BASIC ENVIRONMENTAL ENGINEERING & ELEMENTARY BIOLOGY

NOTE:

WBUT course structure and syllabus of 2nd Year has been changed from 2011. Previously **Environment and Ecology** was in 2nd semester. That has been shifted to 2nd Year in present curriculum as **BASIC ENVIRONMENTAL ENGINEERING & ELEMENTARY BIOLOGY**. The Syllabus of Environment and Ecology has been redesigned; few new topics have been introduced. Taking special care of this matter we are providing the relevant WBUT questions and solutions of 2nd semester papers from 2005 to 2009 and & new solution papers of both semesters, so that students can get an idea about university questions patterns.

FUNDAMENTALS OF ENVIRONMENT

Multiple Choice Type Questions

1. Road traffic noise is measured by [WBUT 2013(ODD)]
a) L_{10} (18 hour) index b) $L_e P_n$ c) L_{eq} d) none of these
Answer: (a)

2. In logistic growth equation, zero population growth (ZPG) means [WBUT 2013(ODD)]
a) $dN/dt = 0$ b) $dN/dt > 0$ c) $dN/dt < 0$ d) none of these
Answer: (a)

3. Floods are caused by [WBUT 2015(EVEN)]
a) afforestation b) constructing mega dams
c) cutting the forests d) filling the land
Answer: all of these

4. The important mineral for generation of atomic energy is [WBUT 2015(EVEN)]
a) Uranium b) Thorium c) Hafnium d) Lawrencium
Answer: (a)

5. Biogas is _____ type and nuclear energy is _____ type of energy resource. [WBUT 2015(ODD)]
a) conventional, non conventional b) non conventional, conventional
c) both conventional d) both non conventional
Answer: (b)

6. The mathematical formulation of environmental resistance is [WBUT 2015(ODD)]
a) N = K/2 b) 1 – (N/K) c) 70/r% d) rK/4
Answer: (b)

7. The law of minimum was proposed by [WBUT 2015(ODD)]
a) Liebig b) Woodbury c) Odum d) Krebs
Answer: (a)

8. The growth rate of population at the population saturation value is [WBUT 2016(EVEN)]
a) zero b) negative
c) greater than zero d) none of these
Answer: (a)

9. The maximum sustainable yield is obtained when the population is
a) half of the carrying capacity
b) one-fourth of the carrying capacity
c) double of the carrying capacity
d) two-third of the carrying capacity
[WBUT 2016(EVEN)]

Answer: (a)

10. For maximum sustainable yield
a) $N = K/2$
b) $N/K = 4$
c) $K = N/2$
d) none of these
[WBUT 2017(ODD)]

Answer: (a)

Short Answer Type Questions

1. What is acid rain? Why it is called so? Mention three detrimental effects of acid rain. [WBUT 2005, 2007, 2008, 2014(EVEN)]

OR,

What is acid rain? Write down the causes, reaction and effects of acid rain. [WBUT 2009, 2013(EVEN)]

OR,

What is acid rain? Give the chemical reactions leading to the formation of acids? How does acid rain affect an aquatic ecosystem? [WBUT 2013(ODD)]

OR,

What is acid rain? How is it formed? Discuss its effect on environment. [WBUT 2016(EVEN), 2017(ODD)]

Answer:

Acid rain is an environmental problem that knows no boundary. Acid rain is infact cocktail of mainly H_2SO_4 and HNO_3 where the ratio of these two may vary depending upon the relative quantities of oxides of nitrogen and sulphur emitted. H_2SO_4 is the major contributor (60% –70%) to acid precipitation, HNO_3 ranks second (30% – 40%) and HCl third.

Literally it means the presence of excessive acids in rain-water.

Causes of acid rain:

Acidification of environment is a man made phenomenon. There is no doubt that most acids come from human activities like automobiles, factories, power station etc. But there have always been some acids in rain, coming from volcanoes. This is natural phenomenon.

There is some direct and indirect adverse effects acid rain on different segments of environment. These are -

(a) Effect on aquatic ecosystem:

i) Many fish species disappear due to the acidification of lake, pond, river etc.
ii) Many bacteria and blue green algae, which are important ecological factors, are killed due to the acidification of water body.
iii) Acid rain reduces the production of phytoplankton in the lake.

(b) Effect on Terrestrial ecosystems:

i) Leaves of plants and trees are damaged due to acid rain. As a result rate of photosynthesis is reduced.

ii) Nutrients like Ca, K, Fe and Mg have been leached out from the soil by acid rain. These nutrients are most essential for the plant growth.

(c) Effect of acid rain on building:

i) Acid rain causes extensive damage to buildings and structural materials of marble, limestone, slate etc. Limestone is attacked rapidly.

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2 \uparrow$$

The attack on marble by acids is called 'stone leprosy'

ii) Acid rain also corrodes house, monuments, statues, bridges, railing etc.

(d) Effect of acid rain on human beings:

i) Acid rain affects the human nervous system, digestive system and respiratory system.

ii) Heavy metals such as Cu, Cd, Hg, Zn, Cr etc. liberated from the soil due to acid rain may eventually reach to human body via plant and animal in the food chain or through drinking water supplies.

Reaction for the formation of Acids in Atmosphere:

Acid rain is one kind of acid deposition on Earth, which can be either wet (rain, snow, dew, fog etc.) or dry (dust particles containing sulphates and nitrates). However, wet deposition is much more common.

Every source of energy that we use like coal, wood or petroleum product, has sulphur and nitrogen. These two elements, when burnt in atmospheric oxygen, convert into their respective oxides (SO_x & NO_x), which are highly soluble in water. As a result, the acids are formed in atmosphere.

In case of sulphur, the following reactions are taking place –

$$S + O_2 \rightarrow SO_2$$

$$SO_2 + \tfrac{1}{2}O_2 \rightarrow SO_3$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

In case of nitrogen, the following reactions are taking place –

$$N_2 + O_2 \rightarrow 2NO$$

$$NO + \tfrac{1}{2}O_2 \rightarrow NO_2$$

$$NO + O_2 \rightarrow NO_3$$

$$NO_2 + NO_3 \rightarrow N_2O_5$$

$$N_2O_5 + H_2O \rightarrow HNO_3$$

H_2SO_4 and HNO_3 thus formed combine with HCl which are emitted from different sources, to generate precipitation which is commonly referred to as acid rain.
Normally unpolluted rain is weakly acidic and has pH of 5.6, because CO_2 from the air reacts with water to form H_2CO_3.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

2. What do you understand by the term, 'Maximum sustainable yield'?
[WBUT 2007, 2012 (ODD), 2013(ODD), 2014(EVEN), 2017(EVEN), 2018(ODD)]
Prove that N = K/2 for maximum sustainable yield. (Where N = population size and K = carrying capacity of a system).
[WBUT 2007, 2012 (ODD), 2013(ODD), 2014(EVEN), 2018(ODD)]

OR,

Show if population growth is logistic, then maximum sustainable yield is obtained when population is at half its carrying capacity i.e., $N = k/2$.
[WBUT 2013(EVEN), 2018(EVEN)]

Answer:
Maximum Sustainable Yield is the maximum rate that individuals can be removed without reducing the population size.

In the logistic growth curve of population, growth rate is **not equal at all the points.** The growth rate of population at any point can be determined with the help of the slope at that point. The growth rate would be **maximum** when the slope is **maximum**. The point can be determined when the derivative of the slope is equal to zero.

i.e., $\frac{d}{dt}\left(\frac{dN}{dt}\right) = 0$ [Where, N = population size, K = carrying capacity, r = logistic growth rate const.]

Again, $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$

$\frac{d}{dt}\left[rN\left(1 - \frac{N}{K}\right)\right] = 0$

$r\frac{dN}{dt} - \frac{r}{K}\left(2N\frac{dN}{dt}\right) = 0$

$r\frac{dN}{dt}\left(1 - \frac{2N}{K}\right) = 0$

$1 - \frac{2N}{K} = 0 \quad \left[\text{as}, r\frac{dN}{dt} \neq 0\right]$ ... (1)

$N = K/2$

reduce the population size. The growth at this particular point is called the Maximum Sustainable Yield.

3. Discuss on Logistic model for estimation of population.
[WBUT 2007, 2012(EVEN)]

What is exponential growth of population? Derive the expression. Find out the doubling time of population following the exponential growth.
[WBUT 2007, 2014(ODD)]

OR,

Discuss logistic population growth model. Why is logistic population growth more acceptable?
[WBUT 2016(EVEN)]

Answer:

Population growth curve is not always exponential. Growth of population usually depends on availability of natural resources. With the finite natural resources, a species cannot support any population beyond a certain size. There is an upper limit to the number of individual population which environment can support. This is called the **'carrying capacity'** of environment. Population growth in this kind of environment is known as **logistic growth.**

Carrying capacity of environment often denotes as K and population size (N) is reached to its carrying capacity i.e., N = K, the growth rate of the population I should be zero (Zero Population Growth –ZPG). Population at this point is called **'population at saturation value'.**

In such case, if we plot a graph of population (N) against the time (t), the curve so obtained shall be **'S' shaped.** This kind of curve is called **'sigmoid'** or **'logistic' curve.**

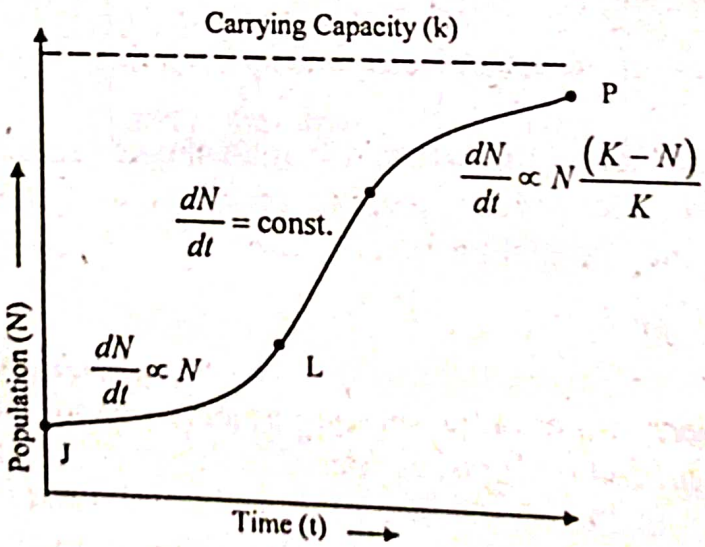


Fig: Logistic Curve

The early part of the above mentioned logistic curve (JLMP) shows that growth rate is **directly proportional** to population, i.e., JL part of the curve is showing that population growth is increasing here **exponentially** $\left(\frac{dN}{dt} \propto N\right)$. Here, population grows exponentially because it is now far below from the carrying capacity i.e., environment is suitable for the growth of population. The growth between point L and M of the above

mentioned curve shows that population growth is constant here $\left(\frac{dN}{dt} = \text{Const.}\right)$. This is called **transitional part of the logistic curve.** Later on the growth from M to P follows the decreasing rate i.e., $\frac{dN}{dt} \propto N\frac{(K-N)}{K}$. As population approaches to the carrying capacity growth rate should be reduced. If population grows beyond the carrying capacity resource limitation shows its adverse effect on population by increasing death rates and reducing birth rates. This is called **'environmental resistance'** or **'growth realization factor'**. Thus the environmental resistance is responsible to change the 'exponential growth curve' to 'logistic growth curve'. The environmental resistance often denoted as $\left(1-\frac{n}{K}\right)$. The logistic equation represents the relationship between the biotic potential, the population growth curve and the environmental resistance. This equation has been proposed by Verhulst (1838), used properly by Lotka (1925) and rediscovered by Pearl and Reed (1930). This is also called ***"Lotka –Volterra model" of population growth.***

4. Explain the basic principle of tracking a pollutant in an environment. How a pollutant can be tracked when pollutant concentration entering the system changes suddenly? **[WBUT 2014(EVEN)]**

Answer:

1st Part:

The basic principles of tracking a pollutant in an environment are

i) redesign products to cause less waste, pollution during manufacture, use or disposal
ii) altering the production process to minimize the use of toxic chemicals
iii) implementing better house keeping practices to minimize leak and fugitive releases from the manufacturing processes

2nd Part:

So far we have computed steady state concentrations in environmental systems that are contaminated with either conservative or non-conservative pollutants. Let us now extend the analysis to include conditions that are not steady state. Quite often, we will be interested in how the concentration will change with time when there is a sudden change in the amount of pollution entering the system. This is known as the *step function response* of the systems.

In Fig: i the environmental system to be modeled has been drawn as if it were a box of volume V that has flow rate Q out of the box. Again, let us assume the contents of the box are at all times completely mixed (a CSTR model) so that the pollutant concentration C in the box is the same as the concentration leaving the box. The total mass of pollutant in the box is therefore VC and the rate of increase of pollutant in the box is $V\,dC/dt$. Let us designate the total rate at which pollution enters the box as S, the source strength, with units of mass per unit time.

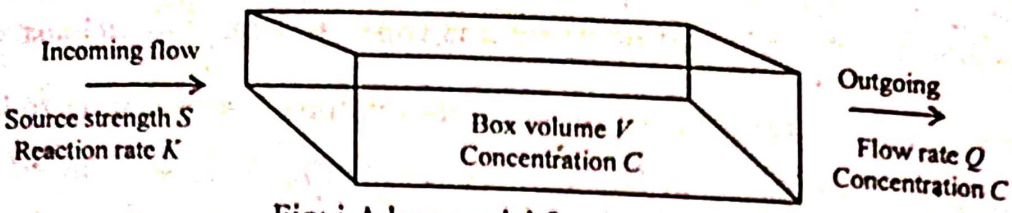


Fig: i A box model for a transient analysis

If the pollutants are non conservative, they will be modeled with a first-order reaction rate coefficient K. We can write

$$\begin{pmatrix}\text{Accumulation}\\ \text{rate}\end{pmatrix}=\begin{pmatrix}\text{Input}\\ \text{rate}\end{pmatrix}-\begin{pmatrix}\text{Output}\\ \text{rate}\end{pmatrix}-\begin{pmatrix}\text{Decay}\\ \text{rate}\end{pmatrix}$$

$$V\frac{dC}{dt}=S-QC-KCV \qquad \ldots (1)$$

where

V = box volume (m^3)
C = concentration in the box and exiting waste stream (g/m^3)
S = total rate at which pollutants enter the box (g/hr)
Q = the total flow rate out of the box (m^3/hr)
K = reaction rate coefficient (hr^{-1})

The preceding units are representative of those that might be encountered; any consistent set will do.

An easy way to find the steady-state solution to the equation (1) is simply to set dC/dt = 0, which yields

$$C_\infty=\frac{S}{Q+KV} \qquad \ldots (2)$$

where C_∞ is the concentration in the box at time $t=\infty$. Our concern now, however, is with the concentration before it reaches steady state, so we must solve the equation (1). Rearranging the equation (1) gives

$$\frac{dC}{dt}=-\left(K+\frac{Q}{V}\right).\left[C-\frac{S}{Q+KV}\right] \qquad \ldots (3)$$

which, using the equation (10), can be rewritten as

$$\frac{dC}{dt}=-\left(K+\frac{Q}{V}\right).(C-C_\infty) \qquad \ldots (4)$$

One way to solve this differential equation is to make a change of variable. If we let

$$y=C-C_\infty \qquad \ldots (5)$$

then

$$\frac{dy}{dt}=\frac{dC}{dt} \qquad \ldots (6)$$

So the equation (4) becomes

$$\frac{dy}{dt} = -\left(K + \frac{Q}{V}\right) y \qquad \ldots (7)$$

which is a differential equation just like (7), which we solved before. The solution is

$$y = y_0 e^{-(K+Q/V)t} \qquad \ldots (8)$$

Where y_0 is the value of y at $t = 0$. If C_0 is the concentration in the box at time $t = 0$, then from the equation (5) we get

$$y_0 = C_0 - C_\infty \qquad \ldots (9)$$

and substituting (5) and (9) into (8) yields

$$C - C_\infty = (C_0 - C_\infty) e^{-(K+Q/V)t} \qquad \ldots (10)$$

Solving for the concentration in the box, writing it as a function of time $C(t)$, and expressing the exponential as exp( ) gives

$$C(t) = C_\infty + (C_0 - C_\infty) \exp[-(K + Q/V)t] \qquad \ldots (11)$$

Equation (11) should make some sense. At time $t = 0$, the exponential function equals 1 and $C = C_0$. At $t = \infty$, the exponential term equals zero, and $C = C_\infty$. Equation (11) is plotted in Fig: ii.

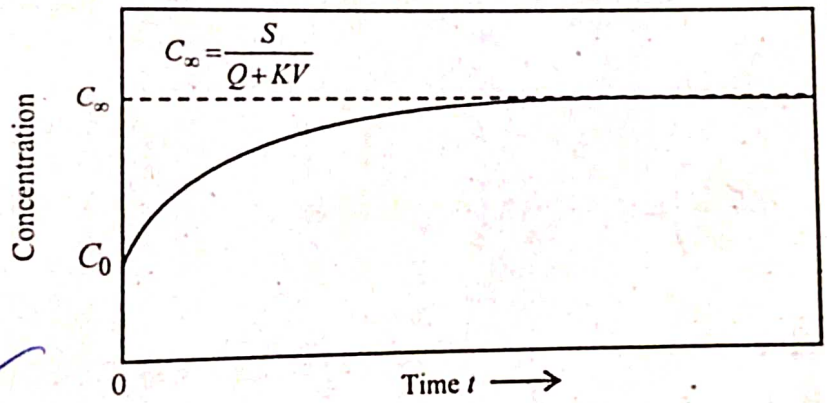


Fig: ii Step Function response for a complete-mix box model

5. It took the world about 300 years to increase in population from 0.5billion to 4.0 billion. If we assume exponential growth at a constant rate over that period of time, what would that growth rate be? **[WBUT 2015(EVEN)]**

Answer:

We know that,

$$N = N_0 e^{Rt}$$

$$4 \times 10^9 = 0.5 \times 10^9 e^{Rx300}$$

or, $e^{Rx300} = 8$

$$R \times 300 = \ln 8$$

$$R = \ln 8 / 300$$

$$R = 0.693\%$$

6. a) What is Maximum Sustainable Yield? **[WBUT 2015(EVEN)]**

b) Prove that maximum sustainable yield $= \frac{R_0 K^2}{4(K - N_0)}$.

[WBUT 2015(EVEN), 2017(EVEN)]]

Answer:

a) & b)

Maximum Sustainable Yield is the maximum rate that individuals can be removed without reducing the population size.

In the logistic growth curve of population, growth rate is **not equal at all the points.** The **growth rate** of population at any point can be determined with the help of the **slope at that point.** The growth rate would be **maximum** when the **slope is maximum.** The point can be determined when the derivative of the slope is equal to zero.

i.e., $\frac{d}{dt}\left(\frac{dN}{dt}\right) = 0$ [Where, N = population size, K = carrying capacity, r = logistic growth rate const.]

again,

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

or, $$\frac{d}{dt}\left[rN\left(1 - \frac{N}{K}\right)\right] = 0$$

or, $$r\frac{dN}{dt} - \frac{r}{K}\left(2N\frac{dN}{dt}\right) = 0$$

or, $$r\frac{dN}{dt}\left(1 - \frac{2N}{K}\right) = 0$$

or, $$1 - \frac{2N}{K} = 0 \quad \left[\text{as, } r\frac{dN}{dt} \neq 0\right]$$

$$\therefore N = K/2 \qquad \ldots (1)$$

This indicates that growth rate would be maximum when population becomes half of its carrying capacity. At this point of the logistic curve, any removal of population will not reduce the population size. The growth at this particular point is called the Maximum Sustainable Yield.

As we know,

$$\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$$

$$\therefore \text{Maximum Sustainable Yield} = \left(\frac{dN}{dt}\right)_{max} = r\frac{K}{2}\left(1 - \frac{K/2}{K}\right)$$

$$\text{or, } \left(\frac{dN}{dt}\right)_{max} = \frac{rK}{4} \quad \ldots (2)$$

Again, initially population grows exponentially, because, at that time $(t=0)$ there is no **'environmental resistance'**. So, population growth

$$\frac{dN}{dt} = R_0 N_0 \quad \ldots (3)$$

[Where, R_0 = population growth rate const. at time t = 0
N_0 = initial population (at, $t=0$)]

Here, $R_0 \neq r$.

Again, we know that, when population follows the logistic growth

$$\frac{dN}{dt} = rN_0\left(1-\frac{N_0}{K}\right) \quad \ldots (4)$$

After comparing these equations, we can write, at $t=0$,

$$R_0 N_0 = rN_0\left(1-\frac{N_0}{K}\right)$$

$$\text{or, } r = \frac{R_0}{1-\frac{N_0}{K}} \quad \ldots (5)$$

$$\therefore \left(\frac{dN}{dt}\right)_{max} = \left(\frac{R_0}{1-\frac{N_0}{K}}\right) \times \frac{K}{4} \quad \text{[From equation no. 2]}$$

$$\text{or, Maximum Sustainable Yield} = \left(\frac{dN}{dt}\right)_{max} = \frac{R_0 K^2}{4(K-N_0)}$$

7. a) What do you understand by the term 'Maximum Sustainable yield'?
b) Define population growth? Prove that population growth is exponential?
[WBUT 2015(ODD)]

Answer:

a) *Refer to Question No. 11(a) of Short Answer Type Questions.*

b) Usually the difference between the birth rate and death rate of the population is called **'population growth rate'**. But sometime rate of migration is also added to it to get the actual population growth.

Prediction or forecasting of population is essential for different engineering as well as scientific purposes. For example, at the time of operation of a waste water treatment plant, the data of growth rate of the bacteria in the 'activated sludge process' over a period of hours or day is required. On the other hand, the data of growth of the local

people for the certain designing period is required to design the water and waste water treatment plant to meet the demand of the people at future.

The population growth may be of two types-

(i) ***Exponential growth:*** The exponential population growth is the rate of change of population with time which is directly proportional to the population itself.

(ii) ***Logistic growth:*** Growth of population depends on the supply of natural resources to them. With the finite or limited natural resources, a species can not support any population beyond a certain size. This type of growth is called **'logistic growth'**.

Exponential Growth of Population

The exponential growth of population is the **change of population with time and it is directly proportional to the size of the population at that time.**

If population size is denoted by 'N' and time by 't', then population growth i.e., rate of change of population with respect to time, can be expressed as –

$$\frac{dN}{dt} \propto N$$

or, $\frac{dN}{dt} = RN$ [R = proportionality const. = rate const.]

or, $\frac{dN}{N} = Rdt$

Integrating the above equation, we get

$$\int_{N_0}^{N_t} \frac{dN}{N} = R\int_0^t dt \qquad \begin{bmatrix} \text{at, time } 't' = 0, N = N_0 \\ \& \text{ time } 't' = t, N = N_t \end{bmatrix}$$

or, $\left[\ln \frac{N_t}{N_0}\right] = R[t-0]$

$\therefore N_t = N_0 e^{Rt}$

If we plot the graph of N Vs t, it would be like the figure above.

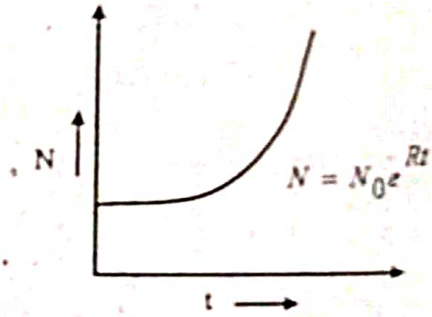


Fig: 1. Graph of Population vs. Time in exponential growth

2nd Part:

Refer to Question No. 3 of Short Answer Type Questions.

8. What do you mean by 'environmental resistance' in determining population growth? Describe step function response in a box system with a suitable diagram.
[WBUT 2015(ODD), 2017(ODD)]

Answer:

Environmental resistance includes a mixture of abiotic factors such as temperature, and biotic factors such as natural enemies (biological control agents) to limit the organism for expressing its full capacity to reproduce.

For rest part: *Refer to Question No. 9 (2nd part) of Short Answer Type Questions.*

9. What is the difference between Resource and Reserve?

[WBUT 2016(EVEN), 2018(ODD)]

Answer:

Mineral reserves are resources known to be economically feasible for extraction. Reserves are either Probable Reserves or Proved Reserves. A Probable Ore Reserve is the part of indicated, and in some circumstances, measured mineral resourcesthat can be mined in an economically viable fashion.

10. World population in 1850 has been estimated to have been about 1 billion. It reaches 4 billion in 1975. Use the exponential growth rate equation to find the growth rate constant and also calculate the doubling time value.

[WBUT 2016(ODD)]

Answer:

We know that

$$N_t = N_0 e^{rt}$$

Here, $N_t = 4$ billion

$N_0 = 1$ billion

$t = (1975 - 1850) = 125$ yrs.

$4 = 1 \times e^{r \times 125}$

or, $e^{125r} = 4$

$\therefore r = 0.01109 = 1.11\%$

$$t_d = \frac{0.693}{0.1109} = 62.5 \text{ yrs.} \quad \text{(Ans.)}$$

11. Suppose the human population follows a logistic curve until it stabilizes at 15.0 billion. In 1986, world's population was 5.0 billion and its growth rate was 1.7%. When would the population reach 7.5 billion?

[WBUT 2017(ODD)]

Answer:

$R_0 = 0.017 \quad N_0 = 5 \times 10^9 \quad K = 15 \times 10^9$

Thus Growth rate $r = \dfrac{R_0}{1 - \dfrac{N_0}{K}} = \dfrac{0.017}{1 - \left(\dfrac{5 \times 10^9}{15 \times 10^9}\right)} = 0.0255$

The time required to reach 7.5 billion or half the final population size (t^*)

$$t^* = \frac{1}{r} \ln\left(\frac{K}{N_0} - 1\right) = \frac{1}{0.0255} \ln\left(\frac{15 \times 10^9}{5 \times 10^9} - 1\right) = 27.18 \text{ Yrs}$$

Long Answer Type Questions

1. In 1970, the world's population was 4 billion and growth rate was 2% per year. Steady-state population is 12 billion. When would the population reach 6 billion? What would be the projected population in 2025 using logistic model? [WBUT 2013(ODD)]

Answer:

$R_0 = 0.02 \quad N_0 = 4\times10^9 \quad K = 12\times10^9$

Thus Growth rate $r = \dfrac{R_0}{1-\dfrac{N_0}{K}} = \dfrac{0.02}{1-\left(\dfrac{4\times10^9}{12\times10^9}\right)} = 0.029$

The time required to reach 6 billion or half the final population size (t^*)

$$t^* = \frac{1}{r}\ln\left(\frac{K}{N_0}-1\right) = \frac{1}{0.029}\ln\left(\frac{12\times10^9}{4\times10^9}-1\right) = 23.9\ Yrs$$

Projected population in 2025 i.e. $t = 55\ yrs$;

$$N = \frac{K}{1+e^{-r(t-t^*)}} = \frac{12\times10^9}{1+e^{-0.029(55-23.9)}} = 8.536\times10^9$$

2. a) Define law of conservation of mass. [WBUT 2014(ODD)]

Answer:

The Law of Conservation of Mass states that matter can be changed from one form into another, mixtures can be separated or made, and pure substances can be decomposed, but the total amount of mass remains constant. We can state this important law in another way. The total mass of the universe is constant within measurable limits; whenever matter undergoes a change; the total mass of the products of the change is, within measurable limits, the same as the total mass of the reactants.

b) Define and classify resource. Discuss how depletion of resource is caused by rapid growth of population and technology. [WBUT 2014(ODD)]

Answer:

1st Part:

Many years ago we used to think that resource should have a material existence. But according to the new conception, resource can be defined as *"a substance or non-substance which has specific functions and can be utilized to meet the needs of people at a definite time and place"*.

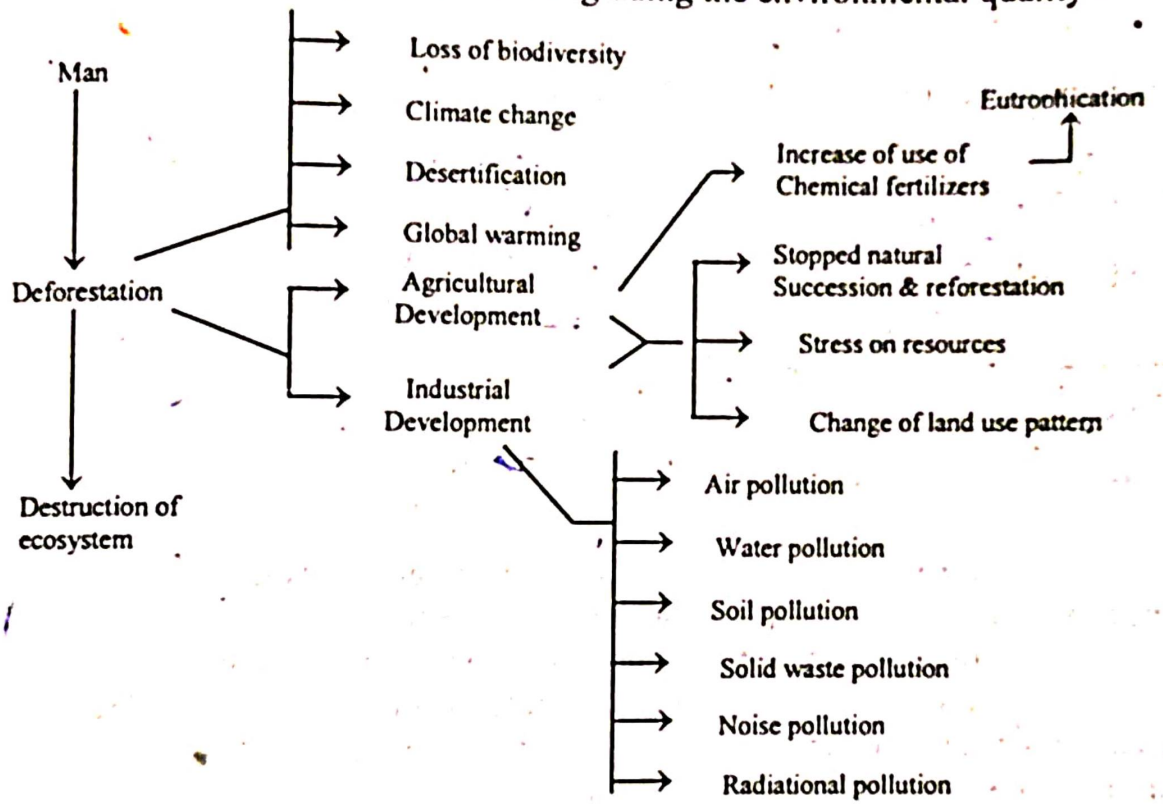
Any substance or non-substance can be classified as resource, resistance and neutral stuff. Resource can be classified as-

(a) Natural resource (air, water, minerals etc.)
(b) Human resource (population, population density etc.)
(c) Cultural resource (knowledge, education etc.)

On the basis of permanency and exhaustibility of resource, it can be classified as –
(a) Renewable resource
(b) Non-renewable resource

2nd Part:

Development of human society requires many natural resources. As a result, the interaction between human beings and the physical environment like land, water, soil air etc. is always going on. But, for all the practical purposes, land is limited, water, though replenish able over a period of time can also become scare. Air is seemingly inexhaustible but become unusable due to severe deterioration of its quality through drastic change in its composition. All these may be attributed to human beings.
The following chart showing how man is degrading the environmental quality –



:) Differentiate conservative substance from non-conservative substance.
[WBUT 2014(ODD)]

Answer:

Conservative Substance – Substance that are not normally physically or chemically transformed to non-toxic substances in the receiving water. These include, but are not limited to, salts and metals.

Non-Conservative Substance – Substance that are transformed to non-toxic substances through physical, chemical, or biological processes in the receiving water. These include biochemical oxygen demand, ammonia and certain other organic compounds.

(3) Define sustainable development. Discuss how depletion of major renewable resources is caused by rapid growth of population and technology.

[WBUT 2015(ODD)]

Answer:

1st Part:

Sustainable development is a development, which **meets the needs of current generation** without **jeoparadising the needs of the future generation.**

There are three basic components of sustainable development –

a) Economic System
b) Social System
c) Environmental System.

These three components are interdependent. The objective of sustainable development is to maximize the goals in the three systems balancing the trade offs and setting priorities among the various goals.

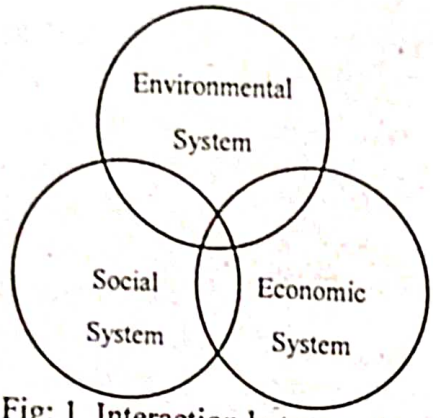


Fig: 1 Interaction between three basic components of Sustainable Development

Objectives of Sustainable Development

Usually, there are two objective of sustainable development –

a) Improvement of **life style** of human beings.
b) **Protection of environment.**

Improvement of Life Style of Human Beings

Both economic and social systems are responsible for the improvement of the life style of human beings.

The economic component of sustainability requires that societies pursue the growth path that generate optimal flow of income while maintaining their basic stock of man made capital, human capital, natural capital. There are three basic goals of an economic system–

i) Increasing production of goods and services
ii) Satisfying basic needs
iii) Improving the economic equity.

But economic development of a particular area should not be considered as a total development of the area. Economic development is only a part of the total development. To achieve the sustainable development, along with economic development, the social development is also required.

The social dimension of sustainable development is built on twin principles of social justice and social equity.

2nd Part:

The growth of population and development of human society requires natural resources. In an ecosystem the interaction between the living organisms and the physical environment like land, water, soil, air etc. is going on. But, for all practical purposes land is limited; water though replenishable over a period of time, can also become scare. Air is seemingly inexhaustible but become unusable due to severe deterioration of its quality through drastic change in its composition. All these may be attributed to the population growth.

The main and immediate priorities for mankind are to provide food for the society. As the population in the society increased and its diversified demand grew, new plant and animal species had to be located and cultivated. To meet the collective requirements, sometimes human beings exploiting his living resources-both flora and fauna.

4. a) Prove that for exponential growth $N_t = N_0^{eRt}$. **[WBUT 2017(EVEN)]**

Answer:

The exponential growth of population is the **change of population with time and it is directly proportional to the size of the population at that time.**

If population size is denoted by 'N' and time by 't', then population growth i.e., rate of change of population with respect to time, can be expressed as –

$$\frac{dN}{dt} \propto N$$

or, $\frac{dN}{dt} = RN$ [R = proportionality const. = rate const.]

or, $\frac{dN}{N} = Rdt$

Integrating the above equation, we get

$$\int_{N_0}^{N_t} \frac{dN}{N} = R\int_0^t dt \qquad \left[\begin{array}{l}\text{at, time } 't' = 0, N = N_0 \\ \text{\& time } 't' = t, N = N_t\end{array}\right]$$

or, $\left[\ln \frac{N_t}{N_0}\right] = R[t - 0]$

$\therefore N_t = N_0 e^{Rt}$

If we plot the graph of N Vs t, it would be

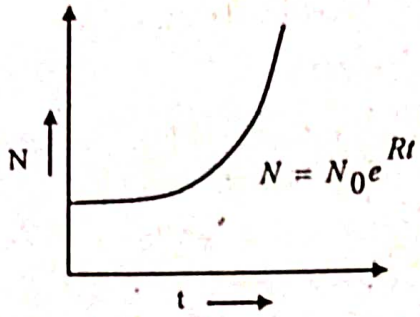


Fig:. Graph of Population Vs Time in exponential growth

b) Show that for doubling time of population for exponential growth $t_b = 70/R(\%)$ where is R is the growth rate. **[WBUT 2017(EVEN)]**

Answer:

The time required for the population becomes double of its present size (N) when it grows exponentially and growth rate is constant through out, is called 'Doubling time' (t_d).

We know that,

$N_t = N_0 e^{Rt}$

$\therefore 2N_0 = N_0 e^{Rt_d}$ [at doubling time (t_d), the initial population (N_0) becomes double $2N_0$]

or, $2 = e^{Rt_d}$

or, $\ln 2 = Rt_d$

$\therefore t_d = \frac{\ln 2}{R} = \frac{0.693}{R}$

If, growth rate is expressed as percentage, then

$t_d = \frac{0.693}{R\%} \simeq \frac{70}{R\%}$

5. Define doubling time (T_d) in an exponential population growth. Show that $T_d = \frac{69.3}{r}$ where, r is the percent population growth rate constant and $\ln 2 = 0.693$.

Answer: **[WBUT 2017(ODD)]**

The time required for the population becomes double of its present size (N) when it grows exponentially and growth rate is constant through out, is called 'Doubling time' (T_d).

We know that,

$N_t = N_0 e^{rT}$

$\therefore 2N_0 = N_0 e^{rT_d}$ [at doubling time (T_d), the initial population (N_0) becomes double $2N_0$]

or, $2 = e^{rT_d}$

or, $\ln 2 = rT_d$

$\therefore T_d = \frac{\ln 2}{r} = \frac{0.693}{r}$

If, growth rate is expressed as percentage, then

$T_d = \frac{0.693}{r\%} = \frac{69.3}{r}$ (Proved).

6. Write short notes on the following:

a) Material balance for steady state system with non-conservative pollutants [WBUT 2013(ODD)]

b) Earthquake [WBUT 2014(ODD)]

c) Logistic growth of population [WBUT 2017(ODD)]

Answer:

a) Material balance for steady state system with non-conservative pollutants:

Many contaminants undergo chemical, biological, or nuclear reactions at a rate sufficient to necessitate treating them as nonconservative substances. If we continue to assume that steady-state conditions prevail so that the rate of accumulation is zero, but now treat the pollutants as nonconservative, then the equation becomes

Input rate = Output rate + Decay rate ... (1)

The decay of nonconservative substances is frequently modeled as a first-order reactions; that is, it is assumed that the rate of loss of the substance is proportional to the amount of the substance that is present. That is,

$$\frac{dC}{dt} = -KC \quad \text{... (2)}$$

where K is a reaction rate coefficient with dimensions of (time^{-1}), the negative sign implies a loss of substance with time, and C is the pollutant concentration. To solve this differential equation, we can rearrange the terms and integrate

$$\int_{C_0}^{C} \frac{dC}{C} = \int_0 (-K)\,dt$$

which yields

$$\ln(C) - \ln(C_0) = \ln\left(\frac{C}{C_0}\right) = -Kt$$

Solving for concentration gives us

$$C = C_0 e^{-Kt} \quad \text{... (3)}$$

where C_0 is the initial concentration. That is, assuming a first-order reaction, the concentration of the substance in question decays exponentially.

The equation (2) indicates the rate of change of *concentration* of the substance. If we assume that the substance is uniformly distributed throughout a volume V, then the total *amount* of substance is CV. The total rate of decay of the amount of a nonconservative substance is thus $d(CV)/dt = V\,dC/dt$, so using (2) we can write for a nonconservative substance:

$$\text{Decay rate} = KCV \quad \ldots (4)$$

Substituting (4) into (1) gives us our final simple, yet useful, expression for the mass balance involving a nonconservative pollutant in a steady-state system:

$$\text{Input rate} = \text{Output rate} + KCV \quad \ldots (5)$$

Implicit in the equation (5) is the assumption that the concentration C is uniform throughout the volume V. This complete mixing assumption is common in the analysis of chemical tanks, called *reactors*, and in such cases the idealization is referred to as a *continuously stirred tank reactor* (CSTR) model. In other contexts, such as modeling air pollution, the assumption is referred to as a *complete mix box model.*

V-1.32

b) Earthquake:

Earthquake is trembling or shaking movement of the earth's surface. Most earthquakes are minor tremors. Larger earthquakes usually begin with slight tremors but rapidly take the form of one or more violent shocks, and end in vibrations of gradually diminishing force called aftershocks. The subterranean point of origin of an earthquake is called its focus; the point on the surface directly above the focus is the epicenter. The magnitude and intensity of an earthquake is determined by the use of scales, e.g., the Richter scale and the Mercalli scale.

Causes of Earthquake:

Most earthquakes are causally related to compressional or tensional stresses built up at the margins of the huge moving lithospheric plates that make up the earth's surface. The immediate cause of most shallow earthquakes is the sudden release of stress along a fault, or fracture in the earth's crust, resulting in movement of the opposing blocks of rock past one another. These movements cause vibrations to pass through and around the earth in wave form, just as ripples are generated when a pebble is dropped into water. Volcanic eruptions, rockfalls, landslides, and explosions can also cause a quake, but most of these are of only local extent. Shock waves from a powerful earthquake can trigger smaller earthquakes in a distant location hundreds of miles away if the geologic conditions are favorable.

Effects of earthquake:

The effects of an earthquake are strongest in a broad zone surrounding the epicenter. Surface ground cracking associated with faults that reach the surface often occurs, with horizontal and vertical displacements of several yards common. Such movement does not have to occur during a major earthquake; slight periodic movements called fault creep can be accompanied by microearthquakes too small to be felt. The extent of earthquake vibration and subsequent damage to a region is partly dependent on characteristics of the

ground. For example, earthquake vibrations last longer and are of greater wave amplitudes in unconsolidated surface material, such as poorly compacted fill or river deposits; bedrock areas receive fewer effects. The worst damage occurs in densely populated urban areas where structures are not built to withstand intense shaking. There, L waves can produce destructive vibrations in buildings and break water and gas lines, starting uncontrollable fires.

Damage and loss of life sustained during an earthquake result from falling structures and flying glass and objects. Flexible structures built on bedrock are generally more resistant to earthquake damage than rigid structures built on loose soil. In certain areas, an earthquake can trigger mudslides, which slip down mountain slopes and can bury habitations below. A submarine earthquake can cause a tsunami, a series of damaging waves that ripple outward from the earthquake epicenter and inundate coastal cities.

Control of earthquake:

There is no such right method to control the earthquake effectively. But earthquake forecasting method is helpful to minimize the damages.

- **Long-Term Forecasting**

Long-term forecasting is based mainly on the knowledge of when and where earthquakes have occurred in the past. Thus, knowledge of present tectonic setting, historical records, and geological records are studied to determine locations and recurrence intervals of earthquakes. Two methods of earthquake forecasting are being employed - paleoseismology and seismic gaps.

- **Short-Term Forecasting**

Short-term predication involves monitoring of processes that occur in the vicinity of earthquake prone faults for activity that signify a coming earthquake.

c) Logistic growth of population:

Refer to Question No. 3 of Short Answer Type Questions.

B-102

ECOLOGY

Multiple Choice Type Questions

1. Living organisms are good examples of [WBUT 2009, 2013(ODD)]
   a) closed system
   b) open system
   c) isolated system
   d) none of these

Answer: (b)

2. An example of a producer is [WBUT 2013(ODD)]
   a) fungus
   b) caterpillar
   c) bird
   d) moss

Answer: (d)

3. Which is not a mega diversity country? [WBUT 2014(EVEN)]
   a) India
   b) China
   c) Mexico
   d) Argentina

Answer: (d)

4. Species with very restricted distribution over relatively small ranges is called [WBUT 2014(EVEN)]
   a) endangered species
   b) extinct species
   c) endemic species
   d) none of these

Answer: (c)

5. Synecology can also be termed as [WBUT 2014(ODD)]
   a) population ecology
   b) landscape ecology
   c) community ecology
   d) none of these

Answer: (c)

6. State the logical sequence of Carbon Cycle in environment is [WBUT 2014(ODD)]
   a) photosynthesis-consumer-decompose
   b) photosynthesis-decompose-consumer
   c) decompose-consumer-photosynthesis
   d) consumer-photosynthesis-decompose

Answer: (a)

7. Agenda 21 is related to [WBUT 2014(ODD)]
   a) greenhouse gases
   b) sustainable development
   c) biodiversity
   d) nuclear pollution

Answer: (b)

8. Synecology can also be termed as [WBUT 2015(EVEN)]
   a) population ecology
   b) landscape ecology
   c) community ecology
   d) none of these

Answer: (c)

9. In which year wildlife (Protection) Act, India, enacted [WBUT 2015(CDD)]
a) 1986 b) 1972 c) 1984 d) 1981
Answer: (b)

10. Energy flow in an ecosystem is [WBUT 2015(ODD)]
a) cyclic b) both cyclic and unidirectional
c) unidirectional d) none of these
Answer: (c)

11. Material cycles go through [WBUT 2015(ODD)]
a) biosphere and lithosphere b) atmosphere and hydrosphere
c) biosphere and hydrosphere d) all of the four spheres
Answer: (d)

12. Species with very restricted distribution over relatively small ranges is called
a) endangered species b) extinct species [WBUT 2016(ODD)]
c) endemic species d) none of these
Answer: (a)

13. An example of biotic factor in a forest ecosystem is [WBUT 2017(EVEN)]
a) water fall b) cliff c) a tree d) a rock
Answer: (c)

Short Answer Type Questions

1. What is ecosystem? [WBUT, 2005, 2018(ODD)]
OR,
What do you understand by 'Ecosystem'? [WBUT 2006]
OR,
Explain what you understand by eco-system. [WBUT 2015(EVEN)]

Answer:
Ecosystem is essentially a technical term for 'nature' that was previously used by many ecologists. The ecosystem is the basic functional unit in ecology since it includes all the living organisms in an area interacting with the physical environment. The term 'ecosystem' was first proposed by a British ecologist, A.G. Tansley in the year 1935.

2. Classify the components of ecosystem. [WBUT 2005, 2006, 2008, 2015(EVEN)]

Answer:
The Earth upon which we live may be considered as a vast ecosystem. The portion of the Earth in which biotic components are present is called biosphere or ecosphere.
The source of energy of an ecosystem is Sun while the Earth comprises the soil, water and air which are non-living (abiotic) materials but provide substance to the vast array of living forms.
From the nutritional (trophic) stand point, an ecosystem has two components, such as,
(a) **Autotrophic components,** in which the organisms fix light energy and utilize substances like **carbon dioxide** (CO_2) and water (H_2O) to produce complex food

materials and (b) **Heterotrophic components** in which the organisms utilize, rearrange and decompose the complex materials synthesized by the autotrophic components.

From the structural stand point, an ecosystem has two sections–

(a) Abiotic component
(b) Biotic component

The abiotic components are again classified as –

(i) Inorganic substances (C, N, CO_2, H_2O etc.)
(ii) Organic substances (Carbohydrate, proteins, lipid etc.)
(iii) Climatic conditions (temperature, humidity etc.)

The biotic components of an ecosystem are again sub divided as –

i) ***Producer:*** These are autotrophic organisms, generally green plants, which are able to manufacture food with the help of abiotic components.

ii) ***Consumer:*** They are relatively big heterotrophic organisms, largely animals which ingest other organisms or get food directly from the producer.

iii) ***Decomposer:*** These are usually microscopic organisms like bacteria and fungi which break down and decompose the complex substances of dead organisms (producers & consumers), absorb the decomposed products and release inorganic nutrients for the reuse by the producers.

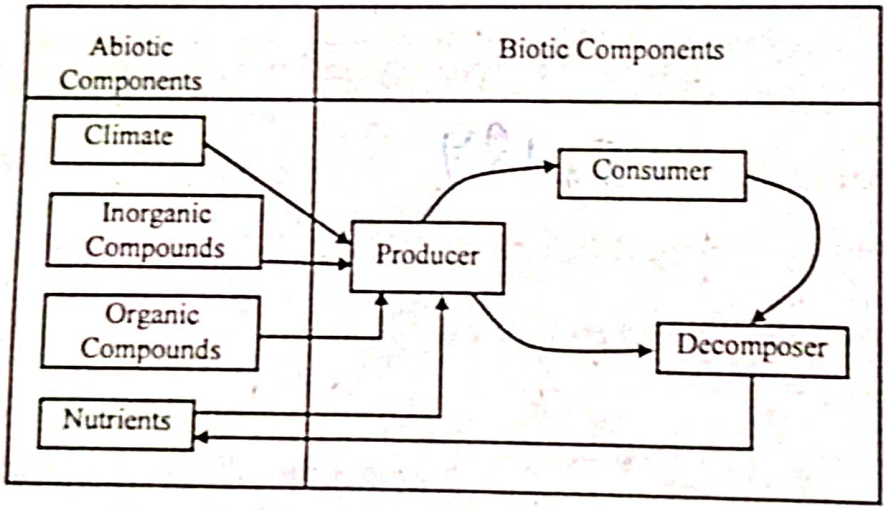


Fig: Structure of an ecosystem

3. What is trophic level? **[WBUT 2005, 2008, 2015(EVEN)]**

Answer:

Each layer of food chain is called trophic level (nutrient level).

4. Explain "Energy flow" in a food chain in terms of the laws of thermodynamics. **[WBUT 2005]**

OR,

"Through the ecosystem, the inorganic nutrients are recycled but flow of energy is unidirectional."– Justify the above statement. [WBUT 2007, 2011(ODD), 2013(ODD)]

OR,

Discuss the energy flow in the ecosystem. **[WBUT 2016(EVEN)]**

Answer:

The Figure (shown below) shows how both energy and inorganic nutrients flow through the ecosystem. Energy flows through the ecosystem in the form of carbon-carbon bonds. When respiration takes place, the carbon-carbon bonds are broken and carbon is combined with oxygen to form carbon dioxide. This process releases the energy, which is either used by the organism or may be lost as heat.

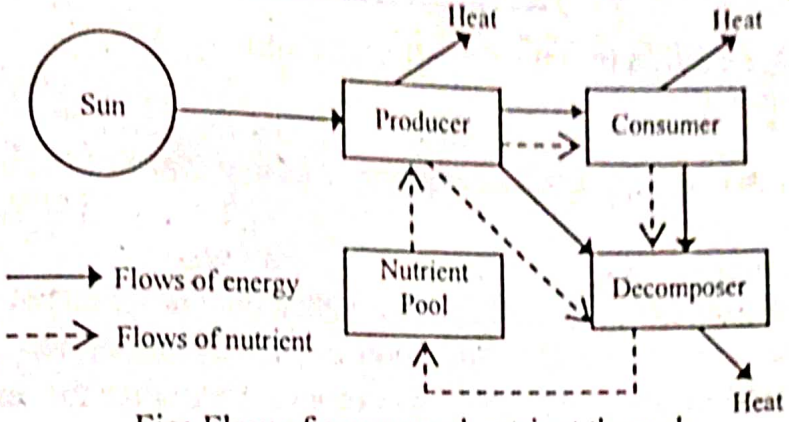


Fig: Flow of energy and nutrient through different components of ecosystem

The dark arrows represent the flow of this energy. All energy comes from the Sun and that the ultimate fate of all energy in the ecosystems is to be lost as heat. Energy does not recycle. It is unidirectional.

The other component shown in the diagram is **inorganic nutrients**. They are inorganic because they do not contain carbon-carbon bonds. The flow of inorganic nutrients is represented by open arrows. The autotrophs obtain these inorganic nutrients from the inorganic nutrient pool (like soil, water etc.). These inorganic nutrients are passed from organism to organism as one organism is consumed by others. Ultimately all organisms die and become detritus, food for decomposers. At this stage, the energy is extracted (and lost as heat) and inorganic nutrients are returned to the pool.

Thus, through the ecosystem, the inorganic nutrients are recycled and energy is not.

5. Define food chain. Discuss grazing food chain with examples.
[WBUT 2006, 2009, 2013(EVEN), 2016(EVEN)]

Answer:

Autotrophs (green plants) convert solar energy into chemical energy and store in food material at the time of photosynthesis. As the autotrophs produce the foods, they are known as producers. The transfer of food (along with energy) from producer (autotroph) to other organisms (consumer or decomposer) forms series of organisms where each one is feeding on the organism preceding it. As a result, a linear chain is developed among the organisms. This chain is known as **food chain.**

In a food chain, the consumers, which feed on only the producer, are known as **Primary Consumer.** Primary consumers are again eaten by **Secondary Consumers** and so on.

Grazing food chain:
This types of food chain starts from producer and ends to a higher consumer level. In every trophic level, the size of the organisms increases while their number decreases.

Grass → Grasshopper → toad → snake

6. Write down nitrogen cycle and explain with a diagram. **[WBUT 2006, 2009]**

OR,

Write down the nitrogen cycle in nature with the help of a suitable block diagram. **[WBUT 2014(ODD)]**

OR,

Write about nitrogen cycle in nature with the help of a suitable block diagram. **[WBUT 2016(EVEN)]**

Answer:
The chief reservoir of nitrogen is atmosphere (78% N_2 is present in atmosphere). Nitrogen as compounds is also present in the bodies of living organisms and in soil. But free nitrogen cannot be utilized directly by the organisms, with the exception of few nitrogen fixing bacteria and blue green algae.

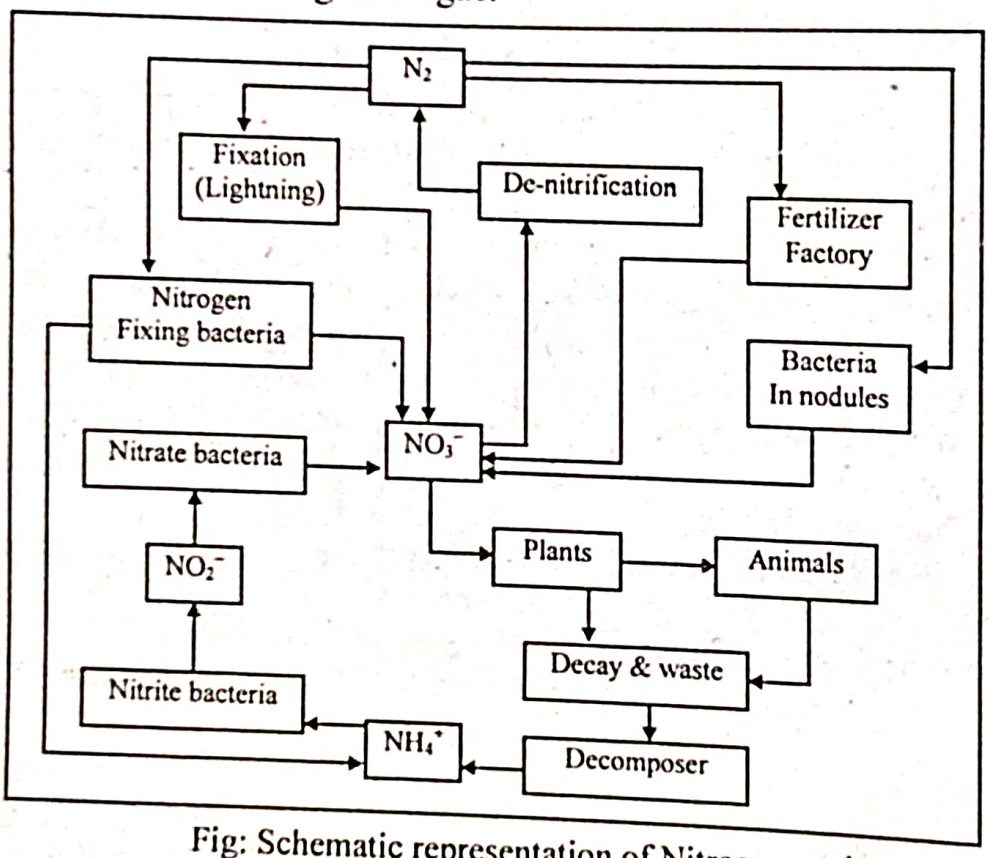


Fig: Schematic representation of Nitrogen cycle

Lightning and some nitrogen-fixing bacteria (Rhizobium, Azotobactor, Anabeana, Nostoc etc.) trapped the atmospheric nitrogen and oxidized to '**nitrate**'. This step is known as **nitrogen fixation.**

The nitrate (NO_3^-) formed in that way is taken up by the plants and animals. After the death, the bodies of both plants and animals as well as their wastes are decomposed by the bacteria to '**ammonia**' (NH_4^+). This step is known as '**ammonification**'.

These ammonium salts (NH_4^+). are converted to nitrite (NO_2^-) This is called nitrification and ultimately nitrite (NO_2^-) returns to nitrate (NO_3^-) This step is known as de-nitrification.

In this way, the whole cycle is completed. This cycle is known as **'Nitrogen Cycle'**.

Oxygen Cycle:

Oxygen is present in large quantities (20.95%v/v) in the atmosphere. It also occurs in the bound state in water and as oxides and carbonates in rocks. It has been estimated that about 1 tonne of oxygen (60,000 moles) is present per square meter of the Earth's surface. Plants in all ecosystems release about 8 moles of oxygen per year per square meter of the Earth's surface during photosynthesis. This amount of oxygen is utilized by plants and heterotrophic organisms in respiration, so that there is a balance between the amount of oxygen production and utilization. Dissolved oxygen in water is the source of oxygen for aquatic life. Another phase of oxygen is the ozone layer of the outer stratosphere of the atmosphere which protects life from ionizing short wave radiation (ultraviolet).

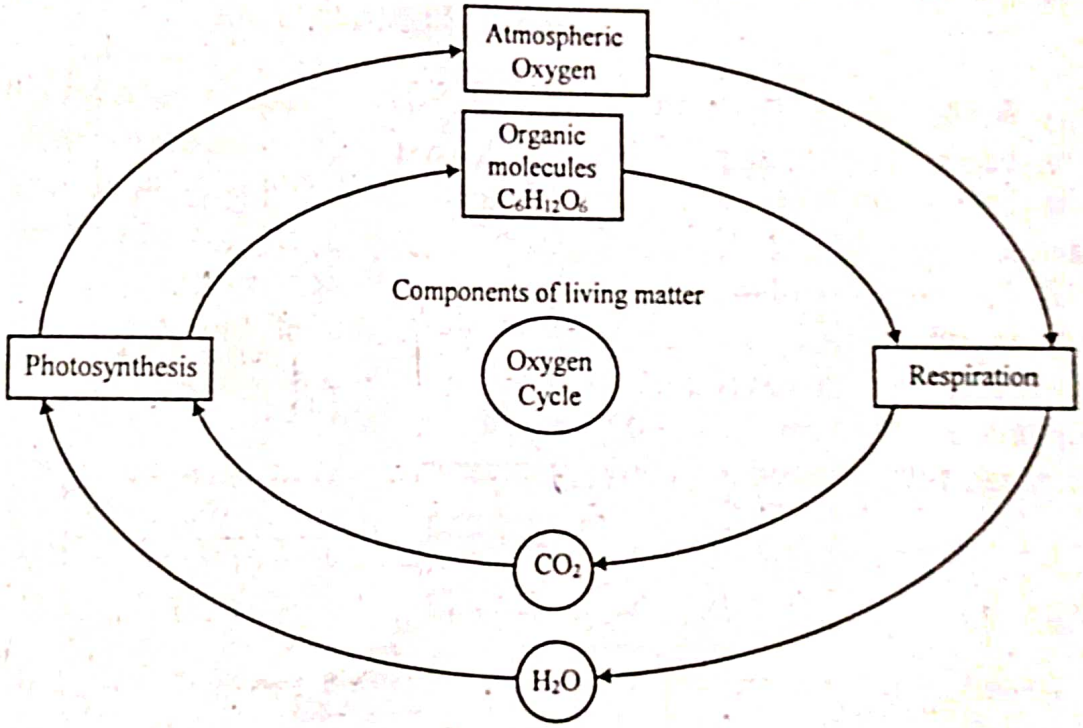


Fig: Oxygen Cycle

Primary Pollutants	Sources
Carbon mono oxide	Automobile
Oxide of nitrogen	Industry

7. Define food chain. State the principal types of food chain with example. **[WBUT 2012(EVEN), 2012(ODD)]**

OR,

Discuss briefly the types of food chain. What is food web? **[WBUT 2014(ODD)]**

Answer:

Refer to Question No. 5 of Short Answer Type Questions.

Food chains are classified as –

i) ***Predator food chain:*** This types of food chain starts from producer and ends to a higher consumer level. In every trophic level, the size of the organisms increases while their number decreases.
e.g., Grass → Grasshopper → toad → snake

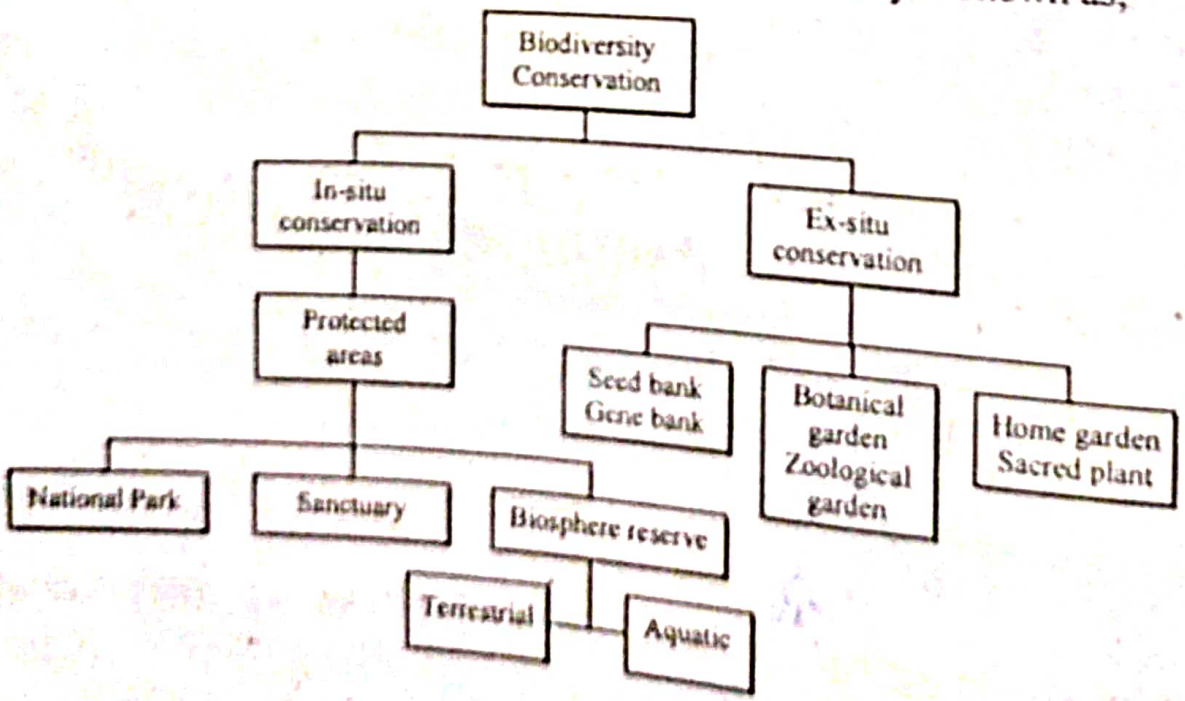
ii) ***Parasitic food chain:*** This types of food chain starts from big host and ends to the parasite animals.
e.g., Man → Warm → Protozoa

iii) ***Saprophytic food chain:*** This type of food chain starts from dead organism and ends to a bacteria (decomposers).
e.g., Dead plant / animal → Fungi → Bacteria

Food Web:
Numbers of food chains are connected together to form a complex web like structure called food web.

8. What is bio-diversity? Discuss various conservation methods in brief.
[WBUT 2012(EVEN), 2012(ODD), 2014(ODD)]

Answer:
Biodiversity is the variety and differences among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part. This includes genetic diversity within and between species and of ecosystems. Thus, in essence, biodiversity represents all life. Biodiversity is the variation of life forms within a given ecosystem, biome, or for the entire Earth. Biodiversity is often used as a measure of the health of biological systems. The biodiversity found on Earth today consists of many millions of distinct biological species, which is the product of nearly 3.5 billion years of evolution.
Different mechanisms involved in the conservation of biodiversity is shown as;



9. State the characteristics of food chain. **[WBUT 2012(ODD), 2015(EVEN)]**

Answer:

The major characteristic features of food chain are-

i) All plants (producer) lie at the base (origin) of each food chain.
ii) Each layer of food chain is called trophic level (nutrient level).
iii) Usually, as food chain proceeds the size increases and number decreases.
iv) The flow of energy through the food chain is unidirectional but that of nutrients (minerals) are cyclic in nature.
v) Existence or isolation of a single food chain in an ecosystem is not possible.

10. Define biodiversity. Classify different types of biodiversity. **[WBUT 2013(ODD)]**

Answer:

Biodiversity is the variety and differences among living organisms from all sources, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part. This includes genetic diversity within and between species and of ecosystems.

There are three interrelated levels of biodiversity namely genetic diversity, species diversity and ecosystem diversity.

Genetic diversity

Genetic diversity is a level of biodiversity that refers to the total number of genetic characteristics in the genetic makeup of a species. It is distinguished from genetic variability, which describes the tendency of genetic characteristics to vary.

Species diversity

Species diversity is an index that incorporates the number of species in an area and also their relative abundance. It is generally a much more useful value than species richness.

Ecosystem diversity

It describe s the interaction of species living together and the physical environment in a given area.

11. Write down the Sulphur cycle in nature with the help of a suitable block diagram. **[WBUT 2014(EVEN), 2017(EVEN)]**

Answer:

Plants and animals depend on continuous supply of sulphur and its compounds for synthesis of some amino acids and proteins. Some sulphur bacteria serve as the media for exchanges of sulphur within ecosystems.

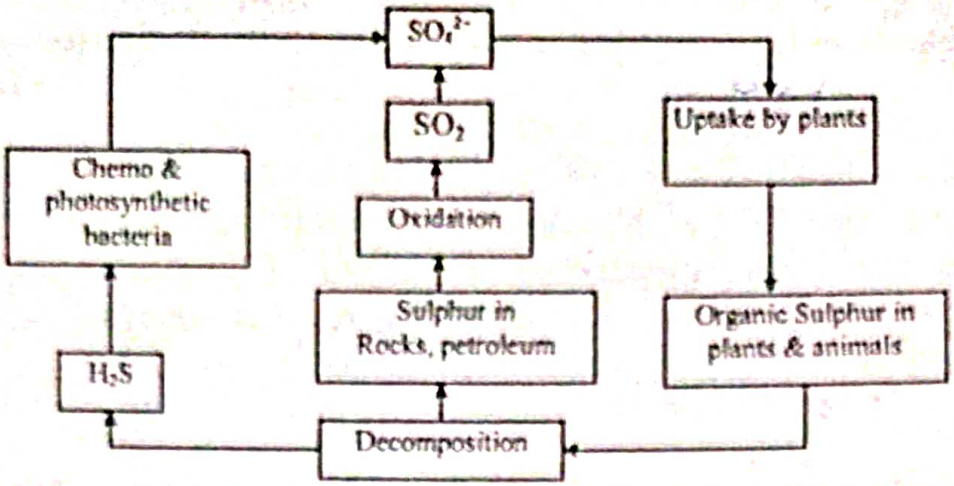


Fig: Schematic representation of Sulphur Cycle

In the sulphur cycle oxidation of sulphur takes place to produce ultimately the sulphate ions. Accumulation of sulphate ions takes place in the plant's and animal's protein. The bacteria then decompose their dead bodies. In polluted water under the anaerobic conditions H_2S gas is produced by the bacteria giving deposits of FeS. In unpolluted waste under the aerobic condition sulphur bacteria transform sulphides into sulphates for further production of proteins.

12. What are endemic species? [WBUT 2014(ODD)]

Answer:

An 'Endemic Species' is one that is only found in a particular region and nowhere else in the world. Since these species are not widespread and may be confined to only one or two protected areas, they are of great conservation concern.

13. Define parasitic food chain with examples. [WBUT 2015(EVEN)]

Answer:

Parasitic food chain: This types of food chain starts from big host and ends to the parasite animals.

e.g., Man → Warm → Protozoa

14. What are endemic species? Differentiate between *in situ* and *ex situ* conservations principles. [WBUT 2015(ODD)]

OR,

Discuss *in-situ* conservation of biodiversity. [WBUT 2016(EVEN)]

Answer:

1st Part: ***Refer to Question No. 15 of Short Answer Type Questions.***

2nd Part:

In-situ conservation of biodiversity

The conservation of species in their natural habitat or natural ecosystem is known as in situ conservation. The factors which are detrimental to the existence of the species concerned are eliminated by the suitable mechanisms in this method of conservation.

The protection and management of biodiversity through in-situ conservation involve certain specific protected areas which include National park, Sanctuary and Biosphere reserve.

Ex-situ conservation of biodiversity

Ex situ conservation is the conservation and maintenance of samples of living organisms outside their natural habitat, in the form of whole plants, seed, pollen, vegetative propagules, tissue or cell cultures.

15. Write down the phosphorous cycle in nature with help of a suitable block diagram. [WBUT 2018(EVEN)]

Answer:

Many rocks contain phosphorous, usually in the form of phosphate (PO_4^{3-}) that are bound into the mineral structure. But when these rocks are weathered, minute amount of phosphates dissolve and become available to the plants. Animals then absorb phosphorous when they eat plants or other animals.

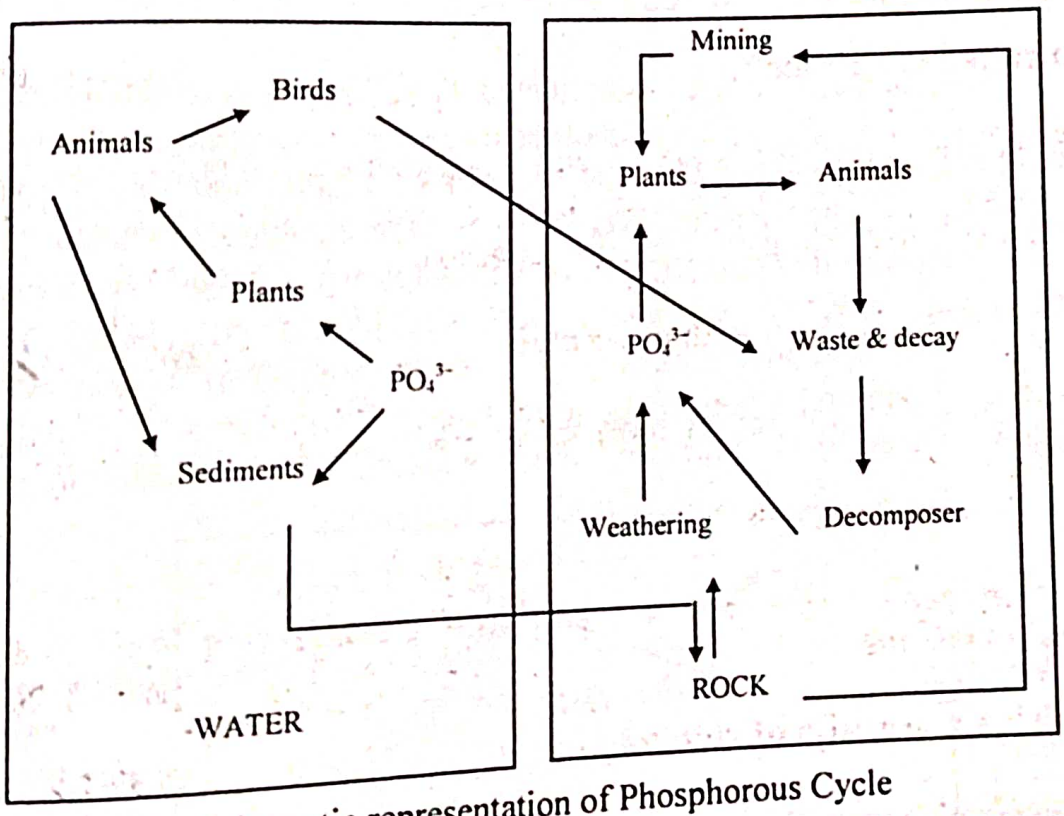


Fig: Schematic representation of Phosphorous Cycle

In fact, much of the phosphorous excreted by animals is also in the form of phosphate, which plants can reuse immediately. On land, phosphate cycle starts form phosphate (PO_4^{3-}) available from weathered rock and then moves to plants, animals and decomposers and ultimately back to phosphate salts (PO_4^{3-})

Phosphorous is essential for the growth of animals, bones and teeth. Phosphorous is also the main constituents of ATP and ADP.

16. Give an example of detritus food chain. [WBUT2018(EVEN)]

Answer:

Detritus food chain : This type of food chain starts from dead organism and ends to a bacteria (decomposers).

e.g., Dead plant / animal → Fungi → Bacteria

Long Answer Type Questions

1. a) Define biodiversity and biome with examples. [WBUT 2014(EVEN)]

Answer:

Biodiversity: *Refer to Question No. 13of Short Answer Type Questions.*

Biome:

Biome is defined as the largest recognizable land community unit. It covers all the species of plants and animals in a particular geographical area.

b) Draw the food web for a forest ecosystem. [WBUT 2014(EVEN)]

Answer:

The real world, of course, is more complicated than simple food chain while many organisms do specialize in their diets and other do not. At the same time, one organism may be the food source of many others and so on. As a result, isolation of a single food chain in an ecosystem is not possible. Numbers of food chains are interconnected with each other and form a web like structure. This web is known as '**food web**'. For example - grass may be grazed on by grasshoppers as well as rabbits or cattle. They are **primary consumers**. These primary consumers may be eaten by many carnivores such as toads, snakes birds etc. depending upon their food habit. They are known as secondary consumers. Thus, instead of a simple food chain, we get a web like structure called **food web**.

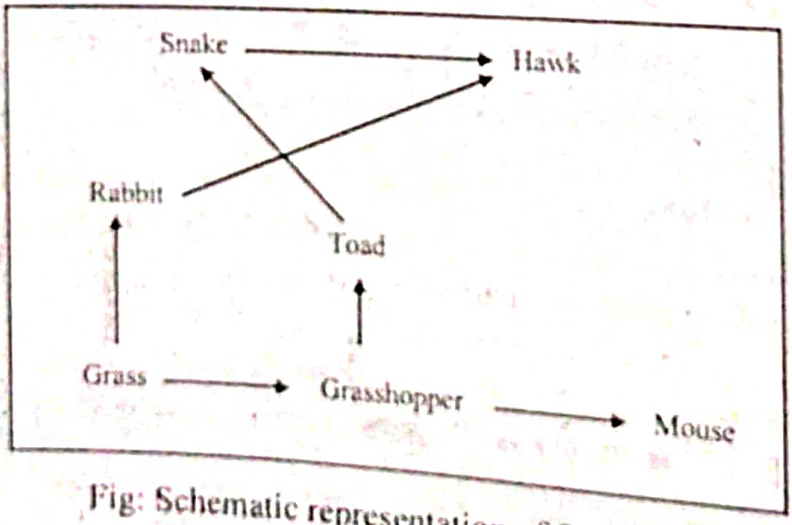


Fig: Schematic representation of food web

c) Discuss different conservation strategies with examples. [WBUT 2014(EVEN)]

Answer:

Refer to Question No. 9 of Short Answer Type Questions.

2. What is biodiversity hotspots? Why India is considered as mega biodiversity country? [WBUT 2014(ODD), 2018(ODD)] [WBUT 2014(ODD)]

Answer:

A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is threatened with destruction. An area is designated as a hot spot when it contains at least 0.5% of plant species as endemic.

There are 25 such hot spots of biodiversity on a global level, out of which two are present in India. These are:

- Indo- Burma (earlier The Eastern Himalayas) and
- The western Ghats & Sri Lanka.

These hot spots covering less than 2% of the world's land area are found to have about 50% of the terrestrial biodiversity.

The criteria for determining hot-spot are-

i. Number of Endemic Species i.e. the species which are found no where else.
ii. Degree of threat, which is measured in terms of Habitat loss.

Last Part:

The United Nations has declared the year 2010 as the 'International Year of Biodiversity' and the theme for this year's environment day is **"Biodiversity: Connecting with Nature"** and India is one of the 12 mega diversity nation in the world. Megadiversity, a term used by international organization (refers World Bank Technical paper no. 343). India is located in south Asia, between latitude 6° and 38° N and longitudes 69° and 97°E. Biogeographically, India is situated at the tri-junction of three realms Afro-tropical, Indo-Malayan and Paleo-Arctic realms and therefore, has characteristic elements from each of them. This assemblage of three distinct realms makes the country rich and unique in biological diversity. The Indian landmass extending over a total geographical area of about 3029 million hectares is bounded by Himalayas in the north, the Bay of Bengal in east, the Arabian Sea in the west and Indian Ocean in the south. Two areas in India have been identified as megadiversity hot spot areas, which are western ghat forests and eastern Himalayan forests, but India as a whole country as megadiversity nation. Miller Meier says, 'India is remarkable in both species richness and endemism although it ranks 10th position.

3. What is ecosystem? Discuss a Mangrove forest as natural ecosystem with all of its components. [WBUT 2018(ODD)]

Answer:

1st part: *Refer to Question No. 1 of Short Answer Type Questions.2*

2nd part:

Mangroves are various kinds of trees up to medium height and shrubs that grow in saline coastal sediment habitats in the tropics and subtropics – mainly between latitudes 25° N and 25°S. The mangrove biome, or mangel, is a distinct saline woodland or shrubland habitat characterized by depositional coastal environments, where fine sediments (often with high organic content) collect in areas protected from high-energy wave action.

Mangroves dominate three quarters of tropical coastlines. The saline conditions tolerated by various mangrove species range from brackish water, through pure seawater (30 to 40 ppt), to water concentrated by evaporation to over twice the salinity of ocean seawater (up to 90 ppt).

The **Sundarbans Mangroves** ecoregion on the coast forms the seaward fringe of the delta and is the world's largest mangrove ecosystem, with 20,400 square kilometers (7,900 square miles) of area covered. The dominant mangrove species *Heritiera fomes* is locally known as sundri or sundari, after which the Sundarbans is thought to be named. Mangrove forests are not home to a great variety of plants. They have a thick canopy, and the undergrowth is mostly seedlings of the mangrove trees. Besides the sundari, other species that make up the forest include *Avicennia spp.*, *Xylocarpus mekongensis*, *Xylocarpus granatum*, *Sonneratia apetala*, *Bruguiera gymnorrhiza*, *Cereops decandra*, *Aegiceras corniculatum*, *Rhizophora mucronata*, and *Nypa fruticans* palms.

Flora:

The Sundarbans flora is characterized by the abundance of *Heritiera fomes*, *Excoecaria agallocha*, *Ceriops decandra* and *Sonneratia apetala*. A total 245 genera and 334 plant species were recorded so far. Whilst most of the mangroves in other parts of the world are characterized by members of the Rhizophoraceae, Avicenneaceae or Lagancullariaceae, the mangroves of Bangladesh and West Bengal are dominated by the Sterculiaceae and Euphorbiaceae.

Fauna:

The Sundarbans provides a unique ecosystem and a rich wildlife habitat. According to the 2011 tiger census, the Sundarbans have about 270 tigers.

There is much more wildlife here than just the endangered Royal Bengal Tiger (*Panthera tigris tigris*). Most importantly, mangroves are a transition from the marine to freshwater and terrestrial systems, and provide critical habitat for numerous species of small fish, crabs, fidler crabs, hermit crabs, shrimps and other crustaceans that adapt to feed and shelter, and reproduce among the tangled mass of roots, known as pneumatophores, which grow upward from the anaerobic mud to get the supply of oxygen. Fishing Cats, Macaques, wild boars, Common Grey Mongooses, Foxes, Jungle Cats, Flying Foxes, Pangolins, and spotted deer are also found in abundance in the Sundarbans.

4. Write short notes on the following:

a) Conservation of Biodiversity [WBUT 2013(ODD)]

b) Hot spot OR, [WBUT 2014(EVEN), 2017(EVEN)]

Biological hotspot

c) Energy pyramid [WBUT 2015(ODD)]

d) Demography [WBUT 2016(EVEN)]

[WBUT 2016(ODD)]

Answer:

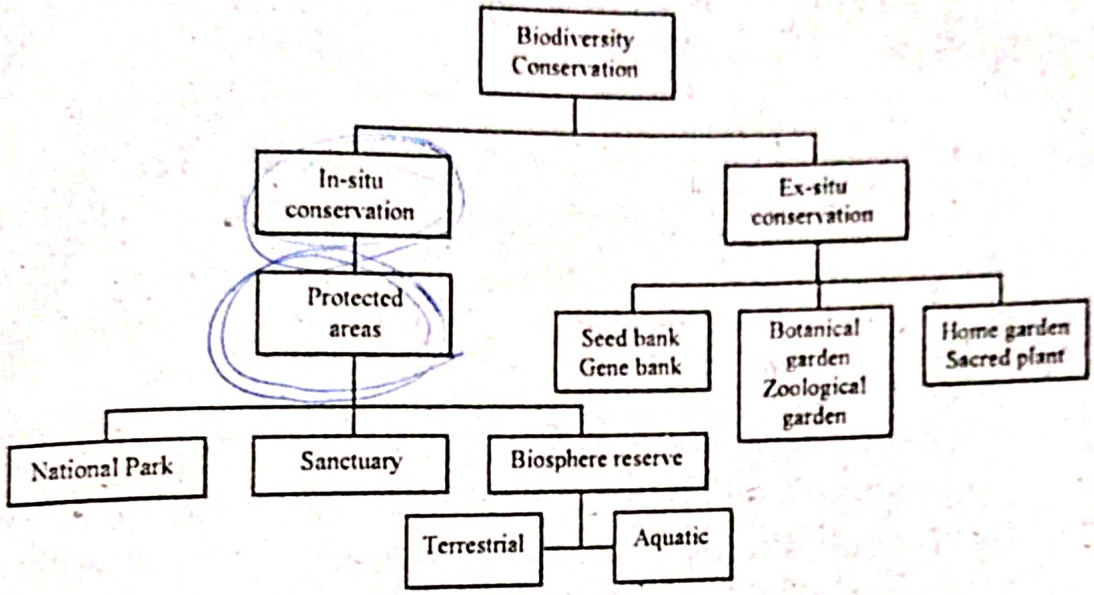
a) Conservation of Biodiversity:

Conservation of biodiversity is protection, upliftment and scientific management of biodiversity so as to maintain it at its threshold level and derive sustainable benefits for

the present and future generation. Mainly the conservation of biodiversity has three basic objectives:

i. To maintain essential ecological processes and life supporting system
ii. To preserve the diversity of species
iii. To make sustainable utilization of species and ecosystem.

Different mechanisms involved in the conservation of biodiversity is shown as



b) Biological Hotspot:

A biodiversity hotspot is a biogeographic region with a significant reservoir of biodiversity that is threatened with destruction. An area is designated as a hot spot when it contains at least 0.5% of plant species as endemic.

There are 25 such hot spots of biodiversity on a global level, out of which two are present in India. These are:

- Indo- Burma (earlier The Eastern Himalayas) and
- The western Ghats & Sri Lanka.

These hot spots covering less than 2% of the world's land area are found to have about 50% of the terrestrial biodiversity.

The criteria for determining hot-spot are-

i. Number of Endemic Species i.e. the species which are found no where else.
ii. Degree of threat, which is measured in terms of Habitat loss.

c) Energy pyramid:

The pyramid of energy is drawn after taking into consideration the total quantity of energy utilized by the trophic levels in and ecosystem or in an unit area over a given period of time. The quantity of energy available for utilization in any trophic levels will always be less than its previous trophic levels (10% of the previous layer). So, if we place the different trophic levels like producers, consumers etc. one after one, we get a 'pyramid of energy', which is always upright.

d) Demography:

Demography is the statistical study of populations, especially human beings. As a very general science, it can analyse any kind of dynamic living population, i.e., one that changes over time or space (see population dynamics). Demography encompasses the study of the size, structure, and distribution of these populations, and spatial or temporal changes in them in response to birth, migration, ageing, and death. Based on the demographic research of the earth, earth's population up to the year 2050 and 2100 can be estimated by demographers. Demographics are quantifiable characteristics of a given population.

AIR POLLUTION & CONTROL

Multiple Choice Type Questions

1. The coldest region of the atmosphere is [WBUT 2006, 2014(EVEN)]
   a) troposphere
   b) stratosphere
   c) mesosphere
   d) thermosphere

Answer: (c)

2. Coal induced smog was formed by the interaction SO_2 smoke and water to form H_2SO_4 and more than 4000 people died in December 1952 in [WBUT 2012(ODD)]
   a) London, England
   b) Los Angeles, California
   c) Donora, USA
   d) Texas, USA

Answer: (a)

3. Atmospheric radioactive window permits thermal radiation of which wavelength to leave the earth? [WBUT 2013(ODD)]
   a) 4.3 to 9.3 μm
   b) 9.5 to 10.6 μm
   c) 7 to 12 μm
   d) 7.3 to 10.3 μm

Answer: (c)

4. Kyoto protocol is related on which of the following? [WBUT 2013(ODD)]
   a) depletion of ozone layer
   b) world's first forest conservation programme
   c) emission of atmospheric CO_2
   d) photochemical smog

Answer: (c)

5. Which one is primary pollutant? [WBUT 2013(ODD)]
   a) acrolein
   b) PAN
   c) O_3
   d) CO

Answer: (d)

6. The value of earth's albedo is [WBUT 2013(ODD)]
   a) 0.7
   b) 0.8
   c) 0.4
   d) 0.3

Answer: (d)

7. Which of the following are likely to be present in photochemical smog? [WBUT 2014(EVEN)]
   a) alcohol
   b) aldehyde
   c) ether
   d) SO_2

Answer: (b)

8. The catalyst used in catalytic converter is finely divided [WBUT 2014(EVEN)]
   a) Ni
   b) P
   c) Pt
   d) Fe

Answer: (c)

9. The value of albedo of the planet Earth is [WBUT 2014(EVEN)]
a) 0.21 b) 0.31 c) 0.41 d) 0.51
Answer: (b)

10. Lapse rate refers to the rate at which [WBUT 2014(ODD)]
a) population increases in area with increase in temperature
b) temperature decreases with increase in elevation
c) temperature decreases with decrease in elevation
d) none of these
Answer: (b)

11. The catalyst used in catalytic converters is finely divided [WBUT 2014(ODD)]
a) Ni b) Pt c) Pd d) Fe
Answer: (b)

12. Greenhouse effect is due to [WBUT 2015(EVEN)]
a) over cultivation of land
b) testing nuclear weapons
c) some atmospheric gases like CO_2, N_2O and some man made gases
d) none of these
Answer: (c)

13. Kyoto protocol is related with [WBUT 2015(EVEN)]
a) Ozone layer depletion b) Green house gas
c) SPM d) Water pollution
Answer: (b)

14. Which one of the following statements is true for Threshold Limit Value (TLV) [WBUT 2015(EVEN)]
a) less the TLV, more toxic the pollutant is
b) more the TLV, more toxic the pollutant is
c) TLV is not at all related with toxicity of a pollutant
d) a substance is said to be pollutant if its concentration falls below its TLV
Answer: (a)

15. Which one of the following shows highest Green-house effect? [WBUT 2015(ODD)]
a) CH_4 b) CO_2 c) NO_2 d) O_3
Answer: (b)

16. The dry adiabatic lapse rate in the troposphere is about [WBUT 2016(EVEN)]
a) –9.8°C/km b) –4.5°C/km c) –8.9°C/km d) –5.4°C/km
Answer: (a)

17. The atmosphere is unstable under the condition of [WBUT 2016(EVEN)]
a) ELR = ALR b) ELR > ALR c) ELR < ALR d) none of these
Answer: (b)

18. Ozone acts as a protective shield when it resides in [WBUT 2016(EVEN)]
a) Mesosphere b) Stratosphere c) Thermosphere d) Troposphere
Answer: (b)

19. The average annual solar intensity of solar radiation (solar constant, S) is [WBUT 2016(EVEN), 2018(EVEN)]
a) 1370 W/m^2 b) 1730 m^2/W c) 0.31 W/m d) 0.69 W^2/m
Answer: (a)

20. The temperature of magnetosphere is about [WBUT 2016(EVEN)]
a) 1200°C b) –100°C c) 0°C d) 34°C
Answer: (a)

21. The IR active gas is [WBUT 2016(ODD)]
a) O_2 b) CO_2 c) N_2 d) He
Answer: (b)

22. The simple global temperature model predicts earth temperature to [WBUT 2016(ODD)]
a) 0°C b) 34°C c) –19°C d) –273°C
Answer: (c)

23. The temperature range of troposphere is [WBUT 2016(ODD), 2018(EVEN)]
a) $-2°C$ to $92°C$ b) $-56°C$ to $-2°C$ c) $15°C$ to $-56°C$ d) $-92°C$ to $1200°C$
Answer: (c)

24. GWP is maximum for [WBUT 2017(EVEN)]
a) CO_2 b) CH_4 c) CFC d) N_2O
Answer: (c)

25. Stratospheric ozone layer concentration approximately is [WBUT 2017(EVEN)]
a) 300 DU b) 200 DU c) 100 DU d) 500 DU
Answer: (b)

26. Choose the correct alternative of MMD value (m^2/s) for a greater possibility of pollutant concentration in atmosphere [WBUT 2017(ODD)]
a) < 6000 b) > 6000 c) < 5000 d) > 5000
Answer: (b)

27. The most unsuitable plume for dispersion of flue gas is [WBUT 2017(ODD)]
a) Trapping plume b) Conic plume
c) Fumigating plume d) Lofting plume
Answer: (c)

28. The saturated adiabatic lapse rate in the troposphere is about [WBUT 2017(ODD)]
a) –2.5°C/km b) –5.4°C/km c) –10°C/km d) –20°C/km
Answer: (b)

29. Ozone acts as a pollutant when resides in [WBUT 2018(EVEN)]
a) Troposphere b) Stratosphere
c) Mesosphere d) Ionosphere
Answer: (a)

30. Looping Plume appears in the atmospheric condition of [WBUT2018(EVEN)]
a) Neutral b) Inversion
c) Super adiabatic d) Sub adiabatic
Answer: (c)

31. The value of Wet adiabatic lapse rate is [WBUT2018(EVEN)]
a) 15°C/km b) 6°C/km c) 10°C/kmd) 9.8°C/km
Answer: (b)

32. Pollutant that affects the oxygen transport in blood is [WBUT2018(EVEN)]
a) CO_2 b) SO_2 c) CO d) Hydrocarbons
Answer: (c)

33. The Coldest Region Of Atmosphere Is [WBUT 2018(ODD)]
a) Troposhere b) Stratosphere
c) Mesosphere d) Thermosphere
Answer: (c)

34. Atmospheric Radiative Window Is [WBUT 2018(ODD)]
a) 12 To 18 μm b) 13 To 18 μm
c) 7 To 12 μm d) 1 To 15 μm
Answer: (c)

35. The Atmosphere Is Neutrally Stable Under The Condition Of [WBUT 2018(ODD)]
a) ELR > ALR b) ELR < ALR
c) ELR = ALR d) None Of These
Answer: (c)

Short Answer Type Questions

1. Explain the mechanism of formation of photochemical smog. [WBUT 2005, 2006-Short note]

OR,

What is photochemical smog? Briefly describe the formation mechanism of PAN. [WBUT 2012(EVEN), 2017(EVEN)]

Answer:

Photochemical smog occurs on **warm sunny days** (both summer and winter season) with initially clear skies and low humidity. A subsidence inversion is an ideal condition for the formation of this type of smog. The following steps are involved in the formation of photochemical smog –

i) Reactive hydrocarbon (RCH_2) having C = C from auto exhaust interact with tropospheric O_3 to form **free radical** $RCH_2^{\cdot}$

ii) $RCH_2^{\cdot}$ $RCH_2^{\bullet}$ rapidly reacts with O_2 to form another free radical $RCH_2O_2^{\cdot}$

iii) $RCH_2O_2^{\bullet}$ reacts with NO to produce NO_2 and free radical $RCH_2O^{\cdot}$

iv) The new free radical then interacts with O_2 to yield a stable aldehyde **(RCHO)** and **hydroperoxyl radical** $HO_2^{\cdot}$

v) $HO_2^{\cdot}$ then reacts with another molecule of NO to give NO_2 and $HO^{\cdot}$.

vi) $HO^{\cdot}$ is extremely reactive and rapidly reacts with the stable hydrocarbon RCH_3 to yield HO_2 and regenerate $RCH_2^{\cdot}$, thereby completing cycle.

2. Write down the photochemical reactions for formation of ozone hole in stratosphere by CFC-12. **[WBUT 2009]**

OR,

Explain how CFC decreases ozone concentration in the stratosphere. **[WBUT 2012(EVEN)]**

OR,

Discuss in detail the mechanism of ozone layer depletion. **[WBUT 2014(ODD)]**

OR,

Write a short note on ozone layer depletion in stratospheric zone. **[WBUT 2016(ODD)]**

OR,

How does Antarctica ozone hole formation take place? **[WBUT 2017(EVEN)]**

Answer:

Formation of ozone layer:

Ozone forms a layer in the stratosphere, thinnest in the tropics (around the equator) and denser towards the pole. The unit which is used to measure the amount of ozone present in a particular area is known as Dobson unit (Du) [1Du = 0.01 mm of the compressed gas at 0°C and 760 mm of Hg pressure].

Ozone layer is created when U.V radiation (sunlight) strikes the stratosphere. This U.V radiation dissociates oxygen molecules (O_2) to atomic oxygen (O). The atomic oxygen quickly combines with other oxygen molecules (O_2) to form ozone.

$$O_2 + h \rightarrow O + O \quad \ldots (1)$$

$$O + O_2 \rightarrow O_3 \quad \ldots (2)$$

Although the U.V radiation splits the O_3 molecule but it reforms again, resulting in no net loss of ozone.

$$O_3 + h \rightarrow O_2 + O \quad \ldots (3)$$

Ozone is also destroyed by the following reaction

$$O + O_3 \rightarrow O_2 + O_2 \quad \ldots\ldots (4)$$

The reactions (1) to (4) are known as the **"Chapman reaction"**. As height increases, rate of dissociation of O_3 molecules increases and rate of formation of the same decreases. The concentration of ozone is a balance between these competing reactions. In this way a layer of O_3 molecule forms in stratosphere. The layer thus formed in stratosphere by the above mentioned reactions, is sometimes called the **'Chapman layer'**.

The ozone layer present in the stratosphere acts like an umbrella. It protects us from the hazardous U.V rays coming from the Sun and returns back to the space. This is not only protects us from the skin cancer, damage of vegetation etc. but also helps to maintain the Earth's heat budget.

Depletion of ozone layer:

The formation of ozone hole depends on mainly the weather condition of the stratosphere. The following steps are involved in the formation of ozone layer-

i) During the **winter polar night**, sunlight does not reach the South Pole. A strong circumpolar wind develops in the middle to lower stratosphere. These strong winds are known as the **'Polar Vortex'**.

ii) Since there is no sunlight, the air within the polar vortex can get very cold. When temperature falls down below -80 C, a special type of cloud is formed. This cloud is known as **'polar stratospheric cloud' (or PSC).**

iii) Once, the PSC form, **heterogenous chain reactions** take place and convert the **inactive chlorine** (or bromine) **present in the stratosphere to more active form.** Here, chlorine (or bromine) is available from the chemicals released by human activities (such as **CFC**, compounds containing Br_2, SO_x, NO_x etc.)

Ozone loss does not take place until **sunlight returns** to the air inside the **polar vortex** and allows the production of **active chlorine** and initiates the **ozone destruction cycle.**

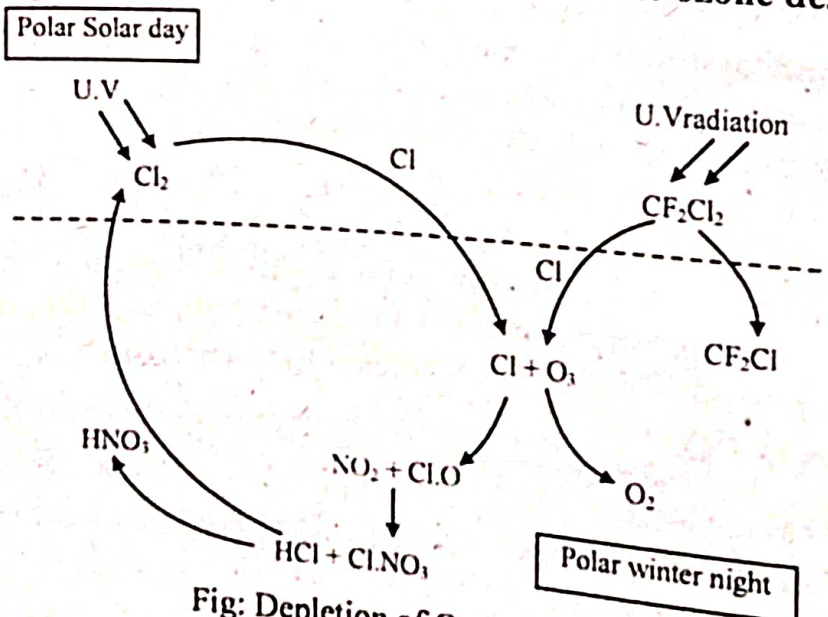


Fig: Depletion of O_3 molecule by CFC

CFC's are a common industrial product; used in refrigeration system, air conditioners etc. One molecule of CFC is responsible for the destruction of 10 lakh molecule of molecule of O_3.

3. Name the different equipment for controlling air pollution due to Suspended Particulate Matter (SPM). Mention the suitability of use of any one equipment. [WBUT 2011(ODD), 2012(ODD)]

OR,

Short Note On: Electroaratic precipitator [WBUT 2018(EVEN)]

Answer:

There are different equipments used in different areas to control the air pollutants. These are- i) *Settling Chamber, ii) Cyclone Separator, iii) Baghouse Filter, iv) Electrostatic Precipitator (ESP), v) Converter, vi) Ventury Scrubber.*

Electrostatic Precipitator (ESP):

Electrostatic Precipitator (ESP) consisting of vertical wires placed in between parallel plates. A strong electric field is created between wire and the plates by impressing a high negative voltage on the wires (as more as 1KV to 50 KV). The intense field created near the wire causes **corona discharge** ionizing gas molecules in the air stream. The negative ions and free electrons thus created move towards the plates and on the way some attach themselves to the particulate matter. The particles now carry a charge, which causes them to move under the influence of the electric field to the surface of the plates. They are removed from the collection electrode either by gravitational forces or by flashing the collecting plates with liquid.

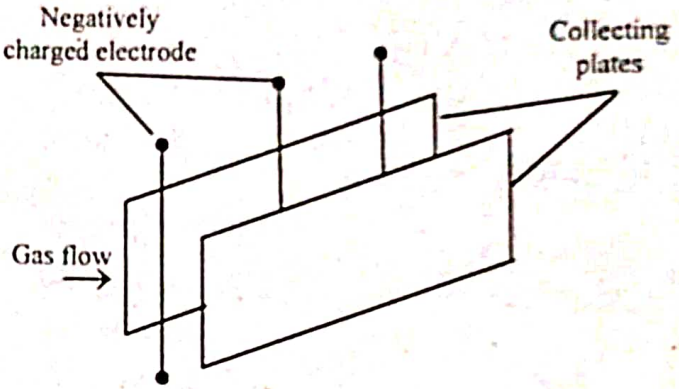


Fig: Electrostatic Precipitator

4. Mention two detrimental effects of ozone layer depletion on the biosphere. What is 'Montreal Protocol' on ozone depleting substances (ODS)? [WBUT 2012(EVEN)]

OR,

What are the harmful effects of ozone layer depletion? [WBUT 2014(ODD)]

Answer:

Adverse Effect of Formation of Ozone Hole:

i) U.V penetrates the ozone layer and fall on the surface. This ray is responsible for skin cancer called "Melanoma" and other diseases.
ii) This ray also disturbs the immune system of the living body.
iii) U.V. rays cause cataract in the eyes.
iv) This ray is also responsible for the retardation in the plant growth.
v) This U.V rays which is coming through the ozone hole, is responsible for the global warming too.

Montreal Protocol

It is an international agreement, signed in 1987 at Montreal, to stop the production of Ozone Destroying Substances (ODS) like CFC etc. by the year 2000.

5. What are the pollutants emitted from automobile exhausts? How are these controlled in urban vehicles? What special type of petrol is used in a modern car? [WBUT 2012(ODD)]

OR,

How is a catalytic converter used for creating automobile emissions? What is the role of tetramethyl lead in the internal combustion of engines? [WBUT 2016(ODD)]

OR,

What does the term "Three ways Catalytic Converter" mean? What catalyst is used in such converter bed? [WBUT 2018(ODD)]

Answer:

The pollutants emitted from automobile exhausts

i) Carbon monoxide
ii) Lead

These are controlled in urban vehicles by using Catalytic Converter.

Most modern car equipped with "**three-way catalytic converter**". The 'three way' refers to that the device (catalytic converter) converts three harmful compounds in car exhaust into the harmless compounds. These harmful compounds are carbon monoxide (CO), volatile organic carbon (VOC) and oxides of nitrogen (NO_x). This conversion takes place with the help of two different types of catalysts – **reduction catalyst** and **oxidation catalyst.** Usually, **platinum, rhodium** and **palladium** are used as catalysts:

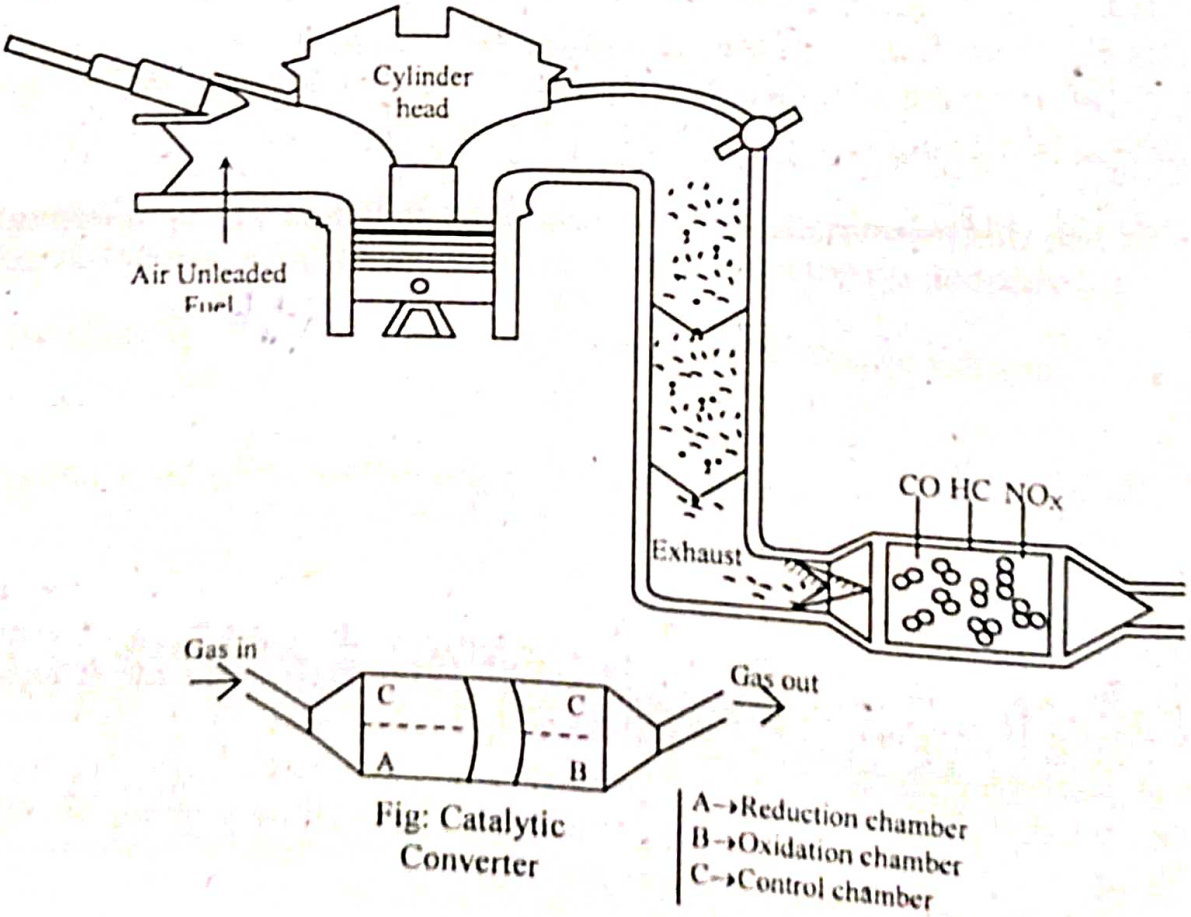


Fig: Catalytic Converter

A→Reduction chamber
B→Oxidation chamber
C→Control chamber

1) Reduction: The first step is the reduction step. Here, platinum and rhodium are used as catalyst. In this step, oxides of nitrogen specially nitric oxide (NO) and nitrogen dioxide (NO_2) are converted to harmless molecular nitrogen (N_2).

$$2NO \rightarrow N_2 + O_2$$

$$2NO_2 \rightarrow N_2 + 2O_2$$

2) Oxidation: The second step of the conversion is oxidation step. Here, **platinum** and **palladium** are used as catalyst. In this step, carbon monoxide (CO) and volatile organic carbon (VOC) are converted to carbon dioxide (CO_2).

$$2CO + O_2 \rightarrow 2CO_2$$

$$HC + O_2 \rightarrow CO_2 + H_2O$$

3) Control System: The third stage of the catalytic converter is control stage. In this stage, **air to fuel** ratio is controlled with the help of **oxygen sensor**. This sensor is placed at the upstream of the catalytic converter and provide signal to the engine about the concentration of oxygen present in the exhaust. The engine then increases or decreases the oxygen concentration in the exhaust by adjusting air-to-fuel ratio.

Unleaded petrol is used in a modern car to avoid pollution.

6. Explain the term Green house effect. Name six green house gases. Why is existence of life not possible in Venus? **[WBUT 2012 (ODD)]**

OR,

a) Explain the term Green House Effect. **[WBUT 2015(EVEN)]**

b) Name the green house gases in the atmosphere. **[WBUT 2015(EVEN), 2017(EVEN)]**

Answer:

The **green house** is a body which allows the shorter wavelength solar radiation to come in, but does not allow the 'long wave outgoing terrestrial infra red (IR) radiation to escape.

The Earth's atmosphere bottles up the energy of the Sun, and is said to act like a '**green house**'. CO_2 and water vapour in the atmosphere which develop a gaseous blanket over the surface, transmit '**short wavelength** solar radiation' but reflect the heat radiation having 'longer wave length'. CO_2 molecules, water vapour are transparent to incoming solar radiation but not to the heat radiated by the Earth's surface. So they trap and re-emit the solar radiation to the surface. As a result, the surface warms up.

This progressive warming up of the Earth's surface due to the blanketing effect of CO_2 & water vapour in the atmosphere is called as **Green house effect.**

Most of the long wavelength energy radiated by the Earth is absorbed by a **combination** of some active gases and re-emits to the surface again. These gases are known as **Green House Gases (GHG).** These are water vapour (H_2O), carbon-dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), molecular oxygen (O_2) and ozone (O_3)

The entire range of radiation emitted by Earth falls in the infrared (IR) region (4-20 μm).

The interaction of infrared radiation with molecules makes them go from one **vibrational energy level** to another **vibrational energy level.** The essential condition for the

radiation to interact is that vibrational mode should be associated with a change in dipole moment. CO_2 and other green house gases involve the change in dipole moment hence absorbs infrared radiation and radiated back.

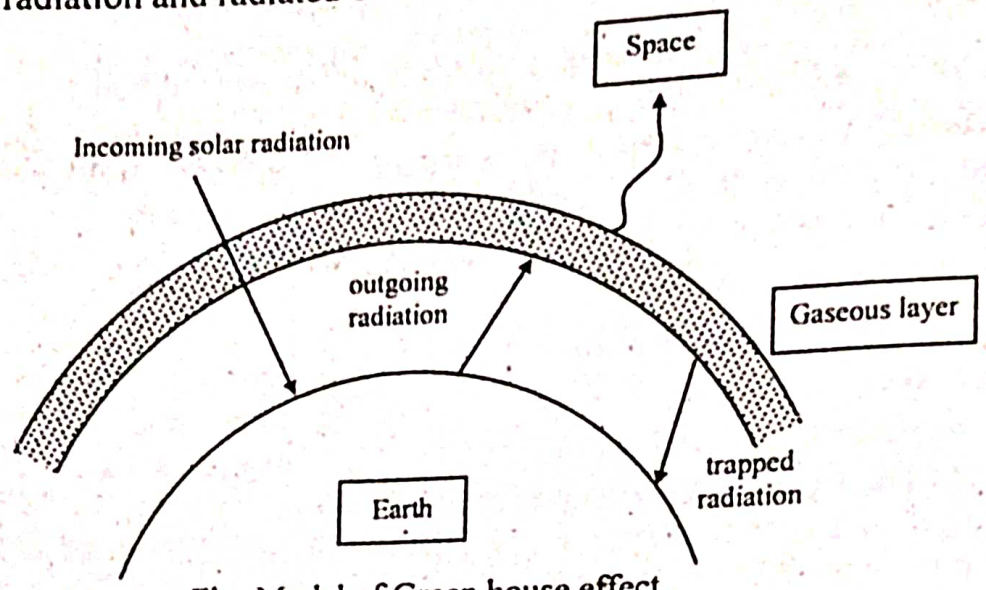


Fig: Model of Green house effect

The atmospheric pressure of Venus is 100 times greater than Earth and the concentration of CO_2 in the atmosphere is 97%. In this atmosphere green house effect is maximum and so the surface temperature of the Venus is very high (750K or 477°C). This high temperature is also not suitable for the living organism and so Venus is free from life.

7. Write note on Earth's albedo. **[WBUT 2012(ODD)]**

OR,

What do you understand by earth albedo? **[WBUT 2017(EVEN)]**

Answer:

30% of the total incoming solar radiations returns back to the space without contributing anything to the Earth's surface temperature. This amount of radiation is known as **'Earth's albedo'**. Remaining incoming energy absorbs by the Earth's surface.

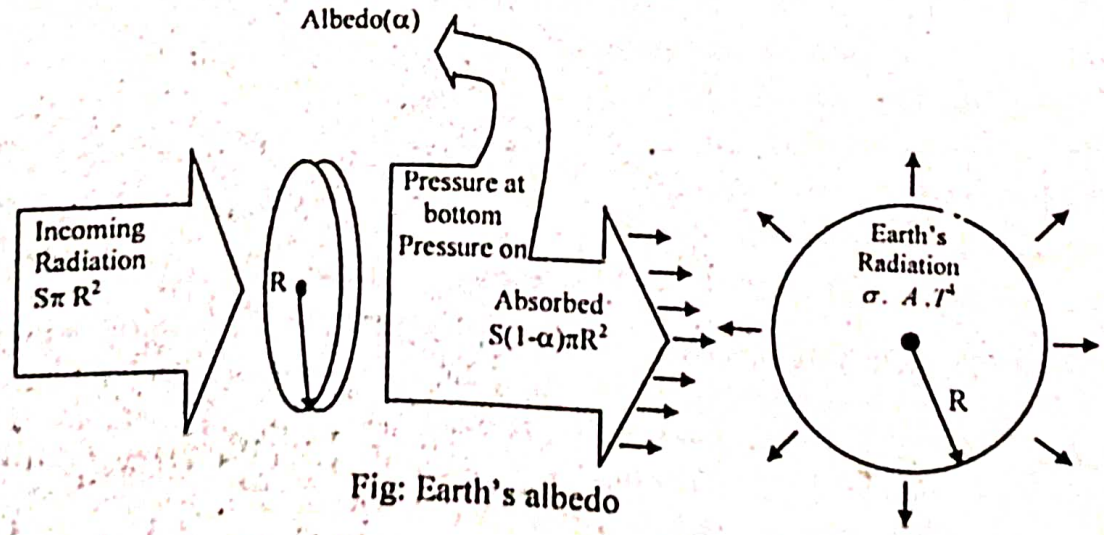


Fig: Earth's albedo

8. What are greenhouse effect and global warming? Write down the different measures to control global warming. [WBUT 2013 (EVEN)]
What is atmospheric radiation window?

OR,

What do you understand by atmospheric window? [WBUT 2017(EVEN)]

Answer:

1st & 2nd Part: *Refer to Question No. 2 of Long Answer Type Questions.*

3rd Part:

Most of the long-wavelength energy radiated by the Earth is absorbed by a combination of radiatively active gases, most important of which are water vapour (H_2O, carbon-di-oxide (CO_2) methane (CH_4) nitrous oxide (N_2O) oxygen (O_2) & ozone (O_3). All these gases (green house gases) have capacity to absorb the radiated energy of different range of frequencies 3 – 40μm). But any gas present in the atmosphere can, not absorb radiated energy having wavelength in between 7 μm and 12 μm. The reason behind this is that the frequency of this energy does not match with the frequency of molecular oscillations of any gas present in the atmosphere. As a result, this radiated energy ($40 W/m^2$) can easily be escaped to the space. This relatively clear sky for this outgoing energy, is referred as **the atmospheric radiative window.**

9. What is lapse rate? [WBUT 2013(EVEN)]
Discuss the plume behavior at different atmospheric conditions.

OR,

Explain Stack and Plumes.
How many types of plumes can be observed? [WBUT 2016(ODD)]

Answer:

1st Part:

The change of temperature of air with respect to height or altitude is called **Lapse rate.**

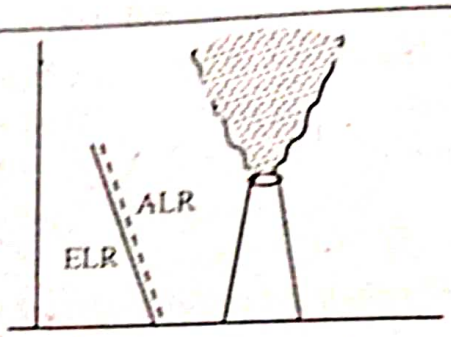
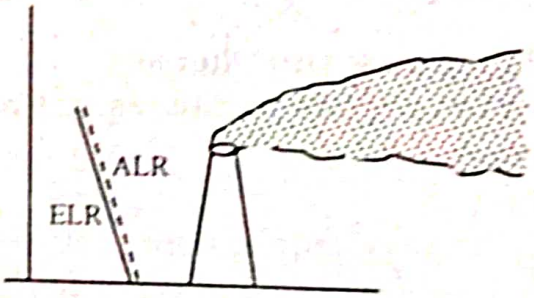
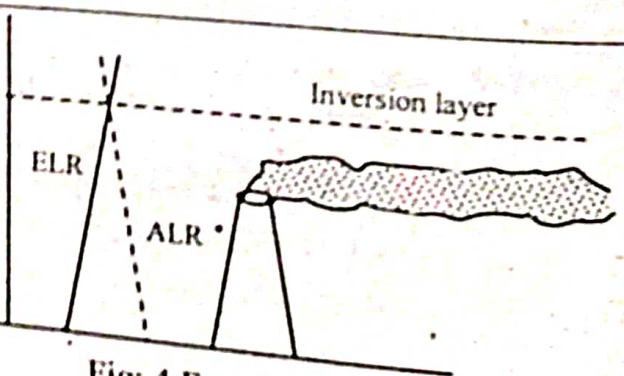
i) Environmental Lapse Rate (ELR)
ii) Adiabatic Lapse Rate (ALR)

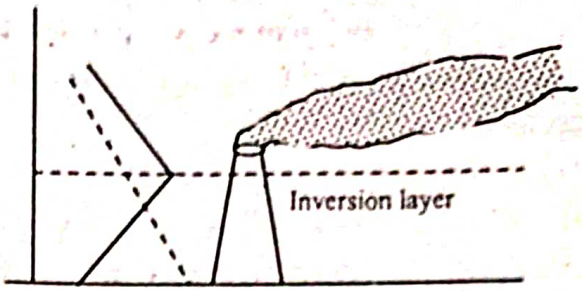
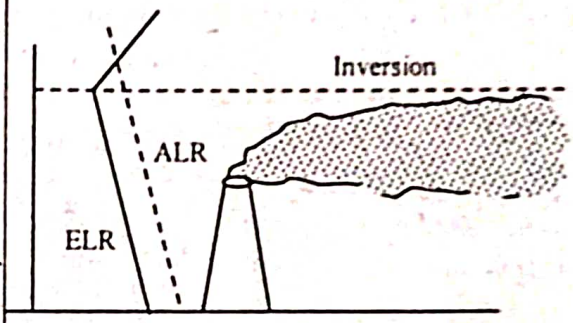
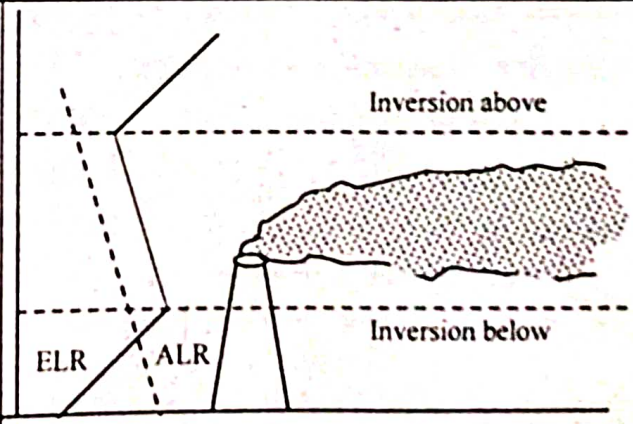
2nd Part:

Stack Plume

The diffusion or dispersion of pollutants into the atmosphere is governed by the **Environmental Lapse Rate (ELR)** as well as **Adiabatic Lapse Rate (ALR).** By comparing these two laps rates, it is possible to predict about the dispersion of emitted gases from the source. These are then known as **plume** and their source of origin as **stack.**

On the basis of Environmental Lapse Rate (ELR) and Adiabatic Lapse Rate (ALR), there are different types of plume behaviour available –

Looping Plume	Looping plume has a wavy character and occurs in **super adiabatic environment** (here, **ELR)ALR)** which produces highly **unstable atmosphere**, because of rapid mixing. During the high degree of **turbulence**, the dispersion of plume would be rapid and as a result **high concentrations near the ground** may take place. To avoid this, it is suggested to design **high stack** where atmosphere is generally super adiabatic.	 Fig: 1 Looping plume
Neutral Plume	Neutral plume is available in the **neutral atmospheric condition** (i.e., ELR = ALR). This type of plume rises vertically in upward direction. This upward lifting of the plume will continue till it reaches at the height where density and temperature of surrounding air equal to it.	 Fig: 2 Neutral plume
Coning Plume	The neutral plume tends to form **cone** like structure, when the horizontal wind velocity is greater than 32 km/hr and when cloud cover blocks the solar radiation by day and terrestrial radiation by night. Coning plume also takes place under **sub adiabatic** conditions (i.e., ELR ⟨ ALR). Under such conditions, the environment is **slightly stable**, and there is a limited **vertical mixing**. This is not suitable for the dispersion of air pollutants. The plume makes a **cone like structure** and so called **coning plume.**	 Fig: 3Coning plume
Fanning Plume	The fanning plume is available under the extreme **inversion condition** (due to negative lapse rate). This inversion condition leads to stable environmental condition just above the stack. As a result, the smoke emitted from the stack does not move in upward direction but moves horizontally.	 Fig: 4 Fanning plume

Lofting Plume	This type of plume is available when there is a strong **super adiabatic** lapse rate just **above** the stack and **negative lapse rate** (inversion) just **below the opening of stack**. Such a plume has minimum downward mixing, as its downward motion is prevented by inversion, but the upward mixing will be quite turbulent and rapid. The dispersion of pollutant will therefore, be rapid, and no pollutants will touch the ground. Hence, this would be the most ideal case for dispersion of air pollutants.	 Fig: 5 Lofting plume
Fumigating Plume	This type of plume is just **opposite to lofting plume**. When **inversion layer** occurs at a short distance **above the top of the stack** and **super adiabatic conditions** prevail **below the stack**, then the plum is said to be **fumigating**. In such a case, the pollutants can not **escape above the top of stack** because of inversion layer and will be **brought down near the ground** due to turbulence in the region above the ground and below the inversion. This represents **quite a bad case** of atmospheric conditions for dispersion.	 Fig: 6 Fumigating plume
Trapping Plume	When the inversion layer exist above the emission source, as well as below the source, then the plume emitted from the stack is known as **trapping plume**. Here, the plume will neither go up nor will go down and would remain **confined** or **trapped** between these two inversion layers. This plume is also considered as a **bad condition for dispersion**, as the dispersion can not go above a certain height.	 Fig: 7 Trapping plume

10. Calculate the temperature of earth by simple global temperature model. **[WBUT 2013(ODD)]**

OR,

What is the global temperature model? **[WBUT 2018(ODD)]**

Answer:

The figure below shows a simple model that treats the Earth as a black body. Radiation from the Sun arrives just outside the Earth's atmosphere with an average annual intensity, called solar constant, S, equal to 1372 W/m^2.

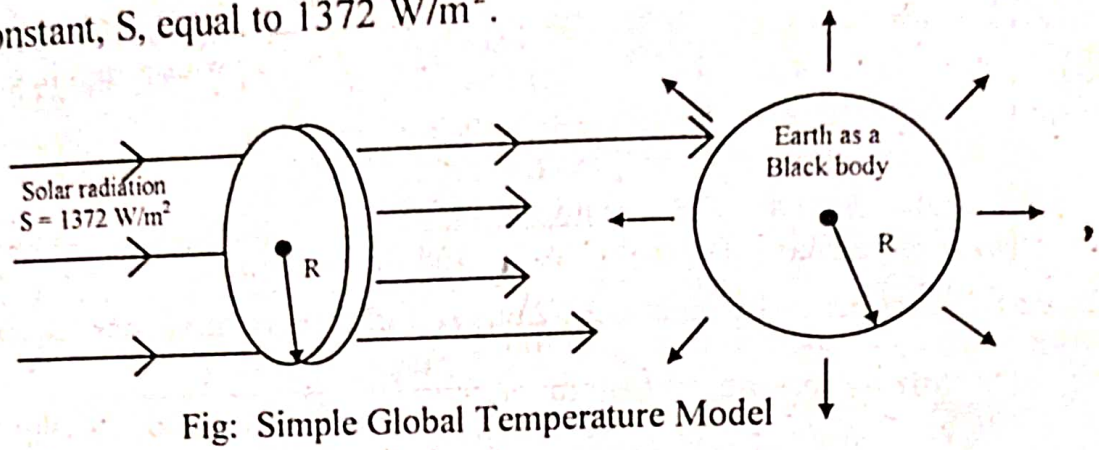


Fig: Simple Global Temperature Model

A simple way to calculate the total rate at which energy is absorbed by the Earth is to note that all the solar radiation passing through a disc having radius equal to that of the Earth, and placed normal to the incoming radiation, strikes the Earth's surface. Since we are considering the Earth to be a black body, all of that incoming radiation is absorbed, so we can write –

$$E_a = S\pi R^2$$

Where, E_a = rate of energy absorbed

S = Solar intensity = Constant

R = radius of Earth & disc.

If we assumed that Earth is isothermal, with temperature T(K), every where, the energy radiated from this blackbody Earth with surface area $4\pi R^2$, is given by the Stefan-Boltzmann equation $E_r = \sigma.4\pi R^2 T^4$

Where, σ = Stefan-Boltzmann Constant = 5.67×10^{-8} W/m^2K^4

If we go on to assume steady-state conditions, that the Earth's temperature is not changing with time, we can equate the rate at which energy from the Sun is absorbed by the Earth surface with the rate at which energy is radiated back to space.

i.e., $S\pi R^2 = \sigma.4\pi R^2 T^4$

or, $$T = \left(\frac{S}{4\sigma}\right)^{1/4} = \left(\frac{1372}{4\times5.67\times10^{-8}}\right)^{1/4} = 279\,K$$

This answer differs from the actual Earth's surface temperature.

11. What are the differences between sulphurous smog and photochemical smog? **[WBUT 2014(ODD), 2017(EVEN), 2018(EVEN)]**

Answer:

Difference between 'LondonSmog' and Photochemical Smog:

Chemical Smog or Sulphourous Smog	Photochemical Smog or Nitrogenous Smog
i) First time took place at **London.**	i) First time took place at **Los Angles.**
ii) Components are $-SO_x$ & **particular matter.**	ii) **Hydrocarbon, NO, & ozone** are the component.
iii) **Sulphate salts** are by-product of this smog.	iii) **PAN** is by-product of this smog.
iv) Temperature of this smog is less than 3°C.	iv) Temperature of this smog is greater than 25°C.
v) High humidity is required (foggy)	v) Low humidity is required.
v) **Radiation inversion** is the ideal condition of this type of smog.	v) **Subsidence inversion** is suitable for this smog.
vi) Usually **early morning** of winter is the good time for the formation of this type of smog.	vi) This type of smog usually takes place in **midday of summer.**
vii) This type of smog is **reducing type.**	vii) This type of smog is **oxidizing type.**
viii) The most adverse effect of this type of smog is **lung & throat irritation.**	viii) **Eye irritation** is the most common effect of this type of smog.

[London smog is also known as sulphourous smog].

12. What is the main composition of troposphere and stratosphere? **[WBUT 2014(ODD)]**

137, 139

Answer:

Composition of troposphere:

i) Nitrogen (78%)
ii) Oxygen (21%)
iii) Carbon dioxide (0.03%)
iv) Water vapour

Composition of stratosphere: Ozone (O_3)

[WBUT 2015(EVEN)]

13. What is black body? 152

Answer:

A **black body (also blackbody)** is an idealized physical body that absorbs all incident electromagnetic radiation, regardless of frequency or angle of incidence. A black body in thermal equilibrium (that is, at a constant temperature) emits electromagnetic radiation called black-body radiation. The radiation is emitted according to Planck's law, meaning that it has a spectrum that is determined by the temperature alone (see figure at right), not by the body's shape or composition.

A black body in thermal equilibrium has two notable properties,

1. It is an ideal emitter: at every frequency, it emits as much energy as – or more energy than – any other body at the same temperature.
2. It is a diffuse emitter: the energy is radiated isotropically, independent of direction.

14. Why is existence of life not possible in Venus? [WBUT 2015(EVEN)]

Answer:

The atmospheric pressure of Venus is 100 times greater than Earth and the concentration of CO_2 in the atmosphere is 97%. In this atmosphere green house effect is maximum and so the surface temperature of the Venus is very high (750K or 477°C). This high temperature is also not suitable for the living organism and so Venus is free from life.

15. What does the term 'Three-way Catalytic Converter' mean? Explain the principle of a three-way catalytic converter. [WBUT 2016(EVEN)]

Answer:

Most modern car equipped with **"three-way catalytic converter"**. The 'three way' refers to that the device (catalytic converter) converts three harmful compounds in car exhaust into the harmless compounds.

These harmful compounds are carbon monoxide (CO), volatile organic carbon (VOC) and oxides of nitrogen (NO_x). This conversion takes place with the help of two different types of catalysts – **reduction catalyst** and **oxidation catalyst.** Usually, **platinum, rhodium** and **palladium** are used as catalysts:

1) Reduction: The first step is the reduction step. Here, platinum and rhodium are used as catalyst. In this step. oxides of nitrogen specially nitric oxide (NO) and nitrogen dioxide (NO_2) are converted to harmless molecular nitrogen (N_2).

$$2NO \rightarrow N_2 + O_2$$
$$2NO_2 \rightarrow N_2 + 2O_2$$

2) Oxidation: The second step of the conversion is oxidation step. Here, **platinum** and **palladium** are used as catalyst. In this step, carbon monoxide (CO) and volatile organic carbon (VOC) are converted to carbon dioxide (CO_2).

$$2CO + O_2 \rightarrow 2CO_2$$
$$HC + O_2 \rightarrow CO_2 + H_2O$$

3) Control System: The third stage of the catalytic converter is control stage. In this stage, **air to fuel** ratio is controlled with the help of **oxygen sensor.** This sensor is placed at the upstream of the catalytic converter and provide signal to the engine about the concentration of oxygen present in the exhaust. The engine then increases or decreases the oxygen concentration in the exhaust by adjusting air-to-fuel ratio.

16. Consider the sun as a perfect sphere of radius 6.8×10^8 m. Calculate the energy radiated by the sun in 12 hours. Surface temperature of the sun is 6200K and Stefan's constant $\sigma = 5.67\times10^{-8}\ Jm^{-2}s^{-1}K^{-4}$. [WBUT 2016(EVEN)]

Answer:

Sun radiates energy in one second

$$E_r = \sigma \times A \times T^4 = 5.67\times10^{-8} \times 4 \times 3.14 \times (6.8\times10^{8})^2 \times (6200)^4 = 4874\times10^{23}\ \text{Jm}^{-2}\text{s}^{-1}\text{K}^{-4}$$

Therefore, sun sun radiated energy in 12 hours $= 4874\times10^{23}\ \text{Jm}^{-2}\text{s}^{-1}\text{K}^{-4}$

$$= 2.1\times10^{31}\ \text{Jm}^{-2}\text{K}^{-4}$$

17. The physical stack (chimney) height 500 metre with an inside diameter of 10 metre. The stack gas velocity is 20 m/sec. The stack gas temperature is 200°C and ambient air temperature is 10°C. The atmospheric pressure is 1000 millibar and average wind speed is 5m/sec. Then calculate the effective stack height.

Answer: **[WBUT 2016(EVEN)]**

The given data is symbolized as below:

$H = 500$ mt

$D = 10$ mt

$u = 5$ mt/sec

$T_a = T_a = 10^{\circ}C = (10 + 273)K = 283$ K

$P = 1000$ milibars

$V_s = 20$ mt/sec

$T_s = 200^{\circ}C = (200 + 273)K = 473$ K

We know that,

Effective stack height (H) = Physical height (h) + Plume rise (Δh)

i.e., $H = h + \Delta h$

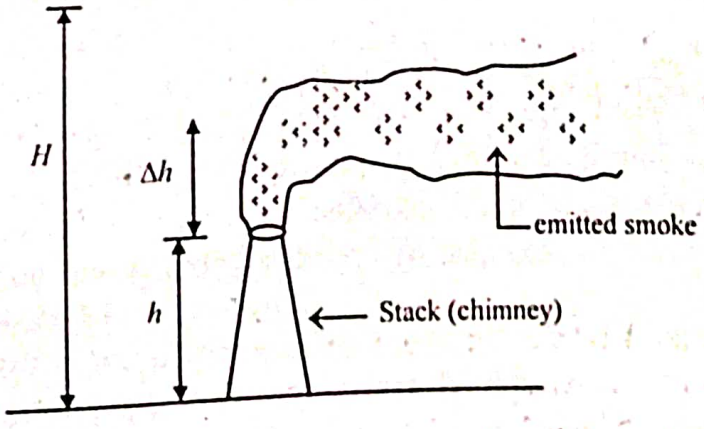
Now, plume rise

$$\Delta h = \frac{V_s.D}{u}\left[1.5 + 2.68\times10^{-3} \times P.D.\left(\frac{T_s - T_a}{T_s}\right)\right]$$

or, $\Delta h = (20 \times 10)/5\ [1.5+2.68 \times 10^{-3} \times 1000 \times 10 \times (473-283)/473]$

$\Delta h = 10.76$

∴ Effective stack height, H = (500 + 10.76) mt. = 510.76 mt.



[WBUT 2017(EVEN)]

18. What is black body?

Answer:

A **black body** is an idealized physical body that absorbs all incident electromagnetic radiation, regardless of frequency or angle of incidence. A **white body** is one with a "rough surface [that] reflects all incident rays completely and uniformly in all directions.

19. What is its impact of ozone hole formation? [WBUT 2017(EVEN)]

Answer:

Adverse Effect of Formation of Ozone Hole

i) U.V penetrates the ozone layer and fall on the surface. This ray is responsible for skin cancer called "Melanoma" and other diseases.
ii) This ray also disturbs the immune system of the living body.
iii) U.V. rays cause cataract in the eyes.
iv) This ray is also responsible for the retardation in the plant growth.
v) This U.V rays which is coming through the ozone hole, is responsible for the global warming too.

20. Consider the earth is flat and an isothermal body. Albedo for the earth is 0.2. Estimate the temperature of the flat earth. Given:

$S = 1372$ W/m2

$\sigma = 5.67 \times 10^{-8}$ W/m2 (°K)4 [WBUT 2017(ODD)]

Answer:

If we consider that the radius of the Earth is R then amount of energy radiated by the Sun and absorbed by the Earth's surface (E_a) i.e., incoming energy is equal to

$$E_a = S(1-\alpha).\pi R^2 \quad \ldots (1)$$

Where, S = Solar intensity, α = albedo.

On the other hand the Earth's surface (having total surface area $\pi R^2 + \pi R^2 = 2\pi R^2$) (since the Earth is flat) radiates the energy (E_r) which is equal to

$$E_r = \sigma.2\pi R^2.T^4 \quad \ldots (2)$$

Here, σ= Stefan=Boltzmann const. $= 5.67 \times 10^{-8}$ W/m^{2}K^4

T = Average surface temperature (K)

As, it is a black body, energy absorbed must be equal to energy radiate, so

$$E_a = E_r$$

or, $S(1-\alpha)\pi R^2 = \sigma.2\pi R^2.T^4$

$\therefore$ $S(1-\alpha) = 2.\sigma.T^4$

or, $$T = \left[\frac{S(1-\alpha)}{2.\sigma}\right]^{1/4} = \left[\frac{1372 \times (1-0.2)}{2 \times 5.67 \times 10^{-8}}\right]^{1/4} = 313.65\,K$$

$\therefore$ The temperature of new Earth would be 313.65 K.

21. Prove that on the basis of global temperature model, the earth's surface temperature is – 19°C.

Answer: [WBUT 2018(OLD)]

Here we will assume that both Earth and Sun behave like a blackbody. Radiation from the Sun arises just outside the Earth's atmosphere with an average annual solar intensity which is equal to 1372 W/m^2. Here, we have to consider that the all the solar radiation which fall on the surface of the Earth and contribute to the surface temperature, should pass through a disc having radius equal to that of Earth. In this case, we have to remember that 30% of the total incoming solar radiations returns back to the space without contributing anything to the Earth's surface temperature. This amount of radiation is known as '**Earth's albedo**'. Remaining incoming energy absorbs by the Earth's surface.

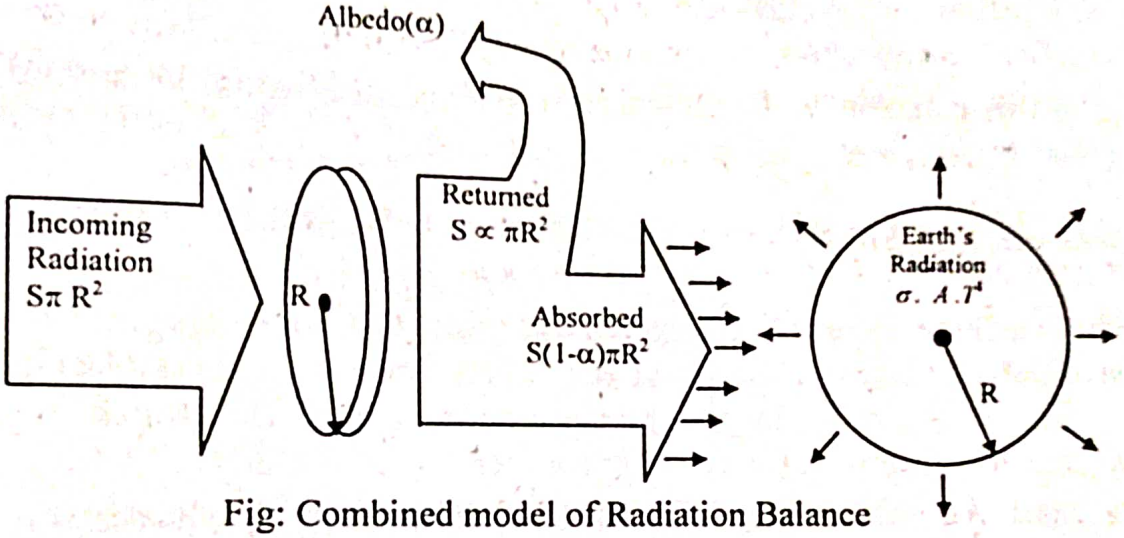


Fig: Combined model of Radiation Balance

Since we are considering that the Earth is a blackbody and so all the incoming radiation which falls on the surface of the Earth, should be absorbed by it.

So we can write – $E_a = S(1-\alpha)\pi R^2$ ... (1)

Where, E_a = rate of energy absorption by the Earth's surface

S = solar intensity = 1372 W/m^2.

α = Earth's albedo = 30% = 0.3

R = radius of the assumed disc (and Earth)

If we assume that the Earth is isothermal, with temperature T(K) everywhere, the energy radiated (E_r) from this blackbody (Earth) with surface area $4\pi R^2$ is given by the 'Stefan-Boltzmann' equation as –

$$E_r = \sigma . AT^4 \quad \text{... (2)}$$

or, $E_r = \sigma . 4\pi R^4 . T^4$

where, E_r = rate of energy radiation

σ = Stefan-Boltzmann constant

$= 5.67 \times 10^{-8}$ W/m^{2}K^4

A = surface area of black body $= 4\pi R^2$

T = temperature of Earth.

If we consider, the steady-state condition (that the Earth's temperature is not changing with time), we can equate equation (1) & (2).

$$E_a = E_r$$

or, $$S(1-\alpha)\pi R^2 = \sigma . 4\pi R^2 T^4$$

$$\therefore \quad T^4 = \frac{S(1-\alpha)}{4.\sigma}$$

or, $$T = \left[\frac{S(1-\alpha)}{4.\sigma}\right]^{1/4} = \left[\frac{1372\ W/m^2(1-0.3)}{4\times 5.67\times 10^{-8}\ W/m^2K^4}\right]^{1/4} = 255K$$

According to this calculation, Earth's surface temperature would be around 255K i.e., -18°C. But, fortunately, our Earth is not so much cold.

22. Define DALR and SALR. **[WBUT 2018(ODD)]**

Answer:

There are two different types of Adiabatic Lapse Rate (ALR) –

i) **Dry-Adiabatic Lapse Rate (DALR):** When the heated air (smoke) is dry i.e., free from any moisture, then the Lapse rate is called Dry-Adiabatic Lapse Rate (DALR). It is –10°C/km.

ii) **Saturated Adiabatic Lapse Rate (SALR):** When the heated air (smoke) is saturated by moisture, then the Lapse rate is called as Saturated Adiabatic Lapse Rate (SALR). It is –8.5°C/km.

Long Answer Type Questions

1. Show that temperature decreases with increasing altitude under adiabatic condition. **[WBUT 2005]**

OR,

Show that the temperature of the artificial surface falls by a rate $r = -\frac{g}{C_p}$

where,

r = rate of change of temperature with altitude.

g = gravitational constant

C_p = specific heat at constant process.

[WBUT 2008, 2012 (ODD), 2013(ODD), 2015(ODD)]

OR,

Prove that adiabatic lapse rate is equal to $-\frac{g}{C_p}$. **[WBUT 2017(EVEN)]**

Derive $-dT/dZ = g/C_p$ with usual notation. **OR,**

Answer: **[WBUT 2017(ODD)]**

Let us consider that a certain amount of artificially heated air is introduced to the atmosphere. This artificially heated air is warmer than the surrounding air and so moves in upward direction. During this movement it will experience less pressure (as height increases pressure decreases), causing it to expand, i.e., increase of volume (as $P \propto \frac{1}{V}$).

If we consider that the whole process is taking place under the adiabatic system where exchange of heat in between system and surrounding is not possible, then the internal energy of the artificially heated air will be utilized for the expansion of volume. As a result it gets cooled. Here temperature decreases with height or altitude and so it is lapse rate. As the whole process is taking place under the adiabatic condition, it is called the Adiabatic Lapse Rate (ALR).

Now, according to the first law of thermodynamics, we can write –

$$dQ = dE + dW$$

Where, dQ = change of heat, dE = change of internal energy,

dW = work done.

or, $dQ = C_v dT + PdV$ ... (1)

Where, C_v = specific heat at constant volume and $dE = C_v dT$ & $dW = PdV$

Again, $PV = nRT$ (according to gas laws)

or, $d(PV) = d(nRT)$

or, $PdV + VdP = nRdT$

or, $PdV = nRdT - VdP$ ... (2)

We can put the value of PdV in the equation (1) and get

$$dQ = C_v dT + nRdT - VdP$$

or, $dQ = (C_v + nR)dT - VdP$

or, $dQ = C_p dT - VdP$ ... (3)

Where, $C_p - C_v = nR$ and C_p = specific heat at constant pressure.

Under the adiabatic condition, exchange of heat i.e., dQ=0.

$\therefore 0 = C_p dT - VdP$

or, $C_p dT = VdP$ ... (4)

$$\therefore \quad \frac{dT}{dP} = \frac{V}{C_p}$$

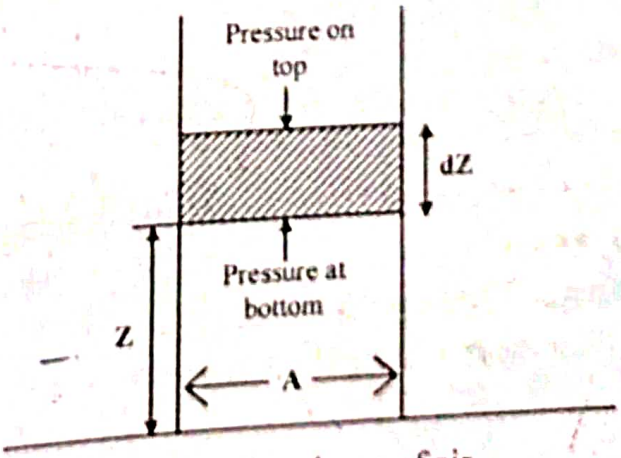


Fig: Static column of air

The above equation is indicating how temperature of atmosphere is changing with respect to the pressure of the atmosphere. Now we will establish the relationship between pressure and altitude.

Consider a static column of air with cross sectional area A. A horizontal slice of air in that column having thickness dZ and density ρ, will have mass = $\rho.A.dZ$ and placed at the height Z from the base.

On the top of the slice pressure is $P(Z+dZ)$ and at the bottom, it is $P(Z)$. The difference of these two pressures (dP) is for the slice of air. Therefore,

$$dP = p(Z+dZ) - P(Z) \qquad \ldots (5)$$

If the pressure on the top of the slice due to the weight of air above it is $P(Z+dZ)$, then the pressure at the bottom of the slice $P(Z)$, will be $P(Z+dZ)$ plus the added weight per unit area of the slice itself; i.e.,

$$P(Z) = P(Z+dZ) + \frac{g.\rho.A.dZ}{A} \qquad \ldots (6)$$

(Where, g = gravitational constant & weight = mass × g)

Put the value of P (Z) in equation no. (5) and we will get,

$$dP = P(Z+dZ) - P(Z+dZ) - \frac{g.\rho.A.dZ}{A}$$

or, $$dP = -g.\rho.dZ$$

$$\frac{dP}{dZ} = -g.\rho \qquad \ldots (7)$$

$$\therefore \frac{dT}{dZ} = \frac{dT}{dP}.\frac{dP}{dZ}$$

$$= \frac{V}{C_p}.-g.\rho \qquad \text{[From equation no. (4) \& (7)]}$$

$$= -V.\rho.{}^{g}/_{C_p} \qquad \ldots (8)$$

As, we know $V = \frac{M}{\rho}$

$$\therefore V.\rho = M$$

Here, M = mass

If unit mass present in the gas slice, then $V.\rho = M = 1$

Therefore, $$\frac{dT}{dZ} = -{}^{g}/_{C_p} \qquad \ldots (9)$$

$$= -\frac{9.8\,m/\sec^2}{1005\,J/Kg\,C} = -\frac{9.8}{1005}\cdot\frac{m.Kg.\,C}{J.\sec^2}$$

$$= -0.00976\,\frac{m.Kg.\,C.\sec^2}{Kg\,m^2.\sec^2}\cdot \quad [1\,J = 1\,Kg\,m^2/\sec^2]$$

$$= -0.00976\ C/m = -9.76\ C/1000\,m$$

$$\frac{dT}{dZ} \approx -10\ C/km.$$

2. Define global warming? Describe the effects of greenhouse gases on global warming.
Explain "Wien's law". Discuss its application for explaining greenhouse effect. **[WBUT 2005]**

What is Global warming? Analyze the causes and comment on the proposed remedial steps. **[WBUT2005, 2018(EVEN)]**

OR,

State & explain Wein's Law. How would you explain Green House effects with its help? **[WBUT 2007]**

OR,

Describe the effects of greenhouse gases on global warming. **[WBUT 2009]**

OR,

a) What is global warming? **[WBUT 2014(EVEN)]**
b) Describe clearly how the greenhouse gases cause global warming. **[WBUT 2016(ODD)]**
c) Explain the 'Wien's Law' and its application for explaining greenhouse effect.

Answer:

The slow gradual rise in the temperature of the Earth due to emission of excess quantities of radiation trapping gases (green house gases), is called '**global warming**'. It is estimated that by 2030 the average global temperature will have risen by 1 to 3 C.

The green house gases absorb the radiated heat and re-emit to the surface again to maintain the optimum temperature of the surface. This is called green house effect. But, due to rapid industrialization, the rate of emission of green house gases specially CO_2, CH_4, water vapour is increasing and as a result the slow and gradual rise in temperature is taking place. Thus, the excess green house effect is responsible for the '**global warming**'.

The effects of Green house gases:

Impact of Global Warming on Environment:

- **Impact of global warming on climate:** Emission of green house gases in the atmosphere in increasing rates may affect the climate to a large extent. Due to increase of average global temperature, water from various sources on Earth may evaporate more rapidly and as a result of which the overall amount of **rainfall** may increase. But this phenomenon will not occur evenly in all the parts of the Earth, there may be heavy rainfall in some parts and **drought** in some other parts of

the world. In some region, the **summer** may be hotter & prolonged, and **winter** becomes shorter & warmer.

- **Impact of global warming on Sea water level:** If the global temperature increases, the **ice-caps** and **glaciers** of the polar regions of the Earth may be melted partially, the floating ice on the water of the seas may also melt partially or completely. Due to an increase in temperature there may be an expansion of volume of sea water and as a result of which the level of sea water may rise. If the global temperature increases by 3°C-5°C on average, then a vast populated low-land area of the world specially coastal areas may be **flooded.**
- **Impact of global warming on Agriculture:** An increase in the amount of CO_2 in air is favourable for an increasing rate of photosynthesis of plants, therefore increase in CO_2 may increase the production of crops in some cases and on the other hand crop production may be reduced in some cases due to **dry soil having higher temperature.** There may be **acute scarcity of water for irrigation** in some places. In some regions, again, production of crops may decrease due to **soil erosion** rate becoming faster due to heavy rainfall and **washing away of fertile top soil** reducing thereby the available cropland area.
- **Impact of global warming on marine food:** Due to increase in temperature, the ice-caps, glaciers melt and as a result, expansion of volume of sea-water takes place. This expansion reduces the concentration of salts and changes the pH of the sea water. The average temperature of sea water is also changed. This changed environment is not suitable for the existence of different marine living organisms, especially fish. Different marine algae that are considered as food also die due to this disturbed condition.

Wien's displacement rule: A black body emits radiation with a different range of wave lengths that can be described with spectral distribution. Stefan-Boltzmann's law gives the energy emission rate by black body but it cannot give any idea about the maximum intensity of radiation. Wien's displacement rule can explain the wavelength at which the spectrum reaches its maximum intensity value.

$$\lambda_{max}(\mu m) = \frac{2898}{T(K)}$$

where, λ_{max} = maximum wavelength, T = Temperature

The surface of earth is around 34°C (288 K) which is much higher than the mathematical prediction. The ***Wien's displacement rule*** is helpful here to understand the reason behind it. If we consider both Sun and Earth as a black body having average surface temperature 5800K and 288K respectively, then according to the ***Wien's displacement rule*** their spectrum peaks will be at 0.5μm and 10.1 μm. If we analyse the spectrum curve of Black body radiation at 5800 K (for incoming solar radiation) and 288K (for out going radiation from earth surface), then we will notice that nearly all the incoming solar energy as it arrives just outside the earth's atmosphere has wavelength less than 3 μm, while the

outgoing radiation by the earth has essentially all of its energy in wavelength more than 3 μm. With so little overlap, it is convenient to say that incoming solar radiation has short wavelength while out going radiation from earth surface has long wavelength. The Infra Red (IR) portion of the spectrum strats about 0.7 μm extend up to 100 μm. So, some of the incoming solar radiation and all of the out going earth's radiation is IR.

Causes of Global Warming:

Global Warming is caused by many things. The causes are split up into two groups, man-made or anthropogenic causes, and natural causes.

Natural Causes

Natural causes are causes created by nature. One natural cause is a release of methane gas from arctic tundra and wetlands. Methane is a greenhouse gas. A greenhouse gas is a gas that traps heat in the earth's atmosphere. Another natural cause is that the earth goes through a cycle of climate change. This climate change usually lasts about 40,000 years.

Man-made Causes

Man-made causes probably do the most damage. There are many man-made causes. Pollution is one of the biggest man-made problems. Pollution comes in many shapes and sizes. Burning fossil fuels is one thing that causes pollution. Fossil fuels are fuels made of organic matter such as coal, or oil. When fossil fuels are burned they give off a green house gas called CO_2. Also mining coal and oil allows methane, another green house gas, to escape.

Another major man-made cause of Global Warming is population. More population means more food, and more methods of transportation which leads to pollution.
Since CO_2 contributes to global warming, the increase in population makes the problem worse because we breathe out CO_2. Also, the trees that convert our CO_2 to oxygen are being demolished because we're using the land that we cut the trees down from as property for our homes and buildings. We are not replacing the trees (an important part of our eco system), so we are constantly taking advantage of our natural resources and giving nothing back in return.

Control of Global warming:

There are two ways to control the global warming. These are

1. Mitigation
2. Adaptation

Mitigation

The scientific consensus on global warming, together with the precautionary principle and the fear of non-linear climate transitions is leading to increasing action to mitigate global warming.

The global energy policy has set a target of limiting the global temperature rise to 2 °C [3.6 °F] compared to preindustrial levels, of which 0.8 °C has already taken place and another 0.5 °C is already committed.

Adaptation to global warming consists of initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. This is in distinction to the mitigation of global warming.
Taking the following important measures may control the 'global warming' –

i) Reducing the consumption of fossil fuels such as coal and petroleum. This can be achieved by depending more on non-conventional renewable sources of energy such as wind, solar, bio-gas etc.
ii) Disposing of the green house gases as they are formed elsewhere than in the atmosphere.
iii) Recovering green house gases as they are formed elsewhere than in the atmosphere.
iv) International co-operation for attempting the reduction of green house gases.
v) Birth control, to lessen demand for resources such as energy and land clearing.

Application of explaining greenhouse effect:
Refer to Question No. 9 of Short Answer Type Questions.

3. Describe the effects of greenhouse gases on global warming. **[WBUT 2005]**

OR,

What are the effects of greenhouse gases on the global climate and on sea water level and agriculture? **[WBUT 2007, 2015(EVEN)]**

Answer:

Effects of greenhouse gases

- **Impact of global warming on climate:** Emission of green house gases in the atmosphere in increasing rates may affect the climate to a large extent.
  Due to increase of average global temperature, water from various sources on Earth may evaporate more rapidly and as a result of which the overall amount of **rainfall** may increase. But this phenomenon will not occur evenly in all the parts of the Earth, there may be heavy rainfall in some parts and **drought** in some other parts of the world. In some region, the **summer** may be hotter & prolonged, and **winter** becomes shorter & warmer.
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4. Consider the earth to be a blackbody with average temperature of 15.0°C and surface area equal to 5.1×10^{14} m^2. Find the rate at which energy is radiated by the earth and the wavelength at which maximum power is radiated. Compare this peak wavelength with that for a 5800-K black-body (the sun).

[WBUT 2007, 2014(EVEN), 2018(EVEN)]

Answer:

$$E = \sigma A T^4$$

$$= 5.67\times10^{-8}\ \text{Wm}^{-2}\text{K}^4 \times 5.1\times10^{14}\text{m}^2 \times (288\text{K})^4$$

$$= 2.0\times10^{17}\ \text{W}.$$

[It is the total amount of energy radiated; to determine the rate of **energy is radiated the equation would be** $E = E = \sigma A T^4 / A$]

$\lambda_{max} = (2898/288) = 10.1\mu m.$

5. How does the earth manage its radiation balance to maintain an average surface temperature of 15°C?

[WBUT 2008, 2014(EVEN), 2017(EVEN)]

OR,

How the green houses gases helps to maintain the earth average temperature of 15°C.

[WBUT 2018(ODD)]

Answer:

The mechanism of maintaining Earth's average temperature at 15°Ccan be explained with the help of some assumptions as well as some mathematical models.

Here we will assume that both Earth and Sun behave like a blackbody. Radiation from the Sun arises just outside the Earth's atmosphere with an average annual solar intensity which is equal to 1372 W/m^2. Here, we have to consider that the all the solar radiation which fall on the surface of the Earth and contribute to the surface temperature, should pass through a disc having radius equal to that of Earth. In this case, we have to remember that 30% of the total incoming solar radiations returns back to the space without contributing anything to the Earth's surface temperature. This amount of radiation is known as **'Earth's albedo'**. Remaining incoming energy absorbs by the Earth's surface.

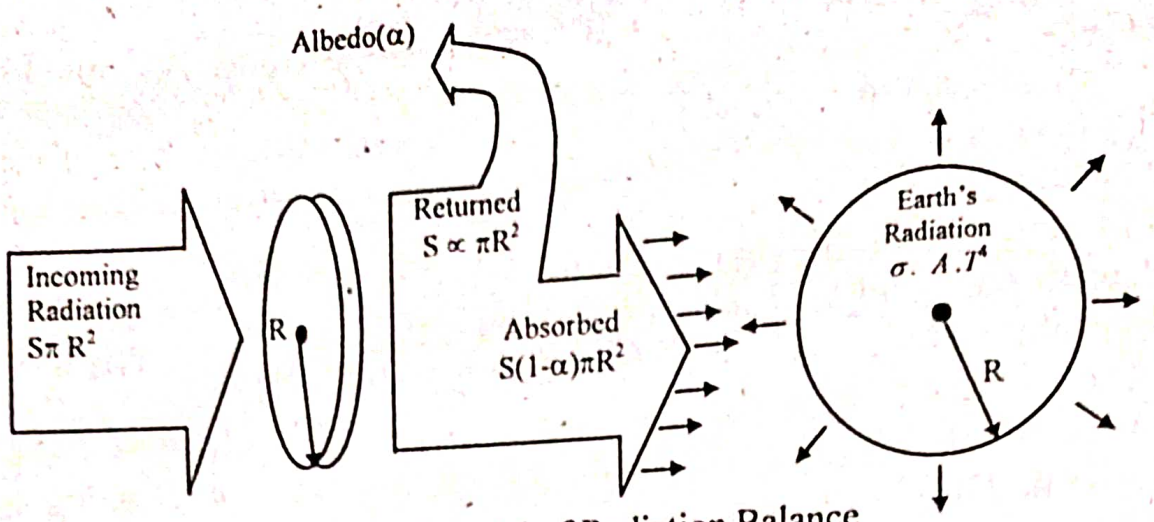

Fig: Combined model of Radiation Balance

Since we are considering that the Earth is a blackbody and so all the incoming radiation which falls on the surface of the Earth, should be absorbed by it.

So we can write – $E_a = S(1-\alpha)\pi R^2$ ... (1)

Where, E_a = rate of energy absorption by the Earth's surface

S = solar intensity = 1372 W/m^2.

α = Earth's albedo = 30% = 0.3

R = radius of the assumed disc (and Earth)

If we assume that the Earth is isothermal, with temperature T(K) everywhere, the energy radiated (E_r) from this blackbody (Earth) with surface area $4\pi R^2$ is given by the 'Stefan-Boltzmann' equation as –

$\therefore E_r = \sigma . AT^4$

or, $E_r = \sigma . 4\pi R^4 . T^4$ ... (2)

where, E_r = rate of energy radiation

σ = Stefan-Boltzmann constant

$= 5.67 \times 10^{-8}$ W/m^{2}K^4

A = surface area of black body $= 4\pi R^2$

T = temperature of Earth.

If we consider, the steady-state condition (that the Earth's temperature is not changing with time), we can equate equation (1) & (2).

$E_a = E_r$

or, $S(1-\alpha)\pi R^2 = \sigma . 4\pi R^2 T^4$

$\therefore T^4 = \dfrac{S(1-\alpha)}{4.\sigma}$

or $T = \left[\dfrac{S(1-\alpha)}{4.\sigma}\right]^{1/4} = \left[\dfrac{1372\ \text{W/m}^2(1-0.3)}{4 \times 5.67 \times 10^{-8}\ \text{W/m}^2\text{K}^4}\right]^{1/4}$

$= 255\text{K}$

According to this calculation, Earth's surface temperature would be around 255K i.e., –18°C. But, fortunately, our Earth is not so much cold.

The actual temperature of our Earth is 288 K i.e., 15°C. This indicates that, the surface is [15(18)]°C i.e., 33°C hotter than the predicted value. The key factor that makes our calculation differ from the actual result is that we never consider the interactions between the atmosphere and radiation, i.e., emitted by the Earth's surface. This key factor is nothing but '**Green House**' effect.

The incoming solar radiation having **shorter wavelength** can easily penetrate the gaseous layer of CO_2, water vapour etc. (green house gases) which is present just above the surface. After strike on surface, certain amount of radiation absorbed by it and then radiated back to the space. This radiated energy having **longer wavelength** (usually **I. R. range**) is not able to escape through the gaseous layer and absorbed there. Certain portion of this absorbed radiation then re-emitted back to the surface, resulting '**heat trapped**'. This trapped heat compensates that 33°C to the Earth's surface. As a result, the average temperature of the Earth's surface remains constant at 15°C.

6. a) What do you mean by temperature inversion? 1 8 2 **[WBUT 2013(ODD)]**

OR,

What is temperature inversion? **[WBUT 2013(EVEN)]**

b) What are the important classes of inversion? **[WBUT 2013(ODD)]**

Answer:

In an unusual case, when the temperature of the environment (i.e., ambient air) increases with altitude, then the lapse rate becomes inverted or negative from its normal state. This is called **negative lapse rate.**

Negative Lapse rate takes place under the conditions where the **warmer air lies over the cooler air.** As a result, temperature here increases instead of decreasing with height. This is called **temperature inversion.**

There are three types of FV in atmosphere –

i) Radiation inversion
ii) Subsidence inversion
iii) Advective inversion.

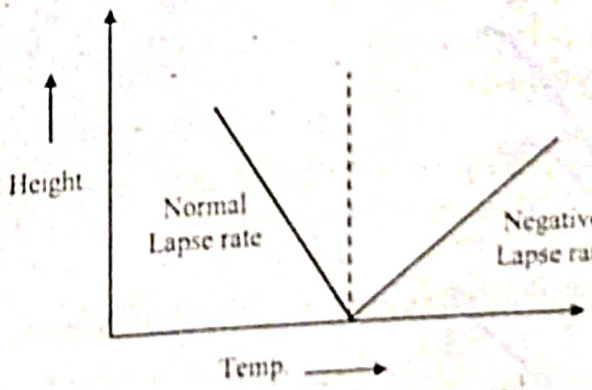

Fig: 1 Graph showing the negative Lapse rate

- **Radiation Inversion:**

When the Earth cools rapidly and moves quickly than the air above it (as may happen at nights when the Earth may loose heat by radiation and thereby cooling the surrounding air), then naturally the temperature of the surrounding air increases with the height. This causes **negative lapse rate** and **inversion condition.** This type of inversion is taking

place due to unequal rate of radiation of Earth's surface and air above it and so it is called **radiation inversion.**

This type of inversion may extend a **few hundred meters** and characteristically a nocturnal phenomenon and that is likely to break up easily with the rays of the morning Sun. Such an inversion in the environment helps in formation of fog. This type of inversion is more common in winter than in summer because of the longer nights.

- **Subsidence Inversion**

This type of inversion is usually associated with a high pressure system and is caused by the characteristic sinking or subsiding motion of air in a high pressure area surrounded by low pressure area. The air, circulating around the stationary high pressure area, descends gently at the rate of about 1000 mt per day. As the air sinks, it is compressed and gets heated to form a warm dense layer over the cooler air below. Such inversion layers may be formed from the ground surface to around 1600 mt. Such an inversion layer, by stopping the upward movement of polluting smokes, will cause the concentration of the pollutants in our immediate environment. Such type of inversion may be more dangerous than radiational inversion and may occur at modest altitudes and may remain for several days.

- **Advective Inversion**

This type if inversion is formed when warm air moves over a cold surface or cold air. The inversion can be ground-based in the former case or elevated in the latter case. An example of an elevated advective inversion occurs when a hill range forces a warm land breeze to flow at high levels and a cool sea breeze flows at low levels in the opposite direction.

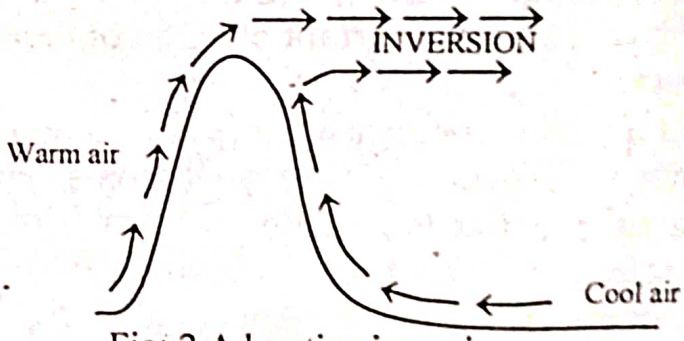

Fig: 2 Advective inversion

7. a) Define coning, looping, fumigation, lofting fanning plume.
b) What is the CFC number for CCl_2FCClF_2? **[WBUT 2015(EVEN)]**

Answer:

a) *Refer to Question No. 12 of Short Answer Type Questions.*

b) CFC 113

8. a) Discuss the role of $ClONO_2$ in formation of Antarctic ozone Hole. **[WBUT 2015(ODD)]**

Answer:

Over **Antarctica**, stratospheric ozone has been depleted over the last 15 years at certain times of the year. As a result, the density of O_3 molecule in that particular region

becomes very less and the U.V ray can easily penetrate that region and fall on the surface of the Earth. This particular region is known as **'Ozone hole'.**

Mechanism of Formation of Ozone hole

The formation of ozone hole depends on mainly the weather condition of the stratosphere. The following steps are involved in the formation of ozone layer-

i) During the **winter polar night**, sunlight does not reach the South Pole. A strong circumpolar wind develops in the middle to lower stratosphere. These strong winds are known as the **'Polar Vortex'.**

ii) Since there is no sunlight, the air within the polar vortex can get very cold. When temperature falls down below –80°C, a special type of cloud is formed. This cloud is known as **'polar stratospheric cloud' (or PSC).**

iii) Once, the PSC form, **heterogenous chain reactions** take place and convert the **inactive chlorine** (or bromine) **present in the stratosphere to more active form.** Here, chlorine (or bromine) is available from the chemicals released by human activities (such as **CFC**, compounds containing Br_2, SO_x, NO_x etc.)

i) Ozone loss does not take place until **sunlight returns** to the air inside the **polar vortex** and allows the production of **active chlorine** and initiates the **ozone destruction cycle.**

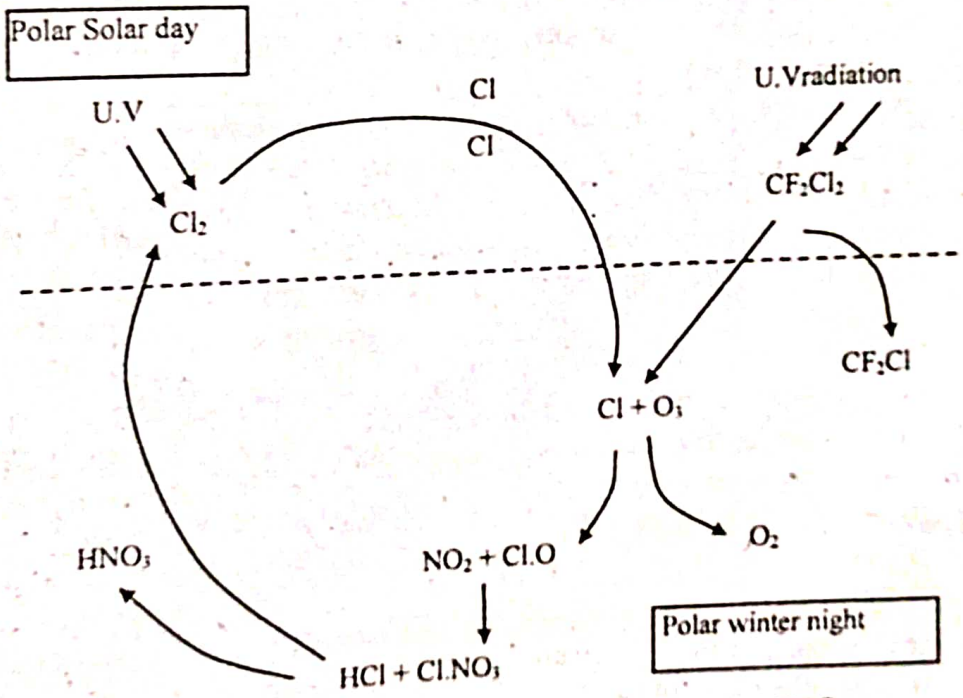

Fig: Depletion of O_3 molecule by CFC

CFC's are a common industrial product; used in refrigeration system, air conditioners etc. One molecule of CFC is responsible for the destruction of 10 lakh molecule of molecule of O_3.

b) Enlist the different criteria pollutants as far as Air pollution is concerned. What is NAAQS? **[WBUT 2015(ODD)]**

OR,

Name six important criteria pollutants. Why are they called so? **[WBUT2018(EVEN)]**

Answer:

Scientists have established specific levels of each of six common air pollutants viz. which are dangerous to our health and welfare. These are known as **criteria pollutants.** In order to protect us, levels of these criteria pollutants are monitored and strictly regulated. Four of the six are directly produced by burning. Burning either fossil fuels (coal, oil or natural gas) or wood causes air pollution which has devastating effects on our lungs and our environment.

Name of the pollutants	*Description*	*Sources*	*How It Hurts*
Nitrogen Dioxide - NO_2	Nitrogen dioxide is a brown noxious gas leftover from burning fossil fuels. On sunny days, it mixes with volatile organic compounds to make ozone, a major ingredient of smog.	Cars and trucks produce over 3/4ths of it. Oil refineries, power plants and industry produce the rest.	Nitrogen dioxide irritates our lungs and causes bronchitis and other diseases. Nitrogen oxides also cause acid rain and snow.
• *Ozone* - O_3	Ozone is a colorless, smelly, irritating gas made of 3 atoms of oxygen. It is created when volatile organic compounds and nitrogen oxides react with sunlight in the atmosphere. Ozone is a major ingredient of smog and is very toxic to humans and other life. High up in the stratosphere, ozone protects us from dangerous ultraviolet radiation from the Sun, but at ground level it literally corrodes our lungs.	60% of ozone's ingredients come from vehicle emissions and the rest come from industry and consumer products we buy every day.	Ozone (O_3) damages the lungs so that we can't inhale and exhale enough air and aggravates asthma, bronchitis and other respiratory problems. It also interferes with photosynthesis in plants.

Name of the pollutants	Description	Sources	How It Hurts
Carbon Monoxide - CO	Carbon monoxide is a poisonous, invisible gas released from exhaust pipes when gasoline burns.	Over 80% of CO comes from cars and other vehicles.	Carbon monoxide prevents our blood from delivering oxygen to our bodies. Small amounts cause headaches. Large amounts in closed spaces can suffocate and kill us.
Sulfur Dioxide - SO_2	Sulfur-containing gases called sulfur oxides are formed when oil products burn.	Sulfur oxides are produced by cars, oil refineries and chemical plants, when fuels are burned that contain sulfur (like coal, oil products and wood).	Sulfur dioxide constricts the airways and triggers asthma attacks. Other sulfur compounds are a big part of acid rain, acid snow and haze.
Particulate Matter - PM	Fewer than 10 microns in diameter, these fine particles in the air are much smaller than a human hair. They lodge in the deepest parts of our lungs and don't come out.	Particulate matter comes from dirt, soot, car and truck exhaust, cigarette smoke, spray paint droplets and toxic chemical compounds.	Fine particulate matter collects in the nose, throat, bronchial tubes and lungs where it causes respiratory infections. It also makes the sky hazy.
Lead - Pb	Lead is a metallic element that occurs naturally in soil, rocks, water and food. Until the mid-1970's we used huge, concentrated amounts of lead in gasoline for our cars and in paint for our houses. The biggest success story for cleaner air came when we changed to unleaded gas and paint, reducing the lead in the air by 90%. However, we still use lead in some products.	Even though lead in the air from car exhaust has been dramatically reduced, leaded gas is still used for small planes and race cars. Lead is also used in lead-acid car batteries. Although it is no longer allowed in U.S house paints, it is still used in industrial coatings. Right now, at least 70% of lead pollution comes from smelters, power plants fueled by coal and lead used in the processing of oil shale.	Lead enters our bodies in contaminated soil, water, dust, paint and food. We can also just directly breathe it in. Lead particles small enough to be inhaled into the lungs are easily absorbed into the blood and circulated throughout the body. Their most important target is the brain. Even low levels of lead exposure can increase blood pressure and permanently lower children's IQ. Higher levels can make any of us anemic -- damaging our red blood cells and sapping our energy.

9. a) Explain with diagram: [WBUT 2015(ODD)]
(i) Sub Adiabatic Lapse rate
(ii) Super Adiabatic Lapse rate
(iii) Neutrally stable Lapse rate.

Answer:

Unstable Atmospheric Condition

There are four different types of instable conditions of atmosphere:

1. Absolute instability
2. Mechanical instability
3. Conditional instability
4. Convective instability

- ***Absolute instability:***

The atmosphere is said to be **unstable** when ELR (say 15°C/km.) is more than ALR (say 8°C/km.). In such case, if a pocket of artificially heated air introduce to the atmosphere, it will move in the upward direction and always be warmer than the surrounding air. This is so because as we go up, the environment is getting cooler more quickly than the rising heated air (as ELR ⟩ ALR). As a result, the upward movement of warmer and lighter air will continue. This is called **vertical mixing of air.** In such circumstances, the **dispersion of pollutants will be rapid.** This is called absolute instability in atmosphere. In this particular case, **Environmental Lapse Rate (ELR)** is greater than **Adiabatic Lapse Rate (ALR)** and so it (ELR) is called as **Super-adiabatic Lapse Rate.**

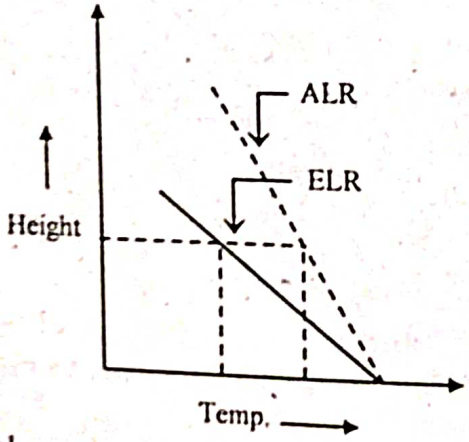

Fig. 1 The above graph showing that ELR ⟩ ALR i.e., unstable condition

- ***Mechanical instability:***

During the abnormal condition in the atmosphere, when the lapse rate is too steep (around 35°C/km), and the upper layers of the atmosphere become far denser than the underlying layers, there is an automatic overturning of air without any initial impulse being applied to it. Such atmospheric condition is known as mechanical instability in atmosphere.

- ***Conditional instability:***

This occurs when the ELR is *less* than the DALR *but more* than the SALR. This is the most common situation in Britain. The rising air is stable in the lower layers of the atmosphere, but if it the reason that it started to rise in the first place remains (e.g. being forced to rise over hills) then it may rise and cool to below its dew point. This will mean

that it will then rise freely as it is unstable (even if it has passed the reason for it rising, e.g. the hills have been passed). The weather found with this sort of stability is usually fine and sunny in low lying areas (i.e. those below the condensation level) but showery and cloudy in higher areas.

- ***Convective instability:***

Convective instability (also known as **potential instability** or **thermal instability**) occurs when dry mid-level air rises (usually caused by mountains or hills) over very warm, moist air in the lower troposphere. The differences saturation cause changes adiabatic lapse rates, and can result in the air layer becoming unstable and possibly overturning.

Convective instability is also termed ***static instability***, because the instability does not depend on the existing motion of the air; this contrasts with dynamic instability.

b) What is maximum mixing depth and ventilation coefficient? [WBUT 2015(ODD)]

OR,

Explain maximum mixing depth and ventilation coefficient. [WBUT 2016(ODD)]

Answer:

The amount of air available to dilute pollutants is related to the wind speed and to the extent to which emissions can rise into the atmosphere. If certain amount of artificially heated air is introduced in the atmosphere and if it is warmer and lighter than the surrounding air, it will move upward direction due to its buoyancy. As the heated air moves upward it cools adiabatically at about 1°C/100 mt. The heated air will move up to that height where its temperature and density become equal to those of surrounding air. This height is known as **maximum mixing height** or **maximum mixing depth**. The maximum mixing depth can be obtained simply by plotting ELR and ALR in a graph. The vertical distance from the point of intersection to the base is called the **maximum mixing depth.** (Here, we have to consider that the initial temperature of the artificially heated air is equal to the daily maximum surface temperature of the month).

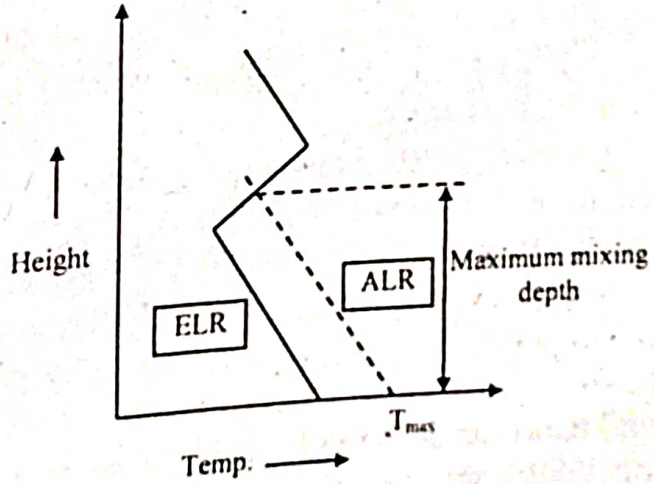

Fig: 1 Maximum mixing depth

Ventilation co-efficient: The **product of the maximum mixing depth** and the **average wind speed** in that region is called **Ventilation co-efficient**. This is sometimes used as an

indicator of the atmosphere's **dispersive capability**. Values of ventilation co-efficient less than 6000 m^2/s are considered as bad condition for the dispersion of the pollutants.
An anemometer at any height usually measures wind speed. If we know the wind speed (u_0) at the height where the anemometer is placed (Z_0), then we can determine the wind speed (u) at any height (Z) by using the formula $u = u_0\left[\frac{Z}{Z_0}\right]^K$

Where, K = dimensionless parameter that varies with atmospheric stability.
The direction and speed of winds primarily govern the drift and diffusion of polluted gases and particulate emissions from automobiles and factories etc. emitted near the ground levels. The higher the wind speed at or near the point of emission, the more rapidly the pollutants would be carried away from the source. The pollutants so dispersed will not exist at the same concentration, but will rapidly dilute with greater volume of air.

On the other hand, when the wind speeds are low, the pollutants tend to concentrate near the area of their emission, indicates poor dispersion.

Gustiness, which is another important characteristic feature of wind, is directly proportional to the wind speed. This determines the extent to which the pollutants are mixed and diluted with the ambient air.
Wind speed and the concentration of pollutants are inversely proportional to each other. This simple relationship becomes complicated by various other factors, like atmospheric turbulence and stability, geographical conditions and the moisture present in air etc.

10. a) Name four Ozone Depleting Substances (ODS). How do these substances cause ozone depletion in the stratosphere? **[WBUT 2016(EVEN)]**

Answer:

- Chlorofluorocarbons (CFCs)
- Halon.
- Carbon tetrachloride (CCl_4), Methyl chloroform (CH_3CCl_3)
- Hydrobromofluorocarbons (HBFCs)
- Hydrochlorofluorocarbons (HCFCs)
- Methyl bromide (CH_3Br)
- Bromochloromethane (CH_2BrCl)

2nd Part: ***Refer to Question No. 4 of Short Answer Type Questions.***

b) Deduce the chemical formula for CFC-115. **[WBUT 2016(EVEN)]**

Answer:
CFC 115 = C_2F_5Cl
115+ 90 = 205
So, Number of C atom= 2

Number of H atom= 0
Number of F atom = 5
Remaining valency of C are to be satisfied by the Cl atoms. So, number of Cl = 1.

c) Mention the uses of CFC. **[WBUT 2016(EVEN)]**

Answer:

A hydrocarbon, in which some or all of the hydrogen atoms have been replaced by chlorine and fluorine, is called Chlorofluorocarbon (CFC). These compounds are used as a feedstock, as a refrigerant, as a solvent and as blowing agent of plastic foam.

11. Consider earth to be a black body having average temperature of 15°C and surface area = $5.1 \times 10^{14} m^2$. Find the rate at which energy is radiated by the earth and the wavelength at which the maximum energy is radiated.
Given that Stefan-Boltzmann constant,
$\partial = 5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$ **[WBUT 2016(ODD)]**

Answer:

$E_r = \sigma \cdot A \cdot T^4$

Here, $\sigma = 5.67 \times 10^{-8}\ W/m^2/k^4$

$A = 5.1 \times 10^{14}\ m^2$

$T = 15°\ C = 288\ K$

$\therefore \quad E_r = 5.67 \times 10^{-8} \times 5.1 \times 10^{14} \times (288)^4 \frac{W \cdot m^2 \cdot k^4}{m^2 \cdot k^4}$

$= 4.98 \times 10^{11} \times 10^6\ W$

$= 1.98 \times 10^{17}\ W$

12. 'ELR>ALR is the ideal situation for the dispersion of the pollutants in the atmosphere.' –justify it. **[WBUT 2016(ODD)]**

Answer:

Refer to Question No. 9 of Long Answer Type Questions.

13. What do you understand by PSI/AQI in air pollution? What are criteria pollutants? **[WBUT 2017(EVEN)]**

Answer:

This index is usually used to assess a particular day's air quality. The PSI converts air pollution concentrations to a simple number between zero and 500 and assigns a descriptive term such as 'good', 'moderate' etc. The descriptive terms corresponding to PSI numbers are given below.

PSI value	Descriptor
0 – 50	Good
51 – 100	Moderate
101 – 199	Unhealthy
200 – 299	Very unhealthy
≥ 300	Hazardous

Criteria Pollutants:

Scientists have established specific levels of each of six common air pollutants viz. which are dangerous to our health and welfare. These are known as **criteria pollutants.** In order to protect us, levels of these criteria pollutants are monitored and strictly regulated. Four of the six are directly produced by burning. Burning either fossil fuels (coal, oil or natural gas) or wood causes air pollution which has devastating effects on our lungs and our environment.

14. a) Calculate the earth temperature from radiating heat balance considering albedo. **[WBUT 2017(EVEN)]**

Answer:

The mechanism of maintaining Earth's average temperature at 15°C can be explained with the help of some assumptions as well as some mathematical models.

Here we will assume that both Earth and Sun behave like a blackbody. Radiation from the Sun arises just outside the Earth's atmosphere with an average annual solar intensity which is equal to 1372 W/m^2. Here, we have to consider that the all the solar radiation which fall on the surface of the Earth and contribute to the surface temperature, should pass through a disc having radius equal to that of Earth. In this case, we have to remember that 30% of the total incoming solar radiations returns back to the space without contributing anything to the Earth's surface temperature. This amount of radiation is known as '**Earth's albedo**'. Remaining incoming energy absorbs by the Earth's surface.

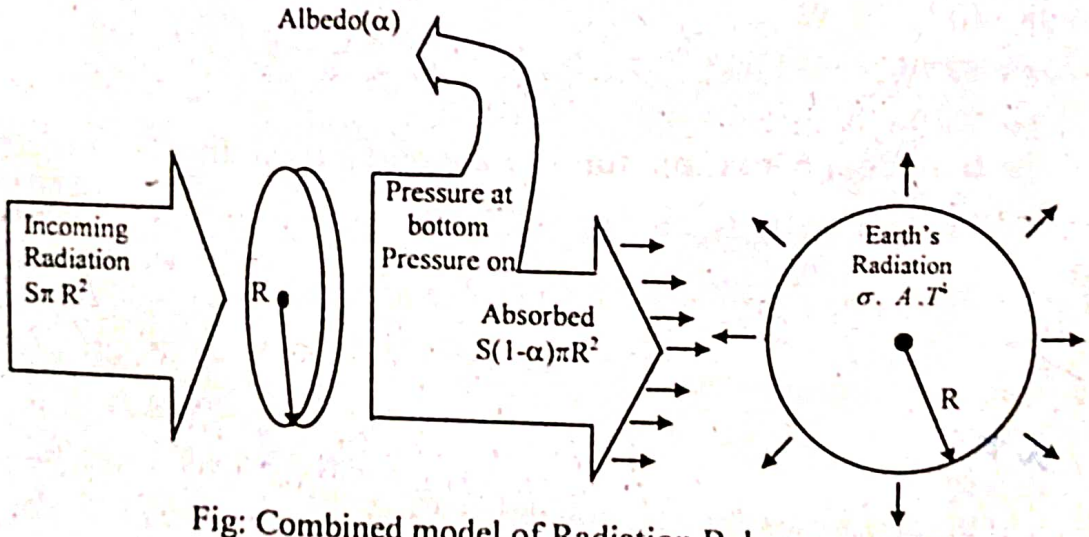

Fig: Combined model of Radiation Balance

Since we are considering that the Earth is a blackbody and so all the incoming radiation which falls on the surface of the Earth, should be absorbed by it.

So we can write – $E_a = S(1-\alpha)\pi R^2$ ... (1)

Where, E_a = rate of energy absorption by the Earth's surface

S = solar intensity = 1372 W/m^2.

α = Earth's albedo = 30% = 0.3

R = radius of the assumed disc (and Earth)

If we assume that the Earth is isothermal, with temperature T(K) everywhere, the energy radiated (E_r) from this blackbody (Earth) with surface area $4\pi R^2$ is given by the 'Stefan-Boltzmann' equation as –

$$E_r = \sigma . AT^4$$

or, $$E_r = \sigma . 4\pi R^4 . T^4 \quad \ldots (2)$$

where, E_r = rate of energy radiation

σ = Stefan-Boltzmann constant

$= 5.67 \times 10^{-8}\ W/m^2K^4$

A = surface area of black body $= 4\pi R^2$

T = temperature of Earth.

If we consider, the steady-state condition (that the Earth's temperature is not changing with time), we can equate equation (1) & (2).

$$E_a = E_r$$

or, $$S(1-\alpha)\pi R^2 = \sigma . 4\pi R^2 T^4$$

$$\therefore \quad T^4 = \frac{S(1-\alpha)}{4.\sigma}$$

or, $$T = \left[\frac{S(1-\alpha)}{4.\sigma}\right]^{1/4}$$

$$= \left[\frac{1372\ W/m^2(1-0.3)}{4 \times 5.67 \times 10^{-8}\ W/m^2K^4}\right]^{1/4} = 255\ K$$

b) Hence justify the difference between equivalent earth temperature and observed earth temperature. **[WBUT 2017(EVEN)]**

Answer:

According to this calculation, Earth's surface temperature would be around 255 K i.e., 18 C. But, fortunately, our Earth is not so much cold.

The actual temperature of our Earth is 288 K i.e., 15 °C. This indicates that, the surface is [15-(-18)]°C i.e. 33°C hotter than the predicted value.

15. a) Draw the schematic diagrams of (i) Fanning plume model and (ii) Looping plume model along with their lapse rate diagram.

b) State two advantages and two disadvantages of filter bag house unit. **[WBUT 2017(ODD)]**

Answer:

a) i) Fanning plume model: The fanning plume is available under the extreme inversion condition (due to negative lapse rate). This inversion condition leads to stable environmental condition just above the stack. As a result, the smoke emitted from the stack does not move in upward direction but moves horizontally.

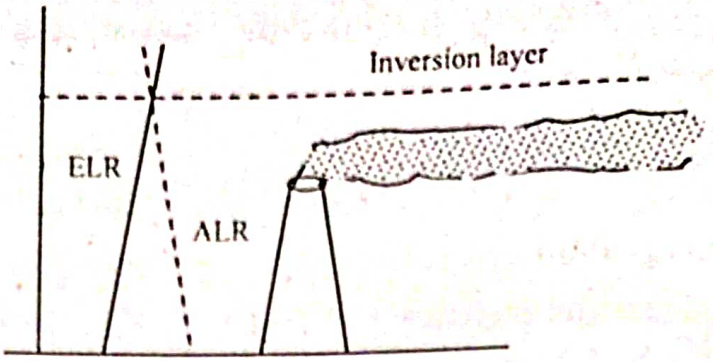

Fig: Fanning plume

ii) Looping plume model: Looping plume has a wavy character and occurs in **super adiabatic environment** (here, ELR)ALR) which produces highly **unstable atmosphere**, because of rapid mixing. During the high degree of **turbulence**, the dispersion of plume would be rapid and as a result **high concentrations near the ground may** take place. To avoid this, it is suggested to design **high stack** where atmosphere is generally super adiabatic.

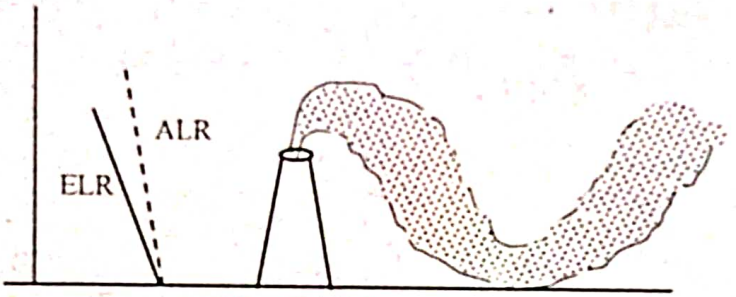

Fig: Looping plume

b) *Refer to Question No. 17(f) of Long Answer Type Questions.*

16. a) What is positive lapse rate? Why stratosphere shows positive lapse rate?
b) Mercury is 58 × 109 m away from the sun and has albedo equal to 0.06. Find out the average surface temperature of Mercury. (Distance from Sun to Earth is 15 ×1010 m).
c) What is atmospheric radiative window? Write down the name of four green house gases.
[WBUT 2018(EVEN)]

Answer:

a) The rate of change of temperature with respect to the height or the altitude of atmosphere is called Lapse rate. If temperature increases with height or altitude, then it is called positive lapse rate.

The Ozone molecule present in the stratosphere has the capacity to absorb the radiation which increases the temperature of the surrounding area. The temperature in this layer gradually increases with height. This is just opposite to troposphere. At lower boundary (at tropopause) temperature is about -56 C, while at the upper boundary (at stratopause) it is about -2 C.

This is the reason why stratosphere shows the positive lapse rate.

b) In case of Mercury, $d = 58\times10^9\, mt$, albedo $(\alpha) = 0.06$. Solar intensity

$$\therefore S = \frac{K}{d^2} = \frac{3087\times10^{22}}{(58\times10^9)^2} = 91.76\times10^2\, W/m^2$$

Therefore, we can write $S(1-\alpha)\pi R^2 = \sigma, 4\pi R^2 . T^4$

or, $91.76\times10^2(1-0.06) = 4\times5.67\times10^{-8}\times T^4$

$$\therefore T = \left[\frac{91.76\times10^2(1-0.06)}{4\times5.67\times10^{-8}}\right]^{1/4} = 441K.$$

c) *Refer to Question No. 17(k) of Long Answer Type Questions.*

17. a) What is adiabatic lapse rate and environmental lapse rate? Considering the two lapse rates explain the term "Mixing height" and "Ventilation Coefficient".
b) What are the differences between photochemical smog and sulphurous smog?
c) What is 'Montreal Protocol'? **[WBUT 2018(ODD)]**

Answer:

a) 1st part: Environmental Lapse Rate (ELR)

In the atmosphere, the temperature of the ambient (surrounding) air changes with an increase in altitude (height). This is called **ambient lapse rate of Environmental Lapse Rate (ELR)**. This rate will differ from place to place and from time to time even at same place. Generally this is about 6.5 C per 1000m. This rate does vary and depends on local air condition. There are several influencing factors –

i) Height
ii) Season: Environmental laps rate is lower in winter or during a rainy season.
iii) Surface: Environmental lapse rate is lower over land than sea.
iv) Air mass: Different properties of air masses mean different lapse rate.

Adiabatic Lapse Rate (ALR)

This is a theoretical rate and can be calculated. Under the prevailing environmental conditio , when a parcel of air (e.g., automobile exhaust, smoke from factories etc.), which is hotter and lighter than the surrounding air is released, then naturally it tends to move in upward direction. It will move, until it reaches to a level or height where its own temperature and density become equal to that of the air surrounding it. Hence, when a pocket of artificially heated air (i.e., automobile exhaust or gas coming from factories) is emitted into the atmosphere, it rises up, expands, become lighter and **gets cooled**. Actually, air pressure reduces as height increases. So as the heated air moves in upward direction, the pressure on it gradually **decreases** and as a result, the **expansion of volume** takes place. If this process takes place under the **adiabatic condition** [i.e., the condition where exchange of heat in between surrounding and system (heated air) is not possible]

the internal energy of the heated air should be utilized here to expand the volume of it and as a result it becomes cooled. This change of temperature with height, (i.e., lapse rate) may be considerably different from the Environmental Lapse Rate and can be calculated using the law of conservation of energy and gas law. As we consider that the whole process is taking place under the adiabatic condition, the Lapse rate is known as 'Adiabatic Lapse Rate (ALR)'.

2nd part: *Refer to Question No. 9.b) of Long Answer Type Questions.*

b) *Refer to Question No. 11 of Short Answer Type Questions.*

c) *Refer to Question No. 4 of Short Answer Type Questions.*

18. Write short notes on the following:

a) Catalytic converter [WBUT 2005, 2008, 2012(ODD), 2017(EVEN)]

b) Electrostatic precipitators [WBUT 2006, 2012(ODD), 2013(EVEN), 2016(ODD), 2017(EVEN), 2017(ODD)]

OR,

ESP for removal of particulate matter [WBUT 2016(EVEN)]

c) Cyclone separator [WBUT 2007, 2013(EVEN), 2015(EVEN), 2015(ODD)]

d) Ventury scrubber [WBUT 2007, 2013(ODD)]

e) Comparison of Montreal protocol and Kyoto protocol [WBUT 2013(ODD)]

f) Baghouse filter [WBUT 2014(EVEN), 2016(EVEN)]

g) PAN [WBUT 2014(EVEN)]

h) SPM [WBUT 2014(EVEN)]

i) Montreal protocol [WBUT 2016(ODD)]

j) Temperature inversion [WBUT 2016(ODD)]

k) Atmospheric radiation window [WBUT 2017(ODD)]

l) Global warming [WBUT2018(EVEN)]

Answer:

a) Catalytic converter:

Refer to Question No. 7 of Short Answer Type Questions.

b) Electrostatic precipitators:

Electrostatic Precipitator (ESP) consisting of vertical wires placed in between parallel plates. A strong electric field is created between wire and the plates by impressing a high negative voltage on the wires (as more as 1KV to 50 KV). The intense field created near the wire causes **corona discharge** ionizing gas molecules in the air stream. The negative ions and free electrons thus created move towards the plates and on the way some attach themselves to the particulate matter. The particles now carry a charge, which causes them to move under the influence of the electric field to the surface of the plates. They are removed from the collection electrode either by gravitational forces or by flashing the collecting plates with liquid.

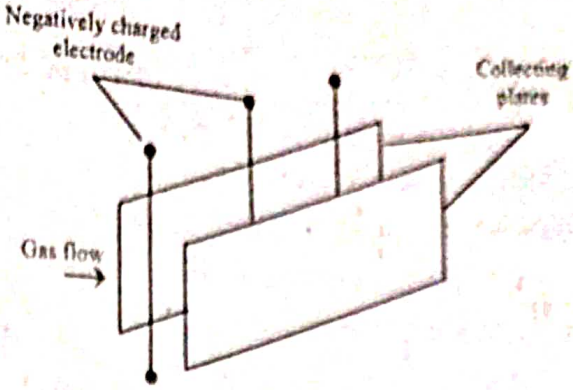

Fig: Electrostatic Precipitator

Advantages:

- Power requirement is less
- Economical & easy to operate
- 99% efficiency is obtainable
- Very small particles can be collected in wet or dry forms

Disadvantages:

- High initial cost
- Large space require
- Safeguard of operating person from high voltage is necessary
- Collection efficiency can deteriorate gradually

c) Cyclone separator:

Cyclone separator utilize a centrifugal force generated by a spinning gas stream to separate the particulate mater from the carrier gas. The centrifugal force on particulate matters in a spinning gas stream is much greater than gravity; therefore, cyclones are effective in the removal of smaller particles than the settling chamber. The efficiencies of cyclone separator can be above 90% for the particles larger than 5μm and drop rapidly for the small particle sizes.

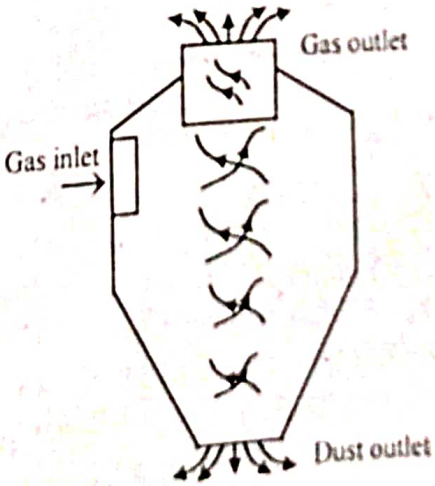

Fig: Cyclone Separator

Advantages:

- Low initial cost
- Simple construction & operation
- Low pressure drop
- Low maintenance
- It has no moving parts
- Continuous disposal of solid particles

Disadvantages:

- Low collection efficiency for the particles below 5μm in diameter

Equipment is subjected to severe abrasive deterioration.

d) Ventury scrubber:

It is a high energy wet scrubber with a good efficiency. In this device, the particulate laden stream is directed through a ventury tube at a velocity of 60 – 100 mt/sec. Water sprays are introduced just ahead of the throat of ventury scrubber.

Through the throat of the ventury scrubber the scrubbing liquid is injected to the inward direction. The velocity of this liquid (usually water) is low as compare to the velocity of gas containing particulate matter. Due to the velocity difference between the particles and the droplets of the water (scrubbing liquid), the particles are impacted against the slow moving droplets. Then the gas-liquid mixtures are collected at end part of the Ventury Scrubber. After that, this collected mixture is directed to a separation device such as cyclone separator where particulate matters are separated from the gas stream.

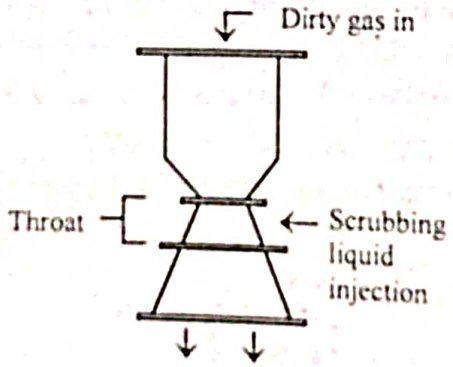

Fig: Ventury Scrubber

Advantages:

- Low initial cost
- High collection efficiency
- Applicable for high temperature
- Able to separate both gas & particulate

Disadvantages:

- High power consumption
- High maintenance cost
- Wet disposal of the collected material

e) Montreal Protocol: It is an international agreement, signed in 1987 at Montreal, to stop the production of Ozone Destroying Substances (ODS) like CFC etc. by the year 2000.

Kyoto Protocol: The Kyoto Protocol is an international agreement proposed on December 11, 1997 in Kyoto, Japan. In a nutshell the agreement requires the United States, the European Union and Japan to reduce greenhouse gas emissions (below 1990 levels) by 7%, 8% and 6%, respectively, by the year 2010. The burden of initial emission reduction rests on the industrialized countries, which have built high standards of living based on fossil fuel use, and which have produced most of the greenhouse gases residing in the Earth's atmosphere. Eventually, developing countries will have to reduce their carbon emissions too.

f) Baghouse filter:

Advantages:

- Very high efficiency
- Retention of fine particles
- Collection of particles in dry form
- Relatively low pressure drop

Disadvantages:

- Large space require
- High construction cost
- Operation can be possible when the temperature of the carrier gas is below 285°C.

g) PAN:

Peroxy acyl nitrate (PAN) is produced as a by product during the formation of photochemical smog. The aldehyde (RCHO), the important ingredient of photochemical smog, interacts with the $HO^{\bullet}$ radical in the intermediate step to produce Peroxyacyl nitrate (PAN).

h) SPM:

Pollutants	Major sources	Human health	Vegetation	Materials	Asthetic
Particul-ates	power generation, space heating/cooling and industrial process	Interfere with respiratory functions, possible contribution to lung cancer	Reduction in plant growth by physical blockage of light when deposited on leafed surface	Soiling of fabrics and buildings and corrosion of metal when combined with SO_2	Creation of smoke plumes, scattering of sunlight to produce haze and colourful sunsets, and formation of hydroscopic nuclei to produce fog

Different control measures (any three) for SPM in industries

a. Settling Chamber
b. Cyclone Separator
c. Baghouse Filter
d. Electrostatic Precipitator (ESP).

i) Montreal protocol: ***Refer to Question No. 6 Short Answer Type Questions.***

j) Temperature inversion: ***Refer to Question No. 6 Long Answer Type Questions.***

k) Atmospheric radiation window: ***Refer to Question No. 11(3rd Part) Short Answer Type Questions.***

l) Global warming: Refer to Question No. 2 of Long Answer Type Questions.

WATER POLLUTION & CONTROL

Multiple Choice Type Questions

1. Which of the following can be used for disinfection of water? [WBUT 2008, 2015(EVEN), 2018(ODD)]
   a) Chlorine
   b) Hydrogen peroxide
   c) Ozone
   d) None of these

Answer: (a)

2. While carrying out BOD test, BOD-bottle is stoppered [WBUT 2011(ODD), 2016(ODD)]
   a) to avoid evaporation of water
   b) to avoid photosynthesis
   c) to avoid diffusion of atmospheric oxygen
   d) to avoid diffusion of atmospheric carbon dioxide

Answer: (c)

3. Temporary hardness of water is due to the presence of [WBUT 2012(EVEN), 2014(ODD)]
   a) NO_3^- b) SO_4^{2-} c) Cl^- d) HCO_3^-

Answer: (d)

4. Which one of the following is true for a waste water sample? [WBUT 2013(EVEN), 2013(ODD), 2014(ODD), 2018(EVEN)]
   a) BOD > COD b) COD > BOD c) BOD = COD d) BOD = 1/COD

Answer: (b)

5. More scientific method than BOD to determine water quality parameter is [WBUT 2013(ODD)]
   a) COD b) DO c) both of these d) none of these

Answer: (a)

6. Coliform test is performed to detect [WBUT 2014(EVEN)]
   a) Klebsiella b) Staphylococcus c) E.coli d) none of these

Answer: (c)

7. EL Nino starts from [WBUT 2014(EVEN)]
   a) Mediteranean coast
   b) Chinese coast
   c) South American coast
   d) Indian coast

Answer: (c)

8. Natural reservoirs of water below the earth's surface is [WBUT 2014(ODD)]
   a) aquiclude b) aquifer c) aquitard d) aqueduct

Answer: (b)

9. BOD test in laboratory is done for [WBUT 2014(ODD)]
a) one day b) two days c) five days d) eight days
Answer: (c)

10. The most toxic chemical as carcinogen is [WBUT 2014(ODD)]
a) carbon tetrachloride b) vinyl chloride
c) tetrachloro ethylene d) trichloro ethylene
Answer: (d)

11. Blue baby syndrome is related to [WBUT 2015(EVEN)]
a) NO_2^- b) PO_4^{3-} c) NO_3^- d) SO_4^{2-}
Answer: (c)

12. In nephrotoxicity the affected body part is [WBUT 2015(EVEN)]
a) Liver b) Kidney c) Lungs d) Stomach
Answer: (b)

13. The cause of eutrophication is [WBUT 2015(ODD)]
a) increase of pathogens b) increase of BOD
c) increase in algae's productivity d) increase in DO
Answer: (c)

14. Oxygen demanding waste is the [WBUT 2015(ODD)]
a) inorganic pollutant b) radioactive material
c) organic pollutant d) none of these
Answer: (c)

15. The unit of BOD reaction rate constant is [WBUT 2016(EVEN)]
a) $Time^{-1}$ b) ML^{-1} c) $ML^{-1}S^{-1}$ d) $M^{-1}LS^{-1}$
Answer: (a)

16. For a sample of waste water containing both biodegradable and non-biodegradable waste is [WBUT 2016(EVEN), 2016(ODD)]
a) BOD > COD b) BOD < COD c) BOD = COD d) BOD $\propto$ COD
Answer: (b)

17. Water will be considered saline if the TDS value is [WBUT 2016(ODD), 2018(ODD)]
a) < 1500 mg/L b) > 5000 mg/L c) < 500 mg/L d) None of these
Answer: (d)

18. In nephrotoxicity the affected body part is [WBUT 2017(EVEN)]
a) Liver b) Kidney c) Lungs d) Stomach
Answer: (b)

19. In five days BOD test, BOD_5^{20} is [WBUT 2017(EVEN)]
a) CBOD b) NBOD c) Both CBOD & NBOD d) DO
Answer: (a)

20. DO_{min} for aquatic life is [WBUT 2017(EVEN), 2018(EVEN)]
a) 3 ppm b) 5 ppm c) 1 ppm d) 7 ppm
Answer: (b)

21. Trickling filter is classified under [WBUT 2017(EVEN)]
a) Primary treatment b) Secondary treatment
c) Tertiary treatment d) none of these
Answer: (b)

22. The most important elements causing algal bloom are [WBUT 2017(EVEN)]
a) C, N, P b) Ca, Pb, Cu c) Co, Ni, Nn d) Na, K, Mg
Answer: (a)

23. In Genotoxicity the target area is [WBUT 2017(EVEN)]
a) Blood b) Liver c) Kidney d) Gene
Answer: (d)

24. The saturated value of DO at 0°C is approximately [WBUT 2017(ODD)]
a) 2 mg/L b) 4 mg/L c) 9 mg/L d) 14 mg/L
Answer: (c)

25. Minimum DO prescribed for a river stream, to avoid fish kills, is [WBUT 2017(ODD)]
a) 2 ppm b) 4 ppm c) 8 ppm d) 10 ppm
Answer: (c)

26. A water filled tank with organic matter and having no inlet and outlet would be categorized as [WBUT 2017(ODD)]
a) CMBR b) CSBR c) PFR d) none of these
Answer: (b)

27. The unit of measuring hardness is [WBUT 2017(ODD)]
a) ppm b) gm/litre c) mole/litre d) mole/kg
Answer: (a)

28. A coagulant can be highly effective if it has [WBUT 2017(ODD)]
a) High charge b) Low charge
c) Moderate charge d) None of these
Answer: (a)

[WBUT2018(EVEN)]

29. Lakes poor in nutrient status is called
Oligotrophic lake
b) Eutrophic lake
c) Mesotrophic lake
d) None of these

Answer: (a)

30. There are two samples of waste water sample; sample-I has BOD 200mg/L and sample-II has BOD 50mg/L [WBUT 2018(ODD)]

a) sample-II is more polluted than sample-I
b) sample-I is more polluted than sample-II
c) the degree of pollution is same in both the sample
d) no interference can be drawn on the degree of pollution

Answer: (b)

31. In carbonate hardness Ca^{2+} and Mg^{2+} are associated with [WBUT 2018(ODD)]

a) SO_4^{2-}
b) NO_3^-
c) NO_2^-
d) none of these

Answer: (d)

32. Minamata disease is due to following species: [WBUT 2018(ODD)]

b) CH_3Hg^+
c) Hg^{2+}
d) Cd^{2+}

Answer: (b)

33. Colloid particles remain suspended in solution because they have [WBUT 2018(ODD)]

a) net negative surface charge
b) net positive surface charge
c) no charge on surface
d) none of these

Answer: (a) & (b)

Short Answer Type Questions

1. Discuss about activated sludge process for the treatment of waste water. [WBUT 2005, 2014(ODD)]

OR,

Briefly explain the activated sludge treatment process. [WBUT 2006, 2008]

Answer:

The process involves air or oxygen being introduced into a mixture of primary treated or screened sewage or industrial wastewater (called wastewater from now on) combined with organisms to develop a biological floc which reduces the organic content of the sewage. This material, which in healthy sludge is a brown floc, is largely composed of saprotrophic bacteria but also has an important protozoan flora mainly composed of amoebae, Spirotrichs, Peritrichs including Vorticellids and a range of other filter feeding

species. Other important constituents include motile and sedentary Rotifers. In poorly managed activated sludge, a range of mucilaginous filamentous bacteria can develop including *Sphaerotilus natans* which produces a sludge that is difficult to settle and can result in the sludge blanket decanting over the weirs in the settlement tank to severely contaminate the final effluent quality. This material is often described as sewage fungus but true fungal communities are relatively uncommon.

The combination of wastewater and biological mass is commonly known as mixed liquor. In all activated sludge plants, once the wastewater has received sufficient treatment, excess mixed liquor is discharged into settling tanks and the treated supernatant is run off to undergo further treatment before discharge. Part of the settled material, the sludge, is returned to the head of the aeration system to re-seed the new wastewater entering the tank. This fraction of the floc is called return activated sludge (R.A.S.). Excess sludge is called surplus activated sludge(S.A.S.) or waste activated sludge(W.A.S). S.A.S is removed from the treatment process to keep the ratio of biomass to food supplied in the wastewater in balance. S.A.S is stored in sludge tanks and is further treated by digestion, either under anaerobic or aerobic conditions prior to disposal.

Many sewage treatment plants use axial flow pumps to transfer nitrified mixed liquor from the aeration zone to the anoxic zone for denitrification. These pumps are often referred to as internal mixed liquor recycle pumps (IMLR pumps). The raw sewage, the RAS, and the nitrified mixed liquor are mixed by submersible mixers in the anoxic zones in order to achieve denitrification.
Activated sludge is also the name given to the active biological material produced by activated sludge plants.

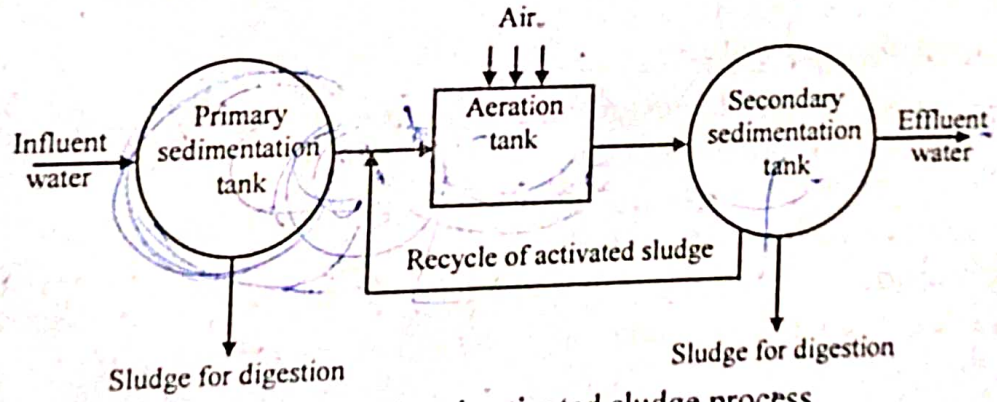

Fig. Conventional activated sludge process

Advantages of activated sludge process:

i) Activated sludge process reduces maximum amount of BOD from the waste water.
ii) Pathogens are reduced by this method.
iii) Little space is required.

Disadvantages of activated sludge process:

i) The efficiency of the process depends on separation of solids from liquid.
ii) It is difficult to operate and skilled man power is required.

2. Describe the hydrologic cycle.
[WBUT 2006-Short note, 2009-Short note, 2018(EVEN) -Short note, 2018(ODD)]

OR,

Discuss the hydrological cycle showing the water balance of the Earth. What role is played by man in the hydrological cycle? [WBUT 2014(EVEN)]

Answer:

The hydrological cycle or water cycle is the cycling, of water through the different parts of the Earth. This cycle includes evaporation and transpiration of water, formation of cloud, precipitation of water from cloud and followed by infiltration or runoff into surface water courses.

Hydrological cycle is a natural cycle and the **backbone** of the hydrosphere. This cycle is also responsible for the proper distribution of water and maintains the **hydrological budget.**

Different Stages of Hydrological Cycle

i) Evaporation & transpiration:

Evaporation and transpiration are the two ways in which water enters the atmosphere. Evaporation is loss of water from the surface while transpiration is the loss of it by the plants. **Water is converted to vapour by means of these two processes.** As evaporation and transpiration are so difficult to measure separately, they are often combined into single term, **evapotranspiration.** The solar radiation, air temperature, humidity, wind speed, soil moisture etc. are the influencing factors to the rate of evapotranspiration.

ii) Condensation & Precipitation:

The resulting water vapour from the evapotranspiration transported by moving air masses to upward direction and eventually condenses to form **cloud** with the help of different dust particles present in the atmosphere (dust particles act like a nucleus of the cloud). Further condensation of cloud leads to forms larger droplet of water which is enough to fall (as **precipitation).** Over the oceans, there is more evapotranspiration than precipitation and over the land more precipitation than evapotranspiration.

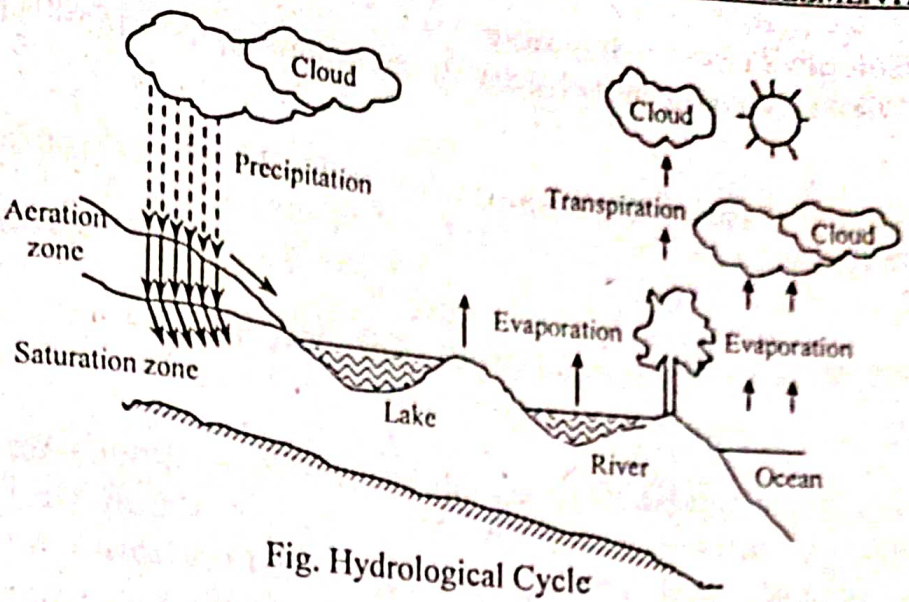

Fig. Hydrological Cycle

3. Define 'aquifers'. Under what conditions is an automatically flowing artesian well possible?
[WBUT, 2006-Short note, 2008-Short note, 2012(ODD)]

OR,

Describe aquifer. Name different types of aquifers. What is hydraulic gradient? State Darcy's law.
[WBUT 2016(EVEN)]

OR,

What is aquifer?
[WBUT 2017(ODD)]

Answer:

Any underground rock formation containing water is called **aquifer.** The rock of an aquifer must be porous and permeable so that it can absorb water. Aquifers are an important source of fresh water.

In an unconfined aquifer, the slope of the water table, measured in the direction of the steepest rate of change is called **hydraulic gradient.** It is important because ground water flow is in the direction of the gradient and also proportional to it.

the hydraulic gradient can be measured as

$$\text{HtdraulicGradient} = \frac{\text{Change in head}}{\text{Horizontal distance}} = \frac{h_1 - h_2}{L}$$

$$\therefore \text{Hydraulic Gradient} = \frac{dh}{dl}.$$

Again, the rate of flow of ground water is first time formulated by Henry Darcy. According to him, the flow rate (Q) is directly proportional to the cross sectional area(A) and hydraulic gradient $\left(dh/dl\right)$.

So, $Q \propto A$ .... (1)

$Q \propto dh/dl$ .... (2)

or $Q \propto A \cdot dh/dl$

or $Q = K \cdot A \cdot dh/dl$

4. What is biological oxygen demand? How is it related to water quality? What is chemical oxygen demand? [WBUT 2006, 2013(EVEN)]

OR,

What is Chemical Oxygen Demand (COD)? What are the steps involved in COD test? How is it related to Biological Oxygen Demand (BOD)? [WBUT 2006]

OR,

What is COD? What are steps involved in COD test? How is it related to BOD? [WBUT 2007, 2008-Short note]

OR,

What is COD? What are steps involved in COD test? How is it related to BOD? [WBUT 2014(EVEN)]

Answer:

Biological oxygen demand (BOD) is an important water quality parameter. It is defined as the quantity of dissolved oxygen (DO) required during stabilization of the decomposable organic matter presence in water by aerobic micro organisms. In other word, the amount of oxygen demanded (or required) by microorganism to stabilize organic wastes aerobically, is called Biological Oxygen Demand (BOD).

BOD test is the indirect method to assess the quality of waste water. It is very difficult to measure the concentration of organic waste present in the waste water. But with value of BOD, we can understand how much oxygen is consumed by the microorganisms to decompose the organic waste present in the waste water. High BOD value indicates high consumption of oxygen by microorganism i.e. a large amount of organic wastes is present. On the other hand low BOD value indicates low consumption of oxygen i.e. less amount of organic wastes is present. So, the high BOD value corresponds to bad quality of water and the low BOD value indicates the good quality of water.

The Chemical Oxygen Demand (COD) is one of the important water quality parameters. This is used to determine the quantity of oxygen required to oxidize the waste materials (both biodegradable & non biodegradable) in the waste sample, under specific conditions of oxidizing agent, temperature and time. This method is more scientific than the BOD.

The steps involved in COD test:

i) Take 20 ml. sample of waste water in a refluxing flask and add 0.4 gm $HgSO_4$ to it. $HgSO_4$ eliminates the interference effect of chlorine present in the waste water.
ii) Then add 10 ml $K_2Cr_2O_7$ solution followed by careful addition of 30 ml. conc. $HgSO_4$
iii) Attach the reflux flask to the condenser and reflux the mixture for 2 hrs.
iv) Cool and wash down the condenser with distilled water.
v) $K_2Cr_2O_7$ oxidizes the waste materials present in waste water.
vi) Dilute the residue (mixture after reflusk) upto 100 ml and titrate the excess dichromate with standard ammonium sulphate $[Fe(NH_4)_2(SO_4)_2]$ using 2 or 3 drops of ferroin indicator.
The end point is indicated by a colour change from blue green to reddish brown.

vii) Consumed $K_2Cr_2O_7$ (i.e., the difference of initial dichromate solution and the residue of dichromate solution) indicates that the amount of oxygen demanding waste present in the waste water.

- ***Differentiate between BOD & COD methods.***

B O D method	*C O D method*
i) This method determines the biologically oxygen demand.	i) This method determines the chemically oxygen demand.
ii). Demanded oxygen is supplied by the water itself in the form of dissolve oxygen (DO).	ii) Demand oxygen is supplied by the oxidizing agent $K_2Cr_2O_7$.
iii) This method determines the oxygen demand for the biodegradable waste only.	iii) This method determines the oxygen demand for the both biodegradable as well as non biodegradable wastes.
iv) The value of BOD is always less than COD.	iv) The value of COD is always greater than BOD.
v) The duration of BOD test or method is very high.	v) Only 2 hrs. are required to complete the COD test.
vi) BOD method is less scientific than COD method.	vi) COD method is more scientific than BOD method.

5. Discuss the principle of 5-day BOD test. **[WBUT 2006, 2008, 2012(EVEN)]**

OR,

Write short note on 5 days BOD test **[WBUT 2013(ODD)]**

Answer:

The steps involved in five day BOD test:

i) The sample should be collected from the source and diluted appropriately. The dilution of raw sample of waste water is required because for the decomposition of organic waste present in waste water needs a higher amount of dissolved oxygen (DO). But, the concentration of DO is maximum 9.1 mg/L at 20°C. Usually pure water which is free from any microorganism, use for the dilution. The dilution factor (P) is measured as

$$P = \frac{\text{volume of raw sample}}{\text{volume of rawsample} + \text{volume of pure water used for dilution}}$$

ii) This diluted water should be kept inside a reagent bottle having volume of 300 ml. The bottle should be kept in dark to avoid photosynthesis (if some algae are present in sample water). Because photosynthesis may increase the concentration of DO in the 'diluted' sample waste water. At the same time the bottle should be stoppered to avoid any further addition of atmospheric oxygen to the sample waste water.

iii) The initial concentration of DO (DO_i) should be measured at 20°C by means of any standard method.

iv) After getting the initial concentration of DO, the bottle should be kept inside the 'BOD incubator' where temperature should be fixed at 20°C and other parameters like humidity, pressure should be maintained.

v) After 'five day' period, the bottle should be removed from the 'incubator' and the final concentration of DO (DO_f) is measured at the same temperature i.e. 20 C. The difference of DO's, i.e. $(DO_i - DO_f)$ indicates the amount of dissolved oxygen consumed by the microorganisms during this five days period to decompose the organic matters present in this diluted waste water.

vi) The BOD_5 at 20°C of that raw sample water can be measured as

$$BOD_5 \text{ at } 20°C = \frac{DO_i - DO_f}{P}$$

6. What is meant by hardness of water? How is it expressed? Can hard water be used in boilers or in laundries? Justify your answer. Discuss the sources and impacts of hardness. [WBUT 2007, 2013(EVEN), 2013(ODD)]

OR,

What is the hardness of water and how does it affect the water quality? [WBUT 2009]

OR,

What is meant by hardness of water? Can hard water be used in boilers or in laundries? Justify your answer. [WBUT 2012(EVEN)]

OR,

What is called hardness of water? Describe briefly Lima-Soda process for softening of water. [WBUT 2012(ODD)]

OR,

Write short notes on hardness of water. [WBUT 2014(EVEN), 2018(EVEN)]

OR,

What is hardness of water? What ions are responsible for hardness of water? Discuss the principle of lime-soda process for removal of hardness of water. [WBUT 2016(EVEN)]

OR,

What is hardness of water? How do you like to remove the hardness of water? [WBUT 2017(EVEN)]

OR,

What is meant by hardness of water? What ions are responsible for hardness in natural hard water? Mention the disadvantages of using hard water in boilers and laundries. [WBUT 2017(ODD)]

Answer:

The presence of multivalent cations, mostly Ca^{2+} & Mg^{2+} and their sulphate, bisulphate, carbonate and bicarbonate salts, is referred to as hardness of water. The degree of hardness of drinking water has been classified in terms of the equivalent $CaCO_3$ concentration as follows:

Soft $\Rightarrow$ 0 – 60 mg/L

Medium $\Rightarrow$ 60 – 120 mg/L

Hard $\Rightarrow$ 120 – 180 mg/L

Very hard $\Rightarrow$ greater than 180 mg/L

Hardness may also be classified based on the Carbonate (temporary) and non-carbonate (permanent) hardness.

Temporary hardness can be removed or precipitated by boiling. This type of hardness is responsible for the deposition of scale in hot water pipes and kettles. Non-carbonate hardness is caused by the association of the **'hardness causing cations'** with SO_4^{2-}, Cl^- & NO_3^-. It can not be removed by boiling. Public acceptability of degree of hardness may vary considerably from community to community, depending upon the local condition.

Hardness can be reported in one of three different expressions:
Mg/l - milligrams per liter
Ppm - parts per million
Gpg - grains per gallon
Hard water produces scale around the wall of the boiler. As a result excess amount of heat accumulation takes place which may be the cause of explosion.

$$Ca(HCO_3)_2 + Heat \rightarrow H_2O + CO_2 \uparrow (gas) + CaCO_3 \downarrow (scale)$$

Hard water did not produces foam with soap readily. This is the reason why it is not use in laundries.

Lime-Soda Process: Simply addition of lime can not remove the sulphate salts of Ca^{2+} & Mg^{2+} from the water. Hence permanent hardness removal is not possible in that way. But if Soda-ash is added in lime, the non-carbonate hardness (permanent) can be easily removed. This method is known as lime-soda process. The following chemical reactions take place –

$$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow MgCO_3 \downarrow + CaCO_3 \downarrow + 2H_2O$$

$$MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow$$

$$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaSO_4 \downarrow$$

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7. What are the biochemical effects of Cadmium and Arsenic? **[WBUT 2007, 2013(ODD), 2018(ODD)]**

OR,

Discuss the toxic effects of Arsenic and Cadmium in human body. **[WBUT 2009]**

OR,

What are the biochemical effects of Arsenic pollution? **[WBUT 2015(EVEN)]**

OR,

Mention the biochemical effects of toxicity due to Cadmium. **[WBUT 2016(ODD)]**

Answer:
The permissible limit of As in drinking water is 0.05 ppm. If the drinking water collected from the aquifer (ground water) contains arsenic more than the permissible unit, is called arsenic pollution.
Elemental Arsenic is usually not soluble in water. Over extraction of water from the aquifer reduces the height of water table. The soil pores present in this zone are now filled up by the air instead of water. The Arsenic (As) which are present in this particular area are oxidized to form Arsenate (As_2O_3). This is soluble in water. In this way

concentration of arsenic increases in ground water. After that when ground water is extracted and used the arsenic pollution spreads among the other parts of the environment.

Toxic effects of Arsenic in human body:

Arsenic exerts its toxic action by attacking SH groups of an enzyme, thereby inhibiting enzyme action.

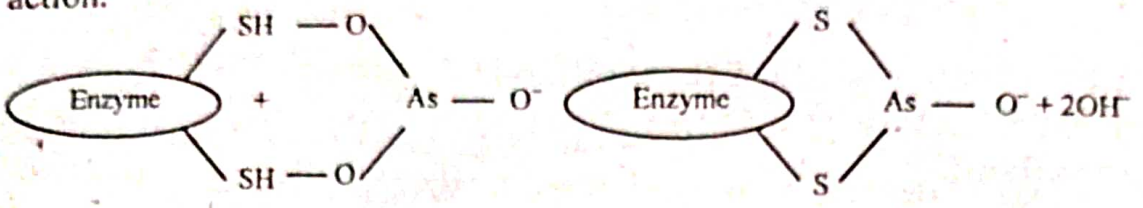


Fig Arsenic exerts its toxic action by attacking SH groups of an enzyme

The enzymes which generate cellular energy in the citric acid cycle are adversely affected because the generation of ATP is prevented by the formation of an intermediate complex compound of arsenic. By virtue of its chemical similarity to P in that way arsenic (As) interferes with some biochemical process involving phosphorous (P).

1. Symptoms of arsenic poisoning begin with headaches, confusion, severe diarrhoea, and drowsiness.
2. As the poisoning develops, convulsions and changes in fingernail pigmentation called leukonychia may occur.
3. When the poisoning becomes acute, symptoms may include diarrhea, vomiting, blood in the urine, cramping muscles, hair loss, stomach pain, and more convulsions.
4. The organs of the body that are usually affected by arsenic poisoning are the lungs, skin, kidneys, and liver.
5. The final result of arsenic poisoning is coma to death.
6. Arsenic is related to heart disease (hypertension related cardiovascular), cancer, stroke (cerebrovascular diseases), chronic lower respiratory diseases, and diabetes.
7. Night blindness: Long term exposure to arsenic is related to vitamin A deficiency which is related to heart disease and night blindness.

Toxic effects of Cadmium in human body:

Major portion of Cd ingested into our body is trapped in the kidney and eliminated. A small fraction is bound most effectively by the body proteins, **metallothionein**, present in the kidneys, while the rest is stored in the body and gradually accumulates with age. When excessive amounts of Cd^{2+} are ingested, it replaces Zn^{2+} at key enzymatic sites causing metabolic disorder.

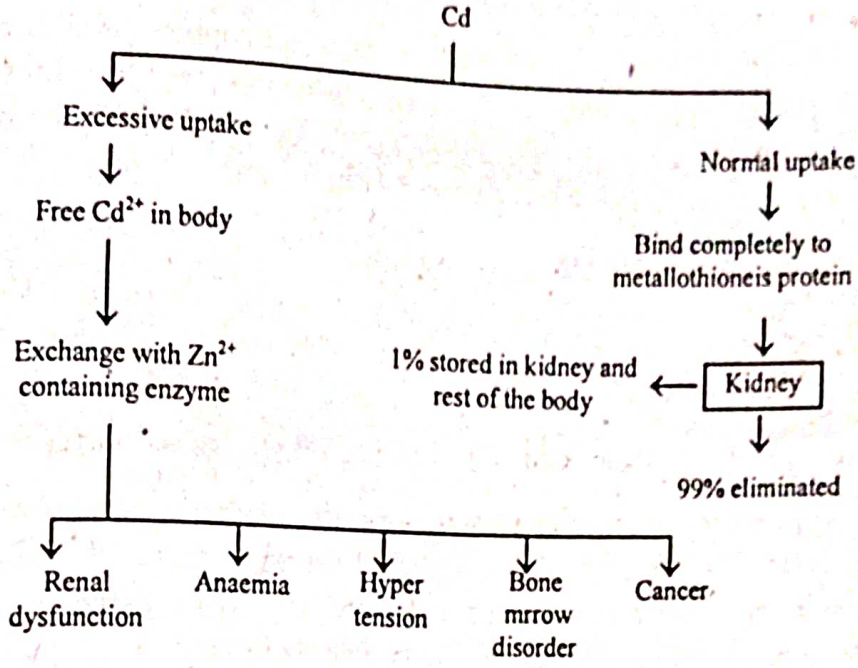


Chart: Biochemical effect of Cd

Night blindness: Long term exposure to arsenic is related to vitamin A deficiency which is related to heart disease and night blindness.

Possible remedial measures which may be taken up for its control or prevention:

a) Avoid the use of ground water.
b) Remove the Arsenic from water by different physico-chemical process.
c) Use different biosorrbent to remove it from water.
d) Meyhod of bioaccumulation may helpful to reduce the concentration of As in water.

8. What is Eutrophication?
[WBUT 2007-Short note, 2009-Short note, 2013(EVEN),2014(ODD)-Short note, 2015(EVEN),2016(EVEN)-Short note, 2018(EVEN)]

Answer:
All the lakes are subjected to a **natural aging** process known as **Eutrophication.** Due to **increase of nutrients** to the water of lakes, the rate of productivity of algae increases. This is mainly responsible for the **Eutrophication.**

Types of Eutrophication
Eutrophication is a natural phenomenon and it starts as soon as lake is formed. But its rate of progress is very low due to lack of natural supply of nutrient. The increased nutrient supply through human activities may accelerate the rate of eutrophication. Thus, on the basis of this, eutrophication can be subdivided as –

(i) Natural eutrophication
(ii) Cultural eutrophication.

Natural Eutrophication:
In the process of eutrophication, lakes pass from oligotrophic condition to eutrophic condition through some intermediate stages like **oligo-mesotrophic, mesotrophic and mesoeutrophic**. The rate of eutrophication does not depend only on the rate of nutrient supply, but other factors like climate are also very important.

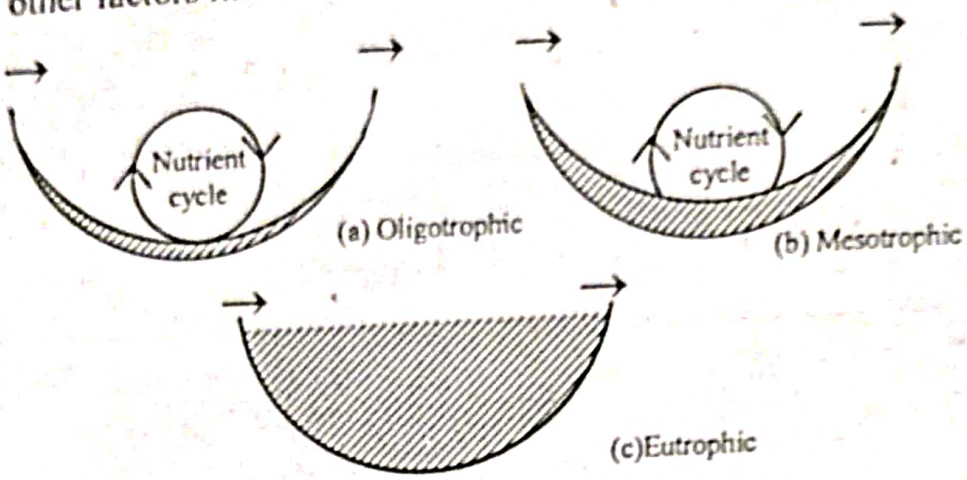


Fig. Different intermediate stages of natural eutrophication

Cultural eutrophication
The supply of nutrients by human activities accelerate the rate of eutrophication and so this is also called as **cultural eutrophication**. As speed of cultural eutrophication is much greater than the natural eutrophication, it reaches the extreme point i.e., eutrophic condition, much earlier.

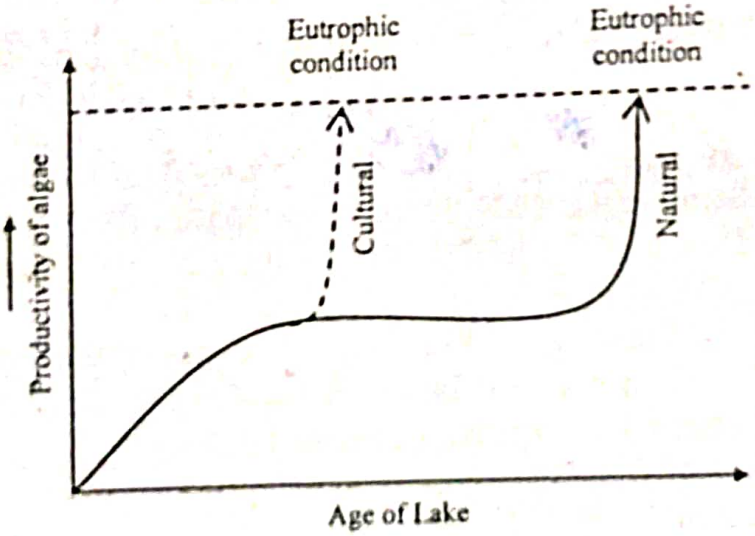


Fig: Relationship between productivity of algae & age of lake

9. Name two hazardous chemicals present in waste water. Write down their source(s) and biochemical effects. **[WBUT 2012(EVEN), 2017(EVEN)]**

OR,

Mention the biochemical effect of toxicity due to As & Cd. **[WBUT 2016(EVEN)]**

Answer:

Elements	Sources	Effects & significance
i) Arsenic (As)	Mining by product, pesticides, chemical waste	Toxic, possibly carcinogenic
ii) Cadmium (Cd)	Industrial discharge, mining waste, metal plating, water pipes.	Replaces Zn bio-chemically, causes high blood pressure, damage of kidney, toxicity on aquatic biota also.

10. Define BOD and COD. [WBUT 2012(EVEN), 2012(ODD)]

Answer:

Biological oxygen demand (BOD) is an important water quality parameter. It is defined as the quantity of dissolved oxygen (DO) required during stabilization of the decomposable organic matter presence in water by aerobic micro organisms. In other word, the amount of oxygen demanded (or required) by microorganism to stabilize organic wastes aerobically, is called Biological Oxygen Demand (BOD).

The Chemical Oxygen Demand (COD) is one of the important water quality parameters. This is used to determine the quantity of oxygen required to oxidize the waste materials (both biodegradable & non biodegradable) in the waste sample, under specific conditions of oxidizing agent, temperature and time. This method is more scientific than the BOD.

11. Write the sources of the metals Cadmium, Mercury, Lead and Arsenic in water and their adverse effects on human body? [WBUT 2012(ODD), 2016(EVEN), 2016(ODD)]

Answer:

Elements	Sources	Effects & significance
i) Arsenic (As)	Mining by product, pesticides, chemical waste	Toxic, possibly carcinogenic
ii) Cadmium (Cd)	Industrial discharge, mining waste, metal plating, water pipes.	Replaces Zn bio-chemically, causes high blood pressure, damage of kidney, toxicity on aquatic biota also.
iii) Chromium (Cr)	Metal plating tannery. Normally found as Cr (VI) in polluted water.	Essential trace elements, possibly carcinogenic.
iv) Lead (Pb)	Industry, mining, plumbing, coal, gasoline.	Toxic, responsible for anaemia, kidney failure, nervous disorder, wild life destroyed.
v) Mercury (Hg)	Industrial waste mining, pesticides, coal.	Highly toxic

12.The BOD_5 of a sample of waste water is found to be 150 mg/L. The initial DO of diluted waste water is 10 mg/L and the test requires a decrease in DO of the least 3 mg/L, with at least 2 mg/L of DO remaining at the end of five days. Now find out the range dilution factor (P), required to produce acceptable results. [WBUT 2013(ODD)]

Answer:
We know that BOD5= DOi-DOf/P
or, 150= 3/P1
P1= 0.02
Again,
150= 10-2/P2
or, 150 = 8/P2
P2 = 0.0533.
The desired range of dilution factor (P) is 0.02 to 0.0533.

13. What is trickling filter? Explain its use with a diagram.
[WBUT 2013(ODD), 2016(ODD)]

Answer:
Refer to Question No. 17(b) of Long Answer Type Questions.

14. The BOD_5 of waste water is determined to be 150 mg/lt at 20°C. The *k* value is known to be 0.23 day^{-1}. What would be the BOD_8 if the test was run at 15°C?
[WBUT 2014(ODD)]

Answer:

BOD_5 at 20°C $\Rightarrow$ 150 mg/L

We know that,

$$BOD_t = L_0\left(1-e^{-kt}\right)$$

$$150 = L_0\left(1-e^{-0.23\times5}\right)$$

$$\therefore \quad L_0 = 219.62 \text{ mg/L} \qquad \ldots. (1)$$

Again, we know that

$$k_T = k_{20}\cdot\theta^{(T-20)}$$

or,
$$k_{15} = k_{20}\cdot\theta^{(15-20)} = 0.23\times(1.047)^{-5}$$
$$= 0.23\times0.7948 = 0.18 \qquad \ldots. (2)$$

Then, BOD_8 at 15°C $= 219.62\left(1-e^{-0.18\times8}\right) = 219.62\left(1-e^{-1.44}\right)$
$$= 219.62\times(1-0.236) = 219.62\times0.763$$
$$= 167.57 \text{ mg/L} \quad \textbf{(Ans.)}$$

15. Discuss the working principle of trickling filters used in the secondary treatment of waste water.
[WBUT 2015(EVEN)]

Answer:
Refer to Question No. 17(b) of Long Answer Type Questions.

16. What is Chemical Oxygen Demand (COD)? How is it related to Biological Oxygen Demand (BOD)?
[WBUT 2015(ODD)]

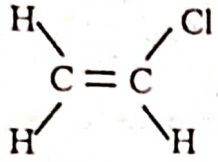
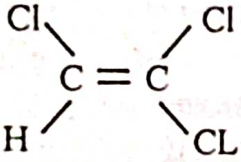
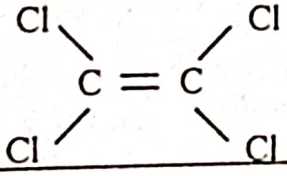
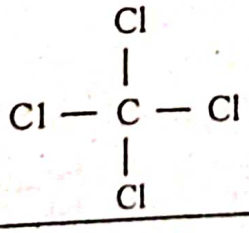
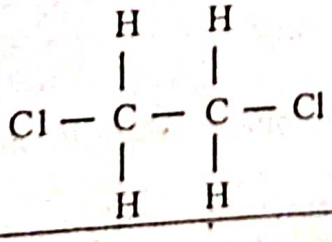
Answer:

The Chemical Oxygen Demand (COD) is one of the important water quality parameters. This is used to determine the quantity of oxygen required to oxidize the waste materials (both biodegradable & non biodegradable) in the waste sample, under specific conditions of oxidizing agent, temperature and time. This method is more scientific than the BOD.

17. What are volatile organic chemicals (VOC's)? Briefly discuss their characteristic features with example. **[WBUT 2016(EVEN)]**

Answer:

Volatile Organic Compounds (VOC) are among the most commonly found pollutants in ground water. They are often used as solvents in industrial processes and many of them are either known or suspected as **carcinogens** or **mutagens**. Their volatility means they are not often found in concentrations above a few μm/L in surface water, but in ground water their concentrations can be hundreds or thousands of times higher.

i) Vinyl chloride		Most toxic & carcinogen. The source is effluent of polyvinyl chloride industry.
ii) Trichloro- ethylene		Most commonly available and used as a solvent of cleaning substance of small electronic parts to jet engine and even septic tank. It is suspected carcinogen.
iii) Tetrachloro-ethylene		Non carcinogenic but responsible for animal tumor. Its source is manufacturing industry of CFC.
iv) Carbon –tetrachloride		It is very toxic if ingested. It is used in the industry of fire extinguishers
v) 1,2, - Dichloro ethane		It is not carcinogenic but high levels of its exposure are known to cause injury to CNS, liver and kidney. It is coming out from the effluent of soap, varnish industries.

18. Discuss the winkler method of analysis of DO in the laboratory. **[WBUT 2016(ODD)]**

Answer:

Winkler method of analysis of DO

1. Carefully fill a 300-mL glass Biological Oxygen Demand (BOD) stoppered bottle brim-full with sample water.

2. Immediately add 2mL of manganese sulfate to the collection bottle by inserting the calibrated pipette just below the surface of the liquid. (If the reagent is added above the sample surface, you will introduce oxygen into the sample.) Squeeze the pipette slowly so no bubbles are introduced via the pipette.
3. Add 2 mL of alkali-iodide-azide reagent in the same manner.
4. Stopper the bottle with care to be sure no air is introduced. Mix the sample by inverting several times. Check for air bubbles; discard the sample and start over if any are seen. If oxygen is present, a brownish-orange cloud of precipitate or floc will appear. When this floc has settle to the bottom, mix the sample by turning it upside down several times and let it settle again.
5. Add 2 mL of concentrated sulfuric acid via a pipette held just above the surface of the sample. Carefully stopper and invert several times to dissolve the floc. At this point, the sample is "fixed" and can be stored for up to 8 hours if kept in a cool, dark place. As an added precaution, squirt distilled water along the stopper, and cap the bottle with aluminum foil and a rubber band during the storage period.
6. In a glass flask, titrate 201 mL of the sample with sodium thiosulfate to a pale straw color. Titrate by slowly dropping titrant solution from a calibrated pipette into the flask and continually stirring or swirling the sample water.
7. Add 2 mL of starch solution so a blue color forms.
8. Continue slowly titrating until the sample turns clear. As this experiment reaches the endpoint, it will take only one drop of the titrant to eliminate the blue color. Be especially careful that each drop is fully mixed into the sample before adding the next. It is sometimes helpful to hold the flask up to a white sheet of paper to check for absence of the blue color.
9. The concentration of dissolved oxygen in the sample is equivalent to the number of milliliters of titrant used. Each mL of sodium thiosulfate added in steps 6 and 8 equals 1 mg/L dissolved oxygen.

Results Analysis

The total number of milliliters of titrant used in steps 6-8 equals the total dissolved oxygen in the sample in mg/L. Oxygen saturation is temperature dependent - gas is more soluble in cold waters, hence cold waters generally have higher dissolved oxygen concentrations. Dissolved oxygen also depends on salinity and elevation, or partial pressure. Click here to access an online oxygen saturation calculator that takes these parameters into account. Otherwise, use the chart below to find saturation at a given temperature.

19. What do you mean by eutrophic lake? How does thermal stratification influence an eutrophic lake? 2350 [WBUT 2016(ODD)]

Answer:

A eutrophic body of water, commonly a lake or pond, has high biological productivity. Due to excessive nutrients, especially nitrogen and phosphorus, these water bodies are able to support an abundance of aquatic plants. Usually, the water body will be dominated either by aquatic plants or algae.

20. Give a concise account of the chemical speciation of lead? How can lead be removed from the atmosphere? **[WBUT 2017(ODD)]**

Answer:

The main biochemical effects of lead are:

i) Interference with heme synthesis which leads to **hematological damage.**

ii) Tetra ethyl lead (TEL) coming out with the exhaust of automobile, is fat soluble and affects mainly central nervous system (CNS).

iii) Inorganic lead can cause the damage to the kidney.

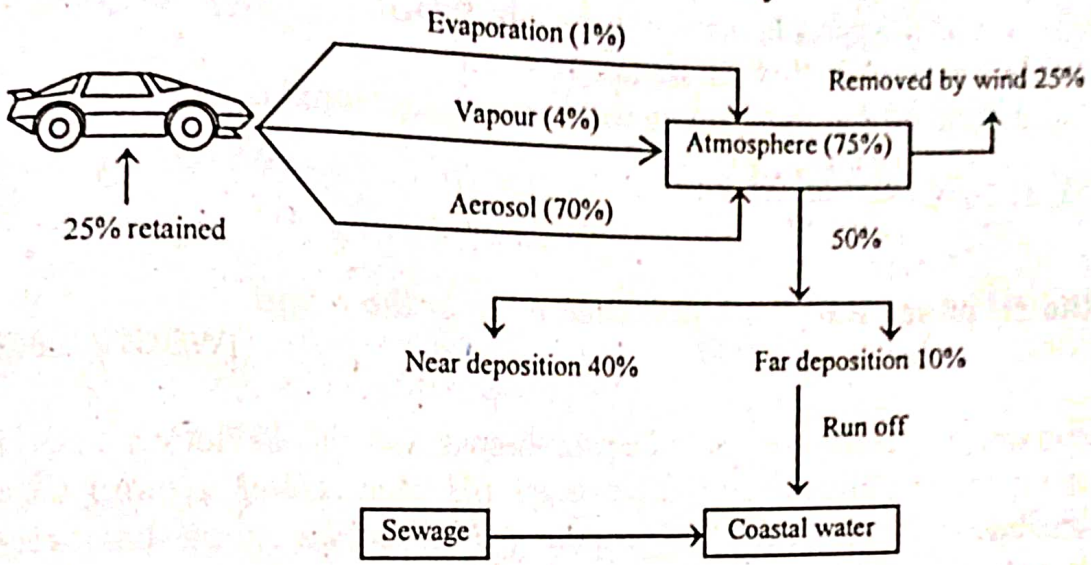


Fig: The pathways of Pb in environment

21. Briefly discuss the BODs test and illustrate it with mathematical equations. **[WBUT2018(EVEN)]**

Answer:

- ***The steps involved in five day BOD test:***

i) The sample should be collected from the source and diluted appropriately. The dilution of raw sample of waste water is required because for the decomposition of organic waste present in waste water needs a higher amount of dissolved oxygen (DO). But, the concentration of DO is maximum 9.1 mg/L at 20°C. Usually pure water which is free from any microorganism, use for the dilution. The dilution factor (P) is measured as

$$P = \frac{\text{volume of raw sample}}{\text{volume of rawsample + volume of pure water used for dilution}}$$

ii) This diluted water should be kept inside a reagent bottle having volume of 300 ml. The bottle should be kept in dark to avoid photosynthesis (if some algae are present in sample water). Because photosynthesis may increase the concentration of DO in the 'diluted' sample waste water. At the same time the bottle should be stoppered to avoid any further addition of atmospheric oxygen to the sample waste water.

iii) The initial concentration of DO (DO_i) should be measured at 20°C by means of any standard method.

iv) After getting the initial concentration of DO, the bottle should be kept inside the 'BOD incubator' where temperature

v) should be fixed at 20°C and other parameters like humidity, pressure should be maintained.

vi) After 'five day' period, the bottle should be removed from the 'incubator' and the final concentration of DO (DO_f) is measured at the same temperature i.e. 20 C. The difference of DO's, i.e. $(DO_i - DO_f)$ indicates the amount of dissolved oxygen consumed by the microorganisms during this five days period to decompose the organic matters present in this diluted waste water.

vii) The BOD_5 at 20°C of that raw sample water can be measured as

$$BOD_5 \text{ at } 20°C = \frac{DO_i - DO_f}{P}$$

22. How is the pH of sea water is maintained all over the world. [WBUT2018(EVEN)]

Answer:

Calcium carbonate minerals are the building blocks for the skeletons and shells of many marine organisms. Historically, the average pH of seawater around the globe is 8.2. Since the industrial age began, the average pH of surface oceans has decreased to 8.1, a 30% increase in acidity.

23. A sample of ground water at pH 10.0 has 32mg/L of CO_3^{-2} and 56mg/L of HCO_3^-. Find the alkalinity as $CaCO_3$. [WBUT2018(EVEN)]

Answer:

Alkalinity of 32mg/L of CO_3^{-2} as $CaCO_3$ = (50/60) x 32 mg/L = 26.66 mg/L

Alkalinity of 56mg/L of HCO_3^- as $CaCO_3$ = (50/61) x 56 mg/L = 45.90 mg/L

Therefore, total alkalinity of the sample is (26.66+45.90) mg/L= 72.56 mg/L as $CaCO_3$.

24. Why BOD experiment is always performed in a dark place? [WBUT2018(EVEN)]

Answer:

Refer to Question No. 9(c) of Long Answer Type Questions.

Long Answer Type Questions

1. a) Establish the relation $BOD_t = L_o (1-e^{-kt})$,
where, BOD_t = amount of oxygen consumed by the waste in first *t* days.
L_o = the ultimate carbonaceous oxygen demand
and k = the BOD reaction rate constant (time^{-1}).
[WBUT 2006, 2012(EVEN), 2013(EVEN), 2013(ODD), 2015 (ODD), 2017(ODD)]

OR,

Prove that $BOD_t = L_0(1-e^{-kt})$ [WBUT 2008, 2012(ODD)]

OR,

Prove that $BOD_t = LO\left(1-e^{-kt}\right)$

BOD_t = oxygen consumed by a waste in first t days
LO = Ultimate carbonaceous oxygen demand
K = BOD reaction rate constant. [WBUT 2017(ODD)]

Answer:

BOD_t = Oxygen consumed by a waste in first t days.

L_0 = Ultimate carbonaceous oxygen demand.

K = BOD reaction rate constant (time^{-1})

Consider that the decomposition of organic waste in waste water by the microorganism is a first order reaction.

Let, after time 't', the concentration of oxygen be L_t

According to first order rate reaction, rate of the reaction is directly proportional to the concentration of reactant (here oxygen) left at that time(t).

$$-\frac{dL_t}{dt} \propto L_t \qquad \ldots (1)$$

The negative sign (–) is indicating that along with time (t) the concentration of oxygen decreases.

We can rearrange the equation (1) as

$$-\frac{dL_t}{dt} = kL_t \text{; where, k = BOD reaction constant}$$

or,
$$-\frac{dL_t}{L_t} = k\,dt. \qquad \ldots (2)$$

Integrate the above equation within the limit.

When, $t = 0$, $L_t = L_0$

And $t = t$, $L_t = L_t$

So, equation (2) becomes

$$-\int_{L_0}^{L_t}\frac{dL_t}{L_t} = k\int_0^t dt$$

or, $[\ln L_t]_{L_0}^{L_t} = -k[t-o]$

or, $\ln \frac{L_t}{L_o} = -kt$

or, $\frac{L_t}{L_o} = e^{-kt}$

$\therefore \quad L_t = L_0 e^{-kt}$ ... (3)

Now, ultimate oxygen demand (L_0) is the sum of the amount of oxygen already consumed by the microorganism for the decomposition i.e. Biological Oxygen Demand at that time (BOD_t) and the concentration of oxygen left for the consumption at that time (L_t).

So, $L_0 = BOD_t + Lt$

or $BOD_t = L_0 - L_t$

$= L_0 - L_0 e^{-kt}$ [Put the value of L_t from equation (3)]

or $BOD_t = L_0 (1 - e^{-kt})$ Proved.

b) The dissolved oxygen in an unseeded sample of diluted waste having an initial D.O. of 9 mg/lit is measured to be 3 mg/lit after 5 days. The dilution factor P is 0.030 and the reaction rate constant K is 0.22/day.

i) What is the 5-day BOD of the waste?

ii) What would be the ultimate carbonaceous BOD?

iii) What would be the remaining oxygen demand after 5 days?

[WBUT 2006, 2012 (ODD), 2015(ODD)]

OR,

The dilution factor *P* for an unseeded mixture of wastes and water is 0.030. The DO of the mixture was initially 9.0mg/L and after 5 days it has dropped to 3.0 mg/L. The reaction rate constant is 0.22/day.

Calculate:

(i) The 5-day BOD of the wastes

(ii) L_0

(iii) The remaining oxygen demand after 5 days.

Answer: **[WBUT 2017(ODD)]**

5-day BOD of the waste:

$BOD_5 = (9-3)/0.030 = 200$ mg/l

Ultimate carbonaceous BOD (BOD_u):

$BOD_u = BOD_5 / (1 - e^{-kt})$; here t = 5 days

$= 200/(1 - e^{-0.22 \times 5})$

$= 303$ mg/l

Remaining oxygen demand after 5 days = (303 – 200) mg/l = 103 mg/l.

2. What do you mean by water softening? What are the methods of water softening? [WBUT 2007, 2012(EVEN), 2012(ODD), 2013(EVEN), 2013(ODD)]

Answer:

The removal or reduction of hardness from the water is known as **water softening.**

There are two types of water softening. These are –

i) Removal of temporary hardness

ii) Removal of permanent hardness

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i) Removal of temporary hardness:

Temporary hardness can be removed by the following ways –

(a) Boiling: When the water has temporary hardness, it can be removed by the boiling. The following reaction is taking place during the boiling –

$$Mg(HCO_3)_2 \xrightarrow{\text{Boiling}} MgCO_3 + CO_2 + H_2O$$

(b) Addition of lime water: The temporary hardness can also be removed by addition of lime water. The following reaction takes place –

$$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow CaCO_3 \downarrow + Mg(OH)_2 \downarrow + H_2O.$$

ii) Removal of permanent hardness:

Removal of permanent hardness from the water is a difficult process as compare to the reduction or removal of temporary hardness. Following are the various methods which are commonly adopted for the removal of permanent hardness.

(a) Lime-Soda Process: Simply addition of lime can not remove the sulphate salts of Ca^{2+} & Mg^{2+} from the water. Hence permanent hardness removal is not possible in that way. But if Soda-ash is added in lime, the non-carbonate hardness (permanent) can be easily removed. This method is known as lime-soda process. The following chemical reactions take place –

$$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow MgCO_3 \downarrow + CaCO_3 \downarrow + 2H_2O$$

$$MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow$$

$$MgSO_4 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaSO_4 \downarrow$$

(b) Base exchange process: This process is also known as **Zeolite process** or **cation exchange process.** In this process, the hard water should pass through a bed of **sodium-zeolite sand.** When hard water is passes through it, the Ca^{2+} & Mg^{2+} get replaced by Na^{+} from the bed (exchanger) and water become soft. But the reactions are reversible and Zeolite bed can be recharged by passing through a solution of common salt.

3. Which of the Hg^0, Hg^{+1}, Hg^{+2} and CH_3Hg^+ is most toxic and why?

[WBUT 2008, 2016(ODD)]

OR,

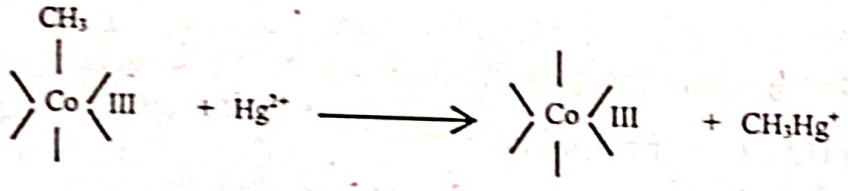
Which one of the species Hg^0, Hg^{+1}, Hg^{+2} and CH_3Hg^+ is most toxic and why? The Minamata Chemical company discharges Hg into Minamata Bay, but the fish in the bay were found to contain CH_3Hg^+. How can you explain this missing link?

[WBUT 2014(ODD), 2018(ODD)]

Answer:

Organomercurials, specially methyl mercury (CH_3Hg^+) is most toxic than other. This methyl mercury is soluble in fat and its covalent bond between C and Hg is not easily disrupted. As a result, it is not easily disrupted and it is retained in the cells for prolonged period of time. Attachment of Hg to cell membranes is likely to inhibit active transport of sugars across the membranes and allow the passage of K to the membrane. In case of brain cells, this results in energy deficiency in the cell and disorders in the transmission of nerve impulses. This will explain why babies born to mothers subjected to methyl mercury poisoning suffer from irreversible damage to the central nervous system, including cerebral palsy, mental retardation and convulsions. Methyl mercury poisoning also leads to segregation of chromosome, chromosome breakage in cells and inhibited cell division.

The elemental mercury (Hg) present in water is converted to methyl mercury (CH_3Hg^+) by anaerobic methane-synthesizing bacteria in water. This conversion is called biological methylation of mercury. This conversion is facilitated by Co(III) containing vitamin B_{12} coenzyme –methyl cobalamine. This methyl cobalamine reacts mercuric salt (Hg_2^{2+}) and converts to methyl mercury which is soluble in water.



4. a) What is waste water? Discuss the sequential methods of raw water treatment.

[WBUT 2008]

b) Describe the Rotating Biological Contactor reactor. What are the advantages and disadvantages of such reactor?

[WBUT 2008, 2012(ODD)]

OR,

Briefly describe the steps of surface water treatment procedure.

[WBUT 2014(EVEN)]

OR,

Describe, in brief, about the various process involved in surface water treatment to make it of drinkable quality.

[WBUT 2018(ODD)]

Answer:

a) Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential

contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources.

Water treatment describes a process used to make water more acceptable for a desired end-use. These can include use as drinking water, industrial processes, medical and many other uses.

The goal of all water treatment process is to remove existing components in the water, improving it for subsequent utilization.
The goal may be to allow treated water to discharge into the nature environment without adverse ecological impact.

The following steps are involved in water treatment

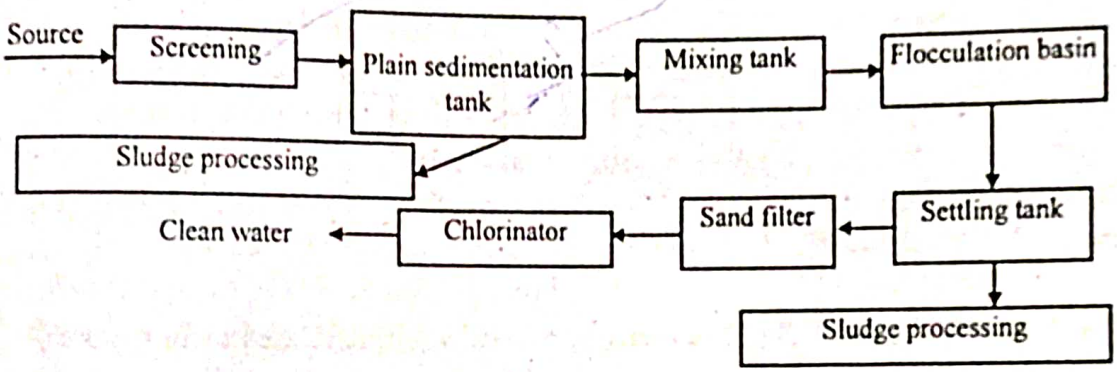


Chart: A typical flow diagram of water treatment Plant

b) Rotating disc Biological Contactor (RBC):
Rotating disc Biological Contactor (RBC) is one of the newest methods of biological treatment of wastes. The treatment unit consists of a **cylindrical bottomed horizontal flow tank** on which a partially submerged light weight rotating unit is placed, along the direction of flow. The rotating unit consists of a series of closely spaced biologically inactive discs mounted on the rotating rod or shaft. The microbial film grows and covers the entire available surface of the discs.

There are two halves of the rotations of the discs. During the first half, the disc should be partially merged inside the waste water of the tank; the remaining part should be in air. The microbial film of the submerged part of the disc is getting food i.e. organic wastes from the waste water during this period. As a result, the concentration of organic wastes reduces which leads to reduction of BOD of the waste water too. During the next half, the portion which was inside the waste water rotates and exposed to the air while the remaining portion which was in air initially now dipped into the waste water. The portion which is now in air, the microbial films of it are getting oxygen from the atmosphere and maintain their aerobic growth. During this rotational process, the thickness of the microbial film increases and ultimately **slide off** the disc and collected at the bottom of the tank. This is called **sloughing** and as it is a continuous process, a constant thickness of microbial film on the disc is maintained.

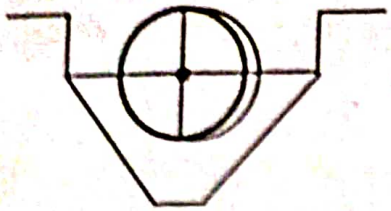


Fig. (a)

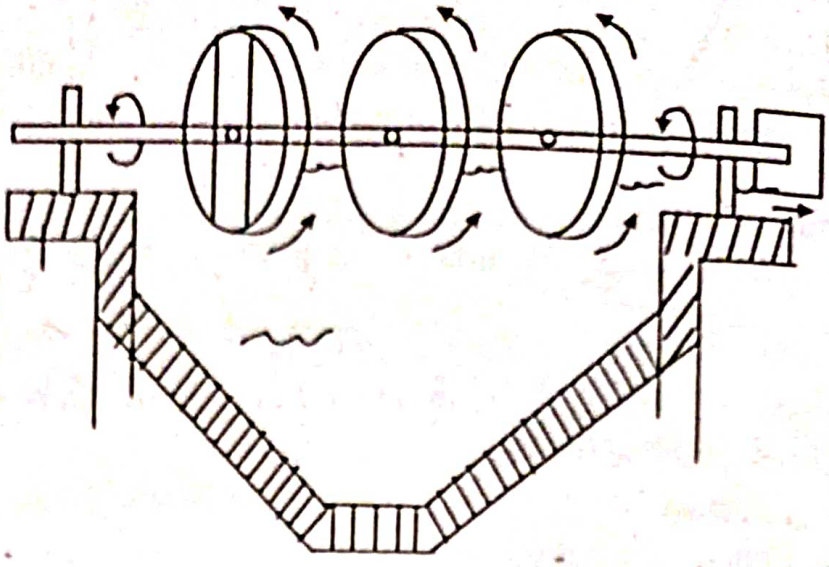


Fig. (b)

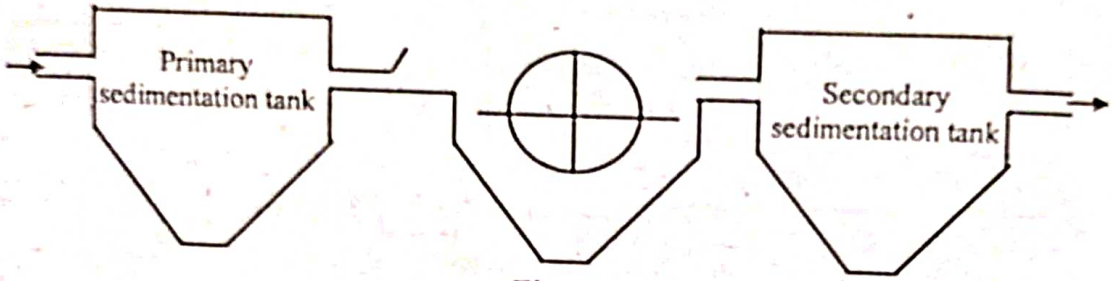


Fig. (c)

Fig. (a) & (b) Cross section of RBC & (c) RBC treatment system

5. Discuss different types of aquifers.

[WBUT 2009]

OR,

Mention the different types of aquifer.

[WBUT 2017(ODD)]

State Darcy's law.

[WBUT 2009, 2013(ODD), 2017(ODD)]

OR,

State Darcy's law for groundwater flow and hence define hydraulic conductivity.

[WBUT 2014(EVEN)]

Answer:

A confined aquifer is an aquifer below the land surface that is saturated with water. Layers of impermeable material are both above and below the aquifer, causing it to be under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer. A water-table, or unconfined, aquifer is an aquifer whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall. Water-table aquifers are usually closer to the Earth's surface than confined aquifers are, and as such are impacted by drought conditions sooner than confined aquifers.

Darcy's Law:

The rate of flow of ground water is first time formulated by Henry Darcy. According to him, the flow rate (Q) is directly proportional to the cross sectional area(A) and hydraulic gradient $\left(dh/dl\right)$.

So, $Q \propto A$ ... (1)

$$Q \propto dh/dl \quad \ldots (2)$$

$$\text{or } Q \propto A \cdot dh/dl$$

$$\text{or } Q = K \cdot A \cdot dh/dl$$

Here, K is proportionality constant and its value depends on the nature of the soil through which water is flowing. Sometime it is also called as **hydraulic conductivity**. Aquifers that have same hydraulic conductivity throughout are said to be **homogeneous** and when hydraulic conductivity differs from place to place is called **heterogeneous**.

Ground Water contamination

Once a ground water is contaminated, it is very difficult for it to be restored. There are several ways that an aquifer can be contaminated: Through a legally or illegally constructed hazardous waste landfill or old sanitary landfill as well as new, injection wells, impoundments and illegal dumping grounds.

[Usually heavy metals like As, Cr, Hg and VOC are expected in the ground water].

6. What are different stages for waste water treatment? Mention the principle objective of each stage? 252/253 **[WBUT 2012(ODD)]**

OR,

What is important of waste water treatment? **[WBUT 2014(EVEN)]**

What is the primary and secondary treatment procedures for industrial waste water treatment? **[WBUT 2014(EVEN)]**

OR

Describe the Municipal waste water treatment by using flow chart. **[WBUT2018(EVEN)]**

Answer:

Waste water treatment plants are usually designated as providing primary, secondary or advanced treatment, depending on the degree of purification. Primary treatment plants utilize physical processes, such as **screening, gritting** and **sedimentation**, to remove pollutants that will settle or that are too large to pass through simple screening devices. The floating pollutants like oil & grease can be removed by a separate unit known as **skiming**. As primary treatments utilize the physical process, they are also called '**Physical treatment**'.

Primary treatment usually removes about 35% BOD and 60% suspended solids.

The next to the primary treatment is called the **secondary treatment** of waste water. In this treatment microbial oxidation of waste takes place and so this treatment process is known as '**Biological treatment**'. There are different kinds of biological units, such as i) Trickling filter, ii) Rotating disc Biological Contactor (RBC), iii) Activated Sludge Process, iv) Oxidation Pond etc. All of the above mentioned biological units, take the advantage of the ability of microorganisms to convert the organic wastes into stabilized, low-energy compounds. So, any one of the units can be adopted for the secondary

treatment. When properly designed and operated, secondary treatment plants remove about 90% of the BOD and 90% of the suspended solids.
After the secondary treatment, water must be discharged to the natural stream. Chlorination should be done to kill the germs before the discharge. It provide degree of safety by disinfection.

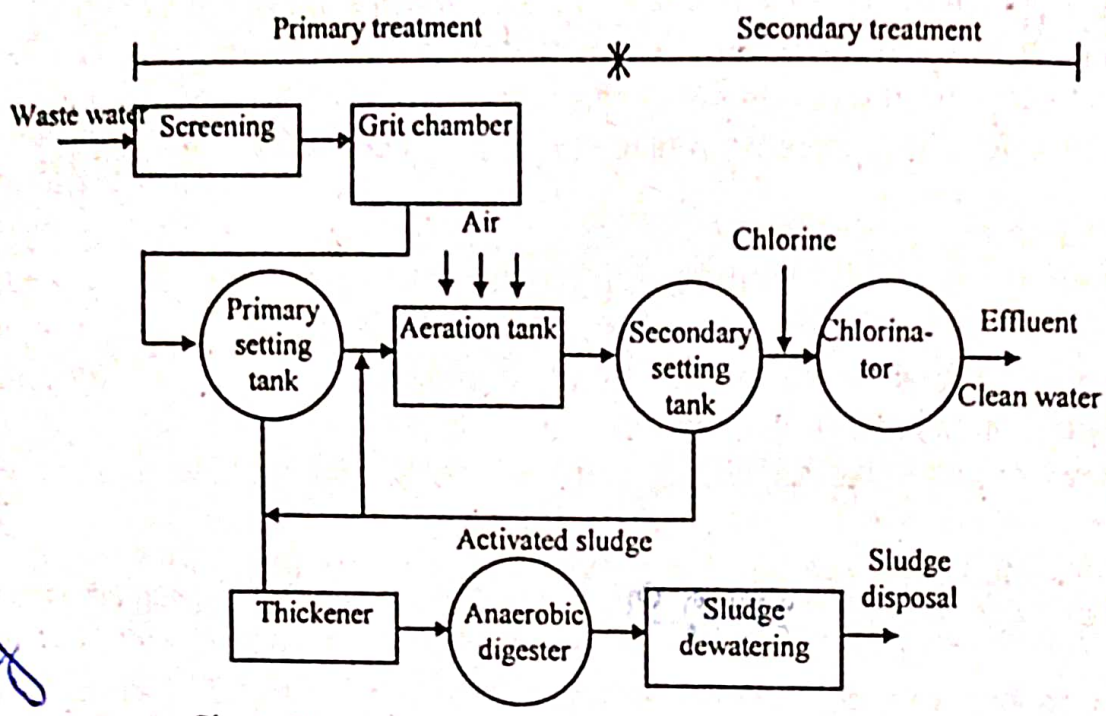


Chart: Wastewater treatment plant-providing primary and secondary treatment facility using activated sludge process.

7. (i) Distinguish between an aquifer and an aquitard. **[WBUT 2014(EVEN)]**

Answer:

An aquifer is an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be usefully extracted using a water well.

An 'aquitard' is a geological formation of layers comprised either of clay, with tiny connected pores, or on non-porus rock that resrict water flow from one aquafer to another.

(ii) A confined aquifer 30 m thick, has two monitoring wells placed 600 m apart along the direction of groundwater flow. The difference in piezometric head in wells is 2.0 m. The hydraulic conductivity is 50m/day. Calculate the flow rate per meter of distance perpendicular to the flow. **[WBUT 2014(EVEN)]**

Answer:

The rate of flow of ground water is first time formulated by Henry Darcy. According to him, the flow rate (Q) is directly proportional to the cross sectional area(A) and hydraulic gradient $\left(dh/dl\right)$.

So, $Q \propto A$ ... (1)

$Q \propto dh/dl$ ... (2)

or $Q \propto A \cdot dh/dl$

or $Q = K \cdot A \cdot dh/dl$

using Darcy's law, with an arbitrary aquifer width of 1 m, the flow rate per meter of distance perpendicular to the flow

$= 50 \times 1 \times 30 \times 2/600 = 5.0\ m^3/$ day per meter of width

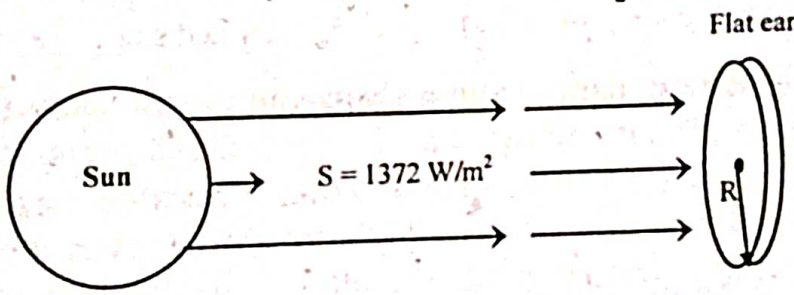
8. a) Discuss the advantages of Biological Towers over conventional Trickling filters. **[WBUT 2014(ODD)]**

Answer:

1. Power saving as blowers are not required for aeration
2. Space saving
3. Less quantity of sludge generation
4. Sludge recycling is not required
5. Bio-sludge can be used as manure for garden
6. Applicable for large capacity plants

b) Had the Earth been flat instead of being spherical in shape, what would have been its surface temperature, calculated on the basis of zero-dimensional energy balance model? (Given: $S = 1370\ Wm^{-2}$, $\sigma = 5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$, $\alpha = 0.31$) **[WBUT 2014(ODD), 2018(ODD)]**

Answer:



For our convenience, we consider that all energy coming from Sun should pass through a disc having same radius equal to that of Earth.

If we consider that the radius of the Earth is R then amount of energy radiated by the Sun and absorbed by the Earth's surface (E_a) i.e., incoming energy is equal to

$$E_a = S.\pi R^2 \quad \ldots (1)$$

Where, S = Solar intensity.

On the other hand, the Earth's surface (having total surface area $\pi R^2 + \pi R^2 = 2\pi R^2$ radiates the energy (E_r) which is equal to

$$E_r = \sigma.2\pi R^2.T^4 \quad \ldots (2)$$

Here, σ = Stefan=Boltzmann const. $= 5.67 \times 10^{-8}\ W/m^2K^4$

T = Average surface temperature (K)

As, it is a black body, energy absorbed must be equal to energy radiate, so

$$E_a = E_r$$

or, $S\pi R^2 = \sigma.2\pi R^2.T^4$

$\therefore \quad S = 2.\sigma.T^4$

or, $T = \left[\frac{S}{2.\sigma}\right]^{1/4} = \left[\frac{1372}{2\times 5.67\times 10^{-8}}\right]^{1/4} = 331K$

∴ The temperature of new Earth would be 331 K.

9. In a BOD_5 test [WBUT 2015(EVEN)]

a) Why it is necessary to cover the bottle with a stopper?

b) Why the dilution of waste water sample is necessary?

c) In dark test run is conducted explain why?

d) What is the necessity of seeding the sample?

e) Why ultimate BOD is not measured?

f) Giving a sketch and discuss the typical treatment plant for surface water to make potable water.

Answer:

a) It is necessary to cover the bottle with the stopper to avoid any further addition of atmospheric oxygen to the sample waste water.

b) The dilution of raw sample of waste water is required because for the decomposition of organic waste present in waste water needs a higher amount of dissolved oxygen (DO).

c) The bottle should be kept in dark to avoid photosynthesis (if some algae are present in sample water). Because photosynthesis may increase the concentration of DO in the 'diluted' sample waste water.

d) Sometimes raw waste water contains less amount of microorganism which is not sufficient to decompose the organic matters present in it. In that particular case, introduction of microorganisms to the waste water is required. This is called **'seeding'**.

e) The ultimate BOD (Lo) is defined as the maximum BOD exerted by the wastewater. It is difficult to assign exact time to achieve ultimate BOD, and theoretically it takes infinite me. So, it is not measured.

f) The following steps are involved in water treatment.

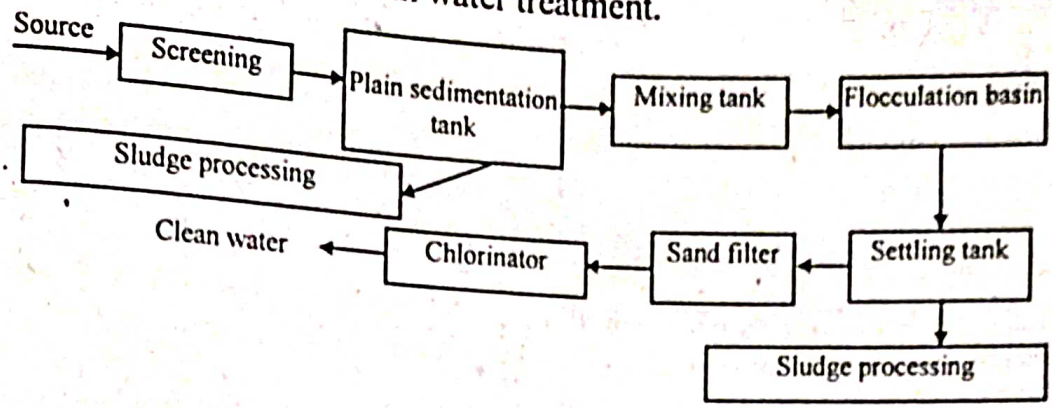


Chart: A typical flow diagram of water treatment Plant

The functions of each unit of water treatment plant –

i) Screening:

This unit removes the relatively large floating and suspended materials from the water.

ii) Plain Sedimentation:

The suspended materials which are not easily removed by the screening process, can be removed easily by the process of Plain Sedimentation. In this process water is retained in a basin so that the suspended particles may settle down due to force of gravity only. After the settlement of suspended particles, the water is taken out from the basin without causing any disturbance to the settled suspended impurities.

iii) Mixing with coagulants:

Very fine particles cannot be removed by plain sedimentation. Because they take long time for the settlement at the bottom of the tank.

To avoid this, some coagulants, such as Aluminium Sulphate $[Al_2(SO_4)_3,\ 18H_2O]$ or Alum is mixed to the water. This coagulants produce insoluble, gelatinous, flocculent precipitation.

iv) Flocculation:

After mixing of coagulants in water, the next operation is flocculation. In this process, the water rotates gently with the help of horizontally or vertically movable paddles. During this time, the coagulants attracts the very fine particles present in water and produce insoluble, gelatinous **floc.** This is called flocculation.

v) Sedimentation:

Flocculation process is always followed by the sedimentation process. Flocs which are produced during the flocculation process flows to the final sedimentation tank or settling tank. Due to larger size and weight, the flocs sedimented at the bottom of the tank.

vi) Sludge Processing:
In this process, the sedimented particles collected from bottom of both plain sedimentation tank and final sedimentation tank i.e., settling tank, is dewatered and disposed of.

vii) Filtration:
Very fine particles present in water can be removed by the sedimentation with flocculation. But, very fine particles still remain present in it. Usually sand filters are used to remove that type of particles. There are two types of sand filter: (a) rapid sand filter and (b) slow sand filter.

viii) Disinfection:
After the filtration the water is almost free from any kind of particles. But to make it free from germs or pathogen, usually **disinfection** process is used.
The process of killing the infective or disease causing bacteria from water and make it safe to the user is called **disinfection.**
The chemicals or substances which are used for killing the bacteria are known as **disinfectants.**

10. a) What is dissolve oxygen? Why is it considered as an important water quality parameter to know the health of a water body? [WBUT 2015(ODD)]
Answer:
Oxygen is available in water in dissolved condition. This is called dissolved oxygen (DO). The concentration of DO depends on pressure, temperature and other physical, chemical and biochemical conditions of water.
The following points reveal the importance of DO as a parameter –

1. It is necessary to know DO levels to assess quality of waste water and to keep a check on stream pollution.
2. In liquid waste DO is the factor that determines whether biological changes are removed by aerobic or anaerobic organisms.
3. DO test is the basis of BOD test which is an important parameter to evaluate pollution potential of waste.
4. Oxygen is an important factor in corrosion. DO test is used to control amount of oxygen in boiler fed water, either by chemical or physical methods.

Critical dissolved oxygen
The minimum concentration of oxygen in the water needed for the growth of a culture which has been submerged, where oxygen is the limiting factor to the growth of the culture.
Effects of low DO on aquatic life –

- Direct Mortality
- Reduced Swimming Performance
- Reduced Growth
- Impaired Development

- Reduced Spawning Success
- Reduced Fecundity/Fertility
- Altered Behavior
- Indirect Effects (Susceptibility to Predation, Susceptibility to pathogens, and Susceptibility to Contaminants)

Factors influencing DO:
The physical factors that influence DO are temperature, altitude, salinity, and stream structure.

Temperature inversely controls the solubility of oxygen in water; as temperature increases, oxygen is less soluble. In contrast, there is a direct relationship between **atmospheric pressure** and DO; as the pressure increases due to weather or elevation changes, oxygen solubility increases. **Salinity** also reduces the solubility of oxygen in water. **Stream structure** also influences DO concentrations. Atmospheric oxygen becomes mixed into a stream at turbulent, shallow riffles, resulting in increased DO levels.

b) What is biodegradation rate constant? org+24, **[WBUT 2015(ODD)]**

Answer:
The BOD reaction rate constant (k) is a factor that indicates the rate of decomposition of wastes. As k increases, the rate at which dissolved oxygen is consumed increases, although the ultimate amount required for the decomposition i.e. ultimate oxygen demand (L_0), does not change. The reaction rate (k) will depend on a number of factors, these are:

i) the nature of the waste itself
ii) the ability of the available microorganisms to degrade the waste
iii) the temperature.

The rate of decomposition of wastes increases with increasing temperature. To account for these changes, the reaction rate constant k is often modified using the following equation –

$$K_T = K_{20}\theta^{(T-20)} \quad \text{—(1)}$$

where, $K_{20} \Rightarrow$ reaction rate constant at 20°C

$K_T \Rightarrow$ reaction rate constant at any temp. (°C)

$\theta \Rightarrow$ (constant) 1.047.

c) A sample of ground water has 140 mg/L of Ca^{2+} ion. Express its hardness in units of mg/L of $CaCO_3$. Same as 285 **[WBUT 2015(ODD), 2018(ODD)]**

Answer:

The equivalent weight of Ca^{2+} is $\frac{40}{2} = 20\,mg/meq$

$\therefore 140$ mg/L $Ca^{2+} \Rightarrow$ 140/20 meq/l = 7 meq/l

So, its hardness in mg/L as $CaCO_3$ = Hardness in meq/L × Equivalent weight of $CaCO_3$

= 7 meq/l X 100/2 = 350 mg/l as $CaCO_3$

11. a) What is heavy metals? How heavy metals interact with enzymes. 225 and 267 [WBUT 2015(ODD)]

Answer:

Usually we use the term 'heavy metal' to refer the metals which are very much toxic and harmful to the ecosystem. These heavy metals have a specific gravity of 4-5 times greater than that of water and usually belong to atomic numbers 22-34 and 40-52. They are usually members of **lanthenides** and **actinides** of the **periodic table.**

In general, toxic chemicals attack the active sites of enzymes, inhibiting essential enzyme function. Heavy metal ions act as effective **enzyme inhibitors.** They have affinity for sulphur containing ligands (SCH_3, -SH etc.) of different compounds present in enzyme structure.

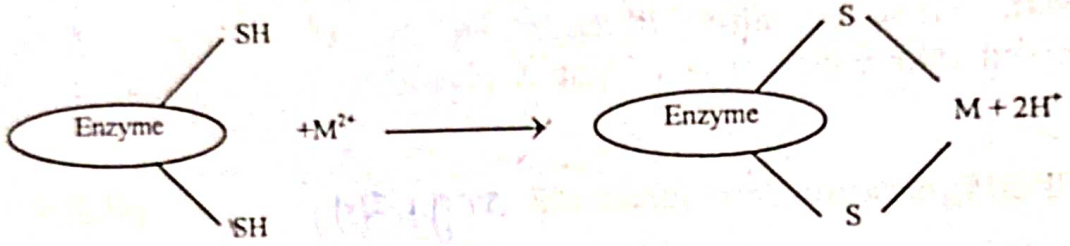


Fig. 1 Attack of heavy metal to enzyme

Metalloenzymes contain metal in their structures. Their action is inhibited when one metal ion of a metalloenzyme is replaced by another metal ion of similar size and charge. If the new metal is toxicant, then it will show the toxicity and inhibits the actual activities of enzyme.

- **Toxicity**

Toxicity is a relative potential of a substance or combination of different substances for producing injury or harm to living organism. When different chemical substances are responsible for the toxicity, then it is called **chemical toxicity** and the chemical substances are **chemical toxicants.**

- ***Classification of toxicity***

On the basis of target organs, it is classified as –

(a) Hepato toxicity (target is liver)
(b) Nefro toxicity (target is kidney)
(c) Hemato toxicity (target is blood)
(d) Pulmono toxicity (target is lungs)
(e) Geno toxicity (target is gene i.e., DNA)

On the basis of exposure duration, it is classified as –

(a) Acute toxicity (short term)
(b) Chronic toxicity (long term)

The transmission of toxic substances through the body of living organism follow a definite path. This flow of toxic substance is called '**Pharmoco-kinetics**'.

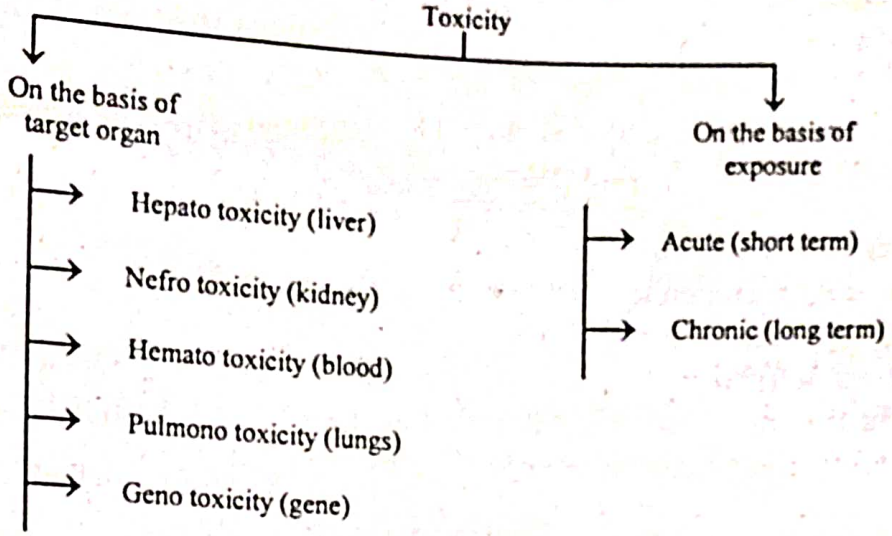


Chart: Classification of toxicity

- ***Pharmoco-kinetics***

The flow or transmission of chemical substances through our body is known as '**Pharmoco-kinetics**'. There are four stages of **Pharmoco-kinetics.**

These are:

i) Absorption
ii) Storage
iii) Distribution
iv) Excretion

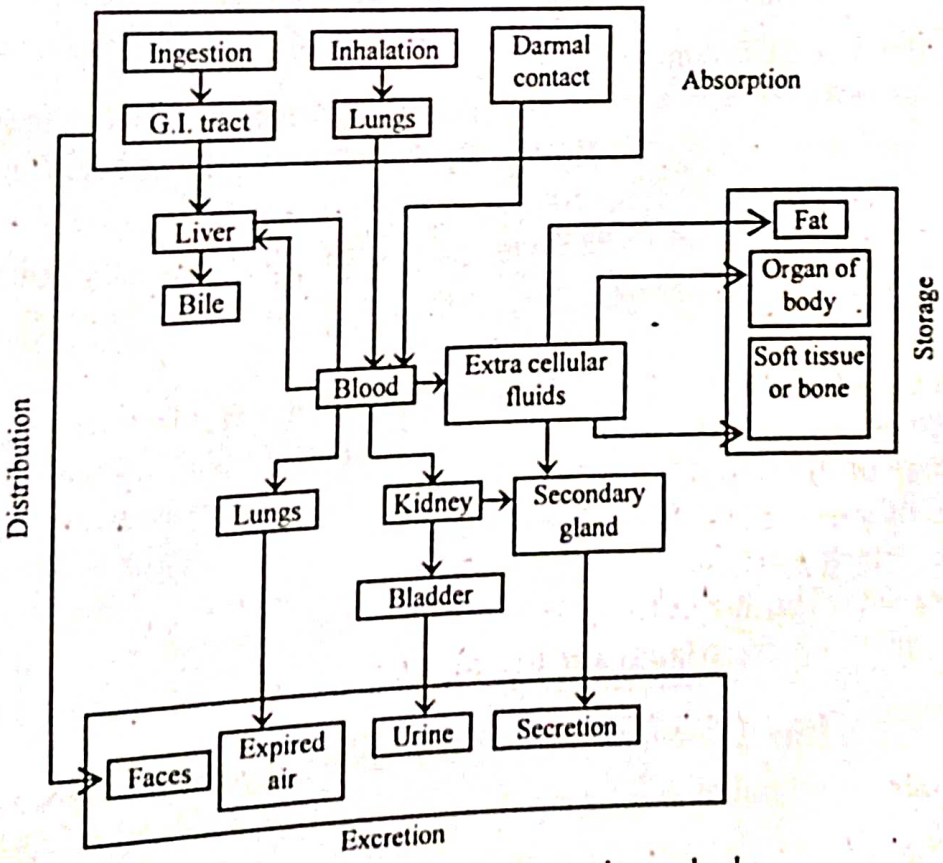


Fig. Fate of chemical substances in our body

A toxicant can enter the body by means of **absorption** process. There are three pathways of absorption of chemical toxicants in our body. These are ingestion with food or drink, inhalation or dermal contact. Once in the body it can be absorbed by the blood, **distributed** to various organs and systems. The toxicants may then be **stored** or it may be eliminated from the body by **excretion.**

- ***Mutagenesis and Mutagen***

Mutagenesis: Deoxyribonucleic acid (DNA) is an essential component of all living things and a basic material in the chromosomes of the cell nucleus. Certain chemical agents as well as ionizing radiation are **capable of altering DNA.** This is called **mutation** and the process of mutation is called **mutagenesis.** The substances or an agent of mutation is called **mutagenic substances or mutagen.**

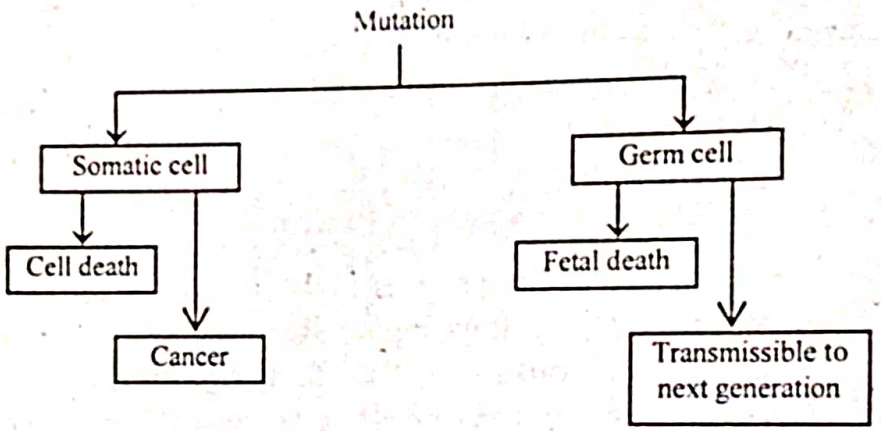


Chart: Possible consequence of mutagenic event

- ***Carcinogenesis and Carcinogen***

The abnormal growth and activities of a cell is known as cancer. Cancer may be initiated by different substances. These substances are known as **carcinogen.** The process of cancer is known as **carcinogenesis.**

There are two stages of carcinogenesis –

(i) Initiation
(ii) Promotion

In the **initiation stage,** a mutation alters a cell's genetic material in a way that may result the uncontrolled growth of cells that characterizes **cancer.** In the **promotion stage** which is known as **stage of development, tumor develops.** This is also known as **Oncogenesis.** Tumor may be of two types – **Benign & Malignant.** Benign tumor is less harmful and **non-cancerous.** Its growth is limited within its own boundary. But when a tumor undergoes **metastis** – i.e., it breaks apart and portion of it enter other areas of body – is said to be malignant tumor. **Malignant tumor** is much harder to treat or remove, and it **is cancerous.**

Example of Carcinogen: Benzene, Vinyl chloride, 2-Napthylamine, Hydrozine, Arsenic trioxide, Hexavalent chromium (Cr^{6+}) etc.

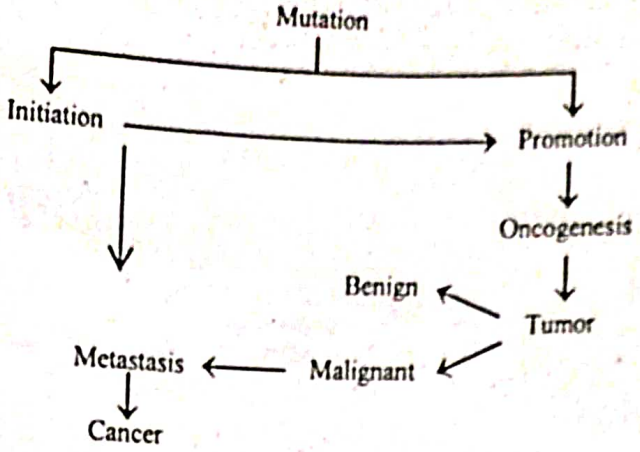


Chart: Steps of Carcinogenesis

Toxic effect of Cadmium

The disease due to the ground water contamination by **cadmium** in Japan, is popularly known as '**Itai-itai**' or '**Ouch-ouch**'. The incident took place in the **Jintsu** river basin which was highly contaminated with cadmium (Cd) by drainage water from the surrounding mines. Concentration of Cd in the river water reached a high level. The irrigation of the rice fields by this water progressively increased Cd concentration of rice (because crop can accumulate metal in their body). Rice was the main food of the people living in the basin, these people consumed 2 to 20 times more Cd than their normal consumption. This extra Cd stored in their bodies that resulted in a **severe bone disease** due to development of **microfractures**. .Thousands of death occurred and several hundred people were seriously affected by this disease.

Biochemical effect of Cadmium (Cd): Major portion of Cd ingested into our body is trapped in the kidney and eliminated. A small fraction is bound most effectively by the body proteins, **metallothionein**, present in the kidneys, while the rest is stored in the body and gradually accumulates with age. When excessive amounts of Cd^{2+} are ingested, it replaces Zn^{2+} at key enzymatic sites causing metabolic disorder.

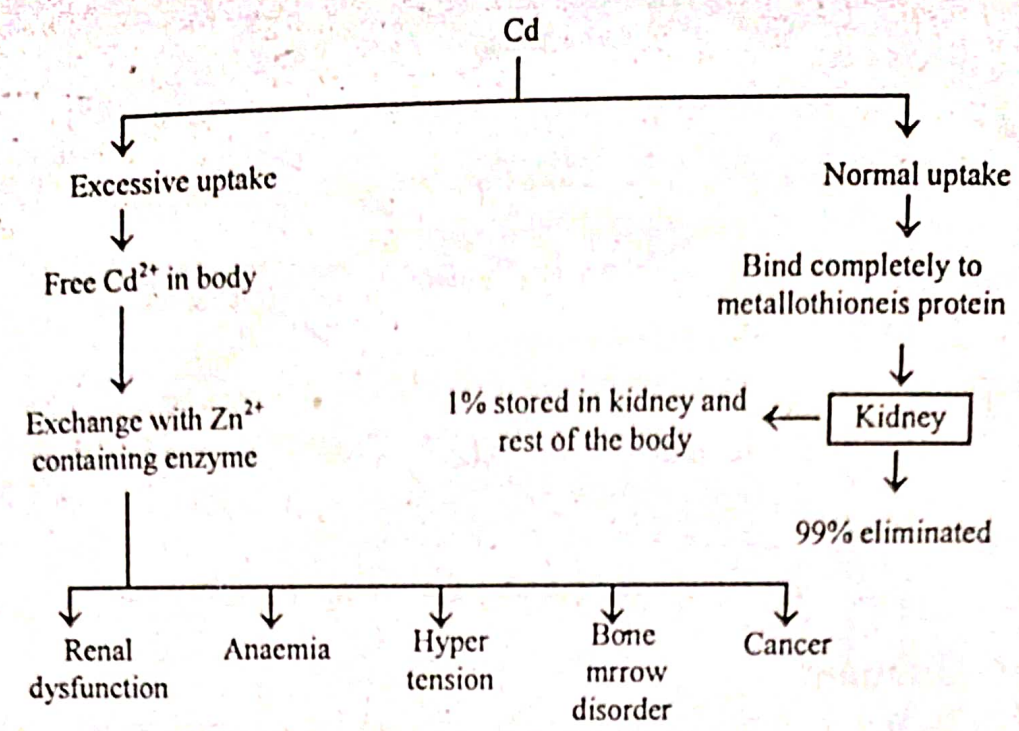


Chart: Biochemical effect of Cd

b) Discuss biomagnifications. **[WBUT 2015(ODD)]**

Answer:

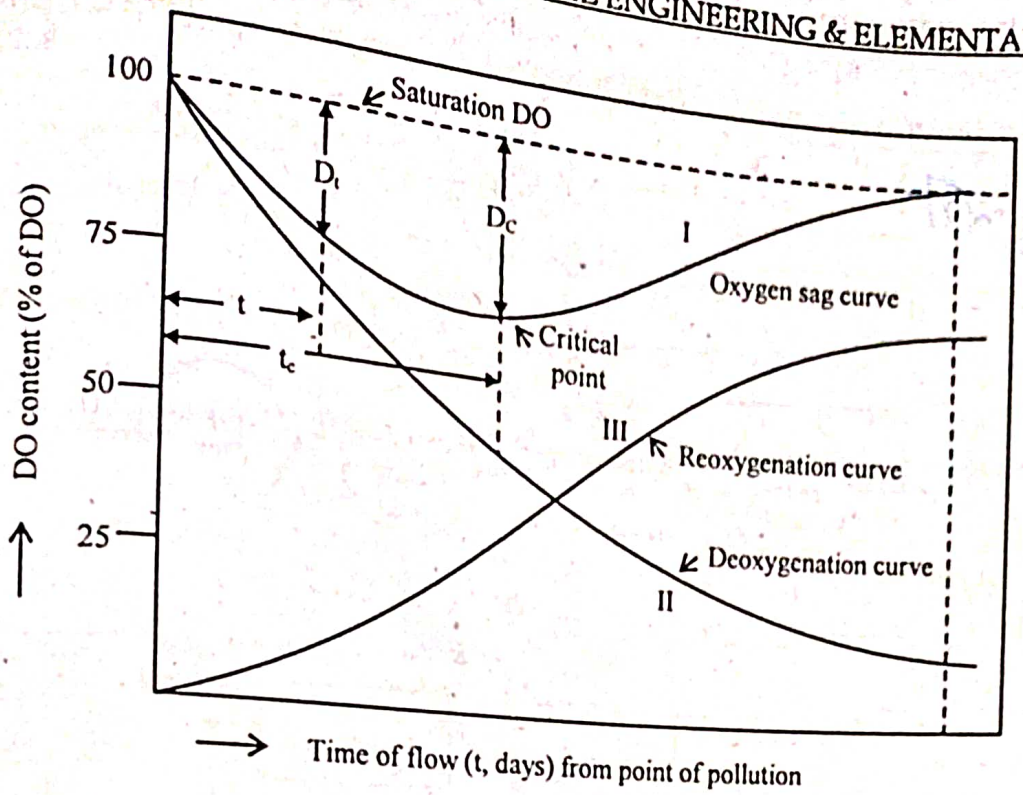
Biomagnification (or bioaccumulation) refers to the ability of living organisms to accumulate certain chemicals to a concentration larger than that occurring in their inorganic, non-living environment, or in the case of animals, in the food that they eat. Organisms accumulate any chemical needed for their nutrition.

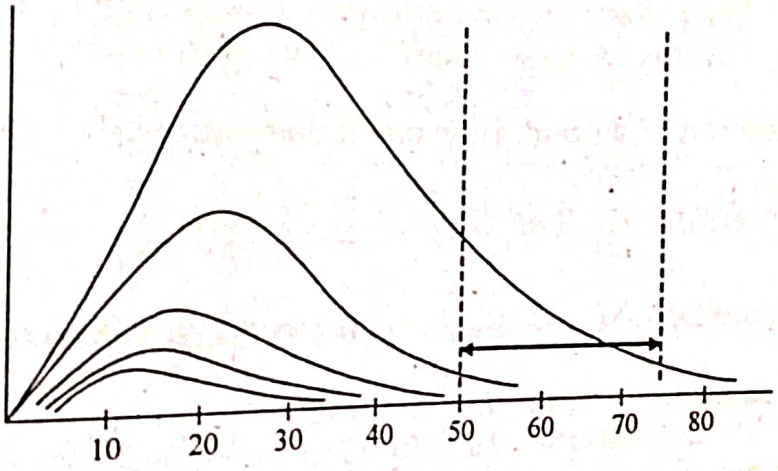
12. a) What is oxygen sag curve? Explain it by a diagram. **[WBUT 2017(EVEN)]**

Answer:

Oxygen sag curve The curve obtained when the concentration of dissolved oxygen in a river into which sewage or some other pollutant has been discharged is plotted against the distance downstream from the sewage outlet (see graph). Samples of water are taken at areas upstream and downstream from the sewage outlet. The presence of sewage reduces the oxygen content of the water and increases the biochemical oxygen demand. This is due to the action of saprotrophic organisms that decompose the organic matter in the sewage and in the process use up the available oxygen.

Deoxygenation and Reoxygenation curves





The oxygen sag or oxygen deficit in the stream at any point of time during self-purification process is the difference between the saturation DO content and actual DO content at that time. Oxygen deficit, D = Saturation DO – Actual DO The saturation DO value for fresh water depends upon the temperature and total dissolved salts present in it; and its value varies from 14.62 mg/L at 0° C to 7.63 mg/L at 30° C, and lower DO at higher temperatures. The DO in the stream may not be at saturation level and there may be initial oxygen deficit 'Do'. At this stage, when the effluent with initial BOD load Lo, is discharged in to stream, the DO content of the stream starts depleting and the oxygen deficit (D) increases. The variation of oxygen deficit (D) with the distance along the stream, and hence with the time of flow from the point of pollution is depicted by the 'Oxygen Sag Curve'. The major point in sag analysis is point of minimum DO, i.e., maximum deficit. The maximum or critical deficit (Dc) occurs at the inflexion points of the oxygen sag curve.

b) Describe effluent treatment in details by block diagram. **[WBUT 2017(EVEN)]**

Answer:

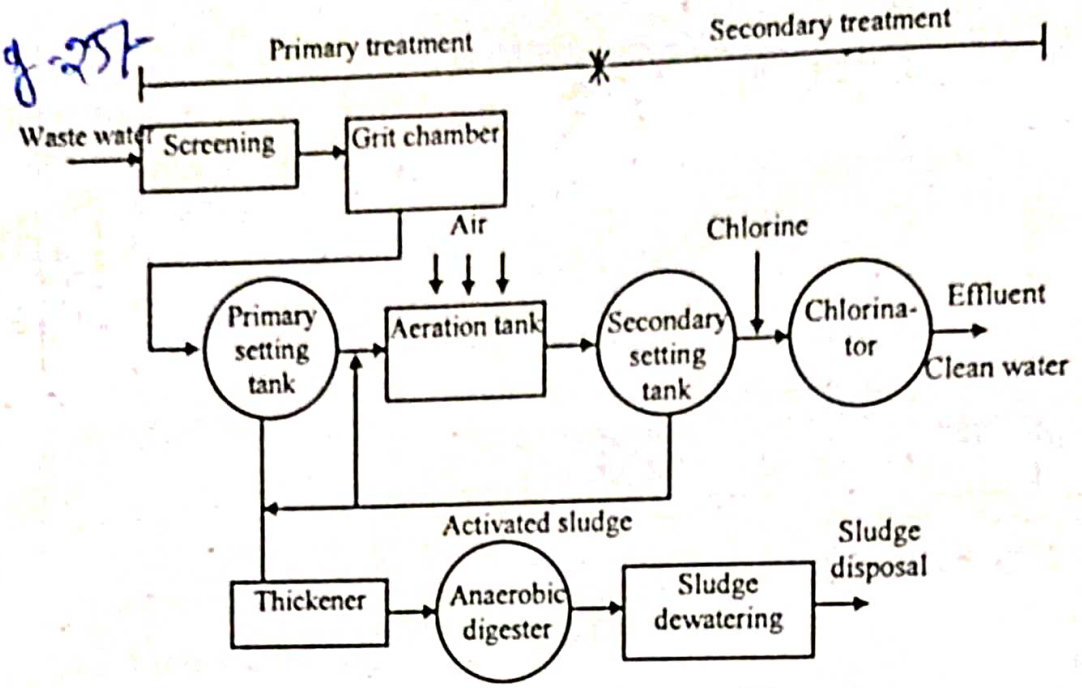


Chart: Wastewater treatment plant-providing primary and secondary treatment facility using activated sludge process.

13. Define Eutrophication of a pond. How can it be controlled? **[WBUT 2017(ODD)]**

Answer:

1st Part: ***Refer to Question No. 8 of Short Answer Type Questions.***

2nd Part: ***Refer to Question No. 12 of Short Answer Type Questions.***

14. a) Name the three sources of thermal pollution.

b) Mention water polluting substances produced by chemical industries, two each from organic and inorganic origin. **[WBUT 2017(ODD)]**

Answer:

a)

Major sources	Methods of pollution
Power plants creating electricity from fossil fuel	1. Electricity is generated by heat stored in the fossil fuels and the stored energy creates a heat flow that drives turbine 2. The turbines then generate electricity 3. All the electricity try to be organized so that it may travel in the same direction in a small line 4. Organization of this sort is created by man and so it does not occur naturally 5. Excess heat is then created because of the unnatural processes of creating organization

Major sources	Methods of pollution
Water as cooling agent	• **heat exchangers** exchange heat with other streams in the factory because there steps which needs heat while other steps generates heat, leaving streams no options for intermediate temperature • **evaporate cooling** steam is used in many final heating processes. Cooling by condensation generates great amount of waste heat from factory. Cooling comes from evaporation because ambient air is not saturated with water. Air discharged from cooling tower is a direct contribution to global warming
Soil erosion	• sedimentation at lakes and streams makes the water muddy • muddy water lowers the clarity of water, with the introduction of impurities to the water, containing microbes and dissolved minerals, which increase the light absorption from the atmosphere • increase light absorption will see a rise in the temperature of water from the heat energy of light.

b) **Organic** water pollutants include:

- Detergents
- chloroform
- Food processing waste,
- Insecticides and herbicides,
- Petroleum hydrocarbons,
- Tree and bush debris from logging operations
- Volatile organic compounds (VOCs)

Inorganic water pollutants include:

- Acidity caused by industrial discharges (especially sulfur dioxide from power plants)
- Ammonia from food processing waste
- Chemical waste as industrial by-products
- Fertilizers containing nutrients--nitrates and phosphates
- Heavy metals from motor vehicles
- Silt (sediment) in runoff from construction sites, logging, slash and burn practices or land clearing sites

15. a) Discuss the adverse effect of eutrophication in the lake.
b) Discuss the effect of oil pollution on marine environment
c) Describe the principle of reverse osmosis for removal of dissolved solids from water. What are the advantages and disadvantages of reverse osmosis process?
[WBUT 2018(EVEN)]

Answer:

a) Effects of Eutrophication

i) During eutrophication, algal bloom releases toxic chemicals which kill fish and other aquatic animals.

ii) Decomposition of algal bloom leads to oxygen depletion in water. Thus with high CO_2 level and poor oxygen supply, aquatic organisms begin to die.

iii) When oxygen level falls to zero i.e., anaerobic condition, some bacteria derive oxygen through reduction of nitrates. On the complete reduction of nitrate oxygen may be obtained by the reduction of sulphate which produces hydrogen sulphide (H_2S) and causes foul smell.

iv) Many pathogenic microorganisms like bacteria, protozoa etc. may on the eutrophic lake.

b) An **oil spill** is the release of a liquid petroleum hydrocarbon into the environment, especially the **marine** ecosystem, due to human activity, and is a form of **pollution**. The term is usually given to **marine oil spills**, where **oil** is released into the ocean or coastal waters, but **spills** may also occur on land. **Oil** destroys the insulating ability of fur-bearing mammals, such as **sea** otters, and the **water** repellency of a bird's feathers, thus exposing these **creatures** to the harsh elements. Without the ability to repel **water** and insulate from the cold **water**, birds and mammals will die from hypothermia.

c) Reverse osmosis (RO) is a water purification technology that uses a semipermeable membrane to remove ions, molecules and larger particles from drinking water. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property, that is driven by chemical potential differences of the solvent, a thermodynamic parameter. Reverse osmosis can remove many types of dissolved and suspended species from water, including bacteria, and is used in both industrial processes and the production of potable water. Reverse osmosis is the process of forcing a solvent from a region of high solute concentration through a semipermeable membrane to a region of low solute concentration by applying a pressure in excess of the osmotic pressure.

Advantage:

Reverse osmosis systems have plenty of advantages. They are friendly to the environment, as they do not produce or use any harmful chemicals during the process. These systems also require a minimal amount of power. Reverse osmosis systems work well in home filtration systems because they are typically small in size.

Taste of the purified water is another distinct advantage. Reverse osmosis removes dissolved minerals and other contaminants that cause water to smell unpleasant, taste poorly and take on unusual colors.

Removal of dissolved minerals, metals and other particles benefits plumbing systems. There is nothing in the water to corrode pipes or collect as sediment.

Disadvantage:

Household reverse osmosis units use a lot of water because they have low back pressure. As a result, they recover only 5 to 15% of the water entering the system. The remainder is discharged as waste water. Because waste water carries with it the rejected contaminants, methods to recover this water are not practical for household systems. Wastewater is typically connected to the house drains and will add to the load on the household septic system. A reverse osmosis unit delivering five gallons (19 L) of treated water per day may discharge between 20 and 90 gallons (75–340 L) of waste water per day.

Large-scale industrial/municipal systems recover typically 75% to 80% of the feed water, or as high as 90%, because they can generate the high pressure needed for higher recovery reverse osmosis filtration. On the other hand, as recovery of wastewater increases in commercial operations, effective contaminant removal rates tend to become reduced, as evidenced by product water total dissolved solids levels.

Due to its fine membrane construction, reverse osmosis not only removes harmful contaminants present in the water, but it also may remove many of the desirable minerals from the water. A number of peer-reviewed studies have looked at the long-term health effects of drinking demineralized water.

16. a) Why seeded BOD test is necessary over ordinary BOD test?
b) Describe the seeded BOD test and derive the formula

$$BOD_w = \frac{\left[(DO_i - DO_t) - (B_i - B_t)(1-P)\right]}{P}$$

where the terms DO = Dissolved Oxygen and P = Dilution factor.
c) In 5 days DO level drops by 2.0 mg/l of seeded dilution water. A 300ml BOD bottle filled with 35ml waste water and the rest seeded dilution water, shows a drop of 6mg/l in the same period (5 days). What would be the BOD5 of the waste?
d) What will be the ratio of BOD5 at 20°C, to that of BOD2.5 at 35°C?
[WBUT 2018(EVEN)]

Answer:

a) Sometimes raw waste water contains less amount of microorganism which is not sufficient to decompose the organic matters present in it. In that particular case, introduction of microorganisms to the waste water is required. This is called **'seeding'**. At the time of dilution of raw waste water, instead of pure water, contaminated water (by microorganism) is used. This seeded water i.e. contaminated water not only reduces the concentration of organic waste, but also provides sufficient microorganisms to decompose it. But this water should have its own BOD and that should be subtracted from the BOD of raw waste water.

b) $BOD_m\ V_m = BOD_w . V_w + BOD_d\ V_d$ ... (1)

Where, BOD_m = BOD of the mixture of waste water and seeding water (blank)

BOD_w = BOD of waste water alone

BOD_d = BOD of seeding water or dilution water (blank) alone.
V_m = Volume of mixture of waste water and seeding water (blank)
V_w = Volume of waste water alone
V_d = Volume of seeding or dilution water (blank) alone.

Equation (1) can be rearranged as

$$BOD_w\ V_w = BOD_m . V_m - BOD_d\ V_d$$

$$BOD_W = BOD_m \left(\frac{V_m}{V_W}\right) - BOD_d \left(\frac{V_d}{V_w}\right) = BOD_m \left(\frac{V_m}{V_w}\right) - BOD_d \cdot \left(\frac{V_d}{V_w} \cdot \frac{V_m}{V_m}\right)$$

$$= \frac{BOD_m}{(V_w/V_m)} - \frac{BOD_d (V_d/V_m)}{(V_w/V_m)}$$

$$= \frac{BOD_m - BOD_d\ (V_d/V_m)}{(V_w/V_m)} \qquad \ldots (2)$$

Dilution factor (P) $$= \frac{V_w}{V_w + V_d} = \frac{V_w}{V_m} \qquad \ldots (3)$$

Again, $\frac{V_d}{V_m} = \frac{V_m - V_w}{V_m}$; $\left[\begin{matrix} as, V_m = V_w + V_d \\ or, V_d = V_m - V_w \end{matrix}\right]$

$$\frac{V_d}{V_m} = 1 - \frac{V_w}{V_m}$$

$$\frac{V_d}{V_m} = (1 - P) \qquad \ldots (4)$$

Put the value of P & (1 – P) in the equation (2),
We get

$$BOD_w = \frac{BOD_m - BOD_d\ (1-P)}{P} = \frac{(DO_i - DO_f) - (B_i - B_f)(1-P)}{P}$$

where, DO_i = initial DO of diluted waste water
DO_f = final DO of diluted waste water
B_i = initial DO of seeding water
B_f = final DO of seeding water
P = dilution factor.

c) We Know that,

$$BOD_w = \frac{[(DO_i - DO_t) - (B_i - B_t)(1-P)]}{P}$$

Here,
$DO_i - DO_t$ = 6mg/l
$B_i - B_t$ = 2mg/l

p= 35/300 = 0.12

Then, $BOD_5 = [6 - 2(1-0.12)]/0.12 = 35.35$ mg/l

d) BOD_5 at 20°C = $L_0(1 - e^{-k_{20} \times 5})$

or $BOD_5 = L_0(1 - e^{-5k_{20}})$

Now, $K_T = K_{20}\,\theta^{(T-20)}$ ... (1)

Or $K_{35} = K_{20}(1.047)^{(35-20)}$

$K_{35} = 1.99 \times K_{20}$

Therefore,

$BOD_{2.5}$ at 35°C = $L_o(1 - e^{-1.99 \times K20 \times 2.5})$

$= L_o(1 - e^{-4.97\,K20})$ ... (2)

If we divide equation (2) by equation (1), then

$(BOD_{2.5}$ at 35°C)/ (BOD_5 at 20°C) = $L_o(1 - e^{-4.97\,K20})/L_o(1 - e^{-5\,K20}) = 1$

So that, ratio of the 2.5 day BOD at 35°C to the 5 day BOD at 20°C is approximately unity.

17. (a) Sometimes packaged drinking water is labeled as 'Ozonised water' : What do you mean by ozonised water?

b) Describe, in brief, about the various process involved in surface water treatment to make it of drinkable quality. [WBUT 2018(ODD)]

Answer:

Ozone is a blue gas with a relative molar mass of 48 and molecular formula of O{-3}. It converts back into oxygen after its oxidising process. This makes it the most eco-friendly treatment known today.

Ozone is the ultimate in disinfection. When drinking water is treated with chlorine (chlorine is a highly carcinogenic chemical), the residual chlorine in water is also consumed along with the water.

On the other hand ozone, having half the life of only about 20 minutes, unreacted ozone reduces to oxygen, leaving no trace of toxicity in water.

The water is free from chlorine. Ozone reacts with impurities such as micro organisms including bacteria, virus, spores, mould and fungi. Chemicals such as chlorine neutralise them.

As ozone destroys all micro organisms and it removes disagreeable odours, the resultant water is absolutely safe, pure, fresh and healthy. Ozonised water is colourless and odourless.

The advantage of the use of ozone in water is that it does not leave a dangerous chemical residue like many conventional treating chemicals.

Ozone generators produce ozone by passing oxygen through an electrical field.

Then the generated ozone is bubbled through the water to be treated in a specially designed vessel to control rate of injection. The amount of ozone to diffuse in water depends on the contamination of water.

b) *Refer to Question No. 4.a) of Long Answer Type Questions.*

18. Write short notes on the following:

a) Hydraulic gradient [WBUT 2007, 2015(ODD)]
b) Trickling filters [WBUT 2013(EVEN), 2018(EVEN), 2018(ODD)]
c) Oxidation Pond [WBUT 2014(EVEN), 2014(ODD), 2018(ODD)]
d) Hydraulic gradient and Darcy's law [WBUT 2015(ODD)]
e) Oil pollution and its effect in marine life and coastal infrastructure [WBUT 2016(EVEN)]
f) Oxygen Sag Curve [WBUT 2016(ODD)]
g) Activated Sludge Process [WBUT 2016(ODD)]
h) RBC [WBUT 2017(EVEN)]
i) Eutrophication. [WBUT 2017(EVEN)]

Answer:

a) Hydraulic gradient:

In an unconfined aquifer, the slope of the water table, measured in the direction of the steepest rate of change is called **hydraulic gradient.** It is important because ground water flow is in the direction of the gradient and also proportional to it.

The vertical distance from the reference plane, i.e., Datum plane (usually sea level) to water table is called **hydraulic head.**

If we imagine two wells directly in line with the ground water flow, the gradient would be simply the difference in head divided by the horizontal distance between them.

From the diagram, the hydraulic gradient can be measured as

$$\text{Htdraulic Gradient} = \frac{\text{Change in head}}{\text{Horizontal distance}} = \frac{h_1 - h_2}{L}$$

$$\therefore \text{Hydraulic Gradient} = \frac{dh}{dl}.$$

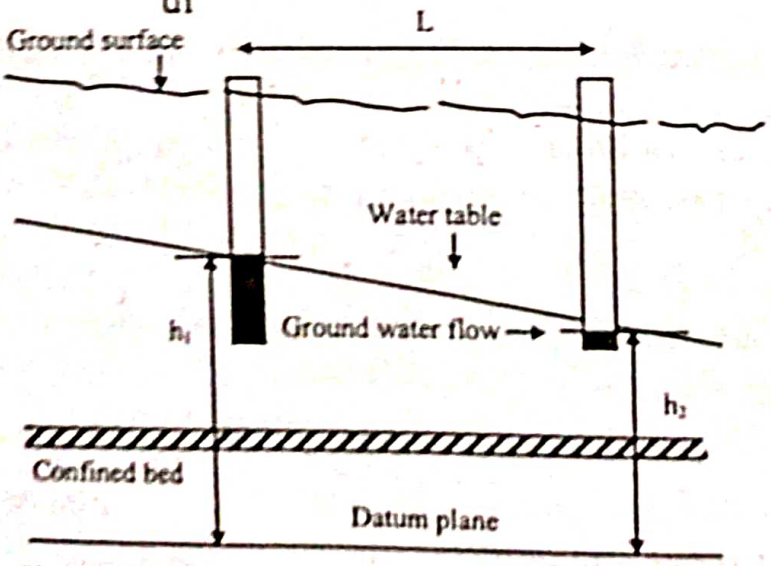


Fig. Showing head and gradient in an unconfined aquifer

b) Trickling filters:

A **trickling filter** consists of a fixed bed of rocks, lava, coke, gravel, slag, polyurethane foam, sphagnum peat moss, ceramic, or plastic media over which sewage or other wastewater flows downward and causes a layer of microbial slime (biofilm) to grow, covering the bed of media. Aerobic conditions are maintained by splashing, diffusion, and either by forced air flowing through the bed or natural convection of air if the filter medium is porous.

The removal of pollutants from the wastewater stream involves both absorption and adsorption of organic compounds by the layer of microbial biofilm. The filter media is typically chosen to provide a very high surface area to volume. Typical materials are often porous and have considerable internal surface area in addition to the external surface of the medium. Passage of the wastewater over the media furnishes dissolved air, the oxygen which the slime layer requires for the biochemical oxidation of the organic compounds and releases carbon dioxide gas, water and other oxidized end products. As the biofilm layer thickens, it eventually sloughs off into the treated effluent and subsequently forms part of the secondary sludge. Typically, a trickling filter is followed by a clarifier or sedimentation tank for the separation and removal of the sloughing. Other filters utilizing higher-density media such as sand, foam and peat moss do not produce a sludge that must be removed, but require forced air blowers and backwashing or an enclosed anaerobic environment.

The treatment of sewage or other wastewater with trickling filters is among the oldest and most well characterized treatment technologies.

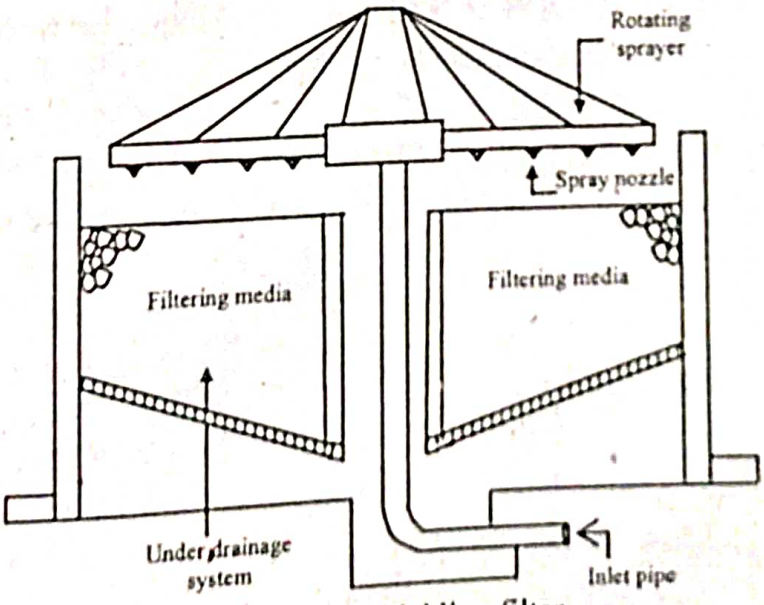


Fig. Trickling filter

c) Oxidation Pond:

Oxidation Ponds are also known as stabilization ponds or lagoons. They are used for simple secondary treatment of sewage effluents. Within an oxidation pond heterotrophic

bacteria degrade organic matter in the sewage which results in production of cellular material and minerals. The production of these supports the growth of algae in the oxidation pond. Growth of algal populations allows furthur decomposition of the organic matter by producing oxygen. The production of this oxygen replenishes the oxygen used by the heterotrophic bacteria. Typically oxidation ponds need to be less than 10 feet deep in order to support the algal growth. In addition, the use of oxidation ponds is largely restricted to warmer climate regions because they are strongly influenced by seasonal temperature changes. Oxidation ponds also tend to fill, due to the settling of the bacterial and algal cells formed during the decomposition of the sewage. Overall, oxidation ponds tend to be inefficient and require large holding capacities and long retention times. The degradation is relatively slow and the effluents containing the oxidized products need to be periodically removed from the ponds. An oxidation pond can be seen in the figure below.

d) Hydraulic gradient and Darcy's law

Hydraulic Gradient

In an unconfined aquifer, the slope of the water table, measured in the direction of the steepest rate of change is called **hydraulic gradient.** It is important because ground water flow is in the direction of the gradient and also proportional to it.

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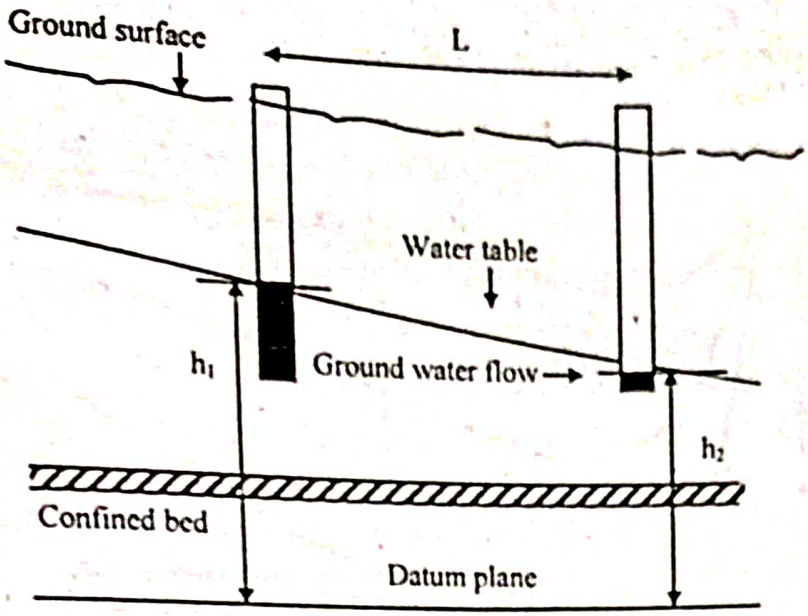


Fig. Showing head and gradient in an unconfined aquifer

Darcy's law: ***Refer to Question No. 5 of Long Answer Type Questions.***

e) Oil pollution and its effect in marine life and coastal infrastructure:

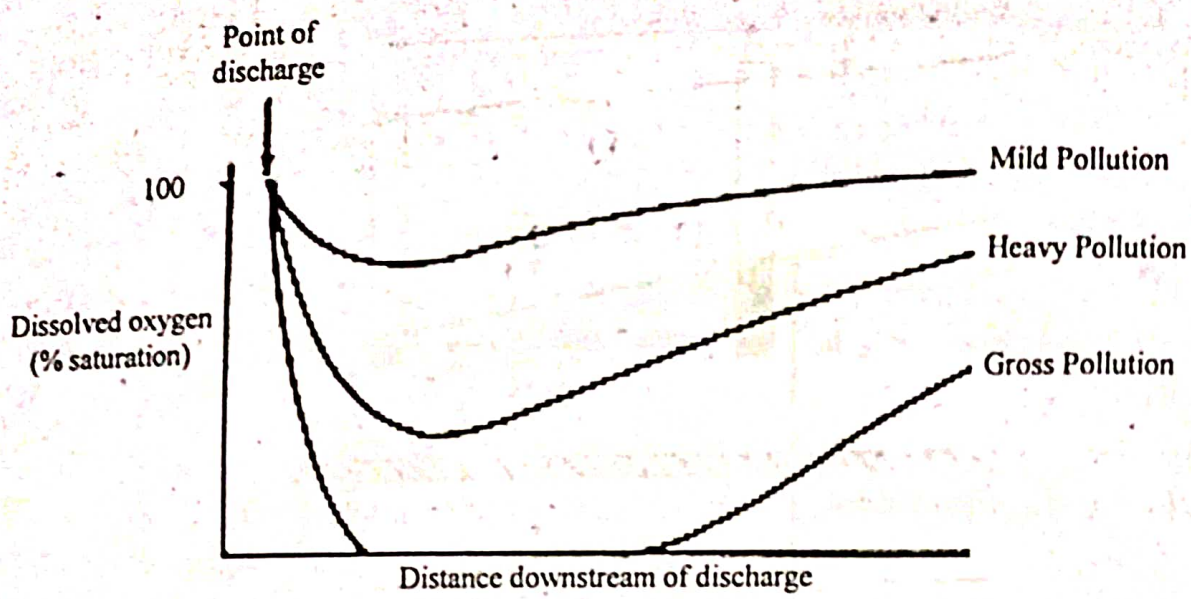
An oil spill is the release of a liquid petroleum hydrocarbon into the environment, especially marine areas, due to human activity, and is a form of pollution. The term is usually applied to marine oil spills, where oil is released into the ocean or coastal waters, but spills may also occur on land.

In general, oil spills can affect animals and plants in two ways: from the oil itself and from the response or cleanup operations. Understanding both types of impacts can help spill responders minimize overall impacts to ecological communities and help them to recover much more quickly.

Spilled oil can harm living things because its chemical constituents are poisonous. This can affect organisms both from internal exposure to oil through ingestion or inhalation and from external exposure through skin and eye irritation. Oil can also smother some small species of fish or invertebrates and coat feathers and fur, reducing birds' and mammals' ability to maintain their body temperatures.

f) Oxygen Sag Curve:

The curve obtained when the concentration of dissolved oxygen in a river into which sewage or some other pollutant has been discharged is plotted against the distance downstream from the sewage outlet (see graph). Samples of water are taken at areas upstream and downstream from the sewage outlet.



g) *Refer to Question No. 2 of Short Answer Type Questions.*

h) *Refer to Question No. 4(b) of Long Answer Type Questions.*

i) *Refer to Question No. 8 of Short Answer Type Questions.*

LAND POLLUTION & CONTROL

Multiple Choice Type Questions

1. The best method of disposal of non-hazardous solid waste is [WBUT 2014(EVEN)]

a) open dumping
b) sanitary land filling
c) incineration
d) composting

Answer: (b)

2. The most useful method of disposal of non-hazardous solid waste is [WBUT 2015(EVEN)]

a) open dumping b) composting c) land filling d) incineration

Answer: (c)

3. The major constituent of soil waste is [WBUT 2015(EVEN)]

a) Silicon b) Iron c) Potassium d) Oxygen

Answer: (a)

4. Anaerobic digestion of carbon containing material produces mainly [WBUT 2016(EVEN)]

a) CH_4 and CO_2
b) CH_4 only
c) CO_2 only
d) H_2S

Answer: (b)

5. Thickness of earth crust varies from [WBUT 2016(EVEN)]

a) 0 - 10 km b) 20 - 50 km c) 64 - 96 km d) 100 - 200 km

Answer: (c)

6. The most useful method of disposal of non- hazardous solid waste is [WBUT 2017(EVEN)]

a) open dumping
b) composting
c) land filing
d) incineration

Answer: (c)

7. The demarcation line between crust and mantle is [WBUT2018(EVEN)]

a) Conred discontinuity
b) Gutenberg discontinuity
c) Mono discontinuity
d) None of these

Answer: (c)

Hint: correct answer Moho discontinuity

Short Answer Type Questions

1. What are solid hazardous wastes? Discuss the disposal methods of those wastes? [WBUT 2005, 2013(ODD), 2014(ODD)]

OR,

What is meant by hazardous wastes? Mention the special care to be taken for their handling and disposal purpose. [WBUT 2009, 2016(EVEN)]

OR,

What are solid hazardous wastes? How can those wastes be disposed? [WBUT 2016(ODD), 2018(EVEN)]

Answer:

A substance is considered as **hazardous substance** because of its **quantity, concentration, physical, chemical** as well as **biological** characteristics which may cause or significantly contribute to an increase of **mortality** or **irreversible illness** of living beings and damage the environment when improperly **treated, stored, transported or disposed** of or otherwise managed.

A substance is called hazardous waste if it meets the following criteria (at least one or two).

These are:

(i) Reactivity
(ii) Ignitability
(iii) Crrosivity
(iv) Toxicity

Category	Waste category	Treatment	Disposal
1.	Human Anatomical Waste	Incineration	Deep burial
2.	Animal waste	Incineration	Deep burial
3.	Microbiological & biotechnological waste	Local autoclaving/micro-waving/ incineration	General disposal
4.	Waste shapes (needles, syringes, blade, glass etc.)	Disinfections/ autoclaving/ micro waving/	Shredding must be such so as to prevent unauthorized re-use.
5.	Discarded medicines & cytotoxic drugs.	Incineration/ destruction	Drug disposal in secured landfills.
6.	Soiled waste (cotton, dressing, plaster etc. Which are contaminated with blood, body fluids.)	Incineration/ autoclaving/ micro waving.	Deep burial
7.	Solid waste (waste generated from disposal items other than the sharps such a tubing's. Catheters, intravenous sets etc.	Disinfection by chemical treatment/ autoclaving/ microwaving.	Shredding must be such so as to prevent unauthorized reuse.

Category	Waste category	Treatment	Disposal
8.	Liquid waste (waste generated from laboratory, washing, cleaning, house-keeping etc.)	Disinfections by chemical treatment	Discharge into drain.
9.	Incineration Ash.	No treatment required.	Disposal in municipal landfill.
10.	Chemical waste	Chemical treatment	Discharge into drains for liquid and disposed landfill for solids.

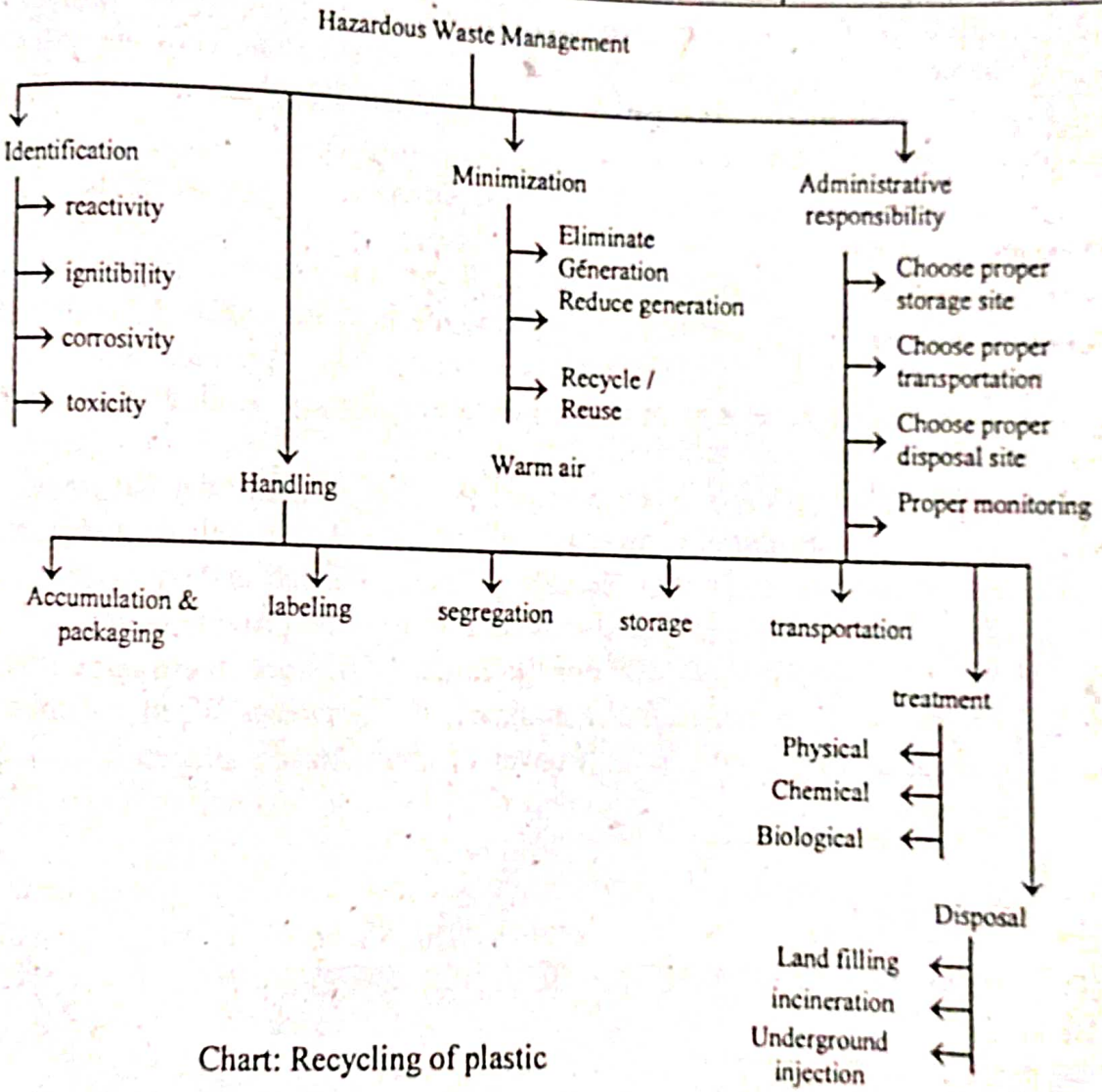


Chart: Recycling of plastic

2. What is solid waste management? 606 book, pg. 296

[WBUT 2012(EVEN & ODD), 2013(EVEN), 2017(ODD)]

OR,

What are the important steps of solid waste disposal management? Write in details.

[WBUT 2017(EVEN)]

Answer:

Different Methods of Disposal of Non-Hazardous Solid Waste

Different disposal methods are being used in the various parts of the world and most prominent of these are – i) Open dumping, ii) Sanitary land filling, iii) Incineration and iv) Composting.

(1) Open dumping:

Open dumping of solid waste is very common in India and other countries. It is cheap and requires no technical planning. Generally low lying areas of the out skirts of the town and cities are used for that purpose. The open dumps cause public health problems by encouraging the breeding of flies, rats, mosquitoes and other pastes. They also become a source of objectionable smell and cause air pollution when the wastes are burnt in order to reduce their volume and conserve space.

(2) Sanitary land filling:

Sanitary land filling is an engineered operation design and operated according to the acceptable standards. It may be defined as a method of disposing wastes on land without creating nuisance or hazard to public health or safety. The operation is carried out without environmental damage and in areas which are already spoiled or in need for restoration.

In sanitary land filling operation, waste is sprayed and compacted in thin layers within a small area. This layer structure is usually called as **cell.** To allow for a proper compaction, the cell death should not exceed about 2mts. The cell is then covered with a layer of soil which is spread uniformly and then compacted. To provide an adequate seal the **'cover'** should normally be at least **20 cm thick.** If the waste includes large irregular objects it may be necessary to increase the thickness of the **cover.** When a numbers of **'cell'** reach the final desired height, a final cover of about 1mt. is placed & it is again compacted.

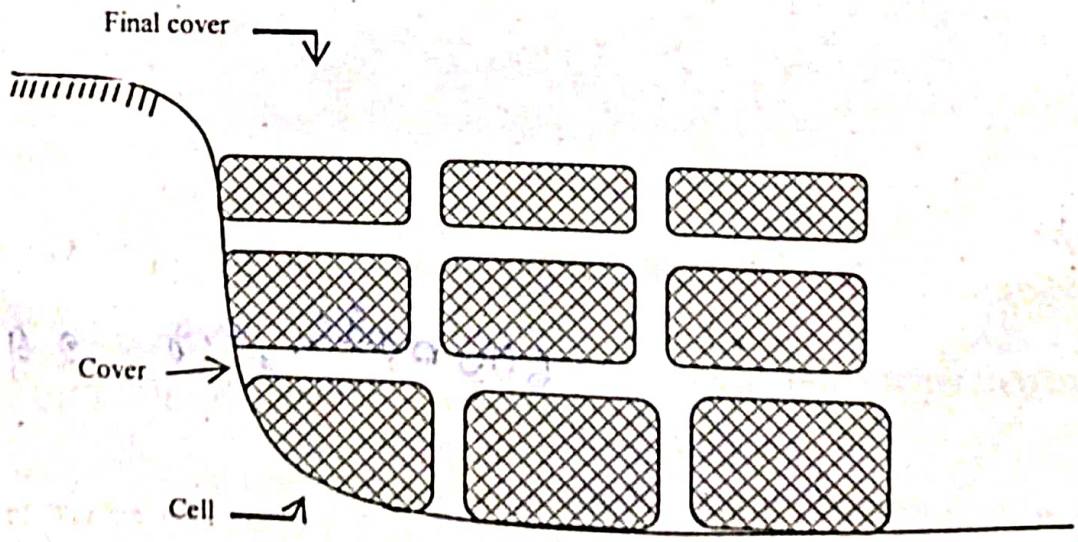


Fig. Sanitary land filling

The land filling operation is essentially a biological method of **waste treatment.** There are five phases of the treatment method. During the **First phase** of operation, **aerobic**

bacteria deplete the available oxygen and as a result of aerobic respiration the temperature increases. In second phase anaerobic condition become established and hydrogen and CO_2 are evolved through acidogenic activity. The third phase is characterized by the establishment of methanogenic population of bacteria and the beginning of methanogenic activity. In fourth phase, the methanogenic activity becomes stabilized. In fifth phase, the methanogenic activity decreases representing depletion of organic matter & ultimately the system returns to aerobic condition within the land fill.
The process of sanitary land filing can be summerised as –

Phase	Operation	Remark
1st	Aerobic digestion and as a result depletion of O_2 present in the waste.	Increase of temperature.
2nd	Anaerobic digestion.	Hydrogen & carbon dioxide are evolved.
3rd	Methanogenic activity.	Formation of CH_4.
4th	Methanogenic activity becomes stabilized.	
5th	Methanogenic activity stopped or reduced.	All the organic matter present in the waste Computably digested and the system returns to aerobic condition.

Table: process of Sanitary land filling

(3) Incineration:
Incineration involves the burning of solid waste at high temperature, left over ashes plus metals and unburnt combustible amount reduced to perhaps 25% of the original waste. This residue must still be disposed of in same manner incineration leads to air pollution unless the plant is designed, equipped and operated to comply with air pollution standards. Typical air pollutions from incineration are **fly ash, sulpher dioxide, hydrogen chloride** and **organic acids**. The materials which are non-combustible are removed from the waste by gravity or magnetic separation. Many of the separated materials, fine glass or metals can be recycled. Air pollution can be controlled by installation of proper controlling equipments.

(4) Composting:
In contrast to sanitary land filling, composting of waste materials is an aerobic method. Many types of micro organisms are present in the waste, stabilize the organic matter in the waste to produce soil conditioner. The organisms include bacteria which predominate at all stages, fungi which often appear after last week and actinomycetes which assist during the final stage.
Initially the process starts with mesophillic bacteria which oxidizes the organic matter in the waste to CO_2 and liberate heat. The temperature rises to about 45°C and at this point the thermophillic bacteria takes over and continue the decomposition. During this phase the temperature rises to about 60°C. The waste is periodically turned over to allow sufficient O_2 to penetrate to all parts of the waste to support aerobic life. After about three weeks the compost is stabilized. The end point of a composting operation can be

[illegible] a drop in temperature. The compost should have typical smell & dark [illegible]

[illegible] waste is the solid material which arises from various human activities and which is [illegible] discarded as useless and unwanted.

[illegible] composting

[illegible] has perfect solutions for managing the waste it creates, if left undisturbed. The [illegible] cycles are design to clear the waste materials and plants. We can follow [illegible] that are present in nature. All dead and dry leaves and twigs [illegible] and are broken down by organisms such as worm and insects and finally by [illegible] and fungi, to form a dark reach soil like material, called compost.

[illegible] in the soil use the organic material as food, which in turn provides them [illegible] for their growth and activities. These nutrients are returned to the soil to be [illegible] again by trees and other plants. This process recycles nutrients in nature. The soil [illegible] used as manure for farms and garden.

[illegible] the effects of hazardous wastes on the environment and on the human [illegible] **[WBUT 2013(ODD)]**

[illegible]

Answer:

When hazardous wastes are released in the air, water, or on the land they can spread, contaminating even more of the environment and posing greater threats to our health. For example, when rain falls on soil at a waste site, it can carry hazardous waste deeper into the ground and the underlying groundwater. If a very small amount of a hazardous substance is released, it may become diluted to the point where it will not cause injury. A hazardous substance can cause injury or death to a person, plant, or animal if:

- A large amount is released at one time
- A small amount is released many times at the same place
- The substance does not become diluted
- The substance is very toxic (for example, arsenic).

a. Irritants are chemicals that inflame living tissue at the site of contact, causing pain and swelling.

b. Asphyxiants are chemicals that prevent the cells of the individual from receiving life-giving oxygen. Carbon monoxide is a well-known asphyxiant, which chemically "ties up" the hemoglobin in the blood so that the body's metabolism slows and stops.

c. Central Nervous System (CNS) depressants affect the nervous system. This broad category includes vapors from most anesthetic gases, depressants, and organic solvents (a general category that includes many paints, glues, adhesives, and alcohol). Some CNS depressants produce a feeling of dizziness or giddiness. More severe effects (including death) can also result.

d. Systemic Toxins dramatically affect specific organ systems. For example, mercury vapor can cause a serious nervous system disorder which could lead to insanity.

4. What is solid waste? **[WBUT 2016(EVEN)]**

Answer:

Solid waste is that solid material which arises from various human activities and which is normally discarded as useless or unwanted. It consists of the highly heterogeneous mass of discarded materials from the urban community as well as more homogeneous accumulation of agricultural, industrial and mining wastes.

Long Answer Type Questions

1. What type of solid wastage are released from domestic, trade and industry? Discuss different method of solid waste disposal. How will you control waste generation? **[WBUT 2005]**

What is the composition of Lithosphere? 240 295 **[WBUT 2007]**

OR,

What are different types of solid waste available for disposal? Discuss in principle only the methods of disposal of solid wastes. **[WBUT 2006, 2007]**

OR,

What types of solid wastes are separated from domestic, trade and industries. **[WBUT 2016(ODD)]**

Answer:

1st Part:

The Earth is a cold, spherical, solid planet of the solar system, which spins on its axis and revolves around the Sun at a certain constant distance. The solid component of Earth is called **lithosphere**. The lithosphere is multilayered and includes following main layers- (1) crust (2) mantle and (3) core. The **core** is the inner most part, the layer next to the core is called mantle and the outer most part is called **crust**. The crust is very complex and its surface is **covered with the soil** supporting rich and varied biotic communities, for living organisms found in soil environment providing food, shelter and concealment from the predators.

(a) ***Crust:*** The crust is composed of varying rocks that are relatively tough. The lithosphere has the **thickness** ranging between **64 to 96 km**. The crust of the Earth is rich in silica (Si) and aluminum (Al) and known as **Si Al layer**. Mainly **granite** rocks are available here. Below the Si Al layer there is another zone which is rich is silica (Si) and magnesium (Mg). This layer is known as Si Ma. Mainly basalt rocks are available here. The basalt rock has **specific granites** of **3.2** compared to **2.9** of the granites rock and this is the reason why SiAl (granites) placed above the Si Ma (basalt). There is an **imaginary line** in between SiAl & SiMa layers. This line called **'corned discontinuity'**.

Below the 'SiMa' layer, the density increases with depth; such difference in density causes the constituting layers floating on others. The floating segments of Earth's crust appear as tentonic plates.

(b) ***Mantle:*** The next layer after the crust is known as mantle. The **thickness is estimated to be about 2800 km**. The mantle is divided into two parts – **upper mantle** and **lower mantle**. The upper mantle is known as **'asthenosphere'** and the lower mantle

is 'mesosphere'. The specific gravity of upper mantle is 3.5 while the specific gravity of lower mantle is 4.5. The imaginary line between crust and mantle is 'Mohorovicic discontinuity' or 'Moho discontinuity'.

(c) *Core:* The most interior of the Earth is known as **core**. Minerals, mostly by **Fe, Ni and Co**, form the core mixed with **sulpher** and **silica**. Sometime, core is known as 'Ni Fe' layer. The **thickness** of core is about **3500 km**. Out of which 1250 km is inner core and 2250 km is the **outer core**. The **inner core** appears to be **solid** and outer core as **molten metallic core**. The **specific gravity** of core may be as high as *13*. The temperature of the core is also high ranging between 5000°C to 5500°C.

The line between mantle and core meet each other, called '**Gutenberg discontinuity**'

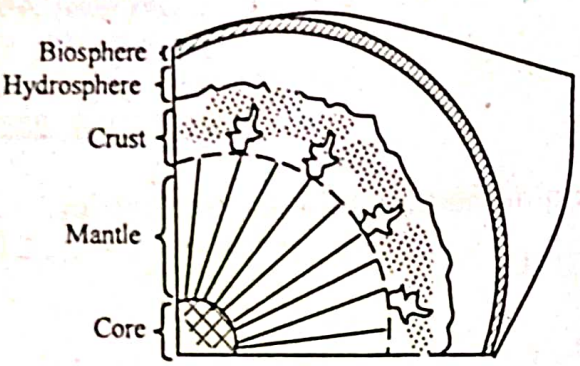


Fig: (a)

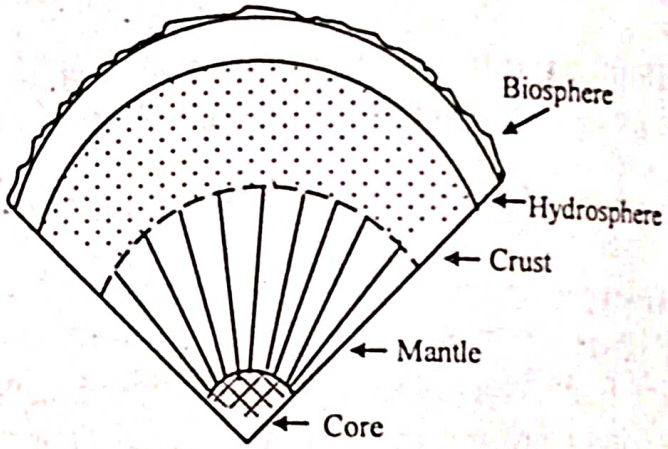


Fig: internal structure of Earth Fig: (b)

2nd Part:

Sources of Solid Waste

The main sources of solid waste are -

i) Domestic area
ii) Commercial area
iii) Industrial area
iv) Agricultural area
v) Hospitals

Classification of Solid Wastes

On the basis of sources of solid waste, may be classified as:

(1) **Garbage:** The solid wastes which are produced during the preparation of storage of meat, fruit, vegetables etc., are called **garbage**. These wastes have **moisture content of 70%** and **heating value of 6×10^6 J/kg**. These are generally **biodegradable.**

(2) **Rubbish:** These types of solid wastes are mainly non-biodegradable. It may be **combustible** and **non-combustible**. The combustible wastes would include paper, wood, scrap, rubber, leather etc. Non combustible wastes are metal, glass, ceramics etc. These wastes contain **moisture content of about 25%** and **heating value of 15×10^6 J/kg**

(3) **Agricultural waste:** Crop residue, animal manure are mainly considered as agricultural waste. Rural people mainly depend on these wastes as their main source of fuels.

(4) **Industrial waste:** All types of industrial waste like metallic, non-metallic, organic compounds come under this category.

(5) **Pathological waste:** The main source of this waste is hospital and nursing home. Dead human being, animals, disposable glass and metallic items come under this category. The disposable and unwanted medical articles are also considered as pathological waste. These waste sometime are referred as biomedical **wastes.** It contains about **85% moisture** and **heating value** is about 2.5×10^{6} **J/kg.**

- Besides these different types, the solid wastes which are generated due to domestic as well as commercial activities are known as **municipal solid waste (MSW)** and which are coming from the industrial sectors are known as **industrial solid waste (ISW).**
- There is another kind of classification of solid waste. This classification is based on the activity and effects on living beings. According to this classification solid waste are grouped into two classes -
  1. Hazardous solid waste (HSW)
  2. Non Hazardous solid waste (NHSW).

Sometime, domestic and commercial wastes are togetherly called as **urban waste.**

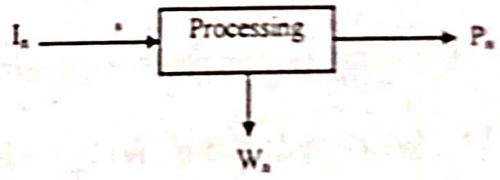
Different Methods of Disposal of Non-Hazardous Solid Waste

Refer to Question No. 1 of Short Answer Type Questions.

Control of waste generation:

The waste generation can be controlled with the help of 3R principle of waste management. The 3R principle stands for.

(1) Reuse
(2) Recycle
(3) Recovery



The above diagram is indicating that in a processing system one input is required (I_n) to get a product (P_n). During the processing, waste must be produced (W_n). The waste may be solid, liquid or gas.

The quality of the input can be denoted as IQ_n, the quality of the product can be PQ_n & that waste is WQ_n.

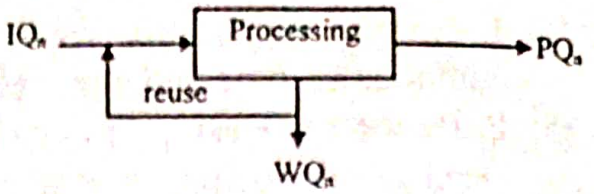
Therefore, $WQ_n = \sum IQ_n + \sum PQ_n$

Thus, waste may consist of some parts of inputs, some part of outputs & intermediate products for med during the processing operation.

There are six different conditions which are helpful to convert the waste to the wealth, there are:

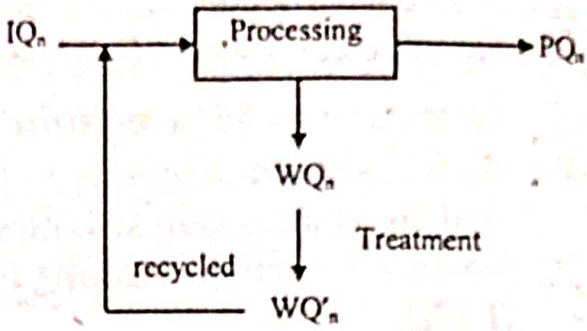
1. The first condition is $IQ_n = WQ_w$.

In this case the quality of waste is similar to the quantity of input. So, waste can be reused as a input of the same processing system.
e.g. Lime sludge in paper & pulp industry can be used again as a input.



2. The second condition is IQn ≅ WQn.

In this case, the waste is recycled back in the processing operation after some treatment.
e.g. Hot water coming out from the cooling tower of the thermal plant. This is waste. After reducing the temperature it can be recycled again as cooling water.



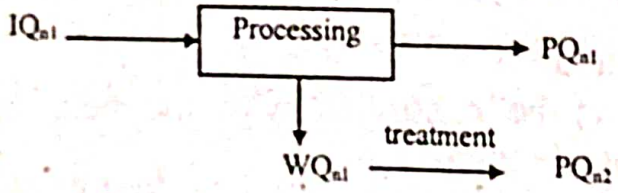
3. The third condition is

$$IQ_{n1} \neq WQ_{n1} \text{ but } IQ_{n2} = WQ_{n1}$$

In this case, the waste quality of a system is not same as the quality of input, but it is suitable for reuse in other system as input.
e.g., Sludge collected from tannery Industry may be used as fertilizer different crop.

4. The fourth condition is $WQ_{n1} \xrightarrow{\text{treatment}} PQ_{n2}$

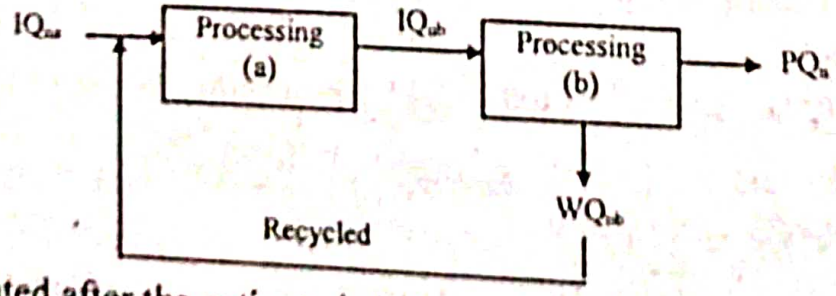
In this case, the wastes generated from one system are converted to a new product after proper treatment.



e.g., Kid's toy can be prepared from the waste plastics.

5. The fifth condition is $WQ_{nb} = IQ_{na}$

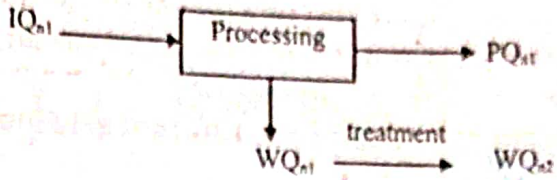
In this case, waste formed in one stage of the process may be used or recycled in the other stage of the same process.



e.g., Sludge generated after the activated sludge process is recycled to accretion tank.

6. The sixth Condition is W_{Qn1} Treatment W_{Qn2}

In this case, the wastes generated from one system changed to different quality of Waste. This new type of waste is either more useful or less harmful than the previous type of waste



Thus, looking to the above six process we can say that waste can be recycled back to the processing unit, it can be used to manufacture of other products, it can be used in other field where it is suitable or its harmful effect can be reduced or destroyed by giving some treatment. So, we can say that the waste can be converted to wealth also.

2. Write the effects of hazardous wastes on the environmental and on the human health.

Answer: [WBUT 2014(ODD)]

Humans have always been exposed to hazardous substances going back to prehistoric times when they inhaled noxious volcanic gases or succumbed to carbon monoxide from inadequately vented fires in caves. Inadequacies in waste management practices can therefore create potentially hazardous situations and pose significant risks of concern to society. If dumped indiscriminately in any environmental media, hazardous wastes may have both short and long-term effects on both human and ecological systems. In addition, improper treatment, storage, and disposal of hazardous wastes can result in contaminant during possible exposures, and potential adverse health and environmental impacts. In general, any chemicals can cause severe health impairment or even death if taken by humans in sufficiently large amounts. On the other hand, there are those chemicals of primary concern which, even in small doses, can cause adverse health impacts. The potential for adverse health effects in population contacting hazardous wastes may involve any organ system, depending on the specific chemicals contacted, the extent of exposure, the characteristics of exposed individual (e.g. age, sex, genetic make up), the metabolism of the chemical involved, and presence or absence of confounding variables such as other diseases.

Several health effects of primary concern may affect populations exposed to hazardous chemicals. These health effects are:

- Carcinogenesis (i.e. causing cancers).
- Genetic defects, including mutagenesis (i.e. causing alterations in genes which are transmitted from one generation to another or causing heritable genetic damage).
- Reproductive abnormalities including teratogenesis (i.e. causing damage to developing fetus not necessarily related to toxic effects on mother).
- Alterations of immunobiological homeostasis.
- Central nervous system (CNS disorder).
- Congenital anomalies.

Invariably, exposure to chemicals escaping into the environment can lead to a reduction of life expectancy and possibly a period of reduced quality of life (due to anxiety from exposure, diseases, etc.). An uncontrolled waste disposal practice can therefore be perceived as a potential source of several health and environmental problems.

3. What is weathering process? Describe different weathering process briefly.
[WBUT 2015(EVEN)]

Answer:
The disintegration of parent rocks by some agents to the smaller parts of it, called **weathering process**. The **process of weathering** starts soil formation. As a result of weathering, rocks are broken down in small particles called **'Rigolith'** which under the influence of various other **pedogenic processes** get converted to mature soil.
On the basis of agents, weathering process is classified as

1) Physical weathering process.
2) Chemical weathering process.
3) Biological weathering process.

(1) Physical weathering:
The agents of physical weathering are primarily climatic in character. They exert mechanical effect on the rocks. As a result the larger rocks are broken down to pieces. The temperature, water, ice, gravity and wind are some of the climatic physical weathering agents.

(2) Chemical weathering:
When different chemical reactions are involved in the weathering process, then it is called **chemical weathering**. The physical weathering produces a larger surface area of rock and this increases the rate of the chemical reactions i.e. **chemical weathering**. Chemical weathering takes place simultaneously with physical weathering and continues much beyond that. The chemical weathering consists of chemical **decomposition** or **transformation** of parent mineral materials to new mineral materials. Moisture and air are essential for chemical weathering.
Chemical weathering takes place through the following chemical reactions –
(i) Dilution, (ii) Hydrolysis, (iii) Oxidation, (iv) Reduction, (v) Carbonation, (vi) Hydration etc.

(3) Biological weathering:
A number of microorganisms extract energy from the rock. As a result, physical structures as well as mineral composition of the rock undergo some change. Some time these rocks are broken down into number of pieces, which leads to **weathering process**. This is called **biological weathering**.

4. Write short notes on the following:
a) Composting
[WBUT 2006, 2013(EVEN), 2014(ODD), 2017(ODD)]
b) Land filling as a method of disposal of solid waste
[WBUT 2012(ODD), 2013(ODD), 2014(ODD), 2016(EVEN)]

c) Biomedical waste disposal method
d) Biomedical waste
Answer:

[WBUT 2013(ODD)]
[WBUT 2014(EVEN)]

a) Composting:

Refer to Question No. 2 (4th Part) of Short Answer Type Questions.

b) Land filling as a method of disposal of solid waste:

Refer to Question No. 2(2nd Part) of Short Answer Type Questions.

c) Biomedical waste disposal method:

The following table is indicating the mode of treatment and disposal of different categories of bio-medical waste.

Rerfer to Question No. 1 of Short Answer Type Questions.

d) Biomedical waste

Refer to Question No. 1 of Short Answer Type Questions.

NOISE POLLUTION & CONTROL

Multiple Choice Type Questions

1. In the industrial area noise is measured by [WBUT 2008, 2014(EVEN), 2018(ODD)]

a) $L_{10}(18hrs)index$ b) L_{eq} c) $L_e P_n$ d) none of these

Answer: (a)

2. Which is the normal hearing frequency range? [WBUT 2015(ODD)]

a) 60 dB b) 20 Hz-20,000 Hz
c) 80 dB d) 60 Hz-60,000 Hz

Answer: (b)

3. In the industrial area noise is measured by [WBUT 2016(EVEN)]

a) L_{10} (18 hrs) index b) L_{eq} c) $L_e P_n$ d) none of these

Answer: (b)

4. For air stability, we must have [WBUT 2016(ODD)]

a) Dry Adiabatic Lapse Rate – Ambient Lapse rate
b) Dry Adiabatic Lapse Rate > Ambient Lapse Rate
c) Dry Adiabatic Lapse rate < Ambient Lapse Rate
d) None of these

Answer: (b)

5. Aircraft noise is measured through [WBUT 2016(ODD)]

a) L_{10} (18 hour) index b) decibel c) Le Pn d) Leq

Answer: (c)

6. In the measurement of SPL, the reference pressure is taken [WBUT 2016(ODD)]

a) 2×10^{-5} N/m^2 b) 1×10^{-5} N/m^2
c) 8×10^{-5} N/m^2 d) 6×10^{-5} N/m^2

Answer: (a)

7. Poor air quality when ventilation coefficient is [WBUT 2017(EVEN)]

a) greater than 6000 m^2s^{-1} b) less then 6000 m^2s^{-1}
c) greater then 8000 m^2s^{-1} d) less then 8000 m^2s^{-1}

Answer: (b)

8. Sound pressure level (SPL) can be defined as [WBUT 2017(EVEN)]

a) SPL= $20\log_{10}\left(\frac{I}{I_0}\right)$ b) SPL= $20\log_{10}\left(\frac{P}{P_0}\right)$

c) SPL= $10\log_{10}\left(\frac{I}{I_0}\right)$ d) SPL= $10\log_{10}\left(\frac{P}{P_0}\right)$

Answer: (c)

9. The noise threshold limit value for the sound level of 110dB is [WBUT 2017(ODD)]

a) 15 minutes b) 10 minutes
c) 8 hours d) 2 hours

Answer: (a)

10. The reference pressure for Sound Pressure Level (SPL) is [WBUT2018(EVEN)]

a) 1×10^{-5} Nm^{-2} b) 2×10^{-5} Nm^{-2} c) 9×10^{-5} Nm^{-2} d) 12×10^{-5} Nm^{-2}

Answer: (b)

11. If the intensity of a sound is 100 times more than the reference intensity, then its Decibel value will be [WBUT 2018(EVEN)]

a) 10 Db b) 30 dB c) 40 dB d) 20 dB

Answer: (d)

Short Answer Type Questions

1. Define noise and noise pollution. How much is a sound of 100 dB (decibels) louder than a sound of 90dB? [WBUT 2005, 2012(ODD), 2015(EVEN)]

Answer:

Noise is unwanted sound without agreeable musical quality. Therefore, when the effects of sound are undesirable, then it may be termed as "noise".

Noise pollution is excessive, displeasing human, animal or machine-created environmental noise that disrupts the activity or balance of human or animal life.

The common scientific acoustic unit is Decibel (dB). It is not an absolute physical unit like volt, meter etc., but it is a ratio expressed as logarithmic scale relative to a reference sound pressure level or intensity level.

$$dB = 10\log_{10}\frac{\text{measured intensity}}{\text{reference intensity}}$$

$$dB = 10\log_{10}\frac{I}{I_0}$$

The community (ambient) noise levels are measured in the A- weighted SPL, abbreviated dB(A). This scale resembles the audible response of human ear. Sounds of frequencies from 800 to 3000 Hz are covered by the A - weighted scale. These meters record the dB A scale, which is commonly used for measurement of general noise levels.

2. What is L_{epn}? Explain different types of noise. [WBUT 2015(ODD), 2017(EVEN)]

Answer:

1st Part:

This is recommended for aircraft by the International Civil Aviation Organization (ICAO) as the standard for use in noise evaluation. Aircraft Noise.

The noise of aircraft is described in terms of *Perceived Noise Levels* (L_{pn}), a scale of noisiness, expressed in pNdB. There is no simple relationship between the dB(A) value and pNdB value for all noises. However, a useful statement is that, the pNdB value for a noise is approximately 13 units greater than the dB(A) value for the noise.

A further refinement resulting from the study of aircraft noise is the effective noise Level (L_{epn}), a scale of noisiness of a time-varying event, expressed in EPNdB. It is used to describe the noise of a single aircraft activity. In order to describe the noise exposure associated with an airport, the EPNdB values are supplemented with such information as the number of flights of each aircraft type, the flight paths that the aircraft use and the time of day at which the operations occur. The resulting picture is often presented in such terms as Noise Exposure Forecast (NEF) contours, which are intended to represent the long-term average noise exposure in communities around airports.

2nd part:

Noise can be broadly classified under three categories:

(1) Transport noise

(2) Occupational noise

(3) Neighbourhood noise.

3. In a work area the noise levels are recorded as follows: 110 dB(A) for 10 min/day 100 dB(A) for 30 min/day, 90 dB(A) for 45 min/day, 80 dB(A) for 2 hr/day. Determine whether the combined noise level is within limit.
given: Noise Threshold limit values of 110 dB(A) is 15 min, 100 dB(A) is 1 hr, 90 dB(A) is 4 hr, 80 dB(A) is 16 hr. [WBUT 2016(EVEN)]

Answer:

$C_t = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \text{------} + \frac{C_n}{T_n} \leq 1$, where C_1 indicates the total duration exposure at specific noise level and T_1 indicates the total duration exposure permitted at that level.

Thus, Ct = 10/15 + 30/60 + 45/ 240 + 120/960 = 1.479.

The combined noise level is beyond the limit thus, it is called noise.

4. How much is a sound of 100 dB louder than a sound of 90 dB? [WBUT 2016(O

Answer:

We know that,

Sound level $L\,(dB) = 10\log\frac{I}{I_0}$

where, I = measured intensity

I_0 = reference intensity

In the first case, i.e. when sound level is 100 dB then,

$$L_1 = 10\log\frac{I}{I_0}$$

or, $$\log\frac{I}{I_0} = \frac{L_1}{10}$$

or, $$\frac{I_1}{I_0} = 10^{L_1/10}$$

$$\therefore\ I_1 = I_0 \times 10^{L_1/10} \quad \text{—(1)}$$

In the sound case, i.e. when sound level is 90 dB then,

$$L_2 = 10\log\frac{I_2}{I_0}$$

or $$\log\frac{I_2}{I_0} = \frac{L_2}{10}$$

or $$\frac{I_2}{I_0} = 10^{L_2/10}$$

$$\therefore\ I_2 = I_0 \times 10^{L_2/10} \quad \text{—(2)}$$

Now, $$\frac{I_1}{I_2} = \frac{I_0 \times 10^{L_1/10}}{I_0 \times 10^{L_2/10}} = \frac{1\times 10^{L_1/10}}{1\times 10^{L_2/10}}$$

Now, $L_1 = 100$ dB

$L_2 = 90$ dB.

$$\therefore\ \frac{I_1}{I_2} = \frac{1\times 10^{100/10}}{1\times 10^{90/10}} = \frac{10^{10}}{10^9} = 10 \text{ times.}$$

So, 100 dB sound is louder than 90 dB sound by 10 times.

8. How much is a sound of 100 dB louder than a sound of 80 dB? (reference intensity = 1×10^{-12} w/m^2). **[WBUT 2017(EVEN)]**

Answer:

We know that,

Sound level $L\,(dB) = 10\log\frac{I}{I_0}$

where, I = measured intensity
I_0 = reference intensity

In the first case, i.e. when sound level is 100 dB then,

$$L_1 = 10\log\frac{I}{I_0}$$

or, $$\log\frac{I}{I_0} = \frac{L_1}{10}$$

or, $$\frac{I_1}{I_0} = 10^{L_1/10}$$

$$\therefore I_1 = I_0 \times 10^{L_1/10} \quad ...(1)$$

In the sound case, i.e. when sound level is 80 dB then,

$$L_2 = 10\log\frac{I_2}{I_0}$$

or $$\log\frac{I_2}{I_0} = \frac{L_2}{10}$$

or $$\frac{I_2}{I_0} = 10^{L_2/10}$$

$$\therefore I_2 = I_0 \times 10^{L_2/10} \quad ...(2)$$

Now, $$\frac{I_1}{I_2} = \frac{I_0 \times 10^{L_1/10}}{I_0 \times 10^{L_2/10}} = \frac{1 \times 10^{L_1/10}}{1 \times 10^{L_2/10}}$$

Now, $L_1 = 100$ dB

$L_2 = 80$ dB

$\therefore$ $I_1/I_2 = 10^{10}/10^8$ times.

So, 100 dB sound is louder than 80 dB sound by 100 times.

6. What is noise dose and explain the same as recommended by Noise Control Board.
[WBUT 2018(ODD)]

Answer:

It is known that exposure to loud sound causes progressive hearing loss and it is also known that hearing deteriorates with age (presbycusis). In order to determine the damaging power due to exposure to noise, the idea of noise dose has been evolved. (The idea is here that certain amount of sound energy can be tolerated in a working day, but above that amount damage starts). In some country the damage risk level is set at 85 dB (A) for 8 hours, but in relevant legislation in the UK and USA a higher dose is prescribed i.e. 90 dB (A) for 8 hours.

On an equal energy basis, an increase of 3 dB in the exposure may be permitted for each halving of the duration of exposure. However, increase in level cannot be tolerated, when the level is increased over a shorter time above 130 dB, hearing damage can occur. However if the level fluctuates by more than + 3 dB (A), it is necessary the equivalence continuous level (LEQ).

Long Answer Type Questions

1. What is noise? Explain the sources of noise pollution. What are the psychological impacts of noise pollution? How can the noise be controlled at the source?

[WBUT 2013(EVEN)]

OR,

What is noise pollution? State the various sources of noise pollution.

[WBUT 2016(ODD)]

Answer:

1st Part:

Sound is produced when an object vibrates, alternately compressing and expanding the air. The compression and expansion travels like wave from the source. They are called as sound waves or simply vibrations.

If we treat sound as an auditory sensation produced by these vibrating bodies, it gets characterized by pitch, loudness and tone quality. However, these characters depend on psychological sensation, ear and judgment of individual. In physical terms, sound may be defined as a fluctuation in pressure in an elastic medium. This definition gives rise to the objective characteristic of sound, frequency, intensity and waveform.

In simple terms, noise unwanted sound. Sound is a form of energy which is emitted by a vibrating body and on reaching the ear causes the sensation of hearing through nerves.

Sounds produced by all vibrating bodies are not audible. The frequency limits of audibility are from 20 Hz to 20,000 Hz.

A noise problem generally consists of three inter-related elements- the source, the receiver and the transmission path. This transmission path is usually the atmosphere through which the sound is propagated, but can include the structural materials of any building containing the receiver.

Noise may be continuous or intermittent. Noise may be of high frequency or of low frequency which is undesired for a normal hearing. For example, the typical cry of a child produces sound, which is mostly unfavorable to normal hearing. Since it is unwanted sound, we call it noise.

The discrimination and differentiation between sound and noise also depends upon the habit and interest of the person/species receiving it, the ambient conditions and impact of the sound generated during that particular duration of time. There could be instances that, excellently rendered musical concert for example, may be felt as noise and exceptional music as well during the course of the concert! Sounds of frequencies less than 20 Hz are

ed, the terms noise and sound are synonymously used. ...noise is also a

simply we can define the sound and noise as-

nd is the form of energy which gives the sensation of hearing and is produced by gitudinal mechanical waves in matter including solid, liquid and gases and transmitted oscillations of atoms and molecules of matter. Noise is unwanted sound without reeable musical quality. Therefore, when the effects of sound are undesirable, then it ay be termed as "noise".

nd Part:

ources of noise are numerous but may be broadly classified in two classes.

1) ***Industrial:*** The "industrial" may include noise from various industries operating in cities, like transportation, vehicular movements such as car, truck train, tempo, motor cycle, aircraft, rockets, defense equipment, explosions etc.

2) ***Non Industrial:*** Among the non-industrial sources, important sources are as follows:

a) **Loudspeakers:** For every occasion, religious or non-religious, public or privates, presence of loudspeakers has been a must now a day, which contribute to noise pollution. In urban life, people have been under various pressure and tensions and the use of loudspeakers has increased their agony. It has been observed on certain occasions that continuous use of loudspeakers create disturbances to the students during examination period. Various persons, groups and companies to popularise their products also use loudspeakers in advertisement purpose.

b) **Construction work:** During demolition of old cities and construction of new buildings huge machines which produce a lot of noise are being used and it has become a common thing in every big cities where construction work in progress. A lot of noise has been created during the construction of repair work of roads.

c) **Road Traffic:** various types of road vehicles especially by auto vehicles have carried out the increase of noise pollution. Generally no regulations have been observed in blowing of horns and use of defective silencer pipes. It has been seen that some miscreants remove their silencers pipe from their motorcycle and scooters which produce undesirable noise and people get annoyed by this sort of game. Again the varying of traffic conditions (motor way, urban, city), the concentration of vehicles (heavy, commercial, private) and speed of which traffic is allowed to flow cause the noise pollution.

d) **Trains:** The steam engine used by railway produce a lot of noise, fast trains are being introduced on various route of railway and they are also contributing to the noise pollution. The impact of noise pollution by trains has been reported to be maximum in those areas where railway tracks pass through residential areas.

e) **Air craft:** The use of aircraft of many types has been generating varying types of noise. The higher the speed of an aircraft the greater the noise pollution. The inversion of supersonic aircraft has added more noise for the people who live near the

airdrome. The take off and landing of aircraft produce unbearable noise. It has been found that supersonic jet planes are one of the biggest irritants in today's noisy world. The noise of these planes may sometime break window glass, crack the plasters and shake buildings.

f) **Projection of satellites in space:** A new source of noise pollution has been satellite program by various countries. Satellite has been thrown into space with the help of high explosion rockets. Application and use of these rockets produce deafening noise at the time of lifting off a satellite. In this process tones of TNT and other explosives have been employed in this operation which creates noise pollution.

g) **Blasting units:** During repairing of roads or to dug the well blasting are clone to break the rocks. The explosion used in blasting gives rise to the noise.

h) **Festivals:** During the festivals noise pollution level increases due to use of loud speakers and crackers.

3rd Part:

Physiological effects or Biological effects

(a) Headache due to continuous exposure of sound.
(b) Increase in the rate of heart beat.
(c) Narrowing of arteries.
(d) Pain in heart.
(e) Digestive spasms through anxiety.
(f) Lowering of concentration and effect on memory.
(g) Muscular strain and nervous break down.

Noise creates the development of cardiovascular problem like heart disease and high blood pressure. Workers exposed to high noise level are having more circulatory problem, cardiac disturbance, neurosensory and motor impairments.

Effects of high intensity noise on human.

Noise (dB)	Effect observed
0	Threshold of audibility
150	Significance change in pulse rate
110	Stimulation of reception of skin
120	Pain threshold
130-135	Nausea, Vomiting etc.
140	Pain in ear, Prolonged exposure causing insanity
150	Prolonged exposure causing burning of skin
160	Minor permanent damage if prolonged
190	Major permanent damage in short time.

Medical scientists have noted that unborn child will move and kick when there is loud noise. It also responds with a sudden increase in heart beat as though it were disturbed or frightened.

The effect of environmental noise on fatal development can produce narrowing vision, vertigo and disruption of equilibrium in unborn baby.
In big cities like Mumbai, Kolkata and Delhi, the average noise level has been found to be between 65-90 dB. The noise levels doubles every 6 year, taking this is into account, by 2000 AD. It is possible that no one above age 10 will hear normally.

4th Part:
There are at least three primary areas where noise control at source can be carried out.

(a) Proper design:
The proper design of equipment to minimize noise generation has been a good way, but it is a complex engineering problem which needs a strong background in the fundamental of vibration, fluid mechanics, dynamics and machine design. In a very general way, the following things should be considered while designing.

i) Using shock absorption technique: for absorbing impact energy.

e.g., The use of non-metallic gears to reduce the noise generated by the metal to metal impact associated with metallic gears; the use of flexible mounts to be supports wood planner knaves to reduce the noise.

ii) Use efficient flow technique for reducing noise associated with high fluid velocities and turbulence.

e.g., A new quite hydraulic pump in the flow path has been redesigned to give less turbulence.

iii) Reducing field jet velocity: as jet noise is proportional to eight power of jet velocity, by reducing jet velocity, noise can be minimize.

iv) Reducing the sound radiating areas.

e.g., by placing the equipment on wooden table or by fitting equipment on concrete base.

(b) Proper Operation:
All the equipments should be operated at the design condition. Operating of equipment of design pressure and speed should result in minimum noise generation. Several ways relating to operations are:

i) If acoustic guards, covers of enclosures have been used, make sure that they are in place and all openings are acoustically sealed. Because noise is like water, which rushes out through any crack or openings.

ii) If equipment has been equipped with a muffler/silencer system, make sure that it is working according to design. Since, many muffler depends upon the absorption within the case.

iii) We should use proper cutting speed and feeding rate in machinery operations.

iv) We should provide good support for tool-bites to reduce the vibrations.

v) We should apply additional sound control device. Inlet and discharge silencers can often be added with a small investment.

(c) Proper maintenance:

When one would like to control noise at the source, then first of all there should be a measurement of noise produced by source. Therefore, the noise level has to be measured at source and at a point round the source. A large source should be measured at respective points around the source. In both cases, measurement should be taken at any position where an operator's ear has been likely to be for substantial lengths of time.

There are at least three primary areas where noise control at source can be carried out.

i) We should maintain good dynamic balance. It decreases the vibrations.
ii) When purchasing or replacing of component likes gear, motors and pumps, we should not ignore noise specifications.
iii) We should improve lubrication. Inadequate lubrication due to poor design, degradation due to age or incorrect lubricants can cause the bearing noise.
iv) We should install bearing correctly.
v) We should avoid mechanical run out of shafts.
vi) We should clean the silencers and there should be surety of healed of cracks on silencers.

Beside these, noise can be controlled by the following ways:

- Reducing the noise levels from domestic sectors.
- Maintenance of automobiles.
- Control over vibrations.
- Low voice speaking.
- Prohibition on usage of loud speakers.

2. In a work area the noise levels are recorded as follows: 100 dB (A) for 30 min/day, 95 dB (A) for 2 hr/day, 90 dB (A) for 4 hr/day, 80 dB (A) for 2hr/day. Determine whether the combined noise level is within limit. Given: Noise Threshold Limit values of 100 dB (A) is 1 hr, 95 dB (A) is 2 hr, 90 dB (A) is 4 hr and 80 dB (A) is 16 hr. **[WBUT 2013(ODD)]**

Answer:

$C_t = \frac{C_1}{T_1} + \frac{C_2}{T_2} + \text{-------} + \frac{C_n}{T_n} \leq 1$, where C_1 indicates the total duration exposure at a specific noise level and T_1 indicates the total duration exposure permitted at that level.

100 dB (A) C_1= 0.5 hr. T_1 = 1 hr; 95 dB (A) C_1= 2 hr. T_1 = 2 hr; 90 dB (A) C_1= 4 hr. T_1 = 4 hr; 80 dB (A) C_1= 2 hr. T_1 = 16 hr.

Thus, $C_t = \frac{0.5}{1} + \frac{2}{2} + \frac{4}{4} + \frac{2}{16} = 2.625$. The combined noise level is beyond the limit thus, it is called noise.

3. Explain the harmful effects of noise pollution on human health and migratory birds. **[WBUT 2015(EVEN)]**

OR,

What are the effects of noise pollution? **[WBUT 2017(ODD)]**

Answer: *Refer to Question No. 1 (3rd part) of Long Answer Type Questions.*

4. a) What is the working unit for measurement of sound intensity level (SIL)? Express it mathematically. [WBUT 2015(ODD)]

Answer:

There are two important parameters of sound or noise which are **sound pressure** and **sound intensity**. They are measured in different units giving varying scale of magnitude. The common scientific acoustic unit is **Decibel (dB)**. It is not an absolute physical unit like volt, meter etc., but it is a ratio expressed as logarithmic scale relative to a reference sound pressure level or intensity level.

$$dB = 10\log_{10}\frac{\text{measured intensity}}{\text{reference intensity}}$$

$$dB = 10\log_{10}\frac{I}{I_0}$$

This logarithmic scale takes care of wide range of sound pressure and intensity. The reference intensity used is the '**threshold of hearing**' which means sound which can be first heard at a sound pressure of $2\times10^{-5}\,N/m^2$ or sound intensity of $10^{-12}\,N/m^2$.

The dB scale is limited in the sense that it is not related to the human ear frequency response and the environmental circumstance in which noise is produced. This has necessitated design of noise measuring meters which reduce the response to low and very high frequencies, characteristic of human ear capacity. ***The community (ambient) noise levels are measured in the A- weighted SPL, abbreviated dB(A). This scale resembles the audible response of human ear. Sounds of frequencies from 800 to 3000 HZ are covered by the A - weighted scale.*** These meters record the dB A scale, which is commonly used for measurement of general noise levels.

The dB has been the basic unit of sound and it has been the unit designed to fulfill the scientific requirement of giving information about the sound. It can be applied to noise assessment.

In air, sound consisting of pressure fluctuation about the mean atmospheric pressure. To be audible, these fluctuations must have frequency between 20 to 20,000 Hz.

If the amplitude of pressure fluctuation has been P then the sound level in dB has been given by $L = 10\log_{10}[P/Po]^2$ dB

Where,

$P_o = 2\times10^{-5}\,N/m^2$ (at reference pressure)

The dB has been thus based on a ratio of pressure.

b) What is the intensity of 100 dB sound? [WBUT 2015(ODD)]

Answer:

We know that,

Sound level $L\ (dB) = 10\log\frac{I}{I_0}$

where, I = measured intensity

I_0 = reference intensity

In the first case, i.e. when sound level is 100 dB then,

$$L_1 = 10\log\frac{I}{I_0}$$

or, $$\log\frac{I}{I_0} = \frac{L_1}{10}$$

or, $$\frac{I_1}{I_0} = 10^{L_1/10}$$

$$\therefore\ I_1 = I_0 \times 10^{L_1/10} \quad \text{—(1)}$$

In the sound case, i.e. when sound level is 90 dB then,

$$L_2 = 10\log\frac{I_2}{I_0}$$

or $$\log\frac{I_2}{I_0} = \frac{L_2}{10}$$

or $$\frac{I_2}{I_0} = 10^{L_2/10}$$

$$\therefore \quad I_2 = I_0 \times 10^{L_2/10} \quad \text{—(2)}$$

Now, $$\frac{I_1}{I_2} = \frac{I_0 \times 10^{L_1/10}}{I_0 \times 10^{L_2/10}} = \frac{1 \times 10^{L_1/10}}{1 \times 10^{L_2/10}}$$

Now, $L_1 = 100$ dB

$L_2 = 90$ dB.

$$\therefore \quad \frac{I_1}{I_2} = \frac{1 \times 10^{100/10}}{1 \times 10^{90/10}} = \frac{10^{10}}{10^9} = 10 \text{ times.}$$

So, 100 dB sound is louder than 90 dB sound by 10 times.

c) What is threshold limit value? Discuss various mechanisms to control noise. **[WBUT 2015(ODD)]**

Answer:

1st part:

When daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each.

If the sum of the ratios of the total duration of exposure at a specific noise level (C) to the total duration of exposure permitted at that level (T) is more than 1, then the mixed exposure should be considered to exceed the threshold limit value.

i.e., if, $\frac{C_1}{T_1}+\frac{C_2}{T_2}+\frac{C_3}{T_3}+\cdots>1$, then the sound exposure exceed the threshold limit value.

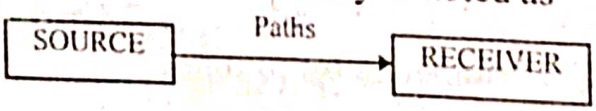
The following table indicates the list of maximum tolerable time of different sound level.

Duration / day, (h)	Sound level (dBA)
16	80
8	85
4	90
2	95
1	100
$\frac{1}{2}$	105
$\frac{1}{4}$	110
$\frac{1}{8}$	115

2nd Part:

Noise generation is associated with most of our daily activities. A healthy human ear responds to a very wide range of SPL from - the threshold of hearing at zero dB, uncomfortable at 100-120 dB and painful at 130-140 dB. Due to the various adverse impacts of noise on humans and environment, noise should be controlled. The technique or the combination of techniques to be employed for noise control depend upon the extent of the noise reduction required, nature of the equipment used and the economy aspects of the available techniques.

All noise control problem could be fundamentally denoted as



Hence noise control methods generally break into three parts.

1) Noise control of source.
2) Noise control along the path to receiver
3) Noise control at the receiver which includes his acoustic environment.

1. Noise Control at Source

There are at least three primary areas where noise control at source can be carried out.

(a) Proper design:

The proper design of equipment to minimize noise generation has been a good way, but it is a complex engineering problem which needs a strong background in the fundamental of vibration, fluid mechanics, dynamics and machine design. In a very general way, the following things should be considered while designing.

i) Using shock absorption technique: for absorbing impact energy.

e.g., The use of non-metallic gears to reduce the noise generated by the metal to metal impact associated with metallic gears; the use of flexible mounts to be supports wood planner knaves to reduce the noise.

ii) Use efficient flow technique for reducing noise associated with high fluid velocities and turbulence.

e.g., A new quite hydraulic pump in the flow path has been redesigned to give less turbulence.

iii) Reducing field jet velocity: as jet noise is proportional to eight power of jet velocity, by reducing jet velocity, noise can be minimize.

iv) Reducing the sound radiating areas.

e.g., by placing the equipment on wooden table or by fitting equipment on concrete base.

(b) Proper Operation:

All the equipments should be operated at the design condition. Operating of equipment of design pressure and speed should result in minimum noise generation. Several ways relating to operations are:

i) If acoustic guards, covers of enclosures have been used, make sure that they are in place and all openings are acoustically sealed. Because noise is like water, which rushes out through any crack or openings.

ii) If equipment has been equipped with a muffler/silencer system, make sure that it is working according to design. Since, many muffler depends upon the absorption within the case.

iii) We should use proper cutting speed and feeding rate in machinery operations.

iv) We should provide good support for tool-bites to reduce the vibrations.

v) We should apply additional sound control device. Inlet and discharge silencers can often be added with a small investment.

(c) Proper maintenance:

When one would like to control noise at the source, then first of all there should be a measurement of noise produced by source. Therefore, the noise level has to be measured at source and at a point round the source. A large source should be measured at respective points around the source. In both cases, measurement should be taken at any position where an operator's ear has been likely to be for substantial lengths of time.

There are at least three primary areas where noise control at source can be carried out.

i) We should maintain good dynamic balance. It decreases the vibrations.
ii) When purchasing or replacing of component likes gear, motors and pumps, we should not ignore noise specifications.
iii) We should improve lubrication. Inadequate lubrication due to poor design, degradation due to age or incorrect lubricants can cause the bearing noise.
iv) We should install bearing correctly.
v) We should avoid mechanical run out of shafts.
vi) We should clean the silencers and there should be surety of healed of cracks on silencers.

Beside these, noise can be controlled by the following ways:

- Reducing the noise levels from domestic sectors.
- Maintenance of automobiles.
- Control over vibrations.
- Low voice speaking.
- Prohibition on usage of loud speakers.

2. Noise Control at Path

Once sound has left a source and get established in the surrounding medium, either air or structure, of the building, it would travel some distance before reaching the point at which the noise nuisance will take place. When this situation arises, certain steps have to be taken to reduce the transmission of noise as it travels down the path. Common paths for noise have seen airborne paths like duct and corridors and it has been usual to include in this category walls that break up airborne sound paths and not to regard these wells as independent vibration path.

Alternatively, vibration energy may transmit through building structure, directly and may arise from direct excitation from the source, where a noise source has been directly coupled with conducting path like pipes of ducts, these paths are able to carry sound energy.

Therefore there should be some techniques to reduce sound or technique to make loss in transmission of sound through ducts, corridors, pipes, walls etc. Following are some of the ways by which we can reduce transmission.

1) Multiple layers: This is an efficient method of the sound isolation. The number of walls has to be constructed to create the separate layers in between source and receiver. As it is the discontinuity of the boundaries between two different materials that make reflection and therefore reduction of transmitted sound possible. Only technique in this is vacuum between two layers should not able to conduct any sound through multilayer.

2) Sound absorbing material: Sound absorbing material plays a vital role in controlling insulation that can be obtained between two rooms. It is assumed that by placing sound absorbers inside the cavity, the resonance mentioned above can get reduced and so the sound insulation. In practice, the result has been not as a good as expected.

3) Design of building: The design of the building incorporating the use of suitable noise absorbing material for wall/door/window/ceiling will reduce the noise levels. The approximate reduction of outside noise levels using typical exterior wall construction is given at Table. The reduction in noise levels for various frequencies and the A-weighted scale are shown. Variations in spectrum shape may change this A-weighted value by as much as +/- 3 dB.

4) Installation of panels or enclosures: A sound source may be enclosed within a paneled structure such as room as a means of reducing the noise levels at the receiver. The actual difference between the sound pressure levels inside and outside an enclosure depends not only on the transmission loss of the enclosure panels but also on the acoustic absorption within the enclosure and the details of the panel penetrations which may include windows or doors.

The product of ***frequency of interest and surface weight of the absorbing material*** is the key parameter in noise reduction through transmission loss. With conventional construction practices, the high-frequency transmission loss of a panel becomes limited to around 40 dB, owing to the transmission of sound through flanking paths other than the panel itself. Examples of such flanking are structural connections or ducts joining the two spaces on either side of the panel of interest.

5) Green belt development: Green belt development can attenuate the sound levels. The degree of attenuation varies with species of greenbelt. The statutory regulations direct the industry to develop greenbelt four times the built-up area for attenuation of various atmospheric pollutants, including noise.

3. Noise Control at Receiver

Noise has been received by people and more exceptionally by delicate instrumentation and it is often necessary to control the noise level received. This is normally achieved by treating the room or area within which the receiver is situated and we therefore have to study the acoustic of these situations.

i) **Permissible noise level:** There exist a little opportunity for noise control of the receiver. Normally by setting **permissible noise level** have been set for the receiver and engineering technique must be used at the source and /or path in order to limit the exposure of the receiver. On the basis of permissible sound level, the city areas are usually divided into four zones.

The permissible sound levels are –

Zones	Day	Night
Industrial	75 dB (A)	70 dB (A)
Commercial	65 dB (A)	55 dB (A)
Residential	55 dB (A)	45 dB (A)
Sensitive zone upto 100 mt. Around hospitals, educational institution etc.	50 dB (A)	40 dB (A)

- Day time: 6:00 am to 10:0 pm; Night time: 10:00 pm to 6:00 am
- Mixed cater

- Gories of areas may be declared as one of the four above mentioned categories by competent authority

ii) **Personal hearing protection** device (ear plugs) can be used to reduce the intensity of sound.

iii) **By rotating the job** between the workers working at a particular noise source or isolating a person, the adverse impacts can be reduced.

iv) **Administrative technique:** Regulations prescribe that, noise level of 90 dB (A) for more than 8 hr continuous exposure is prohibited. Persons who are working under such conditions will be exposed to occupational health hazards. The schedule of the workers should be planned in such a way that, their exposure to the high noise levels should be reduced.

Duration (per hour)	Sound level (dB)
8	90
6	92
4	95
3	97
2	100
1	105
0.5	110
0.25 or less	115

5. How does 60 dB_A of sound level differ form 90 dB_A on the basis of sound intensity? What do you understand by TLV of noise level? [WBUT 2017(EVEN)]

Answer:

We know that,

$$\text{Sound level L (dB)} = 10\log\frac{I}{I_0}$$

where, I = measured intensity

I_0 = reference intensity,

In the first case, i.e. when sound level is 90 dB then,

$$L_1 = 10\log\frac{I_1}{I_0}$$

or, $$\log\frac{I_1}{I_0} = \frac{L_1}{10}$$

or, $$\frac{I_1}{I_0} = 10^{L_1/10}$$

$$\therefore I_1 = I_0 \times 10^{L_1/10} \quad \ldots(1)$$

In the sound case, i.e. when sound level is 60 dB then,

$$L_2 = 10 \log \frac{I_2}{I_0}$$

or $$\log \frac{I_2}{I_0} = \frac{L_2}{10}$$

or $$\frac{I_2}{I_0} = 10^{L_2/10}$$

$$\therefore \quad I_2 = I_0 \times 10^{L_2/10} \qquad ...(2)$$

Now, $$\frac{I_1}{I_2} = \frac{I_0 \times 10^{L_1/10}}{I_0 \times 10^{L_2/10}} = \frac{1 \times 10^{L_1/10}}{1 \times 10^{L_2/10}}$$

Now, $L_1 = 90$ dB

$L_2 = 60$ dB

$\therefore$ $I_1/I_2 = 10^9 / 10^6$ times.

So, 90 dB sound is louder than 60 dB sound by 1000 times.

TLV of noise level:

When daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each.

If the sum of the ratios of the total duration of exposure at a specific noise level (C) to the total duration of exposure permitted at that level (T) is more than 1, then the mixed exposure should be considered to exceed the threshold limit value.

i.e., if, , $\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \cdots > 1$, then the sound exposure exceed the threshold limit value.

The following table indicates the list of maximum tolerable time of different sound level.

Duration / day, (h)	Sound level (dBA)
16	80
8	85
4	90
2	95
1	100
$\frac{1}{2}$	105
$\frac{1}{4}$	110
$\frac{1}{8}$	115

6. a) In a work area the noise levels are read as 95 dBA for 2hrs a day, 90 dBA for 4 hrs a day, 80 dBA for remaining 2hrs a day and permissible duration of each noise level is 95 dBA for 2 hrs, 90 dBA for 4 hrs and 80 dBA for 16 hrs. Find out the noise threshold limit value and predict whether the noise level is within Permissible limit or not? **[WBUT 2017(ODD)]**

b) Write the controlling measures of Noise pollution.

Answer:

a) We know that, the addition of ratios of actual hrs exposed to the noise to the permissible hrs. is called the "noise threshold limit value".

i.e. $\frac{C_1}{T_1}+\frac{C_2}{T_2}+\frac{C_3}{T_3}+.....\frac{C_n}{T_n}$ = "noise threshold limit value"

If the noise threshold limit value exceeds 1, then it is not good for the persons who are exposed to it.

Here, C = actual hrs, exposed to a particular noise level.

T = permissible hrs, of the exposure to that noise level.

Here,

Noise level (dB)	95	90	80
(1) Actual hrs. of exposure	2	4	2
(2) Permissible hrs. of exposure	2	4	16

∴Noise threshold limit value of that particular working place –

$$\frac{2}{2}+\frac{4}{4}+\frac{2}{16}=1+1+\frac{1}{8}=\frac{17}{8}=2\frac{1}{8}.$$

As, the noise threshold limit value crosses the permissible limit i.e., 1, so, the existing working environment is not good for the worker.

b) *Refer to Question No. 4(c) (2nd Part) of Long Answer Type Questions.*

7. Discuss the effect of noise pollution on public health. **[WBUT 2017(ODD)]**

Answer:

Refer to Question No. 1 (3rd Part) of Long Answer Type Questions.

8. a) What do you mean by noise pollution? What are the effects of noise pollution on living organisms? How can you control noise pollution? **[WBUT 2018(EVEN)]**

Answer:

1st Part:

Sound pollution, also known as environmental noise or noise pollution, is the propagation of noise with harmful impact on the activity of human or animal life.

2nd Part:

The generation of unwanted sound (noise) within the environment is regarded as pollution because it lowers the quality of life. There are several specific ways in which

excessive noise can affect people adversely. Noise has been found to interfere with our activities of three levels –

(1) Audiological level – reference with satisfactory performance of hearing mechanism.

(2) Biological level – interfering with biological functioning of our body.

(3) Behavioral level – affecting the sociological behaviour of the subject.

3rd Part:

Noise generation is associated with most of our daily activities. A healthy human ear responds to a very wide range of SPL from - the threshold of hearing at zero dB, uncomfortable at 100-120 dB and painful at 130-140 dB. Due to the various adverse impacts of noise on humans and environment, noise should be controlled. The technique or the combination of techniques to be employed for noise control depend upon the extent of the noise reduction required, nature of the equipment used and the economy aspects of the available techniques.

All noise control problem could be fundamentally denoted as

Hence noise control methods generally break into three parts.

1) Noise control of source.

2) Noise control along the path to receiver

3) Noise control at the receiver which includes his acoustic environment.

b) If two machines produce 50 dB sounds simultaneously, what will be the total sound level? **[WBUT 2018(EVEN)]**

Ansswer:

Consider that the first machine produces L_1 sound level

So, $L_1 = 10 \log \frac{I_1}{I_0}$ ... (1)

Where, I_1 = intensity of sound level L_1

I_0 = reference intensity.

Similarly, the second machine produces L_2 sound level

So, $L_2 = 10 \log \frac{I_2}{I_0}$ ... (2)

When, I_2 = intensity of sound level L_2

I_0 = reference intensity.

So, when both the machine take start from same place and same time, then the total intensity of sound

$I_3 = I_1 + I_2$ ... (3)

After, arranging the equation (1), we get

$$L_1 = 10 \log \frac{I_1}{I_0}$$

or, $$\log \frac{I_1}{I_0} = L_1/10$$

or, $$\frac{I_1}{I_0} = 10^{L_1/10}$$

$$\therefore \quad I_1 = I_0 \times 10^{L_1/10} \qquad \ldots (4)$$

Similarly,

$$I_2 = I_0 \times 10^{L_2/10} \qquad \ldots (5)$$

$$\therefore \quad I_3 = I_0\left(1 \times 10^{L_1/10} + 1 \times 10^{L_2/10}\right) \qquad \ldots (6)$$

When both the machine take start from same time and same place, then the total sound produced is –

$$L_3 = 10\log\frac{I_3}{I_0} = 10\log\frac{I_0\left(1 \times 10^{L_1/10} + 1 \times 10^{L_2/10}\right)}{I_0}$$

$$= 10\log\left(10^{L_1/10} + 10^{L_2/10}\right) \qquad \ldots (7)$$

As, $L_1 = L_2 = 50$ dB

$L_3 = 10 \log (10^5 + 10^5)$

$= 10 \log 2 \times 10^5$

$= 10 (\log 2 + 5) = 53$

So, when both the machine operate from same place and same time, then the total sound would be 53 dB.

9. What is the basic difference of noise pollution from any other pollution? What is noise threshold limit values? **[WBUT 2018(ODD)]**

Answer:

1st part:

Noise features different characteristics that make it different from every other "classic" pollutant. Noise is invisible; it does not smell; it disappears when the source is turned off and leaves no traces in the environment. In addition, when people perceive something wrong about their hearing capacity, it is often long time after the beginning of noise exposure.

2nd part:

When daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each.

If the sum of the ratios of the total duration of exposure at a specific noise level (C) to the total duration of exposure permitted at that level (T) is more than 1, then the mixed exposure should be considered to exceed the threshold limit value.

i.e., if, $\frac{C_1}{T_1}+\frac{C_2}{T_2}+\frac{C_3}{T_3}+\cdots>1$, then the sound exposure exceed the threshold limit value.

The following table indicates the list of maximum tolerable time of different sound level.

Duration / day, (h)	Sound level (dBA)
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$\frac{1}{2}$	105
$\frac{1}{4}$	110
$\frac{1}{8}$	115

10. a) Define 'decibel' and 'sound pressure level'?

b) What is 'Noise Threshold Limit value'? Noise in an area is measured as and permissible noise exposure duration is given below. Find out whether working environment is good for the worker or not?

Noise level dBa	100	95	90	75
Measured hours	½	1	3	3
Permissible hours	1	2	4	∞

[WBUT 2018(ODD)]

Answer:

a) *Refer to Question No. 1 of Short Answer Type Questions.*

b) ∴Noise threshold limit value → ½+ ½+3/4+0= 1.75

The noise threshold limit value is 1.75 i.e. the noise level is not within the limit. As, the noise threshold limit value crosses the permissible limit i.e., 1, so, the existing working environment is not good for the worker.

11. Write short note on Sound Intensity Level (SIL). **[WBUT 2018(EVEN)]**

Answer:

Sound intensity level also known as **acoustic intensity** is defined as the power carried by sound waves per unit area in a direction perpendicular to that area. The SI unit of intensity, which includes sound intensity, is the watt per square meter (W/m^2). One application is the noise measurement of sound intensity in the air at a listener's location as a sound energy quantity.

Sound intensity is not the same physical quantity as sound pressure. Hearing is directly sensitive to sound pressure which is related to sound intensity. In consumer audio electronics, the level differences are called "intensity" differences, but sound intensity is a specifically defined quantity and cannot be sensed by a simple microphone. The rate at which sound energy passes through a unit

area held perpendicular to the direction of propagation of sound waves is called intensity of sound.

ENVIRONMENTAL MANAGEMENT

Multiple Choice Type Questions

1. The full form of EQI is [WBUT 2014(EVEN)]
   a) Environmental Quality Information b) Environmental Quality Index
   c) Environmental Quotient Information d) Environmental Quotient Index

Answer: (b)

2. Environment Impact Assessment (EIA) needs to [WBUT 2014(EVEN)]
   a) start a project b) stop a project
   c) evaluate a project d) none of these

Answer: (c)

Long Answer Type Questions

1. Write short note on Environmental impact assessment? [WBUT 2007, 2015(ODD), 2016(ODD), 2017(ODD),2017]

OR,

What do you mean by environmental impact assessment? How is it related to the setting up of a new process industry? [WBUT 2013(EVEN), 2014(ODD), 2015(EVEN)]

OR,

Define the term EIA. [WBUT 2016(ODD), 2018(ODD)]

OR,

What is Environmental Impact Assessment (EIA)? Describe the methodology for Environmental Impact Assessment. [WBUT 2018(EVEN)]

Answer:

Environmental Impact Assessment (EIA) means a formalized procedure for examination, analysis and assessment for planned activities with a view to ensuring environmentally sound and sustainable development. It is defined as "an anticipatory, participatory integrative environmental management tool, which has ultimate objective of providing information to the decision makers with an indication of the likely consequences of their decision relating to new projects or programs, plans or policies."

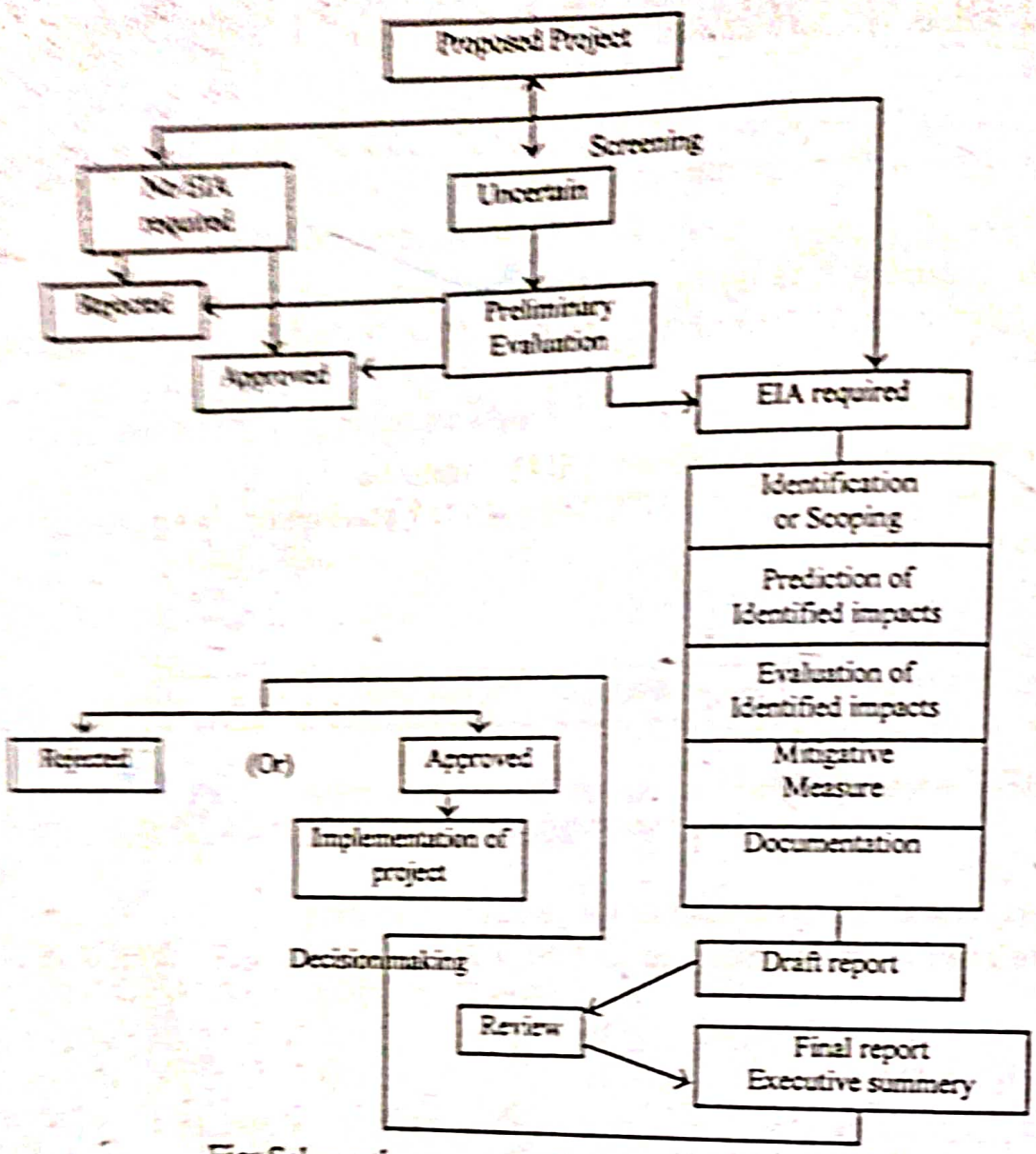

Fig: Schematic representation of EIA process in brief

- The benefits of EIA:

The following is a general over view of the many benefits offered by effective EIA.

1. Reduced cost and time of project implementation.
2. Cost saving modifications in project design.
3. Increased project acceptance.
4. Avoiding impacts and violations of laws and regulations.
5. Improved project performance.
6. Avoiding waste treatment/ Clean up expenses.
7. A healthier local environment
8. Improved human health
9. Maintenance of biodiversity
10. Decreased resource use
11. Fewer conflicts over natural resource use
12. Increased community skills, knowledge and pride

The study Environmental Impact Assessment is related to the setting up of a new process industry because –

1) to establish assessment result before decisions are taken by the concerned authority to undertake the projects, the environmental effects of these activities should be taken fully into account.
2) to promote the implementation of appropriate procedures consistent with national laws and decision-making process.
3) to encourage the development of reciprocal procedures for information exchange, notification and consultation between states if the proposed projects are likely to have significant trans-boundary effects on environment of those state.

Factors to be consider for establishment of thermal power plant in a particular are

a) Land use pattern
b) Metrological condition
c) Existing air quality standard
d) Existing water quality standard
e) Existing soil quality standard
f) Existing vegetation
g) Socio economic condition of the locality
h) Rehabilitation possibility

2. How environmental audit is done? What is its utility? [WBUT 2012(EVEN)]

OR,

Write short note on Environmental audit [WBUT 2013(EVEN), 2014(ODD)]

Answer:

Environmental audits are intended to quantify environmental performance and environmental position. In this way they perform an analogous (similar) function to financial audits. An environmental audit report ideally contains a statement of environmental performance and environmental position, and may also aim to define what needs to be done to sustain or improve on indicators of such performance and position.

Scopes of environmental audits are

1. Verification of legislative and regulatory compliance
2. Assessment of internal policy and procedural conformance
3. Establishment of current practice status
4. Identification of improvement opportunities

3. Write short notes on the following:

a) Conference of parties (COP)-21 Paris [WBUT 2016(EVEN)]
b) Environmental Management System [WBUT 2016(ODD)]
c) EIA [WBUT 2017(EVEN)]

Answer:

a) Conference of parties (COP)-21 Paris:

The 2015 United Nations Climate Change Conference, COP 21 or CMP 11 was held in Paris, France, from 30 November to 12 December 2015. It was the 21st yearly session of the Conference of the Parties (COP) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) and the 11th session of the Meeting of the Parties to the 1997 Kyoto Protocol.

The conference negotiated the Paris Agreement, a global agreement on the reduction of climate change, the text of which represented a consensus of the representatives of the 196 parties attending it.

On 12 December 2015, the participating 195 countries agreed, by consensus, to the final global pact, the Paris Agreement, to reduce emissions as part of the method for reducing greenhouse gas. In the 12-page document, the members agreed to reduce their carbon output "as soon as possible" and to do their best to keep global warming "to well below 2 degrees C".

b) Environmental Management System:

Environmental management system (EMS) refers to the **management** of an organization's **environmental** programs in a comprehensive, systematic, planned and documented manner. It includes the organizational structure, planning and resources for developing, implementing and maintaining policy for **environmental** protection.

c) ***Refer to Question No. 1 of Long Answer Type Questions.***

QUESTION 2013 [DECEMBER]

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following:

i) Road traffic noise is measured by

✓a) L_{10} (18 hour) index b) $L_e P_n$ c) L_{eq} d) none of these

ii) Atmospheric radioactive window permits thermal radiation of which wavelength to leave the earth?

a) 4.3 to 9.3 μm b) 9.5 to 10.6 μm ✓c) 7 to 12 μm d) 7.3 to 10.3 μm

iii) In logistic growth equation, zero population growth (ZPG) means

✓a) $dN/dt = 0$ b) $dN/dt > 0$ c) $dN/dt < 0$ d) none of these

iv) Which one of the following is true for a waste water sample?

a) BOD > COD ✓b) COD > BOD c) BOD = COD d) BOD = 1/COD

v) Living organisms are good example of

a) closed system ✓b) open system c) isolated system d) none of these

vi) Kyoto protocol is related on which of the following?

a) depletion of ozone layer
b) world's first forest conservation programme
✓c) emission of atmospheric CO_2
d) photochemical smog

vii) More scientific method than BOD to determine water quality parameter is

✓a) COD b) DO c) both of these d) none of these

viii) Which one is primary pollutant?

a) acrolein b) PAN c) O_3 ✓d) CO

ix) An example of a producer is

a) fungus b) caterpillar c) bird ✓d) moss

x) The value of earth's albedo is

a) 0.7 b) 0.8 c) 0.4 ✓d) 0.3