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Integrated UG/PG Biotechnology, Semester-III
End Semester Examination, 2014-15
LBTC-304: Plant Ecology

Model Answer

Section 1: Answer all the questions. Each question carries 1.0 mark. Choose one correct answer for the following questions. **(10 x 1 = 10)**

(i) Energy flow in ecosystem is
(a) unidirectional

(ii) The concept of ecological pyramid was first proposed by
(d) Charles Elton

(iii) Exponential growth occurs when there is
(b) no environmental resistance

(iv) The carrying capacity of a population is determined by it
(d) limiting resources

(v) The term Biodiversity was coined by ----------
(a) Walter G. Rosen 1985

(vi) The rate of replacement of species along a gradient of habitats or communities is called ---
(c) beta diversity.

(vii) Succession initiated on large sand deposits or deserts is called
(b) psammosere

(viii) The final stable community in an ecological succession is called the
(c) climax community

(ix) The smog is essentially caused by the presence of
(c) oxides of sulphur and nitrogen

(x) Which of the following is present in maximum amount in acid rain?
(b) H_2SO_4

*Section 2: Each question carries 5 marks. Attempt only **four** questions out of the following **eight** questions.*

Q2. Describe the structure of an ecosystem by taking an example of pond ecosystem. **(4 x 5 = 20)**

Answer:

A pond as a whole serves as a good example of an aquatic and freshwater ecosystem (Fig. 9.2). In fact, it represents a self-sufficient and self-regulating system. It has following components :

1. Abiotic Component

The chief non-living or abiotic substances are heat, light, pH value of water, and the basic inorganic and organic compounds, such as water itself, carbon dioxide gas, oxygen gas, calcium, nitrogen, phosphates, amino acids, humic acid, etc. Inorganic salts occur in the form of phosphates, nitrates and chlorides of sodium, potassium and calcium. Some proportion of nutrients exist in solution state but most of them are present as stored in particulate matter as well as in living organisms.

2. Biotic Component

It includes various organisms which are classified into the following types :

(a) **Producers.** These are photoautotrophic green plants and photosynthetic bacteria. The producers fix radiant energy of sun and with the help of minerals derived from water and mud they manufacture complex organic substances as carbohydrates, proteins and lipids. Producers of pond are of following types :

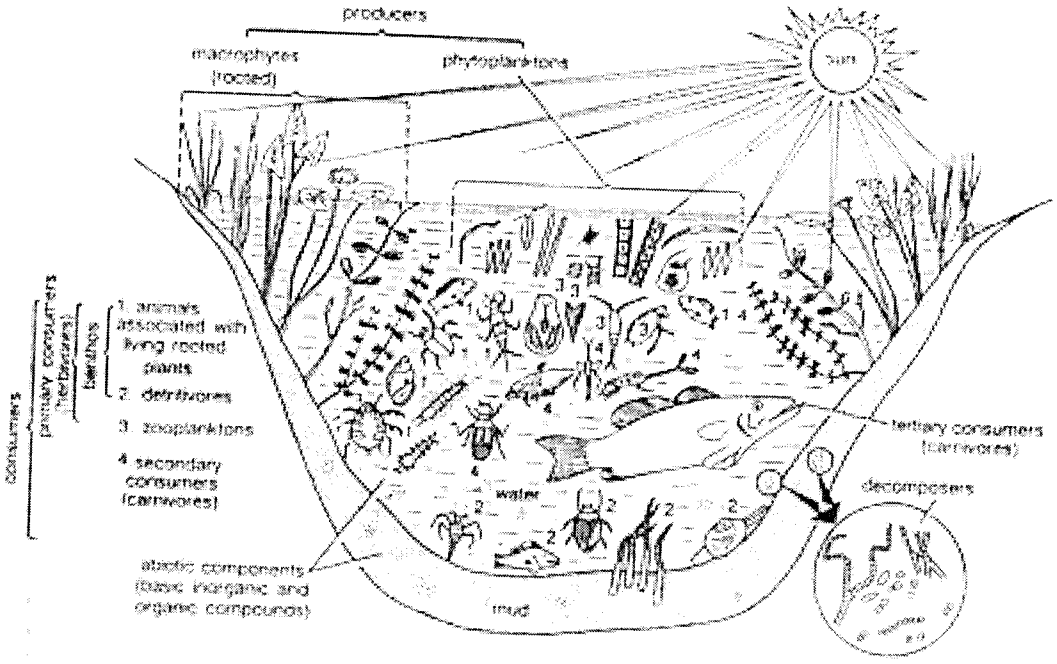

Fig. 9.2. A pond ecosystem showing its basic structural units – the abiotic (inorganic and organic compounds) and biotic (producers, and consumers – herbivores, carnivores and decomposers) components.

(i) Macrophytes. These include mainly the rooted large-sized plants which comprise three types of hydrophytes : partly or completely submerged, floating and emergent aquatic plants. The common plants are species of *Trapa, Typha, Eleocharis, Sagittaria, Nymphaea, Potamogeton, Chara, Hydrilla, Vallisneria, Utricularia, Marsilea, Nelumbo*, etc. Besides these plants, some free floating forms also occur in the pond ecosystem, *e.g., Azolla, Salvinia, Wolffia, Eichhornia, Spirodella, Lemna*, etc.

(ii) Phytoplanktons. These are microscopic (minute), floating or suspended lower plants (algae) that are distributed throughout the water, but mainly in the photic zone. Most of them ar filamentous algae such as *Spirogyra, Ulothrix, Zygnema, Cladophora* and *Oedogonium*. There al occur some chlorococcales (*e.g., Chlorella*), *Closterium, Cosmarium, Eudorina, Pandorina, Pediastrum, Scenedesmus, Volvox*, Diatoms, *Anabaena, Gloeotrichia, Microcystis, Oscillatoria, Chlamydomonas, Spirulina*, etc., and some flagellates.

(b) Macroconsumers. They are phagotrophic heterotrophs which depend for their nutrition on the organic food manufactured by producers, the green plants. Macroconsumers are of following three types :

(i) Herbivores (Primary consumers). These animals feed directly on living plants (producers) or plant remains. They may be large or minute in size and are of following two types : 1. **Benthos** which are the bottom dwelling forms such as fish, insect larvae, beetles, mites, molluscs (*e.g., Pila, Planorbis, Unio, Lamellidens*, etc.), crustaceans, etc. 2. **Zooplanktons** which feed chiefly on phytoplanktons and are chiefly the rotifers as *Brachionus, Asplanchna, Lecane*, etc., although some protozoans as *Euglena, Coleps, Dileptus*, etc., and crustaceans such as *Cyclops, Stenocypris*, etc., are also present in the pond.

Besides these small-sized herbivores, some mammals such as cow, buffaloes, etc., also visit the pond casually and feed on marginal rooted macrophytes. Some birds also regularly visit the pond to feed on some hydrophytes.

(ii) Carnivore order-1 (Secondary consumers). These carnivores feed on the herbivores and include chiefly insects, fish and amphibians (frog). Most insects are water beetles which feed on zooplanktons; some insects are the nymphs of dragonflies which feed upon aquatic insects.

(iii) Carnivore order-2 (Tertiary consumers). These are some large fish as game fish that feed on the smaller fish and, thus, become the tertiary (top) consumers.

(c) Decomposers. They are also called microconsumers, since they absorb only a fraction of the decomposed organic matter. They bring about the decomposition of dead organic matter of both producers (plants) as well as macroconsumers (animals) to simple forms. Decomposers help in returning of mineral elements again to the medium of the pond and in running biogeochemical cycles. Decomposers of pond ecosystem include chiefly bacteria, actinomycetes and fungi. Among fungi, species of *Aspergillus, Cephalosporium, Cladosporium, Pythium, Rhizopus, Penicillium, Thielavia, Alternaria, Trichoderma, Circinella, Fusarium, Curvularia, Paecilomyces, Saprolegnia*, etc., are most common decomposers in water and mud of the pond.

Q3. Describe the nature of J-shaped and S-shaped growth curves along with their mathematical expression. Differentiate between r and k-selection populations.

Answer:

Populations have characteristic pattern of increase which are called **population growth forms**. Such growth forms represent the interaction of biotic potential and environmental resistance. The study of population dynamics is done by three approaches (1) mathematical models, (2) laboratory studies and (3) field studies.

The growth is the most fundamental dynamic feature that a species population displays. Populations characteristically increase in size in a sigmoid, S-shaped or logistic fashion. When a few organisms are introduced into an unoccupied area, the growth of the population is at first slow (**positive acceleration phase**), then becomes very rapid (**logarithmic phase**) and finally slows down as the environmental resistance increases (**the negative acceleration phase**) until an equilibrium level is reached around which the population size fluctuates more or less irregularly according to the constancy or variability of given environment. The level beyond which no major increase can occur represents the saturation level or **carrying capacity**. The carrying capacity or equilibrium density is represented by the letter **K**. It is often useful to define the maximum rate of growth of the population. This parameter, generally termed the **intrinsic rate of natural increase**, is symbolized r_g and represents the growth rate of a population that is infinitely small. Accordingly such type of population growth can be described by following **logistic equation** :

$$dN/dt = r_g N (K - N) / K$$

where r_g = innate capacity of population to increase (birth rate without resource limitation), N = population size and K = highest population density that can be maintained in real environment, i.e., at carrying capacity.

There are two main types of population growth forms. (1) J-shaped and (2) S- shaped or sigmoid forms (Fig. 6.8). The growth forms are due to the nature of species and prevailing environmental conditions. In **J-shaped curve** there is a rapid increase in density with the passage of time (called **exponential growth**). The density values when plotted against time give a J-shaped growth curve and at the peak the population growth ceases abruptly due to environmental resistance. For example, the population growth curve in human populations and growth of yeast, *Drosophila* and rabbit under laboratory conditions show an initial slow rate and then it accelerates and finally slows giving the growth curve which is **sigmoid** or **S-shape**. The peak constant level represented by K or upper level (called **asymptote**) of the sigmoid curve is called the **maximum carrying capacity**. It marks the limit to which the environment can support the population.

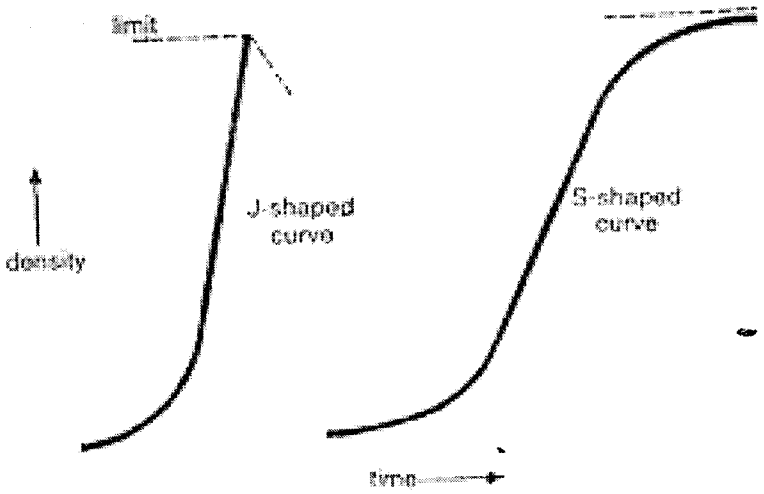

Fig. 6.8. J-shaped and S-shaped population growth curves.

Enlist differences between r and k-selection species.

Q4. Explain different methods of Biodiversity conservation with suitable examples.

Answer: The total diversity and variability of living things and of the system of which they are a part is generally defined as biological diversity. Most people are beginningto recognize that at all levels – gene pool, species and biotic community is important and need to be conserved. We may appreciate the fact that the most effective and efficient mechanism for conserving biodiversity is to prevent further destruction or degradation of habitat by us.

(explain on the following headings with suitable examples as applicable)

Strategies: There are 2 basic strategies of biodiversity conservation, *in situ* and *ex situ*

in situ conservation: on site, this include

(i) Protected area (ii) Biosphere reserves (iii)Sacred forest and lakes:

ex situ conservation : of site, this include

(i) *In vitro* (ii) *In vivo*

International and National efforts:

Benefits:

Q5. What is ecological succession? Describe the process of ecological succession in pond.

Answer: The development of the community by the action of vegetation on the environment leading to the establishment of new species is termed succession. Succession is the universal process of directional change in vegetation during ecological time. It can be recognized by the progressive change in the species composition of the community. The transitional series of communities which develop in a given area are called sere or seral stages, while the final stable and mature community is called the climax.

Hydrosere. A good example of succession is the **hydrarch** succession or **hydrosere** (Fig. 8.2), in which a pond and its community are converted into a land community. In the initial stage, phytoplankton (*e.g.*, some blue green algae (cyanobacteria), green algae (*e.g.*, *Spirogyra, Oedogonium*), diatoms and bacteria) are the pioneer colonizers. They are consumed by zooplankton (*e.g.*, protozoans such as *Amoeba, Paramecium, Euglena*, etc.), fish such as blue gill fish, sun fish, large mouth, etc. Gradually these organisms die and increase the content of dead organic matter in the pond. This is utilized by bacteria and fungi, and minerals are released after the decomposition. The nutrient-rich mud then supports the growth of rooted hydrophytes such as *Hydrilla, Elodea, Vallisneria, Ceratophyllum*, etc., in the shallow water zone. This submerged stage is also inhabited by the animals such as dragon flies, may flies and crustaceans such as *Asellus, Gammarus, Daphnia, Cypris, Cyclops*, etc. The hydrophytes die and are decomposed by microorganisms, thus, releasing nutrients. In addition to this, due to silting, the water depth of the pond is reduced and at the margin of the pond grow rooted floating vegetation (*i.e.*, the plant species whose leaves reach the water surface and roots

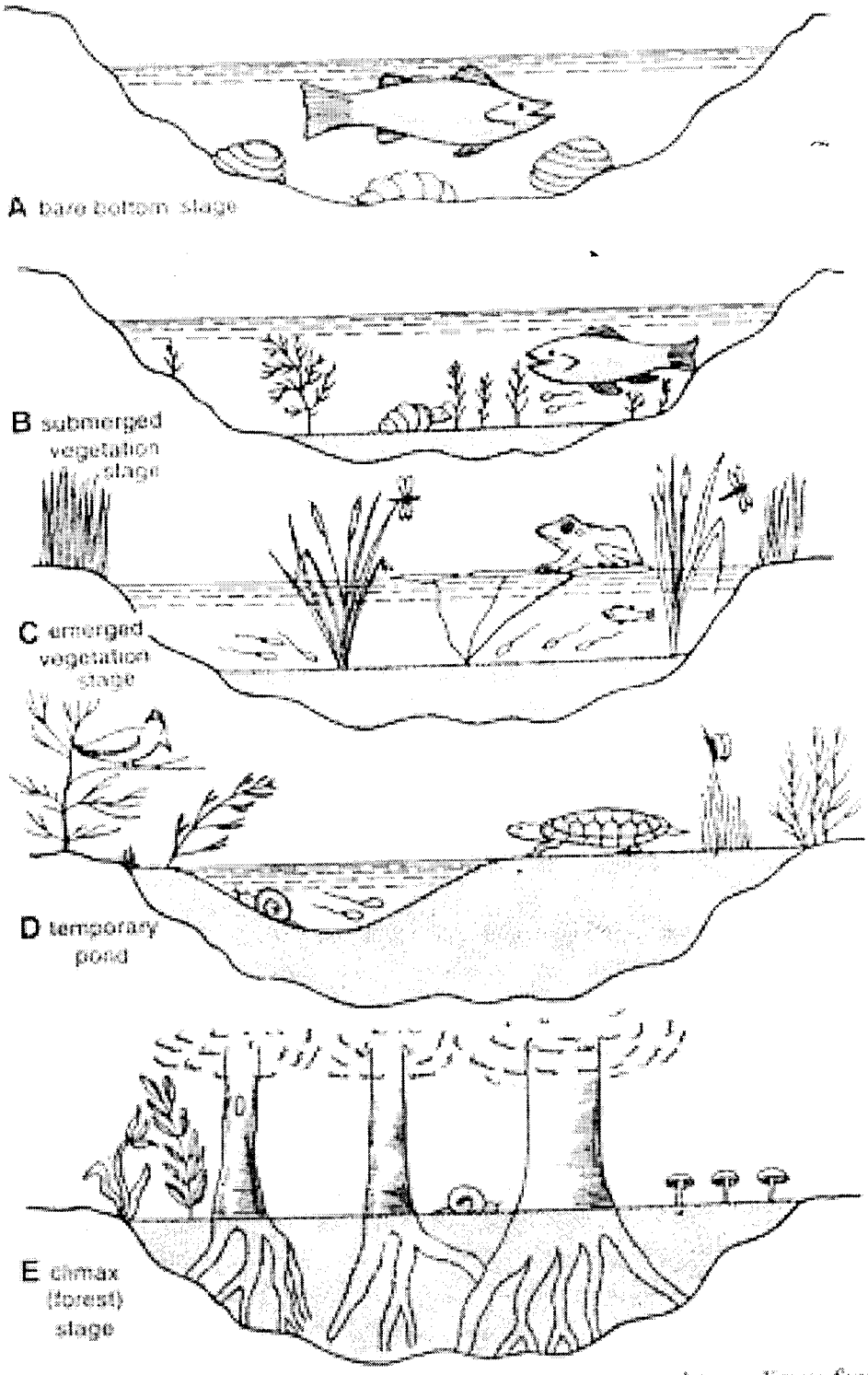

Fig. 8.2. Diagram showing ecological succession from a pond to a climax forest (after Cockrum and McCauley, 1965).

remain in the mud). Plants such as *Nelumbo nucifera, Trapa, Monochoria,* etc., grow in these conditions. In floating stage faunal living space is increased and diversified. Hydras, frogs, salamanders, gill-breathing snails, diving beetles (*Dysticus*) and host of new insects capable of utilizing the under surfaces of floating leaves appear. Some turtles and snakes also invade the pond.

Gradually the water depth in the pond decreases due to evaporation and the deposition of organic matter and the concentration of the nutrients increases. Free-floating plants such as *Azolla, Lemna, Pistia, Wolffia, Spirodella,* etc., increase in number because of the high nutrient availability. Gradually their dead parts fill up the pond ecosystem, resulting in the further build up of the substratum.

At this stage, the pond becomes a swampy ecosystem. The reed swamp species (such as *Scirpus* or bulrushes, *Typha* or cattail, *Phragmites* (reed grass), *Rumex,* etc.) and sedges (*e.g., Carex, Juncus, Cyperus,* etc.) invade the pond and the latter are gradually replaced by mesic communities as the water depth is reduced greatly. Gradually land plants, such as, shrubs (*Salix, Cornus*) and trees (*Populus, Almus*) invade ending in the climax community such as deciduous forest (Fig. 8.2). In association with the changes in water depth and vegetation, the aquatic fauna also change and ultimately gets replaced by land animals.

Thus, possible trend of succession in the aquatic environment is as follows :

Climax community
↑
Open scrub land = Deciduous forest
↑
Terrestrial communities
↑
Mesic communities
↑
Reeds and sedges
↑
Free floating and rooted plants
↑
Rooted and aquatic plants
↑
Phytoplankton
↑
Pond ecosystem

Climax communities vary from place to place. For example, in low lying lands in some parts of Kashmir, the climax community has trees such as *Salix* (**Ambasht,** 1988). In Indian upland plateaus, the climax woody species consist of *Diospyros, Butea* and *Zizyphus* and ground vegetation of *Eragrostis, Sporobolus, Bothriochloa,* etc. Climax vegetation of lowlands and valleys which provide a mesic environment includes *Terminalia, Ficus, Sterculia, Salix,* etc.

Q6. How is photochemical smog formed? What are its effect? How can it be controlled? Distinguish between classical and photochemical smogs.

Photochemical smog or Los Angeles smog. This type of smog was first observed in Los Angeles in 1950 and hence is named as "Los Angeles smog". It is formed when the air contains NO_2 and hydrocarbons and the mixture is exposed to sunlight. As the reaction takes place in the presence of sunlight to form the smog, it is called photochemical smog. Further, as strong sunlight is needed, this type of smog is formed in the months of summer during the day time when NO_2 and hydrocarbons are present in very large amounts due to heavy vehicular traffic.

Formation of photochemical smog. The mechanism of the formation of photochemical smog may be explained as follows :

In the presence of sunlight, NO_2 undergoes photolysis to form NO and atomic oxygen. Atomic oxygen then combines with the molecular oxygen in the presence of some molecule M (which acts as a source of transfer of energy) to form ozone, O_3. The ozone thus formed reacts with NO to regenerate NO_2 and O_2. Thus, NO_2 cycle is completed. The reactions taking place may be represented as follows :

$$NO_2 \xrightarrow{h\nu} NO + O$$

$$O + O_2 \longrightarrow O_3$$

$$O_3 + NO \longrightarrow NO_2 + O_2$$

Thus, NO and O_3 produced are used up and no extra NO_2 is added into the atmosphere. But the trouble arises if hydrocarbons are also present in the atmosphere. These hydrocarbons combine with the oxygen atom produced by the photolysis of NO_2 to form highly reactive intermediates called free radicals (which are reactive species containing unpaired electrons) which may be represented by the general formula $RCO^{\bullet}$ (dot indicates an unpaired electron). These free radicals initiate a variety of reactions, some of which may be as follows :

$$RCO^{\bullet} + O_2 \longrightarrow RCO_3^{\bullet}$$

$$RCO_3^{\bullet} + \text{Hydrocarbons} \longrightarrow RCHO,\ R_2C=O$$

$$RCO_3^{\bullet} + NO \longrightarrow RCO_2 + NO_2$$

$$RCO_3^{\bullet} + O_2 \longrightarrow O_3 + RCO_2$$

$$RCO_3^{\bullet} + NO_2 \longrightarrow \underset{\substack{\text{Peroxyacylnitrates}\\(\text{PAN})}}{RCO_3NO_2}$$

As a result, concentration of ozone, peroxyacylnitrates (PAN) and aldehydes (RCHO) and ketones (R_2CO) builds up in the atmosphere.

As this type of smog contains O_3 and NO_2, it is oxidising in character.

Harmful effects of photochemical smog.

(*i*) All these compounds (particularly ozone and PAN) produce irritation in the eyes and also in the respiratory system.

(*ii*) They also damage many materials such as metals, stones, building materials, etc.

(*iii*) Ozone is particularly destructive to rubber (in which cracks are developed).

(*iv*) It is also harmful to fabrics, crops and ornamental plants.

(*v*) NO_2 present gives a brown colour to the photochemical smog which reduces visibility. Airplane pilots are familiar with this type of fog hanging over the cities.

The word "smog" is a misnormer here because photochemical smog contains neither smoke nor fog. It is a mixture of a number of irritation-causing compounds like NO_2, O_3, PAN, aldehydes, ketones, hydrocarbons and CO.

Control of Photochemical Smog. The formation of photochemical smog can be controlled or suppressed by adopting the following methods :

(*i*) By fitting efficient catalytic converters in the automobiles so that the emission of nitrogen oxides and hydrocarbons by these automobiles into the atmosphere can be prevented.

(*ii*) By spraying certain compounds into the atmosphere which generate free radicals that readily combine with the free radicals that initiate the reactions forming toxic compounds of the photochemical smog.

(*iii*) Certain plants such as Pinus, Juniparus, Pyrus, Vitis etc. can metabolise oxides of nitrogen. Hence, their plantation could be helpful.

Difference between Classical smog (London smog) and Photochemical smog (Los Angeles smog). The main points of difference are given in the table below :

Classical smog (London smog)	Photochemical smog (Los Angeles smog)
1. This type of smog was first observed in London in 1952.	1. This type of smog was observed in Los Angeles in 1950.
2. It is formed due to presence of SO_2 and humidity in the air which combine to form H_2SO_4 fog which deposits on the particulates.	2. It is formed due to photochemical reaction taking place when air contains NO_2 and hydrocarbons.
3. It involves smoke and fog.	3. It does not involve any smoke or fog. The word smog is a misnomer here.
4. It is formed in the months of winter particularly in the morning hours when the temperature is low.	4. It is formed in the months of summer during afternoon when there is bright sunlight so that photochemical reactions can take place.
5. It causes bronchitis irritation, *i.e.*, problem in the lungs.	5. It causes irritation in the eyes.
6. It is a reducing in character.	6. It is oxidizing in character.

Q7. Write short notes on

a. Genetic diversity
b. Community and Ecosystem diversity

Ans-7a: Biodiversity is the term used to describe combined diversity at all levels of biological organization. Among the different level of biodiversity genetic diversity is significant one, which refers to the variation of genes within species. The difference could be in any of the following

In alleles:
In entire gene:
In chromosome structure:
(explain each one above in detail)

Ans-7b: The total variability on earth is known as biodiversity, which includes three hierarchical level i.e. genetic diversity, species diversity and ecosystem/community diversity. Diversity at the level of community/ecosystem is known as ecosystem diversity. This is again of 3 types i.e.

Alpha diversity:
Beta diversity:
Gamma diversity:
(explain each one above in detail)

Q8. What is acid rain? How does it form? What are its effect? How can it be controlled?

Answer: Acid rain is the rain water containing sulphuric acid and nitric acid (along with small amount of hydrochloric acid) which are formed from the oxides of sulphur and nitrogen present in the air as pollutants and has pH of 4-5.

Formation of Acid Rain. Due to natural sources such as bacterial action or volcanic eruptions or due to human activities mainly involving combustion of fuels like coal, wood, petroleum products, etc. or from chemical industries, oxides of nitrogen (NO_x) and those of sulphur (SO_x) enter into atmosphere as pollutants. The oxides of nitrogen undergo oxidation reactions followed by reaction with the water vapours present in the atmosphere to form HNO_3 as follows :

$$NO + O_3 \longrightarrow NO_2 + O_2$$
$$NO_2 + O_3 \longrightarrow NO_3 + O_2$$
$$NO_2 + NO_3 \longrightarrow N_2O_5$$
$$N_2O_5 + H_2O \longrightarrow 2\,HNO_3$$

The nitric acid thus formed comes down to the earth along with rain or reacts with the bases like NH_3 and lime to form nitrates.

The oxidation of SO_2 to SO_3 is catalysed by aerosol containing metal ions like Cu (II), Fe (II), Mn (II) and Ni (II) or by the soot particles or by the presence of NO. The SO_3 thus formed reacts with the water vapour of the air to form H_2SO_4

$$2\,SO_2 + O_2 \xrightarrow[\text{or metal ions}]{\text{NO, soot}} 2\,SO_3$$

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

HNO_3 and H_2SO_4 as formed above combine with HCl present in the air (from natural sources or man-made sources) to produce acidic precipitation which is commonly known as acid rain.

H_2SO_4 is the main contributor (60–70%), next is HNO_3 (30–40%) and least is HCl.

Harmful effects of Acid Rain. (*i*) Acid rain causes extensive damage to buildings, statues and sculptural material, especially those made of marble, limestone, slate, mortar, etc. The reaction with marble takes place as follows :

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + CO_2 + H_2O$$

For example, **Taj Mahal at Agra,** which is a very popular historical monument made of marble is being attacked by acid rain due to high concentration of oxides of sulphur and nitrogen in the air over Agra because of a large number of industries in the surrounding areas which are emitting these gases. As a result, marble is being eaten up causing pitting and discolouring and making it lustreless.

(*ii*) It also damages iron and steel structures.

(*iii*) It corrodes water pipes. As a result, heavy metals like iron, lead and copper are leached into drinking water which have toxic effects

(*iv*) Acid rain increases the acidity of water in the lakes which is lethal for the fishes. For this reason, some of the lakes have become fishless. Thus, it has greatly affected the fish population.

(*v*) Acid rain damages leaves of trees and plants and retards the growth of forests (as it happened in Swedish forests). It also retards the growth of certain crops such as peas, beans, potato, raddish, carrot, spinach, etc.

Methods to reduce the formation of acid rain. Acid rain is due to emission of sulphur dioxide and nitrogen dioxide in the atmosphere. Therefore, to reduce the formation of acid rain, the emission of these gases has to be controlled. The following steps may be taken :

(*i*) By using less vehicles driven by fossil fuels.

(*ii*) By using less sulphur content fossil fuels for power plants and industries, *e.g.*, by using natural gas which is a better fuel than coal or using coal with less sulphur content.

(*iii*) By using catalytic converters in cars so that NO_x present in the exhaust gases is converted into N_2 at 573 K. (The main component of the converter is a ceramic honeycomb coated with precious metals like Pt, Pt and Rh).

(*iv*) By adding powdered limestone to neutralize the acidity of the soil.

Q9. How can you classify water pollution into different types? Briefly explain each one of them. What are the sources of water pollution?

Answer: Any undesirable change in water which has negative impact over living beings is known as water pollution. Water pollution is a major global problem which requires ongoing evaluation and revision of water resource policy at all levels (international down to individual aquifers and wells).Water pollution basically are of two types i.e.

Surface water pollution:

(i) Fresh water (ii) Marine water

Ground water pollution:

(Explain above points in details)

There are different sources of water pollutions which are as follows

(i) Sewage and waste (ii) Industrial effluents (iii) Agriculture discharge

(iv) Industrial waste:

(Explain above points in details with suitable examples)