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NET LIFE SCIENCE

ECOLOGY

FOR CSIR NET LIFESCIENCE

MODULE 10

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A. THE ENVIRONMENT

Ecology is the division of science that examines the interactions between living organisms and their environments. **Ecology** term was coined by Ernst Haeckel from the Latin words Oikos (home) and Logos (study of). Ecology is the study of the interrelationships between organisms and their environment and interaction of the biotic and abiotic components of the environment.

“Ecology is the study of the structure, function, behavior, and interaction of the natural systems that comprise the biosphere.”

A **biological species** includes all organisms of a group that reproduce and produce fertile offspring in nature. In simplest terms, organisms that do not achieve this in nature are different species or kinds, because **gene flow** among them is not possible without reproduction. Most species are divided up into local **populations** that are partially separated from one another by a physical (e.g., mountain) or chemical (e.g., saline) barrier. Gene flow is reduced but not cut off. The several populations of different species that live together and interact form a **community**. The community of organisms and their physical/chemical environment constitute an **ecosystem**.

“Ecology is science of all relations of all organisms to all their environment”. (Taylor)

“Ecology is interaction of forms, functions and factors” (R. Mishra)

Environment:

The term environment etymologically means surroundings. Thus, environment is a complex of so many things (light, temperature, soil, water, etc.) which surround an organism. Any external force, substance or condition, which surrounds and affects the life of an organism in any way, becomes a factor of its environment. These factors have been variously called as environmental factors, ecological factors or simply factors and may be living (biotic) as well as non-living (abiotic). The sum of all these living and non-living factors makes the environment of an organism. The place, where an organism lives - habitat, indeed presents a particular set of environmental conditions - the environmental complex.

Most of the ecologists, prefer to recognise four categories of ecological factors, which Life as follows

1. Climatic or aerial factors:

- (1) Light.
- (2) Temperature of air (atmospheric temperature).
- (3) Rainfall (precipitation).
- (4) Humidity of air.
- (5) Atmosphere (gases and wind).

2. Topographic or physiographic factors:

These are the factors related with physical geography of earth, and include

- (1) Altitude.
- (2) Direction of mountain chains and valleys
- (3) Steepness and exposure of slopes etc.

3. Edaphic factors: these deals with the formation of soil, its physical and chemical properties and details of related aspects.

4. Biotic factors: These are all kinds of interactions between different forms of life, i.e., plants, animals, microorganisms etc.

A1. PHYSICAL ENVIRONMENT

An important aspect of the effects of environment on the life of an organism is the interaction of ecological factors. Actually under natural conditions, at the same time, the life or organism is affected by the sum of all ecological factors-the environment and not by any individual factor. All the factors are interrelated. Variations in one may affect the other. For instance, an increase in temperature would certainly bring out a decrease in humidity values. Increased light intensity, in addition to affecting the rate of photosynthesis, would affect the atmospheric humidity. Thus, at a given time effect on the organism's life is an overall effect of these interrelated factors, and thus it becomes very difficult indeed sometimes to say as which of the individual factors is actually responsible for the marked effect on organism's life. Thus ecological factors in affecting an organism's life under natural conditions, operate in conjunction and not in isolation, as we have an interaction between various factors. Thus, in considering the ecological factors separately for distinguishing and measuring the effect of each, one must remain aware that in nature these factors never act alone. Organism is subjected to many influences at the same time, and the effect of one factor usually modified by the other factor(s).

Since various ecological factors affect the life of an organism in a holistic manner (i.e., all the interacting factors operate in conjunction and not in isolation), it becomes difficult to understand this mechanism of the nature of influence of individual factor. To understand this mechanism of environmental influence, it thus becomes essential to study the effect of each factor separately, and this is said to be an analytical approach.

1. Climatic Factors:

Climate of any region is chiefly determined by such meteorological influences as relative humidity of air, temperature, wind pressures and evaporation rates. Climatic factors characterise, in general, a particular region.

These factors, concerned mainly with the aerial environment of organisms, include light, temperature of air, humidity of air, precipitation (rainfall) and gaseous components of atmosphere including wind. We will discuss each of them in detail.

1.1 Light Factor

Light plays an important role in the species composition and development of vegetation. Light is abundantly received on the surface of the earth. And, on an average approximately only 2-3 per cent of this solar energy is used in Primary Productivity.

Light intensity shows special variations due to the factors like atmospheric water layer, particles dispersed in the air, etc. Further, the vegetation of an area may also affect the light intensity. In deep shade under trees, or under water, light becomes limiting below which photosynthesis is not sufficient for effective growth.

1.1.1 Effect of Light on Plants:

Light plays a vital role directly or indirectly in regulating the growth (structure, form, size), metabolism, development and distribution of plants. The plants are influenced by light in the following ways:

Effect on Chlorophyll synthesis: The synthesis of chlorophyll in green plants can take place only in the presence of light. It is seen that if a coprophilous plant is kept in prolonged darkness, the chlorophyll amount practically disappears.

Effect on number and Position of Chloroplasts: Light has marked effect on the number and position of chloroplasts, the chlorophyll bearing organell. The upper surface of leaves which receive maximum sunlight has the largest number of chloroplasts arranged in line with the direction of light. On the other hand, the leaves of the plants which shade chloroplasts are very few in number and arranged at right angles to the light rays, thus increasing the surface of absorption.

Effect on Photosynthesis: Photosynthesis is a process of conversion of solar energy (light) into chemical energy (in presence of chlorophyll) which is subsequently used for the preparation of carbohydrate from carbon dioxide and water.

From the above statement, it is clear that light is highly essential for photosynthesis. The rate of photosynthesis is slower at lower intensity and it increases linearly with increasing light intensity upto a particular point, known as "Saturation point," and after attaining this point, it remains constant. The intensity of light at which the plants no longer carry on photosynthesis or when the photosynthesis balances respiration is called compensation intensity.

Effect on Respiration: In plants, respiration is a process of the oxidation of carbohydrate (produced in the photosynthesis) into carbondioxide and water. According to Calvin, the rate of respiration increases at higher light intensity and it decreases at lower light intensity.

Effect on Transpiration: The rise in atmospheric temperature which may be due to the conversion of solar radiation into heat increases the rate of transpiration. The process of opening of stomata (which depends upon light) leading to loss of water from the aerial surface of plants is known as transpiration.

Effect on Production of Hormone: Light inhibits the synthesis of auxins or growth hormones in plants as a result of which the shape and size of the plants gets modified.

Effect on development of Flowers, Fruits and Vegetative parts: The intensity of light largely influences the growth and development of flowers, fruits and vegetative parts of plants. Light of higher intensity favours development of flowers, fruits and seeds but light of lower intensity promotes the development of vegetative parts and causes delicacy.

Effect on Formation of Anthocyanin Pigment: Intense light helps in the formation of anthocyanin pigments in plants. The plants in Alpine regions have beautiful flowers containing this pigment.

Effect on Movement: The effect on sunlight in modulating the movement of plants is called phototropism or heliotropism. The elongation on stem towards light is known as positive phototropism and the movement of roots away from light is known as negative phototropism. The leaves grow transversely to light.

Effect on Photoperiodism: The response of plants to the relative length of the day (known as photo-period) is known as photoperiodism. According to the response of the plants to the length of the photoperiod, the plants have been classified into three groups:

(i) Long Day Plants (LDP): The plants which bloom when the light duration is more than 12 hours per day e.g. radish, potato, spinach, etc.

(ii) Short Day Plants (SDP): The plants which bloom when the light duration is lesser than 12 hours per day e.g. cereals, tobacco, cosmos, dahlia etc.

(iii) Day neutral Plants (DNP): The plants which show little response to the length of the day light e.g. cotton, balsam, tomato, etc.

B2. FUNDAMENTAL NICHE AND REALIZED NICHE:

Physical features of the environment such as temperature, water, nutrient availability, light, salinity, and pH, which are termed as abiotic factors; limit both the distribution patterns of organisms and their abundance.

Some species can tolerate a comparatively wide range of physical conditions while others tolerate only a narrow range. Each species usually functions finest over only a limited range of abiotic conditions called a species' physiological optimum or **fundamental niche**. This term was first coined by Joseph Grinnell in 1917 during his studies of the life histories of birds. Indeed, some part of the fundamental niche may be already used by competitors. Hence, the actual niche limit of an organism in nature is termed the **realized niche**. Other organisms, like predators or parasites (biotic factors), may also contribute to the formation of realized niches by limiting the areas inhabited by their prey or hosts.

Sometimes fundamental niche and realized niche are termed as pre-competitive and post-competitive niches, reflecting the interspecific competition's effect on niches. Realized niche for different populations of same species may also vary, because of differences in competitors and predators between locations.

- Fundamental Niche > Realized Niche (Inhibition/Competition)
- Fundamental Niche = Realized Niche (Tolerance)
- Fundamental Niche < Realized Niche (Facilitation/Symbiosis)

Ecologists usually identify the fundamental niche of a species by testing the range of conditions in which it grows and reproduces in the absence of competitors. They also detect whether a potential competitor limits a species' realized niche, by removing the competitor and checking the expansion of first species into the newly available space. The classic experiment shown in Figure 5 demonstrates that the competition between two barnacle species kept one species from occupying part of its fundamental niche.

Ecological Equivalents: Species that use similar niches in different habitats or locations.

Guilds: Group of species with comparable role and niche dimensions within a community.

The study of niche form and niche relationships has become one of the most explosive areas in community ecology in the past few years. Increasingly studies are being devoted to analysis of niche width, separation or overlap within communities in one or many dimensions. A variety of measures have been proposed so that niche widths and overlaps may be quantified.

Ecologist Joseph Connell studied two barnacle species – *Chthamalus stellatus* and *Balanus balanoides* – that have a stratified distribution on rocks along the coast of Scotland. *Chthamalus* is usually found higher on rocks than *Balanus*. To determine whether the distribution of *Chthamalus* is the result of interspecific competition with *Balanus*, Connell removed *Chthamalus* from the rocks at several sites. Distribution didn't change when *Chthamalus* removed – couldn't colonize area ordinarily occupied by *Chthamalus* because too dry. When *Balanus* removed, *Chthamalus* colonized the entire region. Ordinarily *Balanus* would out-compete *Chthamalus* in the lower regions by growing over them. The niche occupied by *Balanus* is unaffected by *Chthamalus*. The niche occupied by *Chthamalus* is reduced in the presence of *Balanus*. Thus it can be concluded that interspecific competition makes the realized niche of *Chthamalus* much smaller than its fundamental niche (Figure 5).

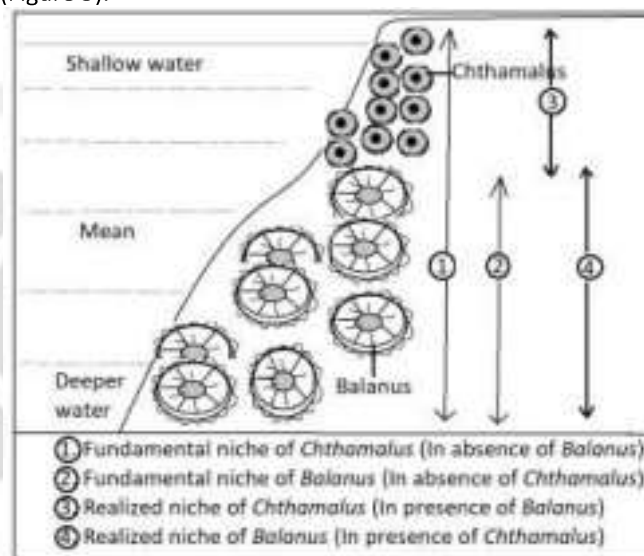


Figure 5: Fundamental and realized niche

B3. NICHE WIDTH

The concept of niche width or niche breadth refers fundamentally to the **diversity of resource use** shown by any one organism or group of organisms.

The organisms/species whose resources use is restricted to a small portion of the available resource spectrum are known to have narrow niches, whereas those who exploit a relatively diverse set of resources within the resource continuum, are defined with broad niches.

There are two situations in which one might wish to compare niche metrics: among species within same community, and between species of different communities. In both cases, the supreme difficulty is standardization of the procedure so that measurements can be compared for different species and different communities.

Practice question 1:

For an experimental population, the net reproductive rate (R_0) is 1.5. If N_t , the population of females at generation t , is 500, then what will be the population of females after four generations (N_{t+4})?

Solution:

$$\text{Step 1: } N_{t+1} = N_t R_0$$

$$\text{Step 2: } N_{t+2} = N_{t+1} R_0$$

$$\text{Step 3: } N_{t+3} = N_{t+2} R_0$$

$$\text{Step 4: } N_{t+4} = N_{t+3} R_0$$

$$N_{t+1} = 500 \times 1.5 = 750$$

$$N_{t+2} = 750 \times 1.5 = 1125$$

$$N_{t+3} = 1125 \times 1.5 = 1687.5$$

$$N_{t+4} = 1687.5 \times 1.5 = 2531.25$$

Thus, the population of females after four generations (N_{t+4}) will be 2531.25

Practice question 2:

Following is the hypothetical life table for species

Age Class (x)	Number alive (n_x)	Number dying (d_x)	Age specific survivorship (l_x)	Age specific fertility (m_x)
0-5	100	50	A	0.0
5-10	50	B	0.5	0.5
10-15	C	10	D	0.5
15-20	20	10	0.2	1.0
20-25	E	10	F	1.0

What will be net reproductive rate (R_0)

Solution:

First, fill value from A to F using concepts of life table.

Value of A (Proportion alive at start of age interval, l_x) will be 1 as at beginning all will be alive. Value of B (number of dying) will be 20 and of C will be 30. If value of C is 30 the value of D will be 0.3. Value of E will be $20-10=10$ and thus value of F will be 0.1.

x	n_x	d_x	l_x	m_x	$l_x m_x$
0-5	100	50	1	0.0	0.0
5-10	50	20	0.5	0.5	0.25
10-15	30	10	0.3	0.5	0.15
15-20	20	10	0.2	1.0	0.2
20-25	10	10	0.1	1.0	0.1
$R_0 = \sum l_x m_x$					0.7

Thus, net reproductive rate (R_0) will be 0.7

Practice question 3:

Complete the following hypothetical life table of a species to calculate the net reproductive rate (R_0):

Age class (x)	Number alive (n_x)	Number of dying (d_x)	Age specific survivorship (l_x)	Age specific Fertility (m_x)
0-1	1000			0
1-2	800			0
2-3		200		0.5
3-4	300	100		1.0
4-5		200		1.0

Solution:

First, fill blank space using concepts of life table.

x	n_x	d_x	l_x	m_x	$l_x m_x$
0-1	1000	200	1.0	0	0
1-2	800	300	0.8	0	0
2-3	500	200	0.5	0.5	0.25
3-4	300	100	0.3	1.0	0.30
4-5	200	200	0.2	1.0	0.20
$R_0 = \sum l_x m_x$					0.75

Thus, net reproductive rate (R_0) will be 0.75

C3. POPULATION GROWTH CURVES**1. Population growth under unlimited resources leads to J-shaped population growth curves**

Population growth often proceeds in a similar pattern to how savings accumulate in an interest-bearing bank account. The greater the population growth rate, the faster a population grows.

Many populations are known to breed seasonally, often once a year. In these cases, the population grows geometrically. On the other hand, some species reproduce almost continuously and generations overlap. All ages of individuals, from babies to juveniles and reproductive adults are present at the same time. In these cases, the population grows exponentially. Geometric growth and exponential growth are described by slightly different mathematical models but both produce J-shaped population growth curves.

1.1 Periodic breeder shows geometric population growth

If a population's net reproductive rate, R_0 is known, the population growth can be predicted on its basis. The simplest type of growth is that of an annually breeding species with no limits to growth at the present, for example, a butterfly that breeds once a year and has a life span of 1 year.

The plant species with the lowest R^* should displace all the others from the habitat, driving the resource concentration to its R^* (Figure 58c).

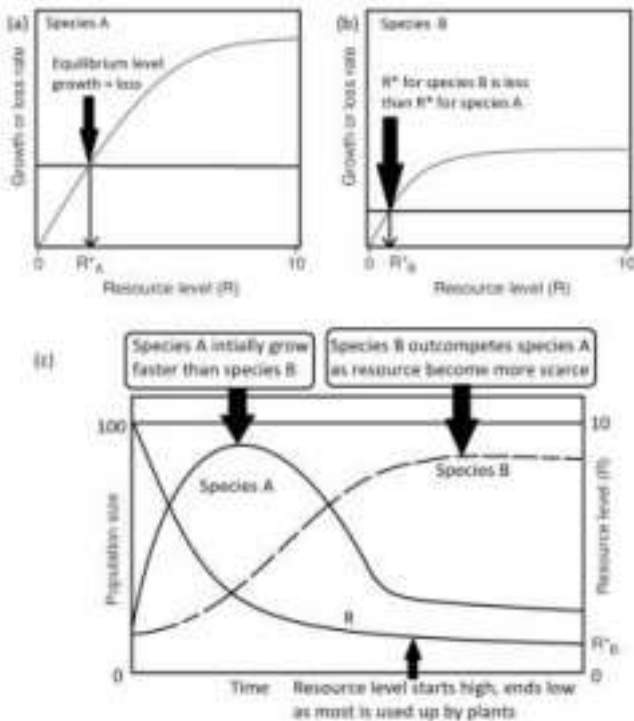


Figure 58: Tilman's R^* (R star concept) of competition between two species, A and B, based on resource utilization curve.

Practice question 1:

For two species A and B in competition, the carrying capacities and competition coefficients are

$$\begin{aligned} K_A &= 150 & K_B &= 200 \\ \alpha &= 1 & \beta &= 1.3 \end{aligned}$$

According to the Lotka-Volterra model of interspecific competition, the outcome of competition will be

Solution:

$$\frac{K_A}{\alpha} = \frac{150}{1} = 150$$

$$\frac{K_B}{\beta} = \frac{200}{1.3} = 153.8$$

Thus,

Carrying capacity for species A is lesser than ratio of K_B/β
 $K_A (150) < K_B/\beta (153.8)$

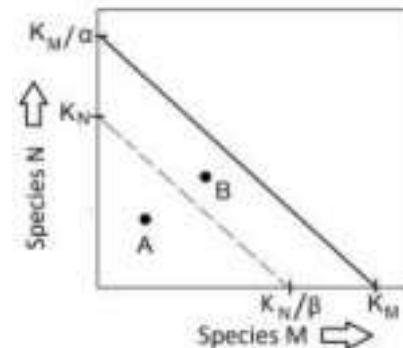
And carrying capacity for species B is higher than ratio of K_A/α

$$K_B (200) > K_A/\alpha (150)$$

Under this scenario, species B will win.

Practice question 2:

Two species, M and N, occupy the same habitat. Given below is a 'state-space' graph in which the abundance of species M is plotted on the X-axis and abundance of species N is plotted on the Y-axis. For each species, the zero-growth isocline is plotted.



— zero-growth isocline for species M
 - - - zero-growth isocline for species N

K_M = carrying capacity of the habitat for species M -in absence of species N

K_N = carrying capacity of the habitat for species N in absence of species M

α = per capita effect of species N on M

β = per capita effect of species M on N

Based on the above plot what deduction can be made?

Answer:

Following deduction could be made on basis of above plot A. At point A, populations of both the species M and N increase since this point below the isoclines of both the species

B. At point B, population of species M increase while that of species N decreases because this point is below the isoclines line for species M but above the isoclines line for species N.

C. Ultimately species M will be winner and species N will be eliminated because $K_M > K_N/\beta$ and $K_N < K_M/\alpha$

Table 23: Effective number of species using the Shannon and Gini-Simpson indices. Data is based on the communities of Table 3, but in communities 1 and 2 there are only two species present.

Community	Relative abundance of species			Sps richness	Diversity index		Effective no of species	
	Species 1	Species 2	Species 3		H_s	D_{GS}	H_s	D_{GS}
1	90	10	-	2	0.325	0.180	1.384	1.219
2	50	50	-	2	0.693	0.50	2.000	2.000
3	80	10	10	3	0.638	0.340	1.893	1.515
4	33.3	33.3	33.3	3	1.099	0.667	3.000	3.000

Each index can be converted to an effective number of species using a different formula. The effective number of species for the most commonly used dominance index, the Gini-Simpson, and the most commonly used information statistic index, the Shannon index are examined for this purpose. For the Shannon index, the exponential is determined and for the Gini-Simpson index, it is subtracted from unity and inverted.

For example, if we take the exponential of the Shannon index of 1.609 we get 5.00. If we subtract the Gini-Simpson index from unity and invert it, $1/(1 - 1.8)$, we also get 5.00. In this example, the effective number of species is the same as the actual number of species, but it is not always true. The value of the effective number of species concept becomes more obvious when the communities with uneven species frequencies are considered, as in **Table 23**.

Here, it is easier to compare communities using the effective number of species. It is found that community 3 is 36.8% more diverse than community 1 when using the Shannon effective number of species. Where one species dominates a community even slightly, the Gini-Simpson effective number of species gives a lower value than the Shannon effective number of species. This is because of the fact that Gini-Simpson index is a dominance index and it more heavily weights the effects of the dominant species.

Any index that involves the sums of squares of the frequencies, occasionally called an order 2 index, is therefore less acceptable than an order 1 index such as the **Shannon effective number of species**. In turn, species richness is an order 0 index, since it does not take into account frequencies and is a function of the sum of the zeroth power of the frequency.

For these reasons, Jost has reasoned that the Shannon effective number of species is the best measure of diversity and gives some convincing examples. He visualizes a continent with 30 million equally abundant species. A plague kills half the species. The species richness drops 50% but the Shannon index drops only 4%, from 17.2 to 16.5. The Gini-Simpson index drops only 0.000003%, from 0.99999997 to 0.99999993. Converting these indices to the effective number of species yields the same 50% drop as noted by using species richness.

Practice question 1:

The following table shows the number of individuals of each species found in two communities:

Community	Species			
	A	B	C	D
C1	25	25	25	25
C2	80	05	05	10

(Hint: $\ln$ values for 0.05, 0.10, 0.25 and 0.80 are -3.0, -2.3, -1.4 and -0.2, respectively)

Calculate Shannon diversity index (H) values for communities C1 and C2, respectively.

Solution:

The **Shannon index**, H_s , is given by

$$H_s = - \sum_{i=1}^s p_i \ln p_i$$

Where p_i is the proportion of individuals found in the i th species, $\ln$ is the natural logarithm, and Σ is a summation sign.

For community A

Species	n	$p_i (n/N)$	$\ln p_i$	$p_i \ln p_i$
A	25	0.25	-1.4	-0.35
B	25	0.25	-1.4	-0.35
C	25	0.25	-1.4	-0.35
D	25	0.25	-1.4	-0.35
	N=100		$-\sum p_i \ln p_i = 1.4$	

For community B

Species	n	$p_i (n/N)$	$\ln p_i$	$p_i \ln p_i$
A	80	0.80	-0.2	-0.16
B	05	0.05	-3.0	-0.15
C	05	0.05	-3.0	-0.15
D	10	0.10	-2.3	-0.23
	N=100		$-\sum p_i \ln p_i = 0.69$	

Thus, Shannon diversity index (H) values for communities C1 is 1.4 and for C2 is 0.69.

Table 36: National Ambient Air Quality Standards of India

Pollutant	Time Weighted Average	Concentration in Ambient Air
Sulphur Dioxide (SO ₂),	Annual	50 µg/m ³
	24 hours	80 µg/m ³
Nitrogen Dioxide (NO ₂)	Annual	40 µg/m ³
	24 hours	80 µg/m ³
PM ₁₀ (Particulate Matter size less than 10 µm)	Annual	60 µg/m ³
	24 hours	100 µg/m ³
PM _{2.5} (Particulate matter size less than 2.5 µm)	Annual	40 µg/m ³
	24 hours	60 µg/m ³
Ozone (O ₃)	8 hour	100 µg/m ³
	1 hour	180 µg/m ³
Lead (Pb)	Annual	0.5 µg/m ³
	24 hours	1.0 µg/m ³
Carbon Monoxide (CO)	8 hour	2.0 mg/m ³
	1 hour	4.0 mg/m ³
Ammonia (NH ₃)	Annual	100 µg/m ³
	24 hours	400 µg/m ³
Benzene (C ₆ H ₆)	Annual	5 µg/m ³
Benzo(a)Pyrene	Annual	1 ng/m ³
Arsenic (As)	Annual	6 ng/m ³
Nickel (Ni)	Annual	20 g/m ³

2. WATER POLLUTION

Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state.

Different type of water is placed in classes A-E on basis of amount of total coliforms, pH, dissolved oxygen and biological oxygen demand (Table 37).

2.1 Sources of Water Pollution:

Water is an essential commodity for survival. We need water for drinking, cooking, bathing, washing, irrigation, and for industrial operations. Most of the water for such uses comes from rivers, lakes or groundwater sources. Water has the property to dissolve many substances in it, therefore, it can easily get polluted.

Pollution of water can be caused by “**point sources**” or “**non-point sources**”. Point sources are specific sites near water which directly discharge effluents into them. Major point sources of water pollution are industries, power plants, underground coal mines, offshore oil wells etc. The discharge from non-point sources is not at any particular site, rather, these sources are scattered, which individually or collectively pollute water. Surface run-off from agricultural fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition etc., are the non-point sources of water pollution.

Table 37: Different class of water with their best use and criteria for classification

Class	Best Use	Criteria
A	Drinking Water without conventional treatment but after disinfection	• Total Coliforms Organism MPN/100ml shall be 50 or less • pH between 6.5 and 8.5 • Dissolved Oxygen 6mg/l or more • Biochemical Oxygen Demand 5 days 20C 2mg/l or less
B	Outdoor bathing (Organised)	• Total Coliforms Organism MPN/100ml shall be 500 or less pH between 6.5 and 8.5 • Dissolved Oxygen 5mg/l or more • Biochemical Oxygen Demand 5 days 20C 3mg/l or less
C	Drinking water source after conventional treatment and disinfection	• Total Coliforms Organism MPN/100ml shall be 5000 or less pH between 6 to 9 • Dissolved Oxygen 4mg/l or more • Biochemical Oxygen Demand 5 days 20C 3mg/l or less
D	Propagation of Wild life and Fisheries	• pH between 6.5 to 8.5 • Dissolved Oxygen 4mg/l or more • Free Ammonia (as N) 1.2 mg/l or less
E	Irrigation, Industrial Cooling, Controlled Waste disposal	• pH between 6.0 to 8.5 • Electrical Conductivity at 25C micro mhos/cm Max. 2250 • Sodium absorption Ratio Max. 26 • Boron Max. 2mg/l
Below-E		• Not Meeting A, B, C, D & E Criteria

2.2 Ground Water Pollution:

Ground water forms about 0.6% of the total water available on planet earth and is about 30 times more than surface water (streams, lakes and estuaries). Ground water seems to be less prone to pollution as the soil mantle through which water passes helps to retain various contaminants due to its cation exchange capacity. However, there are a number of potential sources of ground water pollution. Septic tanks, industry (textile, chemical, tanneries), deep well injection, mining etc., are mainly responsible for ground water pollution, which is irreversible. Ground water pollution with arsenic, fluoride and nitrate are posing serious health hazards.

2.3 Surface water pollution:

The major sources of surface water pollution are:

1. **Sewage:** Emptying the drains and sewers in fresh water bodies causes water pollution. The problem is severe in cities.

Table 43: The mega diversity countries and the number of flowering plants species

S. No.	Country	No. of flowering plant species
1	Brazil	56,215
2	Columbia	48,000
3	China	32,200
4	Indonesia	29,370
5	Mexico	23,424
6	Venezuela	21,073
7	Ecuador	21,000
8	Peru	17,144
9	Australia	15,638
10	Malaysia	15,000

Conservation International takes into account the number of species that are **endemic**, found only in a particular place or region and nowhere else. This approach suggests that conservationists should focus their efforts on biodiversity **hot spots**, areas with the greatest number of endemic species.

Endemic species can be defined as those species which are confined only to a particular locality. There are two important categories of endemic species-

Palaeo-endemics and Neo-endemics: Palaeoendemics are phylogenetically distinct taxa which arose in tertiary and bound to islands or environmentally isolated situations. Neoendemics, on the other hand, are those which have arisen relatively recently. Endemism represents a unique step in the process of evolution which could be perpetuated and sustained only in the locality concerned depending on the environmental quality. It is the environment which is instrumental in the operation of the process of natural selection. This makes the habitats in which endemic species thrive, very important. The significance of the habitat is further highlighted by the fact that in most of the cases such localities possess a number of endemic species distributed in several taxonomic categories.

In the process of natural selection, changes which confer some disadvantage to the organism to survive in the existing environmental condition are eliminated while those changes which are advantageous are retained. There should always be a sustained effort to conserve the endemic species and their habitat.

4.2. Conservation of Hot spot of biodiversity

A biodiversity hotspot is a biogeographic region with significant levels of biodiversity that is threatened with humans. They are also areas with a high diversity of locally endemic species, which are species that are not found or are rarely found outside the hotspot. The concept of biodiversity hotspots was given by Norman Myers.

To qualify as a hotspot, a region must meet two strict criteria:

1. It must contain at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics.
2. It has to have lost at least 70 percent of its original habitat.

Vascular plants were chosen to determine whether an area qualifies as a hot spot, mainly because most other terrestrial organisms depend on them to some extent.

At present there are 36 designated hot spots that together occupy a mere **2.4% of the Earth's surface but contain 180,000 endemic plant species, which accounts for 60% of the world's total plant species**. By one estimate, despite comprising 2.4% of Earth's land surface, forests, wetlands and other ecosystems in hotspots account for 35% of the "ecosystem services" that vulnerable human populations depend on.

Of these areas, **Tropical Andes** are an area of rich biodiversity. This location contains about 45,000 plant species of which 20,000 are endemic which is **highest among hotspots**. It is followed by Sundaland, the region including Malaysia, Indonesia, and surrounding islands have the most endemic plant species (Table 44). This approach suggests that protecting geographic hot spots will prevent the extinction of a larger number of endemic species in comparison with protecting areas of a similar size elsewhere.

Table 44: Global numbers of endemic species in the top 10 hot spots of the world. Areas are ranked by the numbers of species of endemic plants.

Rank	Hot spot	Plants	Birds	Mammals
1	Tropical Andes	20,000	584	75
2	Sundaland	15,000	146	173
3	Mediterranean Basin	11,700	32	25
4	Madagascar	11,600	183	144
5	Brazil's Atlantic Forest	8,000	148	71
6	Caribbean	7,868	148	51
7	Indo-Burma	6,750	73	73
8	Cape Floristic Province	6,210	6	4
9	Philippines	6,091	185	102
10	Brazil's Cerrado	4,000	16	14