cadmium (itai-itai), nickel, cobalt, zinc, arsenic, chromium, etc. (*ii*) Some chemicals like acids contained in industrial effluents are corrosive. They damage water treatment plants. (*iii*) Persistent pesticides enter food chains, undergo biomagnification and harm the aquatic life as well as land animals dependent on it. (*iv*) Organic sulphur inhibits nitrification. (*v*) Nitrate and phosphate cause eutrophication.

2. Turbidity. Water becomes muddy or turbid due to suspension of mineral dust, silt and related colloidal particles. Turbidity hinders penetration of light. It causes clogging of gills in fishes. Therefore, both plant and animal life is destroyed. Turbid water is also not suitable for drinking or industrial use.

3. Colour. Dyes, iron and chromium compounds, and anaerobic decomposition cause colouration of water. The coloured water is not suitable for recreational, drinking and industrial uses.

4. Odour. Free chlorine, ammonia, hydrogen sulphide, phenols, growth of algae and microorganisms produce unpleasant odour.

5. Taste. It is impaired due to occurrence of pollutants like free chlorine, phenol, iron, manganese, detergents, hydrocarbons, oils and decomposition products.

6. Scum and Sludge. They are produced by organic wastes especially H_2S produced by them. The sulphide combines with metallic ions and forms brownish or blackish substances that float over and inside water.

7. Foam. It develops over the surface of water due to mixing of detergents, soaps and alkalies. Foam makes the water unfit for various human uses.

8. Oil Pollution. It comes from spills of oil refineries, oil wells and washing of oil tankers. Oil spreads over water, kills plankton, neuston, necton, water birds and other organisms. Oil may also catch fire.

9. **Thermal Pollution.** Hot effluents and hot waste water increase temperature of water body. It reduces oxygen content, killing plant and animal life. Aerobic decomposition is replaced by anaerobic decomposition. It produces several secondary pollutants with offensive odour, bad taste and colouration.

10. **Eutrophication.** Organic pollutants provide nutrients for stimulating growth of algae and other plants. They may grow in blooms. Bloom formation reduces light to the submerged plants which get killed. Along with dead matter of bloom forming algae, the dead submerged plants consume most of the oxygen in decomposition. Reduced oxygenation kills animals. It increases organic loading and, therefore, makes the water unfit for various uses.

Control of Water Pollution

Two major sources of water pollution are sewage and industrial effluents. They should be treated before allowing them to be discharged in water bodies.

Treatment of Sewage

Three steps are required for sewage treatment—primary, secondary and tertiary.

1. **Primary Treatment (Physical Treatment).** The treatment involves removal of grit and larger pieces of organic matter. The various steps are (*i*) Shredding. With the help of cutting machines, larger pieces are cut into smaller ones. (*ii*) Churning. The sewage is churned by means of machines so as to mix all the constituents thoroughly. (*iii*) Settling. The shredded and churned sewage is passed into a tank having a gentle slope. Grit, sand and other heavier particles settle down. (*iv*) Screening. The sewage is now passed through stationary or moving screens or skimmers that remove all larger pieces of organic matter. It is collected as sludge. Sludge is used for preparing compost and manure. It can also be burnt. The water after removing the sludge contains fine organic matter. It is passed for secondary treatment.

2. **Secondary (Biological) Treatment.** In this step the organic matter is decomposed with the help of microbes. After decomposition the treated water is sterlised through chlorination.

(*i*) **Decomposition of Organic Matter.** It is carried out by one of the following three methods. (*a*) **Water Hyacinth Pond.** The method is primitive. It liberates a lot of stench. Water having fine organic matter is allowed to stay in ponds having good growth of Water Hyacinth or *Eichhornia*. Organic matter is decomposed by microbes. The minerals released by decomposers are picked up by Water Hyacinth for its own growth. (*b*) **Trickling Filter Method.** Waste water is allowed to trickle over a thick bed (2m or more) of gravel having sewage fungus. The organic matter is completely decomposed. The growth of sewage fungus is monitored. It is thinned out at intervals. (*c*) **Activated Sludge Method.** Waste water is passed through a series of four tanks where anaerobic and aerobic decomposition are carried out. The treated water is allowed to flow out slowly for the next step.

(*ii*) **Chlorination.** After having undergone decomposition, the waste water is quite clear. It is passed out into chambers where chlorination is undertaken. Chlorination kills microbes of sewage fungus as well as some pathogens, spores or cysts which have escaped early treatments. Chlorinated waste water is, however, rich in minerals like nitrate, ammonia and phosphates. It should not be passed into water body where it will cause eutrophication. The treated waste water is most suitable for irrigation where extra minerals will help to increase crop growth while the extra water filters down for recharging the ground water.

3. **Tertiary Treatment.** It is costly and is very rarely undertaken, that also where the water has to be recycled. The various steps are as follows :

(*i*) **Precipitation.** The impurities present in treated waste water are precipitated with the help of (*a*) Alum, ferric chloride and lime. (*b*) Caustic soda, ferrous sulphate and lime. (*c*) Zirconium. The precipitate is allowed to settle.

(*ii*) **Filtration.** The clear water is allowed to pass through filters for removing any precipitate left in the water.

(*iii*) **Aeration.** Air is passed through the water to oxidise any of the remaining impurity and make the water fit for any use. In order to ensure purity of water for industrial use mineral impurities are removed in treated waste water with the help of reverse osmosis or ion exchange resins.

Treatment of Industrial Effluents

1. **Neutralisation.** The effluents are first of all tested for *p*H and then neutralised with the hel opposing chemical like acid or alkali.

2. **Precipitation.** The chemicals contained in effluents are precipitated either electrostatically with the help of known chemical reactions.

3. **Adsorption.** It is carried out for removing coloured impurities and highly toxic chemicals.

4. **Photocatalysis.** It is a recent technique of splitting of chemicals so as to convert toxic mater into harmless ones.

5. **Ion Exchange and Reverse Osmosis.** They are carried out for removing the remaining ions af precipitation and photocatalysis.

SOIL POLLUTION AND LAND DEGRADATION

Soil pollution is unfavourable alteration in physical, chemical and biological properties of soil d to addition or removal of substances and factors which reduce its productivity, quality of plar supported by it and ground water lying below it. It is of four types—negative pollution, positi pollution, third pollution and third poison.

1. **Negative Pollution.** Deterioration in the productivity of soil due to reduction in quality quantity of top soil is called negative soil pollution. It is caused by over-use and erosion.

2. **Positive Pollution.** It is reduction in soil productivity and deterioration in quality of plants du to addition of pollution from air, faulty sanitation, industrial effluents and supra-optimum fertilise and pesticides.

3. **Third Pollution.** It is landscape pollution in which the land is so severely misused that i becomes filthy and odorous because of dumping of garbage, rubbish, sludge, ash, industrial wastes, etc over it.

4. **Third Poison.** It is ground water pollution caused by seepage and leaching of sewage, toxi chemicals and extra minerals from surface.

Soil pollution is **direct** if the pollutants are passed over it directly *e.g.*, industrial effluents fertilisers. It is **indirect** if the pollutants reach soil from other resources like air and water, *e.g.*, acid rain

Soil Pollutants

They are chemicals and other substances which make the soil lose its productivity. The important soil pollutants are pesticides, fertilisers, industrial wastes and chemicals, mine dust, radionuclides, discarded materials and manures.

1. **Pesticides.** Pesticides are chemicals used in killing pathogens, pests and unwanted growth in agriculture, horticulture, forestry and water. Most pesticides are broad spectrum, killing most of the organisms. They are, therefore, called biocides. Many of them are also persistent. Some of them even adversely affect the useful organisms in later stages. The phenomena is called ecological boomerang or ecological backlash. For example, weedicides added in Aswan dam of Egypt for controlling aquatic weeds, damaged crops as well as fish production in sea (wherever dam water was discharged). (*i*) **Chlorinated Hydrocarbons (Organochlorines).** They are persistent insecticides which show biological magnification, *e.g.*, DDT, BHC, Aldrin, Endrin, Dieldrin, etc. Use of DDT has been banned. Use of other organochlorines has also been restricted. (*ii*) **Organo-pesticides.** They are of two main types, organophosphates and carbamates. The pesticides are not persistent but are poisonous. They adversely affect other biota and workers handling them. The common symptoms of organophosphate toxicity due to handling alone are nausea, diarrhoea and muscular tremors. (*iii*) **Inorganic Pesticides.** They are compounds of sulphur, copper and arsenic. The inorganic pesticides are persistent. Their use is restricted. (*iv*) **Weedicides or Herbicides.** They are selective metabolic inhibitors, *e.g.*, 2,4-D, 2,4,5-T.

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Biotic Resources and their conservation

Biotic resources are living resources which not only support one another in nature but are also exploited by human beings for building their own environment that provides human beings with food, fibres, shelter, medicines and a number of other articles. They are of two types, terrestrial and aquatic. The term wildlife is used for living beings present in natural habitats which are neither cultivated, domesticated nor tamed. The term was coined by William Hornaday (1913, Our Vanishing Wild Life).

Importance / Necessity of wild life conservation —

1. Ecological Balance. Living beings maintain an ecological balance through the following.

(*i*) Regulation of Populations. Populations of all types of organisms remain almost the same due to self regulation and feed back. The rates of natality and mortality are generally regulated by density of populations. Populations are connected with one another through food chains. If population of a lower trophic level grows, the population of its predator also increases which restores the population of the lower level through greater predation.

(*ii*) Food Chains. They are based on eating and being eaten. Living beings maintain the food chains. Food energy is built up at the producer level. It passes into higher and higher categories of consumers, dissipating inbetween. Ultimately food energy is utilised by decomposers.

(*iii*) Natural Cycles. Living beings bring about biogeochemical cycles. The inorganic nutrients are not allowed to remain in the abiotic environment in any large quantity. This prevents leaching and run-off.

(*iv*) Prevention of Soil Erosion. Soil fertility is maintained and soil erosion prevented by plant cover, litter deposition, detrivory and decomposition that produces humus. Rainfall is not allowed to directly pound the soil. It wets the vegetation and trickles down to the ground for complete absorption. Only a small quantity is able to flow over the surface of soil.

(*v*) Perennial Fresh Water. Most of the rain water is retained by the forests. Water retained in catchment areas slowly flows underground and comes out at places through springs and seepages. They form rivulets and rivers. The latter continue to flow throughout the year and provide fresh water over the land.

(*vi*) Maintenance of CO_2—Oxygen Balance. Vegetation is important in absorbing CO_2 and releasing oxygen for maintaining the balance of these two metabolic gases.

(*vii*) Maintenance of Climate. Vegetation regulates rainfall and moderates the climate of the area.

(*viii*) Pollution. Plant life has a cleansing effect, absorbing most of the air pollutants.

2. Economic Importance. Living organisms are being exploited commerciallly. A lot of potential for further exploitation exists.

(*i*) Plants. They manufacture food and build biomass not only for themselves but also for entire biosphere. Some of these plants has been domesticated by human beings for maintaining their own food bank. Even then a lot of food articles are obtained from wild plants, *e.g.*, Coconut, Almond, Walnut, Pinenut, etc. Besides a large number of other useful products are obtained from them, *e.g.*, timber, fuel wood, paper pulp, resin, essential oils, gums, tannins, spices, dyes, drugs, etc.

(*ii*) Animals. A number of animals have been domesticated for use in transport, meat, eggs and milk. Wild animals provide fur, leather, ivory, horns, musk, lac, feathers, pearls, shells, guano, etc.

(*iii*) Micro-organisms. A number of micro-organisms are exploited commercially by human beings

for preparation of yoghurt, Indian curd, cheese, alcoholic beverages, retting of fibres, curing, biogas generation, antibiotics, enzymes, etc.

3. Biotic Diversity. It is the occurrence of a large number of species in naturally occurring ecosystems. Each species has a number of ecotypes, biotypes and varieties with different types of gene combinations. Biodiversity provides ecological stability by increasing biological control, maintenance of balance of nature, and increasing use of resources without depleting the same. It also function as gene bank. There are several potential uses.

(*i*) Gene Bank. Domesticated plants and animals have a number of relatives in the wild. They can function as a gene bank for increasing productivity, disease and stress resistance. Newer and newer crop varieties are being produced for increasing yield and quality of other desirable traits. However, the average life of a new variety is 5—15 years. New varieties must be continuously produced due to (*a*) Evolution of new traits in pests and pathogens. (*b*) Change in climate. (*c*) Change in soil conditions. (*d*) Variation in consumer demand. (*e*) Requirement of improvement.

(*a*) Brown Plant Hopper (*Nilparvata lugens*) became a serious pest on all modern varieties of rice. Some old rice varieties of Kerala had resistance to the pest. The same was incorporated in modern varieties through breeding.

(*b*) Grassy Stunt Virus attacked rice crop over large tracts spreading in epidemic form. Resistance was obtained through selective breeding with Wild Rice (*Oryza nivara*) found in central India. The new resistant variety was named IR—36.

(*c*) Red rot used to attack Sugarcane (*Saccharum officinarum*). Resistance was obtained from Wild Thatch Grass (*Saccharum spontaneum*). It produced Co-varieties of Sugarcane.

(*d*) Resistance to several diseases was incorporated in potato (*Solanum tuberosum*) from its wild relatives, *e.g.*, *S. acaule* (Mosaic Virus X, leaf roll virus), *S. stoloniferum* (mosaic virus Y), *S. demissum* (late blight) and *S. spegazzini* (damping off, nematodes).

(*ii*) Potential Uses. We cannot be sure as to which species of wild life may tomorrow yield an important biochemical for human beings. Penicillin and later other antibiotics would not have been discovered had *Penicillium notatum* been extinct. Similarly, discovery of Quinine is linked to survival of *Cinchona* tree and silk to Silk Worm.

4. Experimental Organisms. A number of organisms are employed in performing experiments in genetics, physiology, biochemicals, vaccine research and developing new surgical techniques, *e.g.*, *Neurospora, Drosophila*, Guinea Pig, Monkey, Rat, Rabbit, etc.

5. Aesthetic Value. Listening to songs of birds, observing movement of butterflies or a rabbit in wild has a high aesthetic value.

6. Recreation. Visit to a zoo, botanical garden, sanctuary or a natural park provides recreation.

7. Sport. Hunting was been a good sport throughout our civilisation. The same is now highly restricted. Fish angling continues to be a sport and pastime.

8. Ethical Requirement. All present day plants, animals and microbes are a product of some 3·5 billion years of evolution. We have no right, being brothers in evolution, to annihilate anyone of them. A species once lost cannot be retrieved. Therefore, it is our primary duty to conserve wild life for our descendents.

Extinction of Wild Species

Evolution of new species and extinction of old species is a natural process. It is a slow process. However, human beings have started exploiting wild life rather callously. As a result a large number of plants and animals have become extinct during the past 10,000 years. Maximum extinction has occurred in the last 100 years. Today some 25,000 plant species, 1000 vertebrate species and 10% of the invertebrate species are threatened with extinction. The various reasons for this state are as follows.

1. Hunting. Hunting or killing of wild animals is of three types—subsistence hunting for food and safety, sport hunting for recreation and commercial hunting for obtaining a commodity like musk, ivory or fur. Initially human beings performed only subsistence hunting. With the discovery of fire, the same was used for hunting. In the process large forested areas became denuded. Primitive weapons were replaced by arrows and then fire-arms. Hunting has caused extinction of several animals. Dodo (*Raphus*

cucullatus) of Mauritius and Passenger Pigeon (*Ectopistes migratorius*) has disappeared due to hunting. Cheetah (*Acinonyx jubatus*) has become extinct from India due to sport hunting. Several wild animals have become endangered on account of hunting.

2. **Destruction of Habituts.** Use of fire for hunting by the primitive man destroyed a large number of habitats of wild life. Later habitat destruction was also carried out to provide space for human settlements, croplands, grazing grounds, plantations, mines, dams, harbours, etc. Environmental pollution and excessive felling of forest trees have added to this habitat destruction. This has resulted in (*i*) **Absence of Shelter.** It exposes animals to predators and vagaries of nature. Most of them are killed. (*i*) **Absence of Food.** Habitat destruction often leads to deficiency of food. Starvation kills the animals. (*iii*) **Area of Movement.** There is reduction in area of movement of animals. The reproductive cycles are, therefore, disturbed and their population declines.

3. **Dams and Reservoirs.** They are large impoundments of water which submerge natural habitats of several species of wild life bringing about extinction of some and decrease in population of others. Dams and reservoirs block the migratory route of some fishes and prevent their reproduction.

4. **Pollution.** Acid rain kills both terrestrial and aquatic life. Water pollution harms aquatic animals and plants. Air pollution similarly reduces growth of some plants. Lichens are killed.

5. **Highways.** They disturb wild life. Some of the animals are killed by passing vehicles.

6. **Cleanliness.** Carcases are being burnt or buried in order to reduce stench. This has caused decline in the population of California Condor (*Gymnogyps californianus*), the largest flying bird, because it is a scavenger.

7. **Migratory Routes.** Physical alterations are going on everywhere. Changes in route and settling areas of migratory animals may result in their going astray and getting killed.

8. **Ignorance.** Most persons are ignorant about the intricate relationships present in wild life and the importance of maintaining wild life. For them wild life is a resource which can be tapped as and when required.

9. **Over-Exploitation.** Excessive hunting, overgrazing, excessive felling and overfishing are resulting in depletion of a number of species of wild life. Many species of fish, molluscs, sea cow, sea turtle and whale are vanishing due to their indiscriminate catching by mechanised trawlers.

10. **Trade.** Some articles from wild life are highly priced and are always in demand, e.g., exotic meat, ivory, fur, musk, aphrodisiacs, pharmaceuticals. Rare animals and plants are traded for research and zoos. Therefore, wild life is poached and captured for trading despite ban on the same.

11. **Introduction of Exotic Species.** Exotic species disturb the web of relationships amongst the organisms of a place. They also show rapid rate of multiplication on account of the absence of their biological control. (*i*) Dodo of Mauritius disappeared when pig was introduced in that country. Dodo had the habit of laying eggs on ground. The same were eaten by pig resulting in killing of Dodo. (*ii*) Goat was introduced in Galapogos islands. It resulted in killing of tortoise because goat destroyed the vegetation of coastal areas. (*iii*) Rabbit was introduced in Australia in 1859. By 1930 its population had grown to 750 million resulting in its becoming a serious pest. (*iv*) Chestnut Blight (*Endothia crassipes*), introduced from China, caused a serious damage to chestnut plantation of U.S.A. (*v*) Water Hyacinth (*Eichhonia*) has became a water weed in India which has over-run several wetlands. (*vi*) *Eupatorium odoratum*, *Lantana camara* and *Parthenium hysterophonus* have occupied large tracts in India replacing natural vegetation.

Concept of Threatened Species

Threatened species (T) are those species which are likely to become extinct if immediate steps are not taken to ensure that they have proper food, proper habitat, protection from predators and exotic species so that they are able to realise their biotic potential. A record of threatened species of plants and animals is maintained by International Union for Conservation of Nature and Natural Resources (IUCN), Morges, Switzerland. It is called red data book. It has yellow pages for critically endangered species, e.g., the number of endangered mammals is 277 and birds 321. For conservation purposes the book has categorised endangered species. Four criteria have been used for this categorisation. (*i*) **Distribution.** Present, past, continuous or discontinuous distribution, area and degree of decline if

available. (*ii*) **Population.** Decline in population in course of time. (*iii*) **Natural Habitat.** Abundan and quality. (*iv*) **Importance.** Potential value and biology of the species. IUCN has identified fo categories of threatened species.

1. **Endangered Species (E).** They are those threatened species or taxa which are in danger extinction if the current causal factors continue to operate. The causal factors are (*i*) Drastic reducti in habitat. (*ii*) Decline in population to such as extent that multiplication is unable to compensate predation, disease and death. (*iii*) An adverse factor like predator, pollutant or pathogen that is causi more deaths than the number of new borns. Examples,

(*a*) Lion Tailed Macaque	—*Macaca silenus*
(*b*) Asiatic Wild Ass	—*Asinus hemionus khur*
(*c*) Wild Buffalo	— *Bubalus bubalus*
(*d*) Nilgiri Langur	— *Presbytis johni*
(*e*) Snow Leopard	— *Panthera uncia*
(*f*) Red Panda	— *Ailurus fulgens*
(*g*) Musk Deer	— *Moschus moschiferus*
(*h*) Great Indian Bustard	—*Ardeotis nigriceps*
(*i*) Common Indian Monitor	—*Varanus bengalensis*
(*j*) Indian Rock Python	— *Python molurus*

2. **Vulnerable Species (V).** Vulnerable species or taxa have sufficient population at present but th same in depleting fast (hence depleted species) so that they are likely to enter the category endangered species if the factors bringing about depletion are allowed to continue. Examples,

(*a*) Golden Langur	— *Presbytis geeri*
(*b*) Leopard Cat	— *Felix bengalensis*

3. **Rare Species (R).** The populations of species or taxa are small, either localised or thin scattered. The species are at great risk because the small population can any time come under attac from a new predator, pathogen or exotic organism, e.g.,

(*a*) Hawaiian Monk Seal	—*Monochus schauinslandii*
(*b*) Snow Loris	—*Nycticebus corcong*
(*c*) Indian Desert Cat	— *Felis sylvestris*
(*d*) Wild Yak	— *Bos mutus*

4. **Indeterminate Species (I).** The species or taxa are in danger of extinction but a specific caus cannot be assigned. As and when the cause is discovered, the species are shifted to other categories threatened species. For example, Snow Leopard was listed as indeterminate species in 1968 but wa shifted to the category of endangered species in 1970. Examples,

(*a*) 3-banded Armadillo of Brazil.
(*b*) Short Eared Rabbit of Sumatra (Indonesia)
(*c*) Maxican Prairie Dog.

Conservation of Wild Life / measures to protect

Conservation of wild life is the scientific management of wild life in such a way that it remains the optimum level, yielding greatest sustainable benefit to the present generation while retaining i potential to meet the needs and aspirations of future generations. Conservation of wild life is aimed (*i*) Maintaining ecological processes and life support systems at optimum level. (*ii*) Preserve diversity species and the wide range of genetic material present in living organisms of the world. (*ii*) Ensure continuous and sustainable supply of materials for all the human beings and their industries.

World Conservation Strategy for wild life was formulated in 1980 by scientists from 100 countrie The important measures are as follows :

1. **Nondisturbance.** Wild life should be disturbed to the minimum and that also when it is essentia
2. **Threatened Species.** The threatened species should be protected on priority basis as compare to non-threatened species and taxa. It should be for the whole range.

3. Monotypic Forms. Priority for conservation should be given to those species which are lone representatives of their genera and families.

4. Priority Amongst Threatened Species. In conservation, an endangered species is given preference over vulnerable one and vulnerable species over rare species.

5. In Situ and Ex-situ Conservation. Threatened species are protected both in their natural habitats (*in situ* conservation) as well as in man-made habitat of zoos, botanical gardens and arboureta (*ex situ*) conservation). Captive breeding is undertaken and on multiplication the individuals are released back into their natural habitats.

6. Life Support Systems. Life support systems of air, water and land should be properly managed because they affect wild life.

7. Useful Organisms. All varieties of currently useful organisms like food crops, forage plants, timber plants, livestock and animals for aquaculture should be conserved.

8. Wild Relatives. Wild relatives of economically useful organisms should be identified and preserved. Preference is given to the most threatened organisms and those required for national and international breeding programmes.

9. Habitats. The habitats of the wild relatives of valuable and useful organisms are identified and preserved in protected areas.

10. Critical Habitats. Critical habitats related to feeding, breeding, nursery and resting of wild animals should be safe-guarded.

11. Ecosystem versus Species. The whole ecosystem should be preserved rather than a single species.

12. Unique Ecosystems. Unique ecosystems should not be disturbed. They should be provided protection on a priority basis.

13. National Parks and Sanctuaries. They should be established to provide protection to habitats and ecosystems of wild life.

14. Migratory Animals. The routes of migratory animals should not be disturbed at least in the area of their stoppage and rest. Bilateral and multilateral agreements be made amongst the countries to protect the animals from exploitation.

15. Exploitation. Productive capacity of useful species and ecosystems should be determined. Exploitation should be limited to that extent.

16. International Trade. International trade in wild plants and animals should be regulated so as to prevent over-exploitation.

For Competitive Exams

- Wildlife (Protection) Act. Enacted in 1972.
- IBWL. Indian Board of Wild Life (Established in 1952).
- Wild Life Institute of India. Dehradun.
- CITES. Convention on International Trade in Endangered Species.
- WWF. World Wild Life Fund (1961) changed to World Wide Fund for Nature.
- MAB. Man And Biosphere Programme 1971, started in India in 1986 under UNESCO to know human environment, human interference, pollution and conservation strategy.

Protected Areas

They are specific biogeographical areas where wild life is protected from habitat destruction, exploitation, hunting and poaching. They are representatives of different ecological regions, *e.g.*, cold desert (Ladakh, Spiti), hot desert (Thar), temperate forest (Himalayas), tropical rain forest (Andamans), lakes (Wular and Manasbal in Kashmir, Chilka in Orissa, Kolleru in A.P.), coral reefs of Deccan, etc. National Wild Life Action Plan was adopted in 1983 to create protected areas for conservation of wild life. There are three types of protected areas—national parks, sanctuaries and biosphere reserves.

1. National Parks. They are areas reserved for wild life where the latter is able to obtain all the required natural resources and proper habitats. Plantation, cultivation, grazing, felling of trees and habitat manupulation are not allowed. Private ownership is not permitted. At present India has 85 national parks (66 in 1988) occupying more than 1% area of the country.

2. Sanctuaries. They are tracts of land with or without a lake where animals are protected from all types of exploitation and habitat disturbance. Private ownership is permitted. Collection of minor forest products, harvesting of timber and wood, tilling of land and other activities are allowed provided they do not interfere with the welfare of animals. Presently India has 448 sanctuaries (368 in 1988) occupying over 3·2% of the area.

3. Biosphere Reserves. They are large tracts of protected land with multiple use preserving the genetic diversity of representative ecosystem by protecting wild life, traditional life styles of the tribals and varied plant and animal genetic resources. They have been set up under MAB program of UNESCO. A total of 243 biosphere reserves are to be set up in 65 countries. In India 14 potential sites were selected but the number has been raised to 15. First to be established was Nilgiri Biosphere Reserve (parts of Karnataka, Kerala and Tamil Nadu) in 1986, while the second was Nandadevi Biosphere Reserve in 1988. By the end of 1999, eleven biosphere reserves had been established.

Each biosphere reserve has (*i*) **Core Zone.** No human activity is permitted. (*ii*) **Buffer Zone.** Limited human activity is allowed. (*iii*) **Manipulation Zone.** All types of human activities which do not disturb ecology are allowed. A restoration zone is also planned if the area is degraded.

Biosphere Reserve of India

1. Nilgiri Biosphere Reserve (Kerala, Karnataka and Tamil Nadu)—First to be established in 1986.
2. Nanda Devi Biosphere Reserve (Uttar Pradesh)
3. Nokrek Biosphere Reserve (Tura Range, Meghalya)
4. Great Nicobar Biosphere Reserve (Andaman and Nicobar).
5. Gulf of Mannar Biosphere Reserve (Tamil Nadu).
6. Manas Biosphere Reserve (Assam).
7. Sunderbans Biosphere Reserve (West Bengal).
8. Similipal Biosphere Reserve (Orissa).
9. Uttarakhand Biosphere Reserve (Including Valley of Flowers, Uttar Pradesh)—Just established.
10. Namdapha Biosphere Reserve (Arunachal Pradesh)—To be established.
11. North Islands of Andamans Biosphere Reserve (Andaman and Nicobar Islands)—To be established.
12. Kaziranga Biosphere Reserve (Assam)—To be established.
13. Thar Desert Biosphere Reserve (Rajasthan)—To be established.
14. Kanha Biosphere Reserve (Madhya Pradesh)—To be established.
15. Little Rann of Kutch Biosphere Reserve (Gujarat)—To be established.

Important Wild life Projects of India

1. Project Tiger (*Panthera tigris*). The project was started in 1973 in order to check depletion in pupulation of tiger. Initially it was undertaken in 17 national parks. But recently the project has been extended to 6 more national parks (a total of 23). Important National Parks associated with Project Tiger are Corbett National Park, Nainital (U.P.), Sunderbans Tiger Reserve 24 Parganas (W. Bengal) and Ranthambore National Park, Savai Madhopur (Rajasthan).

2. Lion Project (*Panthera leo persica*). The project was started in 1972. It is located in Gir National Park, Junagarh (Gujarat).

3. Snow Leopard Project (*Panthera uncia*). Throughout Himalayas *e.g.*, Khangchendzonga National Park (Gangtok).

4. Musk Deer Project (*Moschus moschifenis*). Kedarnath Sanctury (UP), Manali Sanctuary (H.P.) and Shikari Devi Sanctuary (H.P.).

5. Rhino Project (*Rhinoceros unicornis*). The project was started in 1987. The important sancturies and parks where the project has been undertaken are Kaziranga National Park, Sibsagar, Jorhat (Assam) and Manas Sanctuary, Barpeta (Assam).

6. Elephant Project (*Elephas maximus*). The project was started in 1992 in several sancturies including Kaziranga National Park, Sibsagar, Jorhat (Assam) and Manas Sanctury, Barpeta (Assam).

7. Kashmir Stag or Hangul Project (*Cervus elephus hanglu*). It was one of the earliest projects for conservation of wild life. The project is going on in Dachigam Sanctury Srinagar (J.K.) since 1970.

8. Lion Tailed Macaque Project (*Macaca silenus*). Annamalai Sanctuary (T.N.) and Silent Valley National Park (Kerala).

9. Great Indian Bustard Project (*Ardeotis nigriceps*). Desert National Park Jaiselmer (Raj.) and Great Indian Bustard Sanctuary (Maharashtra).

10. Indian Wild Dog Project (*Canis alpinus*). Kanha National Park (M.P.).

11. Indian Crocodile Project (*Crocodilus palustris, C. porosus*). Bhitar Kanika Sanctuary, Cuttack (Orissa), Nagarjuna Sanctuary, Guntur (A.P.).

12. River Dolphin Project (*Platinisia gangetica*). Vikramshila (Bihar).

Important National Parks and Sanctuaries of India

ANDAMAN AND NICOBAR ISLANDS

1. Barren Island Sanctuary (Bay of Bengal)
2. Marine National Park
3. Middle Button Island National Park (Andaman)
4. Mount Harriet National Park
5. Narcondum Island Sanctuary (Bay of Bengal)
6. North Button Island National Park (Andaman)
7. North Reef Island Sanctuary (Bay of Bengal)
8. Saddle Peak National Park (Bay of Bengal)
9. South Button Island National Park (Andaman)
10. South Sentinel Island Sanctuary (Bay of Bengal).

ANDHRA PRADESH

1. Coringa Sanctuary (East Godavari)
2. Eturnagram Sanctuary (Warangal)
3. Kawal Sanctuary (Adilabad)
4. Kinnersani Sanctuary (Khammam)
5. Kolleru Sanctuary (West Godavari)
6. Lanjamadugu Sanctuary (Adilabad and Karimnagar)
7. Majina Sanctuary (Medak)
8. Nagarjunasagar Srisailam/Ikshwaka Sanctuary (Guntur, Kurnool)
9. Neelapathu Sanctuary (Nellore)
10. Pakhal Sanctuary (Warangal).

ARUNACHAL PRADESH

1. Itanagar Sanctuary
2. Lali Sanctuary
3. Mehao Sanctuary
4. Moiling National Park
5. Namdapha National Park
6. Pakhui Sanctuary.

ASSAM

1. Barnadi Sanctuary
2. Garamani Sanctuary
3. Kaziranga National Park (Sibsagar and Nowgong)
4. Manas National Park (Barpeta).

BIHAR

1. Bhimbandha Sanctuary
2. Dalma Sanctuary
3. Hazaribagh Sanctuary (Hazaribagh)
4. Nakti Dam Sanctuary
5. Nagi Dam Sanctuary
6. Palamau Sanctuary/National Park (Dalton Ganj), also part in Orissa.
7. Rajgir Sanctuary

CHANDIGARH

Sukhna Lake Sanctuary

DELHI

Indira Priyadarshini Sanctuary

GOA

1. Bhagwan Mahavir Sanctuary/National Park
2. Bondla Sanctuary
3. Cotigao Sanctuary.

GUJARAT

1. Bansda National Park (Valsad)
2. Barda Sanctuary
3. Dhrangadhra Sanctuary
4. Gir National Park (Gir, Junagarh)
5. Jessore Slothbear Sanctuary
6. Marine National Park (Jamnagar)
7. Nalsarovar Sanctuary (Ahmedabad).
8. Shoolpaneshwar Sanctuary
9. Velavader National Park (Bhavnagar).

HARYANA

1. Bhindawas Sanctuary
2. Chotala Sanctuary
3. Sultanpur (Lake) Sanctuary (Gurgaon).

HIMACHAL PRADESH

1. Bondi Sanctuary
2. Chail Sanctuary
3. Govind Sagar (Bird) Sanctuary (Bilaspur)
4. Great Himalayan National Park
5. Lippa Asrang Sanctuary
6. Manali Sanctuary
7. Pin Valley National Park.
8. Shikari Devi Sanctuary (Mandi).

JAMMU & KASHMIR

1. Dachigam Sanctuary/National Park (Srinagar)
2. Gulmarg Sanctuary
3. Hemis High Altitude National Park (Srinagar)
4. Karakoram Sanctuary
5. Kishtwar National Park (Srinagar)
6. Limber Sanctuary
7. Nandni Sanctuary
8. Salim Ali National Park
9. Surinsar-Mansar Sanctuary

KARNATAKA

1. Anshi National Park
2. Bandipur National Park (Mysore)
3. Bannerghatta National Park (Mysore)
4. Cauvery Sanctuary
5. Gataprabha Sanctuary (Belgaun)
6. Kudremukh National Park
7. Nagarahole National Park (Coorg)
8. Pushpagiri Sanctuary
9. Ranganathittu (Bird) Sanctuary (Mysore)
10. Sharavathi Valley Sanctuary
11. Shettihalli Sanctuary

KERALA

1. Eravikulum National Park (Idukki)
2. Idukki Sanctuary (Idukki)
3. Neyyar Sanctuary
4. Parambikulum Sanctuary
5. Peppara Sanctuary
6. Periyar National Park (Idukki)
7. Silent Valley National Park (Palaghat)

MADHYA PRADESH

1. Bagdar Sanctuary
2. Bandhavgarh National Park (Shahdol)
3. Bhairamgarh Sanctuary
4. Fossil National Park
5. Gandhi Sagar Sanctuary
6. Madhav National Park
7. Indravati National Park (Bastar)
8. Kanger Ghati National Park
9. Kanha National Park (Mandla and Balaghat)
10. Karera Sanctuary/Great Indian Bustard Sanctuary
11. Madhav National Park (Shivpuri)
12. National Chambal Sanctuary
13. Panna National Park (Panna)
14. Pench National Park
15. Sanjay National Park (Sidhi and Surguja)
16. Satpura National Park (Hoshangabad)
17. Singhori Sanctuary
18. Tamor Pingla Sanctuary
19. Udanti Sanctuary
20. Van Vihar National Park (Bhopal)

MAHARASHTRA

1. Bor Sanctuary
2. Chandoli Sanctuary
3. Chaprala Sanctuary
4. Great Indian Bustard Sanctuary
5. Koyna Sanctuary
6. Nagzira Sanctuary,
7. Nawagaon National Park (Bandara)
8. Pench National Park (Nagpur)
9. Sanjay Gandhi National Park (Mumbai)
10. Tadoba National Park (Chandrapura)
11. Tansa Sanctuary

MANIPUR
1. Keibul Lamjao National Park (Manipur Central)
2. Siroy National Park (Manipur East).

MEGHALAYA
1. Baghmara Sanctuary
2. Balphakram National Park
3. Nokvek National Park
4. Nongkhyllem Sanctuary
5. Siju Sanctuary

MIZORAM
Dampa Sanctuary

NAGALAND
1. Pakim Sanctuary
2. Intanki Sanctuary
3. Pulchatze Sanctuary

ORISSA
1. Baisipalli/Mahanadi Sanctuary
2. Balukhand Sanctuary
3. Bhitar Kanika Sanctuary (Cuttack)
4. Chilka Lake Bird Sanctuary (Balagaon)
5. Debrigarh Sanctuary
6. Lakhari Valley Sanctuary
7. Simplipal Sanctuary/National Park (Mayurbhanj)
8. Palamau National Park (also in Bihar)

PUNJAB
1. Abohar Sanctuary
2. Bir Bunnerheri Sanctuary.
3. Bir Gurhialpura Sanctuary
4. Bir Motibagh Wild Life Sanctuary
5. Harike Lake Sanctuary.

RAJASTHAN
1. Desert National Park (Jaiselmer and Barmer)
2. Jawahar Sagar Sanctuary.
3. Keoladeo/Ghana Bird Sanctuary National Park (Bharatpur)
4. Mount Abu Sanctuary
5. National Gharial Sanctuary
6. Ramgarh Sanctuary
7. Ranthambore National Park (Savai Madhopur)
8. Sariska Sanctuary/National Park (Alwar)
9. Van Vihar Sanctuary.

SIKKIM
Khangchendzonga National Park (Gangtok).

TAMIL NADU
1. Anamalai Sanctuary (Coimbatore)
2. Guindy National Park (Madras)
3. Kalakad Sanctuary
4. Marine National Park (Gulf of Mannar)
5. Mudumalai Wild Life Sanctuary (Nilgiri)
6. Nundanthurai Sanctuary (Tirunelvelli)
7. Pulicat (Lake) Sanctuary

TRIPURA
1. Gumti Sanctuary
2. Rao Sanctuary
3. Sepahijala Sanctuary
4. Trishna Sanctuary.

UTTAR PRADESH
1. Binsar Sanctuary
2. Chandraprabha Sanctuary (Varanasi)
3. Corbett National Park (Nainital)-First to be established.
4. Dudhwa National Park (Lakhimpur Kheri)
5. Hastinapur Sanctuary
6. Kedarnath Sanctuary
7. Nanda Devi National Park (Chamoli)
8. National Chambal Sanctuary
9. Rajaji National Park
10. Valley of Flowers National Park (Chamoli)

WEST BENGAL
1. Ballarpur Sanctuary.
2. Gorumara Sanctuary
3. Jaldapara Sanctuary (Madarihat, Jalpaiguri)
4. Narendrapur Sanctuary
5. Neora Valley National Park
6. Senchal Sanctuary
7. Singhalila National Park
8. Sunderbans Tiger Reserve/National Park (24-Parganas)

National Symbols of India

National Animal – Tiger
National Bird – Peacock
National Flower – Lotus
National Tree – Peepal (*Ficus religiosa*)

State Symbols

State/Union Territory	Mammal	Bird	Flower	Tree
Andhra pradesh	Four Horned Antelope	Grey Pelican	Jasmine	Red Sanders (*Pterocarpus santalinus*)
Assam	One Horned Rhino	White winged Wood duck	Champa	Bamboo (*Bambusa spp.*)
Andaman & Nicobar islands	Crab Eating Hyena	Megapode	Keya	Padauk (*Pterocarpus dalbergioides*)
Arunachal Pradesh	Takin	Peacock Pheasant	Pox-tail Orchid	Hollock (*Terminalia myriocarpa*)
Bihar	Sloth Bear	Nakta (Comb Duck)	Kachnar	Mahua (*Madhuca indica*)
Delhi	Langur	Grey Partridge	*Lagerstroemia indica*	Arjun (*Terminalia arjuna*)
Gujarat	Asiatic Lion	Flamingo	Indian Laburnum	Neem (*Azadirachta indica*)
Goa	Mouse Deer	Brown headed Sea Gull	Wild Morning Glory	*Hibiscus*
Haryana	Nilgai	Black Partridge	Vasak	Babul (*Acacia nilotica*)
Himachal Pradesh	Musk Deer	Monal Pheasant	Bish or Atis	Deodar (*Cedrus deodara*)
Jammu & Kashmir	Kashmir Stag	Western Tragopan	Blue Poppy	Horse Chestnut (*Castanopsis spp.*)
Karnataka	Slender Loris	Great Pied Hornbill	Nandivardhan	Sandal (*Santalum album*)
Kerala	Lion Tailed Macaque	Large Racket	Scarlet *Ixora* or Techi	Rose Wood (*Dalbergia latifolia*)
Madhya Pradesh	Barasingha	Paradise Flycatcher	*Sterculia*	Banyan (*Ficus bengalensis*)
Maharashtra	Gaur	Grey Jungle Fowl	Jarul	Teak (*Tectona grandis*)
Manipur	Thamin	Hume's bar Backed Pheasant	Manipur Lily	Toon (*Cedrela toona*)
Meghalaya	Binturong	Hill Mynah	Pitcher Plant	Wild Orange
Mizoram	Golden Cat	Blyth's Tragopan	Chalta	*Michelia montana*
Nagaland	Clouded Leopard	Imperial Pigeon	Blue Vanda	Areca Nut (*Areca catechu*)
Orissa	Sambar	Blue Jay	Ashoka	Tendu (*Diospyros tomentosa*)
Punjab	Black Buck	Hoopoe	Coral Tree Thab	Shisham (*Dalbergia sisoo*)
Rajasthan	Gazelle	Great Indian Bustard	Karil	Khejri (*Prosopis cineraria*)
Sikkim	Red Panda	Blood Pheasant	Noble Orchid	*Rhododendron*
Tamil Nadu	Nilgiri Tahr	Spoon Bill	Pavalk-Kurinja	Tamarind (*Tamarindus indica*)
Tripura	Pharye's Leaf Monkey	Fairy Blue Bird	Nagkesar	Agar (*Aquilaria agallocha*)
Uttar Pradesh	Leopard	Sarus Crane	Brahma Kamal	Sal (*Shorea robusta*)
West Bengal	Indian Elephant	Barn Owl	Parijat	*Bischofia javanica*