Environmental Science and Engineering (Module – 3,4,5,6)

Course Contents

- Module – I- Ecology & Biogeochemical Cycles
- Module – II- Environmental gradients & Laws
- Module – III- Water & Wastewater Treatment
- Module – IV- Atmospheric chemistry, Soil chemistry, Ground water recharge, Noise source & Abatement
- Module –V- Solid Waste & Hazardous Waste Management
- Module –VI- Environment and Human Health

Module-III

- Water & Wastewater Treatment: Water quality standards and parameters, Pre-treatment and Conventional treatment processes of water, DO, BOD, COD, Wastewater Treatment.

Module-IV

- <u>Atmospheric chemistry, Soil chemistry, Ground water recharge, Noise source & Abatement</u>: Atmospheric chemistry, Air Pollution, Climate change, Soil chemistry, Water table and Aquifer, Ground water recharge, Noise Standards, Noise measurement, Noise control.

Module-V

- <u>Solid Waste & Hazardous Waste Management</u>:
- Source, classification and composition of MSW, MSW Management, 3R Principles, Hazardous waste generation and their management, Environment impact Assessment, Origin & procedure of EIA, Project Screening for EIA, Scope studies, Preparation and review of EIS.

Module-VI

- <u>Environment and Human Health</u>:
- Environment and Human Health, the impact of the IT industry on the environment, including e-waste.
- Activities include presentation and report submission by students on environmental problems.

Text Book

- An Introduction to Environmental Engineering and Science, by Gilbert M. Masters & Wendell P. Ela, PHI Publication.
- Environmental Engineering, by G. Kiely, McGraw Hill International Edition.

Physical Properties of Water

- The various physical properties of water that shows wide variation in magnitude includes –
- Colour
- Turbidity
- Taste & odour
- Temperature
- Solids

Physical Properties of Water

- Colour:-
- It is measured in Hazen's Scale.
- The permissible limit of colour for drinking water is 5mg/L or ppm.

Physical Properties of Water

- <u>Turbidity</u>:-
- It is the measure of cloudiness in water & caused by presence of suspended matter which scatters & absorbs light.
- It is measured in NTU
- (Nephelometric Turbidity Unit)
- The Permissible limit of turbidity for drinking water is 1NTU.

Physical Properties of Water

- <u>Taste & Odour</u> :-
- This may be due to presence of micro-organisms, algae, dissolved minerals, salts etc.
- It is measured in TON
- (Threshold Odour Number)
- The permissible limit of TON for drinking water is 1 to 3.

Physical Properties of Water

- <u>Taste & Odour</u>:-
- TON = (A + B)/ A
  A - Volume of Sample with odour
  B -Volume of Pure Water with no odour Added
- If A was a 100 ml sample and 100 ml of water had to be added to not detect the odour - the TON would be 2.
  TON = (100 + 100)/ 100=200/100=2.

Physical Properties of Water

- Temperature:-
- The temperature of water varies with atmospheric temperature & it is a significant parameter regarding characteristics of water.
- For drinking water the temperature should be 10-25^{0}C.

Physical Properties of Water

- Solids:-
- Solids content of water represents the characteristics of water.
- Solids present in water can be studied as follows-
- a) Total Solids(TS)
- b) Suspended Solids(SS)

Physical Properties of Water

- c) Total Dissolved Solids(TDS)
- = TS – SS
- d) Total Volatile Solids(TVS)
- e) Volatile Suspended Solids(VSS)
- f) Filterable Solids(FS) & Non-Filterable Solids (NFS)

Physical Properties of Water

- NFS = SS
- (Particle Size Range is 10^{0} to 10^{-3} mm)
- FS can be Colloidal
- (Particle Size Range is 10^{-3} to 10^{-6} mm) &
- Dissolved
- (Particle Size Range is 10^{-6} to 10^{-9} mm)

Chemical Properties of Water

- It can be
- Inorganic &
- Organic

Chemical Properties of Water

- Inorganic Chemical properties of water includes –
- P^H
- Alkalinity & Acidity
- Hardness
- Conductivity

Chemical Properties of Water

- Organic Chemical properties of water includes-
- BOD
- (Biological Oxygen Demand)
- COD
- (Chemical Oxygen Demand)
- TOC
- (Total Organic Carbon)
- TOD
- (Total Oxygen Demand)

Inorganic Chemical Properties of Water

- P^H is
- Potential of Hydrogen or Power of Hydrogen
- $P^H = - \log [H^+]$ or
- $= - \log [H_3O^+]$
- P^H range for public water supplies is 6.5 to 8.5.

Problem

- In a water treatment plant, the P^H values of incoming & outgoing water are 7.2 & 8.4 respectively. Assuming a linear variation of PH with time, determine the average P^H value of water.

Inorganic Chemical Properties of Water

- Alkalinity & Acidity :-
- Alkalinity is also known as ANC or
- (Acid Neutralizing Capacity) &
- Acidity is also known as BNC or
- (Base Neutralizing Capacity)

Inorganic Chemical Properties of Water

- Alkalinity can be of
- three types.
- a) Carbonate Alkalinity
- b) Bicarbonate Alkalinity &
- c) Hydroxide Alkalinity

Inorganic Chemical Properties of Water

- <u>Hardness</u>:-
- Hard water has high mineral content.
- Hardness of water are of two types:-
- a) Temporary Hardness or
- Carbonate Hardness
- b) Permanent Hardness or
- Non-Carbonate Hardness

Inorganic Chemical Properties of Water

- a)<u>Temporary Hardness</u>:-
- It is due to carbonate & bicarbonate of Ca^{+2} & Mg^{+2}.
- b)<u>Permanent Hardness</u>:-
- It is due to Chloride & Sulphate of Ca^{+2} & Mg^{+2}.

Inorganic Chemical Properties of Water

- Hardness of water is expressed in mg/L as $CaCO_3$.
- The permissible limit of hardness of drinking water is
- 200 mg/L as $CaCO_3$.

Inorganic Chemical Properties of Water

- Hardness in mg/L as $CaCO_3$
- = [M^{+2}(concentration in mg/L) X 50]/ [equivalent weight of M^{+2}]
- = M^{+2}(Concentration in meq/L) X 50

Problem

- Determine the various hardness of the following water sample.

Constituent	Concentration (in mg/L)
Ca^{+2}	60
Mg^{+2}	29.3
HCO_3^-	366

Inorganic Chemical Properties of Water

- Conductivity or Electrical Coductivity:-
- It is the measure of the ability of an aqueous solution to carry an electric current.

$$ec = \sum_{i=1}^{n} C_i f_i$$

Inorganic Chemical Properties of Water

- where,
- ec is electrical conductivity in μs(siemens)/cm,
- C_i is concentration of ionic species in solution in mg/L &
- f_i is conductivity factor for ionic species.

Organic Chemical Properties of Water

- BOD_5 = 0.6 COD
- CBOD or
- Carbonaceous BOD = 0.92 COD

Organic Chemical Properties of Water

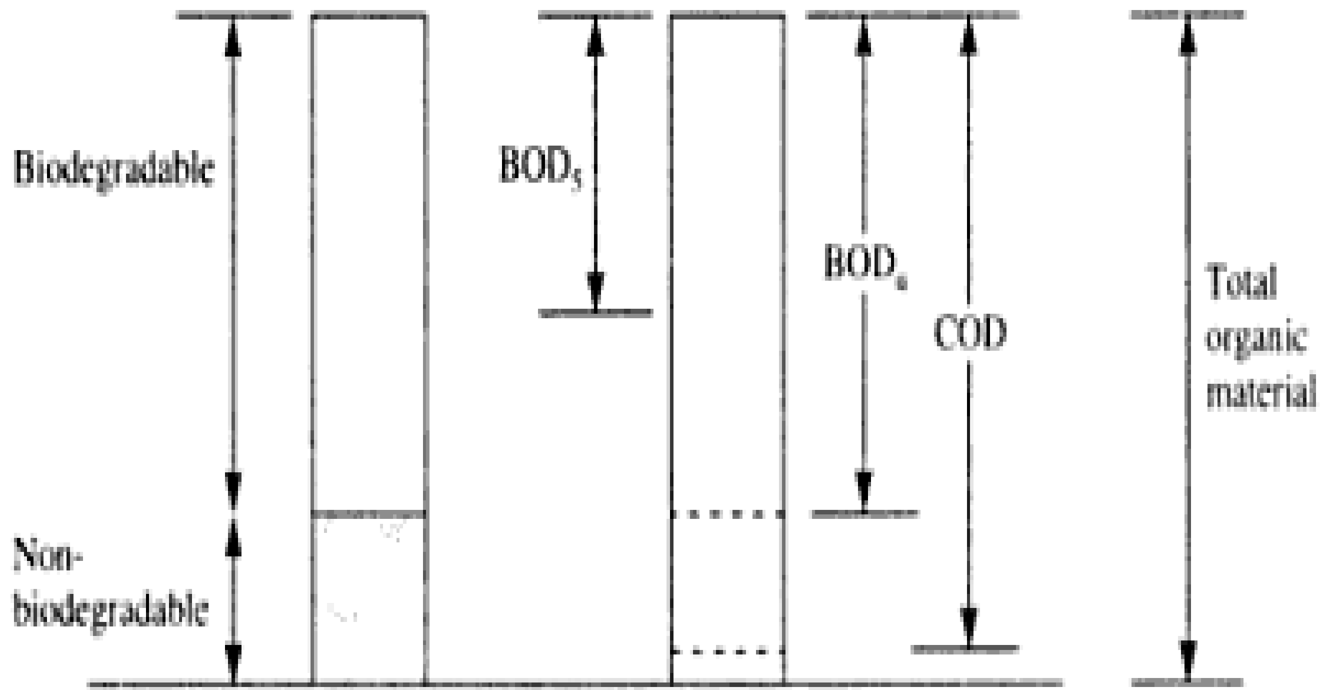


Figure 3.8 Schematic of BOD/COD/T.org matter relationship.

Organic Chemical Properties of Water

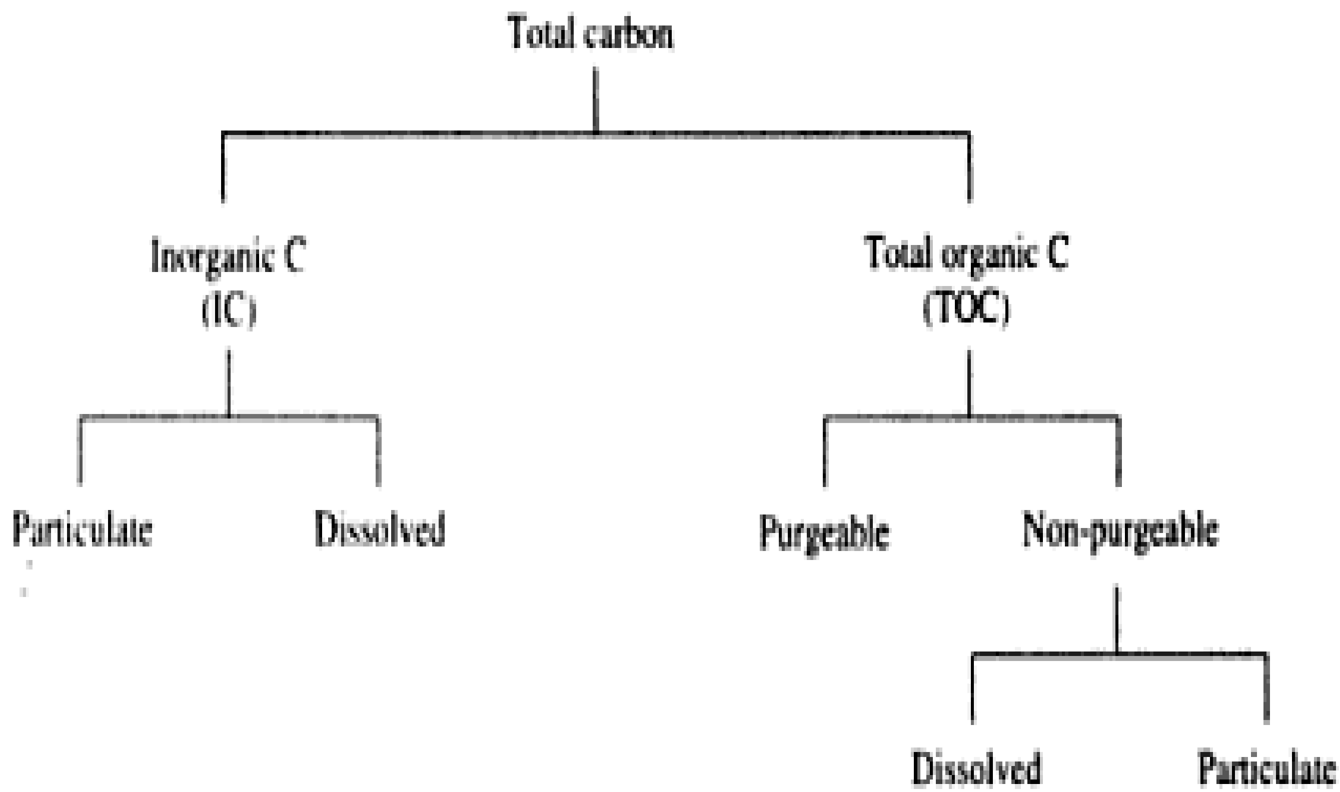


Figure 3.9 Schematic of subdivisions of carbon in water.

Problems

- Q.1. Determine COD & TOC for glucose($C_6H_{12}O_6$)?
- Q.2. If bacteria cells are represented by the chemical formula $C_5H_7O_2N$, then determine the potential carbonaceous BOD, when bacteria cell concentration is 1000mg/L.

Problems

- Q.3. A wastewater is analysed & is shown to contain 100 mg/L of ethylene glycol ($C_2H_6O_2$) & 120 mg/L of phenol(C_6H_6O). Determine COD & TOC.

Organic content parameter

- When an organic waste is discharged to a stream, the organic content of the effluent or discharge undergoes a biochemical reaction with the help of micro-organisms.
- The BOD = $P(DO_I - DO_F)$
- Where, P is Dilution Ratio,
- DO_I & DO_F are initial & final DO(Dissolved Oxygen) concentration

Organic content parameter

- The Corrected BOD = $P[(DO_I-DO_F)-f(B_I-B_F)]$
- Where, f is the correction factor or seeding factor=$1-(1/P)$,
- B_I & B_F are initial & final DO(Dissolved Oxygen) concentration of seeded diluted water or Blank

Problem

- Q. The results from a BOD test diluted by 100 are given below. Calculate the BOD_S.

Time (in days)	DO(in mg/L)
0	7.95
1	3.75
2	3.45
3	2.75
4	2.15
5	1.80

Problem

- Q. The results from a BOD test diluted by 100 are given below. Calculate the Corrected BOD_S.

Time (in days)	DO(in mg/L)	Blank DO(in mg/L)
0	7.95	8.15
1	3.75	8.10
2	3.45	8.05
3	2.75	8.00
4	2.15	7.95
5	1.80	7.90

Organic matter

- The rate of decomposition of organic matter is directly proportional to the amount of organic matter available & it is a first order reaction.
- i.e. $d/dt(L_t) \alpha \ L_t$
- $=> d/dt(L_t) = -k_1 x L_t$
- $=> d(L_t)/L_t = k_1 x dt$
- Where, L_t is BOD remaining in mg/L=BOD_r &
- K_1 is deoxygenation rate coefficient

Organic matter

- Now taking integration of both sides and putting initial condition at t=0, L_t=L_0, we will have final expression for BOD exerted at any time t i.e.
- $BOD_t = L_0(1-e^{-k_1 t})$

Problem

- Q. If K_1 or deoxygenation rate coefficient is 0.15 per day, then determine the ultimate BOD or BOD_u or L_0.

Temperature effect on K_1

- Temperature has an effect on K_1 & is given by,
- $K_T = (K_{20})x(\Theta)^{(T-20)}$
- Where,
- K_T= The deoxygenation rate coefficient at T^0C
- K_{20}=The deoxygenation rate coefficient at 20^0C
- Θ = Coefficient= 1.047 for $20^0C < T < 30^0C$ &
- = 1.35 for $4^0C < T < 20^0C$

NBOD

- The Oxygen demand associated with the oxidation of ammonia(NH_3) to nitrate (NO_3^-) is called Nitrogenous BOD or NBOD.
- $$2NH_3 + 3O_2 \xrightarrow{Nitrosomanas} 2NO_2^- + 2H^+ + 2H_2O$$

$$2NO_2^- + O_2 \xrightarrow{Nitrobacter} 2NO_3^-$$

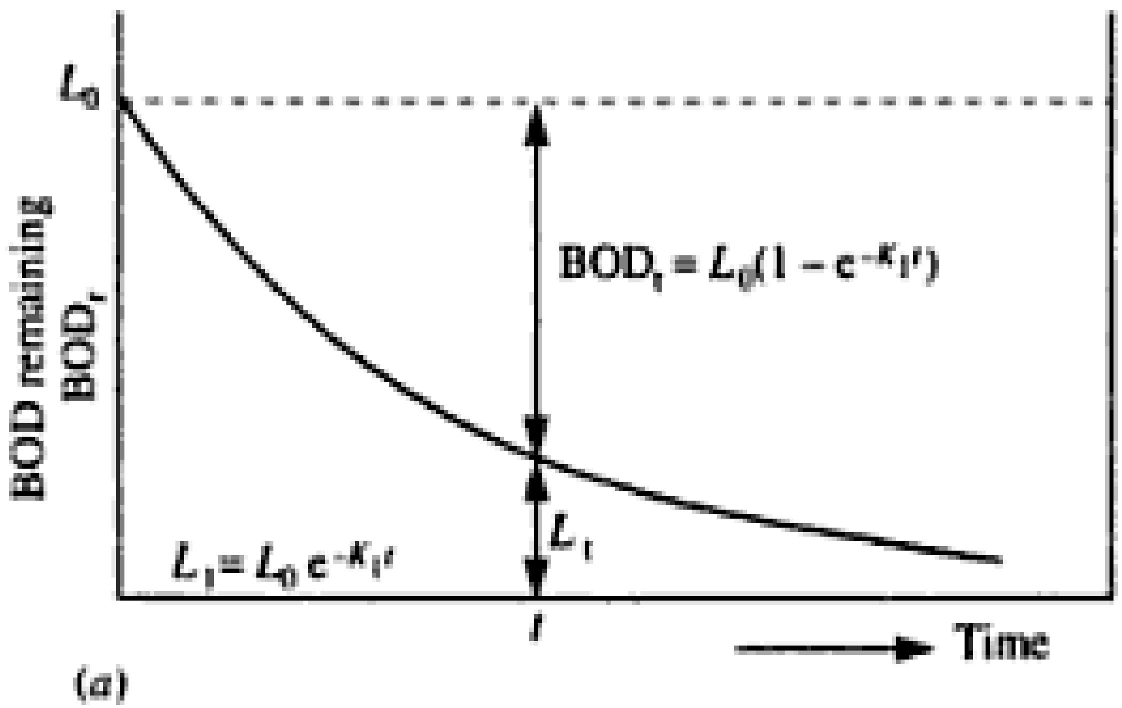
$$So, 2NH_3 + 4O_2 \rightarrow 2NO_3^- + 2H^+ + 2H_2O \;\&$$

$$Finally, NH_3 + 2O_2 \rightarrow NO_3^- + H^+ + H_2O$$

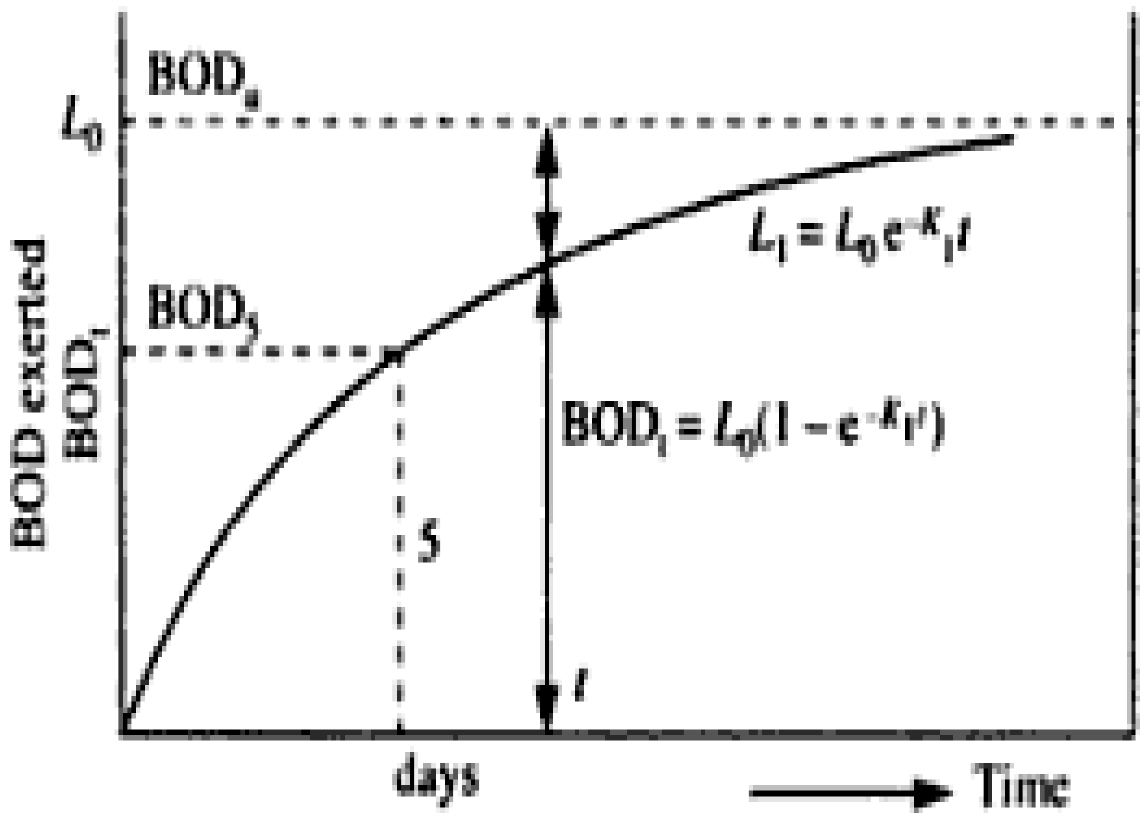
Problem

- Q. Determine the TOD(Total Oxygen Demand) if the sample contains 25 mg/L of N.

BOD remaining(BOD_r) graph



BOD exerted(BOD_t) graph



(b)

CBOD & NBOD relationship

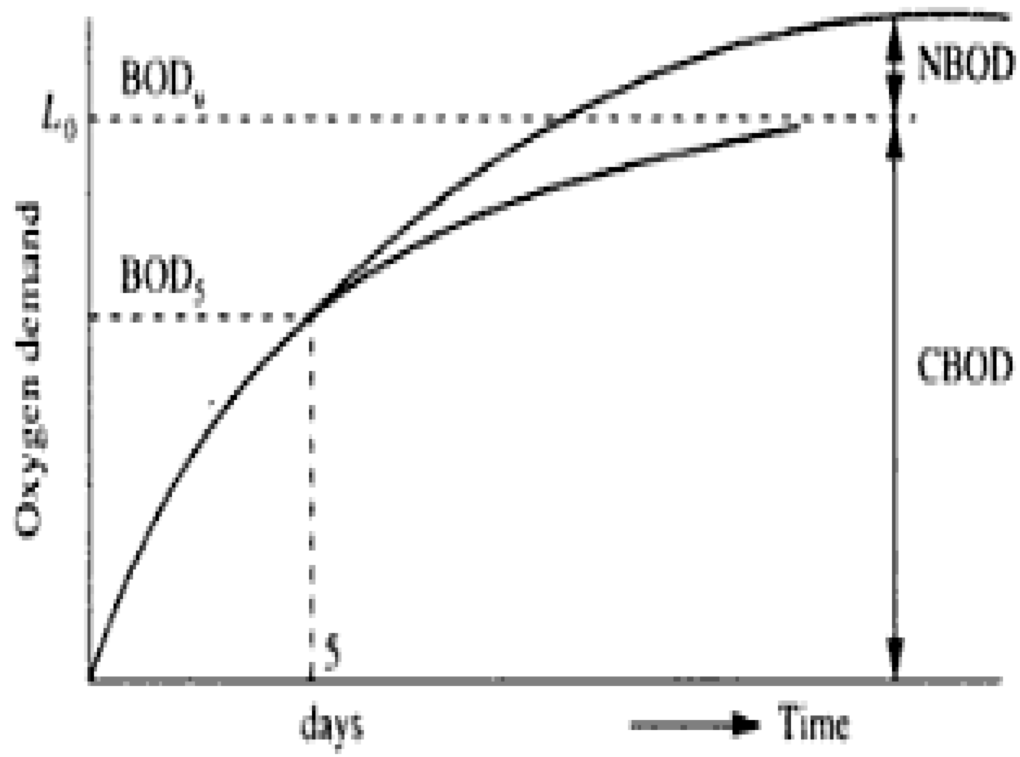


Figure 7.3 Relationship of CBOD and NBOD.

Problem

- Q. 15ml of sample was diluted in 300ml bottle. Initial DO was 8.9 mg/L & final DO after 5days was 4.4mg/L. The corresponding initial & final DO of diluted water was 9.1mg/L & 9.05 mg/L. Find out 5 days BOD at 20^0C.

Problem

- Q. BOD of an sample incubated for one day at 30^0C was found to be 100mg/L. What would be the 5 day BOD at 20^0C. The deoxygenation rate coefficient (K_1) is 0.12 at 20^0C.

Problem

- Determine the two day BOD for a wastewater at 20^0C, while BOD_5 at 20^0C is 250mg/L. The deoxygenation rate coefficient(K_1) value at 20^0C is 0.2 per day. What shall be the BOD after the end of seven days at 25^0C .

Problem

- A BOD test was conducted taking 5% wastewater mixed with 95% aerated water for dilution & the following observations were found out:
- i) DO of the aerated water used for dilution is 3.6 mg/L
- ii) DO of the original wastewater sample is 0.8 mg/L

- iii) DO of the diluted wastewater after incubation at 20^0C for 5 days is 0.7 mg/L
- Calculate the 5 days BOD of the above wastewater sample if the deoxygenation constant is 0.11.

Aquatic Pollution

- The aquatic Pollution can be classified into three broad groups.
- a) Fresh water pollution or
- Surface water pollution
- b) Estuarine pollution
- c) Marine pollution

a)Fresh water pollution

- The pollution of fresh water can be caused by:-
- Wastes from municipality & industries
- Oil from industry wastes & cleaning of vehicles
- Thermal waste from industries & power stations
- Heavy metals etc.

b) Estuarine pollution

- Estuarine means tidal mouth of river or where river mixes with the sea.

c) Marine pollution

- The main pollutants for Marine pollution are:-
- i) Manmade organic poisons like
- Pesticides & herbicides
- ii) Radioactivity due to radioactive substances.

Point & Non-Point Sources of Pollution

- Point Sources are those, which discharge pollutants from specific locations such as chimney, drainpipe of factories etc.
- Point Sources are easier to monitor & regulate.

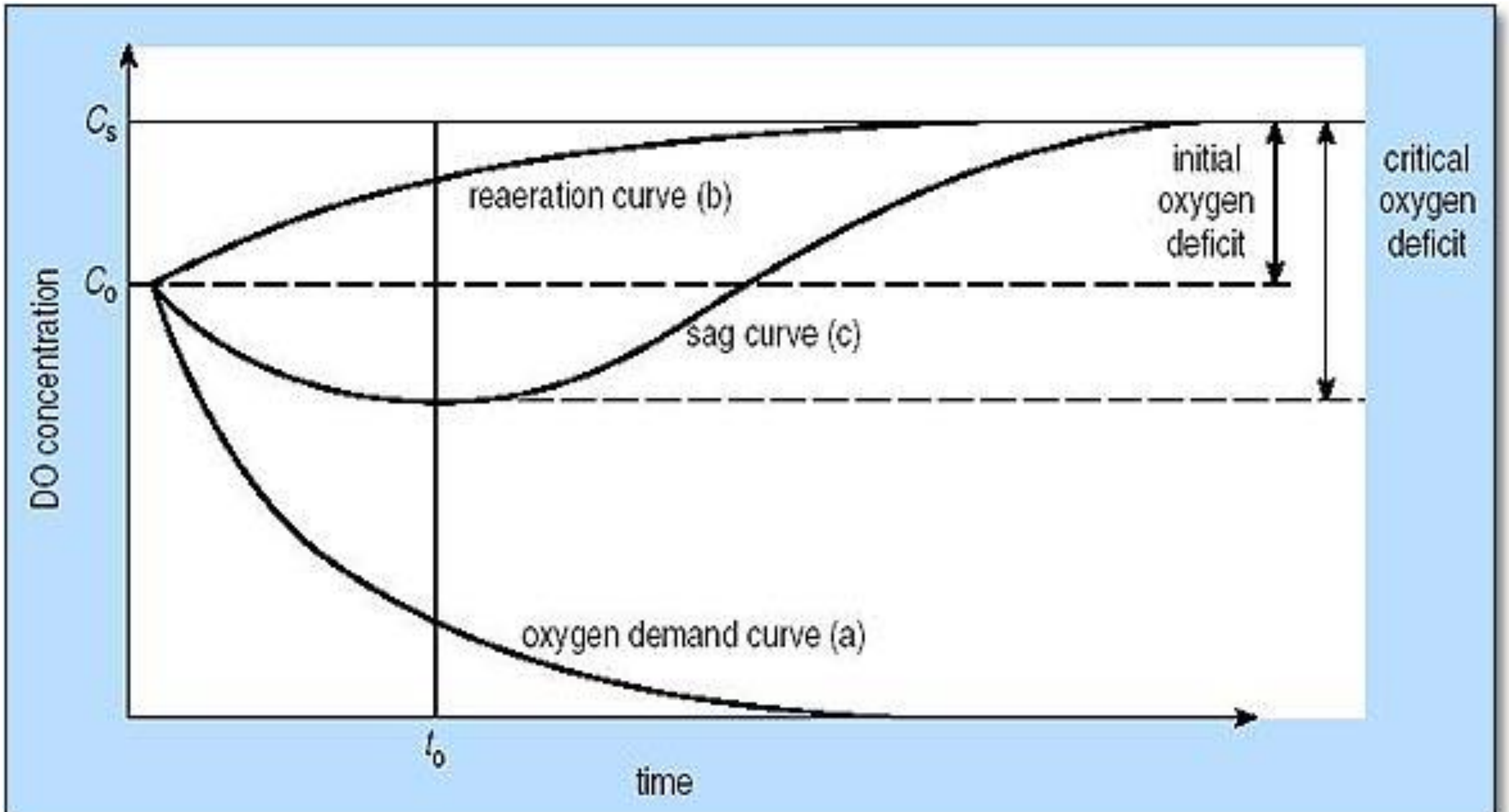
Point & Non-Point Sources of Pollution

- Non-point sources of pollution are those, which don’t have any specific location of discharge.
- As a result, these are difficult to monitor & regulate.
- Ex:- Run-off from paddy fields, Lawns & Gardens.

Oxygen Sag Curve

- The longitudinal profile of Oxygen concentration is Known as Oxygen sag curve.

Oxygen Sag Curve



Eutrophication

- It can be defined as the enrichment of water by inorganic plant nutrients like N & P, which results in increase in primary productivity.
- Artificial eutrophication is known as cultural eutrophication which is caused by adding fertilizers.

Eutrophication

- The problems arising due to Eutrophication are:-
- Water quality may have unacceptable taste & odour
- Water may be injurious to health
- The household usefulness of water may decrease.

Oxygen transfer in waterbodies

- The oxygen transfer in waterbodies is given by Orlob equation i.e.

$$\frac{(C_g - C_0)}{(C_g - C_t)} = e^{K_2 t}$$

Oxygen transfer in waterbodies

- Where,
- C_g = Saturation Concentration of oxygen
- C_0 = Initial Concentration of oxygen
- C_t = Concentration of oxygen after time ‘t’
- K_2 = reaeration rate constant

Problem

- If saturation concentration of oxygen in water is 9.2mg/L & the initial concentration of oxygen is 2.1mg/L, then determine the time it takes to become 7.5mg/L , having K_2 value 0.25 per day. What is the time required for C_t to be 5,6,7,8,9 mg/L.

Ground water Quality/Contamination

- The most simple model of decay of a contaminant is to assume the decay to be a first order reaction i.e.
- $r = - kc$ &
- $C_t = C_0e^{-Kt}$

Ground water Quality/Contamination

- Where,
- C_t = Concentration at time ‘t’ in mg/L
- C_0 = Initial Concentration in mg/L
- t = time in days
- K = first order decay coefficient

Problem

- Determine the concentration of a contaminant at the downstream well, if the upstream concentration is 80mg/L. Assume decay constant (k) to be 10^{-4} per day & time (t) = 274 years.

Ground Water Recharge

- It is also known as deep percolation
- It is a hydrologic process, where water moves downward from surface to ground.
- Recharge can occur both naturally & artificially.
- Natural way of recharge is occurred through hydrological cycle.

Ground Water Recharge

- Recharge occurs artificially, when rainwater, reclaimed water or recycled water is injected or routed to the subsurface.
- Recharge can help move excess salts that accumulate in the root zone to deeper soil layers or into the deep groundwater system.

Ground Water Flow

- The ground water flow is governed by Darcy's law which can be expressed as follows:-
- $Q = KiA$
- $\quad = KA(dh/dL)$
- $\quad = KA\{(h_2-h_1)/(L_2-L_1)\}$

Ground Water Flow

- Where,
- Q = horizontal flow in m^3/sec
- K = hydraulic conductivity in m/sec
- i = dh/dL= hydraulic gradient
- A = cross sectional area in square mtr

Ground Water Flow

- h_2- h_1= water head drop
- L_2-L_1 = Length difference over which water head drop occurs
- q = Q/A
- = Specific discharge or
- discharge per unit area

Problem

- Determine the daily flow capacity and transmissivity of an aquifer, if it’s height, width, length are 15mtr, 800mtr & 2km respectively. The water head change over the length 2km is 3mtr. The hydraulic conductivity(K) value is $6x10^{-7}$ m/sec.

Water Table

- A water table is the underground depth, at which point the ground is totally saturated by water.
- The water table may vary due to seasonal changes in precipitation, evapotranspiration & topography etc.

Aquifer

- An aquifer is a body of saturated rock through which water can easily move.
- An aquifer is an underground layer of water bearing permeable rock from which ground water can be extracted using a water well.
- Aquifer can be of two types:-
- a) Unconfined aquifer
- b) Confined aquifer

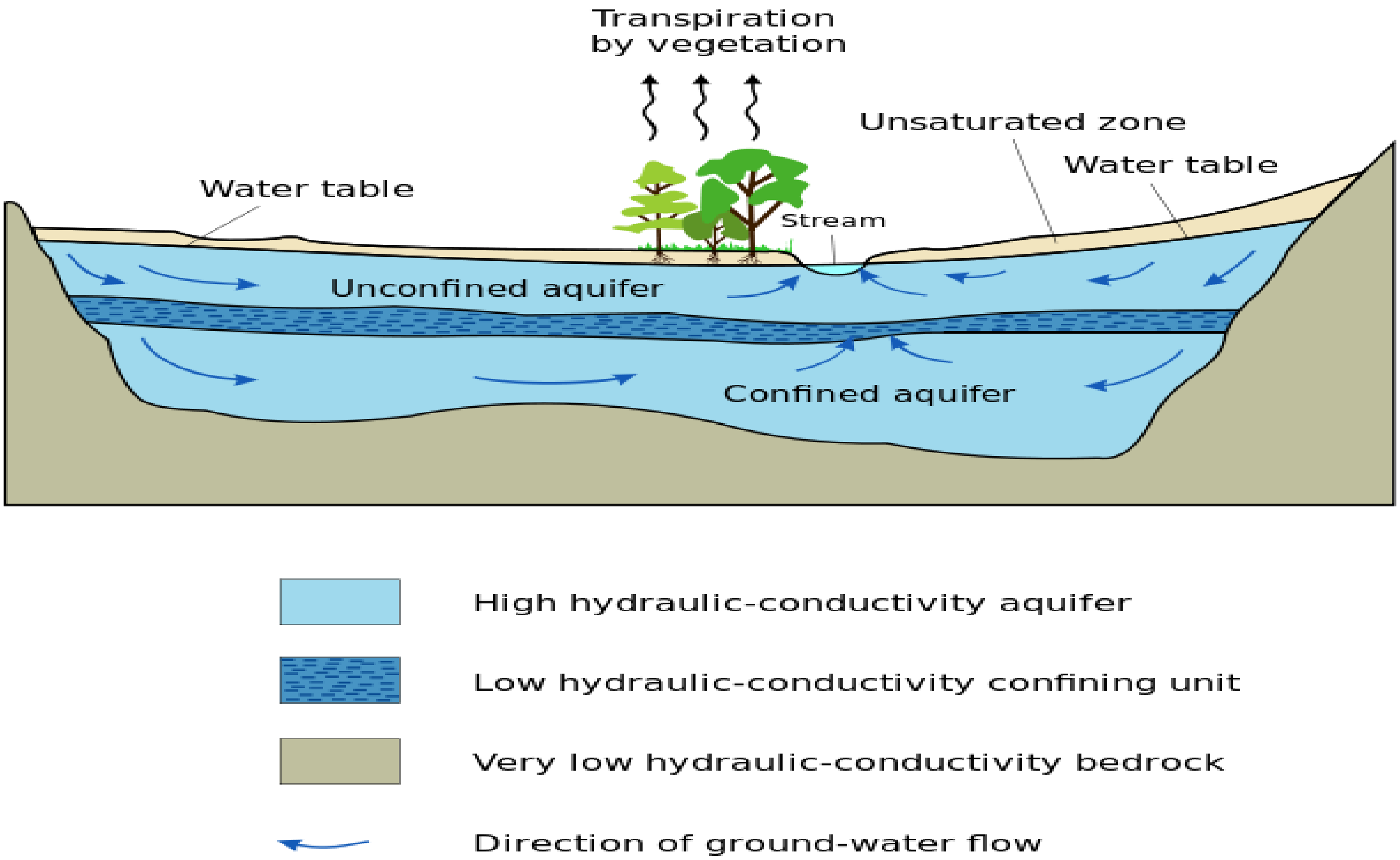
Unconfined aquifer

- An unconfined aquifer is the one which is open to receive water from the ground surface & whose water table surface is free to fluctuate up & down, depending on the recharge & discharge rate.
- These are extremely susceptible to contamination.

Confined aquifer

- These type of aquifers have rock layer with less permeability or confining bed of rock above them due to which water can't enter freely into these type of aquifers from the ground surface.
- These are less susceptible to contamination.

Figure


Transpiration by vegetation
Unsaturated zone
Water table
Water table
Stream
Unconfined aquifer
Confined aquifer
High hydraulic-conductivity aquifer
Low hydraulic-conductivity confining unit
Very low hydraulic-conductivity bedrock
Direction of ground-water flow

Concept of Hydrology

- i)Water Balance or Water Budget
- ii)Hyetograph & Hydrograph
- iii)Rainfall-Runoff Relationship or

  Rational formula for determining runoff

Concept of Hydrology

- <u>i)Water Balance or Water Budget</u>:-
- It gives the quantitative account of hydrological cycle.
- The equation for water balance is based on conservation of mass.

Concept of Hydrology

- The water balance equation is
- $P = R + E \pm \Delta S \pm \Delta G$
- Where, P is Precipitation
- R is Runoff
- E is Evaporation
- ΔS is change in soil moisture status
- ΔG is change in ground water status

Concept of Hydrology

- ii) Hyetograph & Hydrograph :-
- Hyetograph represents rainfall intensity vs time.
- Hydrograph represents runoff or stream discharge vs time.
- If time is unit i.e. 1hr., then hydrograph will be unit hydrograph.

Concept of Hydrology

- iii)<u>Rainfall-Runoff Relationship</u> or
- <u>Rational formula for determining runoff</u> :-
- $Q=CIA$
- Where,Q is runoff in m^3/sec
- C is locality coefficient
- I is Rainfall Intensity in mm/hr
- A is Catchment Area in square Km

Concept of Hydrology

- Peak Discharge (Q_P)or Peak Run-off can be expressed as follows:-
- Q_P=0.278 CIA
- Modified Rational Formula given by Wallingford is :-
- $Q_P=0.278C_VC_RIA$
- Where, C_V is volumetric runoff coefficient &
- C_R is Routing Coefficient

Water Treatment

- The objectives of water treatment are :-
- A) To produce Water which is safe for human consumption
- B) To produce Water at a reasonable cost
- C) To reduce water impurities to acceptable levels

Organoleptic Parameters

- Organoleptic Parameters are those parameters which can be sensed or felt by human organs.
- Ex:- Colour, Taste & Odour etc.

Classes of Water treatment

Class	Descripition	Source
A	No Treatment	Borehole water
B	Disinfection only	Borehole water
C	Standard water Treatment	River,Reservoir
D	Advanced/Special water Treatment	Industrial Water

Monitoring Frequency

- The water quality parameters are required to be monitored depending on the source & quality of raw water.
- The three categories are:-
- A) Minimum monitoring(C1)
- B) Current monitoring(C2)
- C) Periodic Monitoring(C3)

Water Treatment Processes

- The treatment processes of water can be classified into three stages :-
- A) Pretreatment processes
- B) Standard or Conventional processes
- C) Special or Advanced processes

A) Pretreatment processes

- Some treatment processes are required prior to standard water treatment processes which may include :-
- i) Screening
- ii) Storage
- iii) Aeration
- iv) Chemical pre-treatment

A) Pretreatment processes

- i) <u>Screening</u>:-
- Different types of screens are used in this process. Those are can be :-
- a)Coarse Screen
- b)Fine Screen
- c)Micro Screen

A) Pretreatment processes

- a) <u>Coarse Screen</u>:-
- These screens contain typically inclined bars of 25mm dia & 100mm spacing, preventing large floating matters from entering the treatment plant

A) Pretreatment processes

- b) Fine Screen:-
- If storage is not provided, then fine screens are fitted after the coarse screens.
- If there is storage, then fine screens are placed at the outlet of the storage tanks.
- Fine screens are typically mesh with openings about 6mm dia or square

A) Pretreatment processes

- C) <u>Micro Screen</u>:-
- In micro screens, mesh openings range from 20 to 40 µm.
- These type of screens are used only for relatively uncontaminated water.

A) Pretreatment processes

- ii) Storage:-
- Storage tanks balance the flows going to the treatment plant.
- Storage capacity should be equivalent to 7 to 10 days of the average water demand.
- The period of storage shouldn’t be long, so as not to encourage the growth of unwanted organisms

A) Pretreatment processes

- iii) Aeration:-
- Aeration is the supply of oxygen from the atmosphere to water to effect beneficial changes in the quality of water.
- It is a common treatment process for groundwater

A) Pretreatment processes

- Aeration is generally used for the followings:-
- a) To release excess H_2S gas which may cause undesirable taste & odour.
- b) To release excess CO_2 which may have corrosive properties
- c) To increase oxygen content of water.

A) Pretreatment processes

- iv) Chemical pre-treatment:-
- The chemical pre-treatment to remove undesirable properties of water like algae or excess colour is a more expensive process than chemical post-treatment.
- In pre-treatment, greater amount of chemicals are required to effect the same result as some of the chemicals are absorbed by turbidity of water.

A) Pretreatment processes

- The two Chemical pre-treatment processes which are generally used are:-
- a) Pre-Chlorination
- b) Activated Carbon

A) Pretreatment processes

- a) Pre-chlorination:-
- It is used on low turbidity water with a high coliform count. The chlorine is injected into the water stream & it oxidizes & precipitates iron & manganese. It also kill pathogens & reduces colour. The chlorine dose used is 5mg/L. Pre-chlorination also reduces NH_3 in both surface water & ground water supplies.

A) Pretreatment processes

- b) Activated Carbon:-
- The activated Carbon is used for:-
- i) Removal of Photosynthetic Algae
- ii) Improvement of colour & odour
- iii) Removal of organic compounds

A) Pretreatment processes

- Activated Carbon can be used either as PAC (Powdered Activated Carbon) or as GAC (Granular Activated Carbon).
- Generally for water treatment PAC is used, but GAC is used where taste & odour of water have an industrial base.
- PAC has lower cost & efficiency than GAC.
- Doses may vary from 3 to 20 mg/L.

B) Standard or Conventional processes

- It includes:-
- i) Sedimentation
- ii) Coagulation
- iii) Flocculation
- iv) Filtration &
- V) Disinfection

B) Standard or Conventional processes

- i) Sedimentation:-
- The heavier large particles settle down by the force of gravity at the bottom of the sedimentation tank, which is called Sedimentation.
- Stoke's law for settling velocity is the deciding force for sedimentation.

B) Standard or Conventional processes

- Stoke's law can be represented by:-
- $V_S = (g/18\mu)(\rho_s - \rho_w)d^2$
- Where, V_S is settling velocity
- g is acceleration due to gravity
- μ is dynamic viscocity
- d is dia of settling particle
- ρ_s is density of particle settling
- ρ_w is density of water

B) Standard or Conventional processes

- ii) Coagulation:-
- The lighter smaller particles don't settle down by the force of gravity.
- To make them settle down, some amount of coagulants are added to the water, which is called Coagulation.

B) Standard or Conventional processes

- Some examples of coagulants are:-
- Alum i.e. aluminium sulphate
- Ferric Chloride
- Ferric Sulphate
- Ferrous Sulphate

B) Standard or Conventional processes

- iii) Flocculation:-
- When coagulants are added to the water, the lighter smaller particles coagulate or combine with each other forming bigger particles, known as floc & the process is called flocculation.

B) Standard or Conventional processes

- iv) Filtration:-
- It is the process of passing water through a porous medium, with the expectation that the filtrate water has better quality than the incoming water.

B) Standard or Conventional processes

- Generally, two types of filters are used
- a)<u>Rapid gravity filter</u>:-
- Here rate of filtration is high i.e. 5 to 20m/hr.
- b) <u>Slow sand filter</u>:-
- Here rate of filtration is slow i.e. 0.1 to 0.2m/hr.

Comparision

Criteria	Rapid sand filters	Slow sand filters
Improvement of water quality	With pre-treated raw water, a filtrate quality is possible that has less than 1 NTU, 90% removal of coliforms, 50 – 90% removal of Cryptosporidium and Giardia cysts, 10% removal of colour, 5% removal of Total Organic Content (WEDC, 1999 [ref 02]). As a single process, rapid sand filtration was ranked third most effective of all treatment processes, given a range of pathogenic, chemical and aesthetic factors.	With raw water, a filtrate quality is possible that has less than 1 NTU, 95% removal of coliforms, 99% removal of Cryptosporidium and Giardia cysts, 75% removal of colour, 10% removal of Total Organic Content (WEDC, 1999 [ref 02]). As a single process, slow sand filtration was ranked second most effective of all treatment processes, given a range of pathogenic, chemical and aesthetic factors.
Rate of flow	A flow of between 4 – 21 m/h can be expected from a rapid sand filter, which is somewhere between 20 and 50 times faster than the range of slow sand filtration.	Flow rates are usually around 0.1 m/h but can increase up to 0.4 m/h. Check out Flow Rates for more information.
Filter media	Rapid sand filters are made using graded sand, sometimes with an additional coarser layer of material on top of the sand to increase the flow rate (for example, anthracite), in which case they become known as dual-media filters. The effective size for rapid filters is usually greater than 0.55mm with a Uniformity Coefficient of less than 1.5.	Slow sand filters on the other hand, should ideally have an effective size of between 0.15 – 0.35mm, and a Uniformity Coefficient of between 1.5 – 3, but preferably less than 2.
Penetration of solid matter	Penetration of suspended matter into the sand bed is deeper for rapid sand filters, which are usually cleaned by backwashing.	Solids only tend to penetrate slow sand filter beds by between 0.5 and 2 cm by comparison, allowing more manual methods to be employed for cleaning.
Pre-treatment	Pre-treatment is usually necessary for rapid sand filtration. Such treatment could include coagulation and flocculation, followed by sedimentation.	No pre-treatment is usually necessary for raw waters with turbidities of less than 50 NTU. Huisman and Wood (1974 [ref 03]) suggest that the best filtration occurs when turbidity is less than 10 NTU. Note that coagulation and flocculation are not appropriate pre-treatments for slow sand filters because floc carryover is possible, which rapidly blocks the sand bed.

B) Standard or Conventional processes

- V) Disinfection:-
- By disinfection, pathogens & micro-organisms are killed, thereby making water more pure.
- The requirements of a good disinfectant are-
- a) It should be toxic to micro-organisms.
- b) It should have a fast rate of kill.

B) Standard or Conventional processes

- c) It should be persistent enough to prevent regrowth of organisms in the distribution system.
- d) It shouldn’t produce undesirable compounds.
- e) It should be safe to handle.
- f) It should be of reasonable cost.

B) Standard or Conventional processes

- <u>Chick's law</u>:-
- The rate of destruction of micro-organisms is often a first order chemical reaction as given by Chick's law i.e.

$$\frac{d}{dt}(N_t)\alpha(N_t) \Rightarrow \frac{d}{dt}\left(N_t\right) = -k(N_t)$$

$$So, N_t = N_0 e^{-kt}$$

B) Standard or Conventional processes

- Where,
- N_t = Number of organisms at time ‘t’
- N_0 = Number of organisms at time ‘t’= 0
- K = Rate constant depends on types of micro-organisms present & types of disinfectants used

B) Standard or Conventional processes

- The various examples of disinfectants are:-
- a) Chlorine dioxide
- b) Chlorination
- c) Chloramines
- d) UV radiation

Chlorine demand & Breakpoint Chlorination

- When chlorine is added to water, the chlorine at first oxidizes inorganic compounds & some amount of chlorine will be consumed by organic matter present in water. Then some amount of chlorine will be used for formation & subsequent destruction of chloramines.

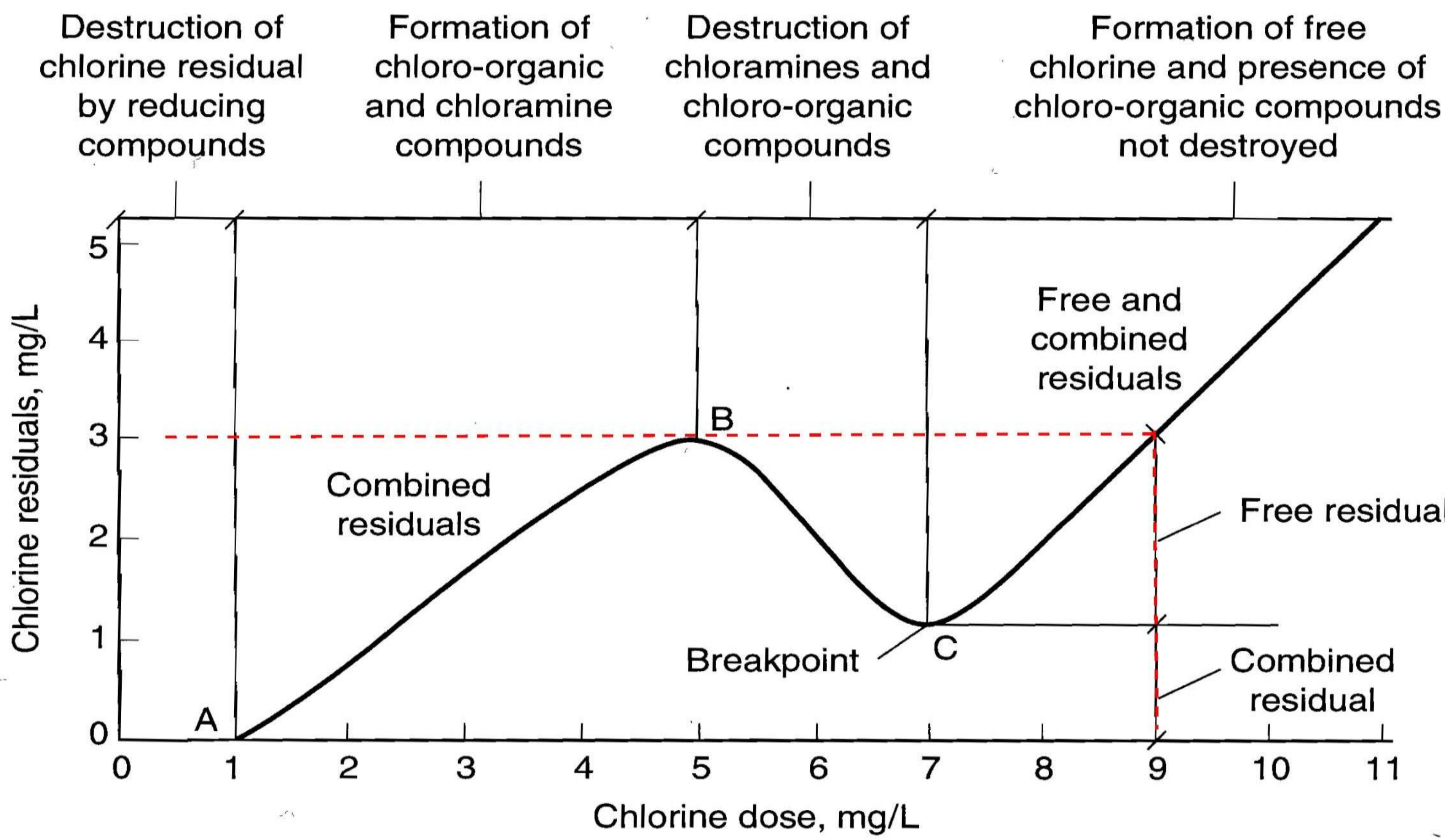
Chlorine demand & Breakpoint Chlorination

- The amount of chlorine required to fulfill the above consumption requirements are called <u>chlorine demand</u>.
- The point at which the chlorine demand is satisfied is called the <u>breakpoint chlorination.</u>

Chlorine demand & Breakpoint Chlorination

- The excess dose of chlorine after breakpoint, is available for disinfection which appears as residual chlorine.
- A residual chlorine of minimum 0.5mg/L is maintained in disinfection practices.

Chlorine demand & Breakpoint Chlorination



C) Special or Advanced processes

- The purposes of advanced water treatment processes are:-
- i) To take water treated by standard water treatment processes & to improve it to an exceptionally high quality water as often required by particular industries like food industry & pharmaceuticals etc.

C) Special or Advanced processes

- ii) To treat water containing specific chemical or microbiological contaminants, so that they can be brought to an acceptable standard.

Flow Diagram

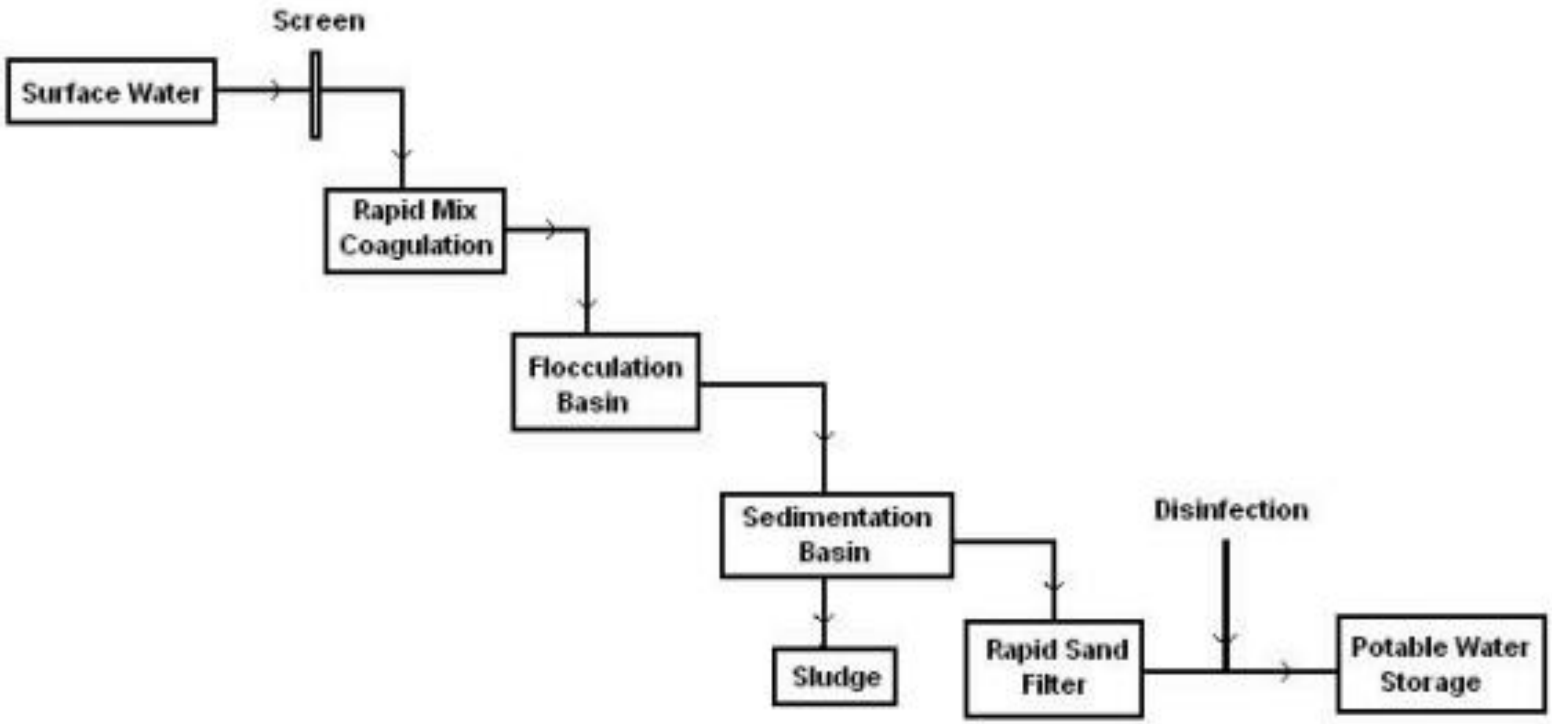


Figure 1 Flow diagram of a conventional potable water treatment plant.

Wastewater Treatment

- Introduction:-
- Generation of wastewater is based on our water consumption rate, which is increasing & the way we use water.
- As undesirable contaminants are likely to be present in the wastewater, it can contaminate or degrade our surface water or ground water resources, hence it should be properly treated before releasing to the water bodies or environment.

Types of wastewater

- a) Domestic/Sanitary wastewater
- b) Industrial wastewater
- c) Agricultural wastewater
- d) Storm/Runoff water

Common Terms

- <u>Sewage</u>:- It refers to domestic / sanitary wastewater.
- <u>Sewer</u>:- It refers to pipes carrying sewage.
- <u>Sewerage</u>:- It refers to sewer network systems.
- <u>FOG</u>:- It refers to Fat, Oil & Grease, which are basically immiscible layer in the wastewater.

Wastewater Treatment Processes

- a) Pre-treatment
- b) Primary treatment
- c) Secondary or Biological treatment

a) Pre-treatment

- Pre-treatment of municipal wastewater is required to make it useful for further treatment & to decrease overall load on the system.
- It includes Screening, Grit Channels, Oil & Grease removal, Chemical pre-treatment etc.

b) Primary treatment

- It basically removes suspended solids(SS) from the wastewater.
- Sometimes, it also removes some organic solids along with inorganic suspended solids.
- It includes sedimentation, coagulation etc.
- The removal efficiency w.r.t. SS is 50-70% and w.r.t. removal of BOD is 25-40%.

c) Secondary or Biological treatment

- It can be divided into two major categories, depending on the availability of oxygen.
- i) Aerobic Process

  i.e. it occurs in presence of oxygen &
- ii) Anaerobic Process

  i.e. it occurs in absence of oxygen.

c) Secondary or Biological treatment

- Aerobic Processes like Trickling Filter, RBC(Rotating Biological Contactor) & ASP(Activated Sludge Process) etc.
- Anaerobic process has three major steps like Hydrolysis, Acidogenesis or Fermentation & Methanogenesis.

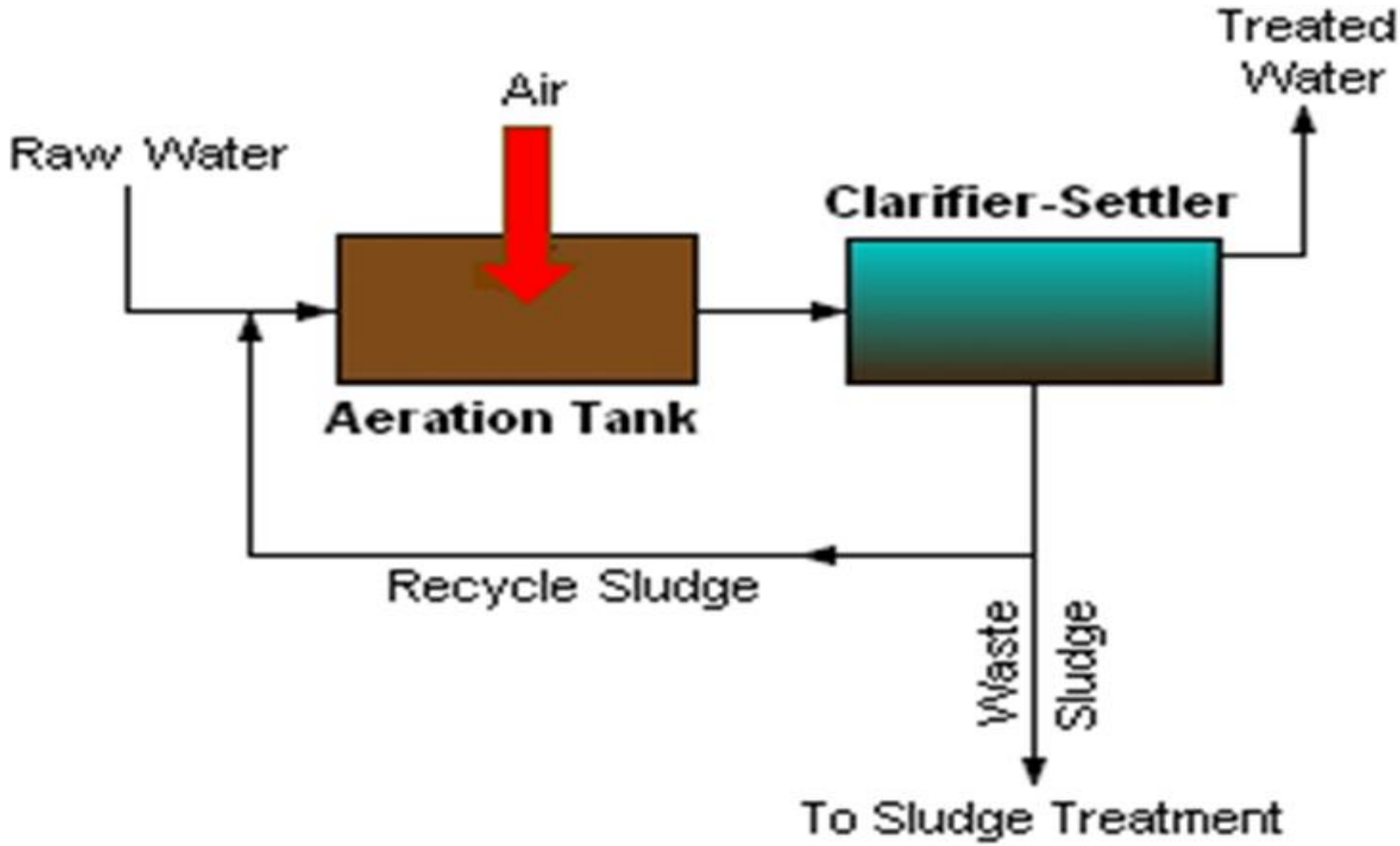
ASP(Activated Sludge Process)

- It is an excellent method of treating either raw sewage or more generally the settled sewage.
- The sewage discharged from the primary sedimentation tank, which is normally used in this process, is mixed with 20 to 30% of activated sludge, which contains a large concentration of highly active aerobic micro-organisms, which increases the rate of decomposition.

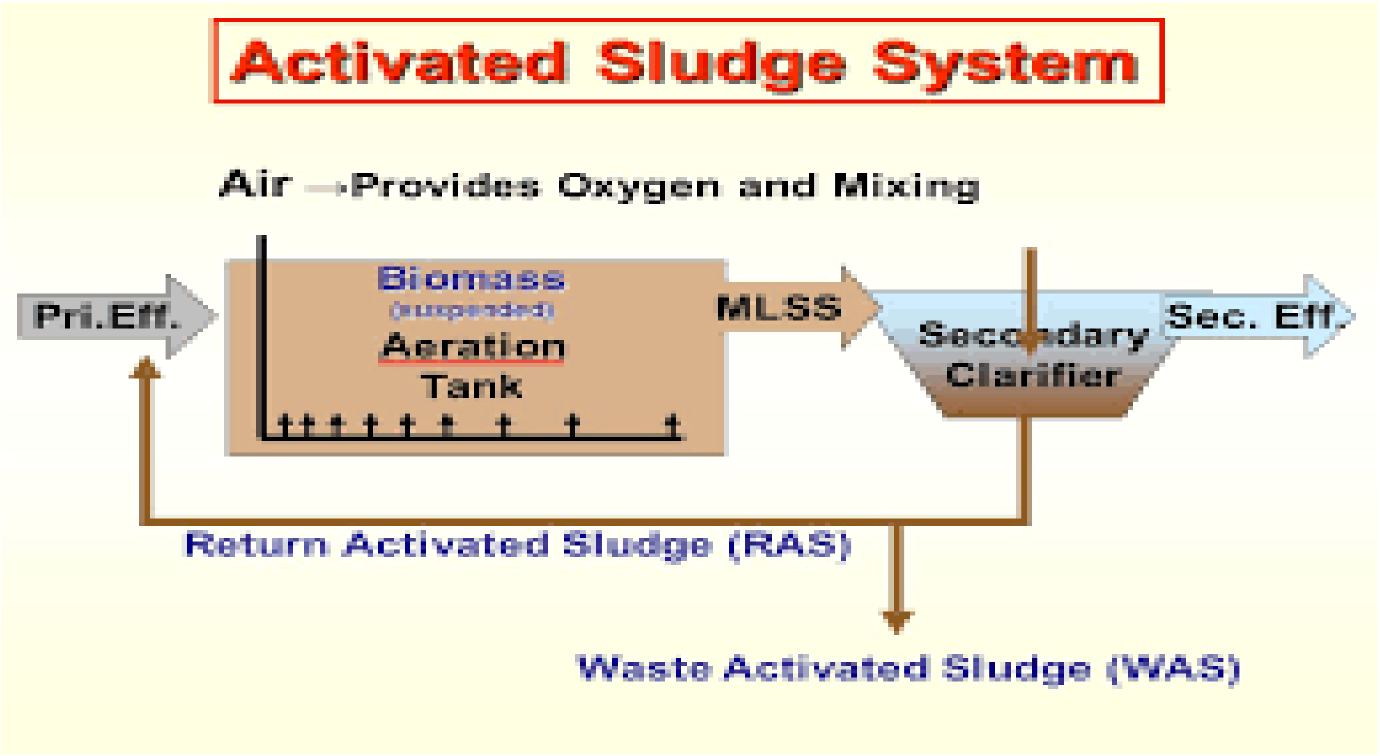
ASP(Activated Sludge Process)

- The ASP unit basically consists of CSTR (Continuously Stirred Tank Reactor), which is an aeration basin equipped with surface aerators and secondary clarifier unit.
- The aerobic bacteria culture is developed in the reactor and remain in suspension.

ASP(Activated Sludge Process)



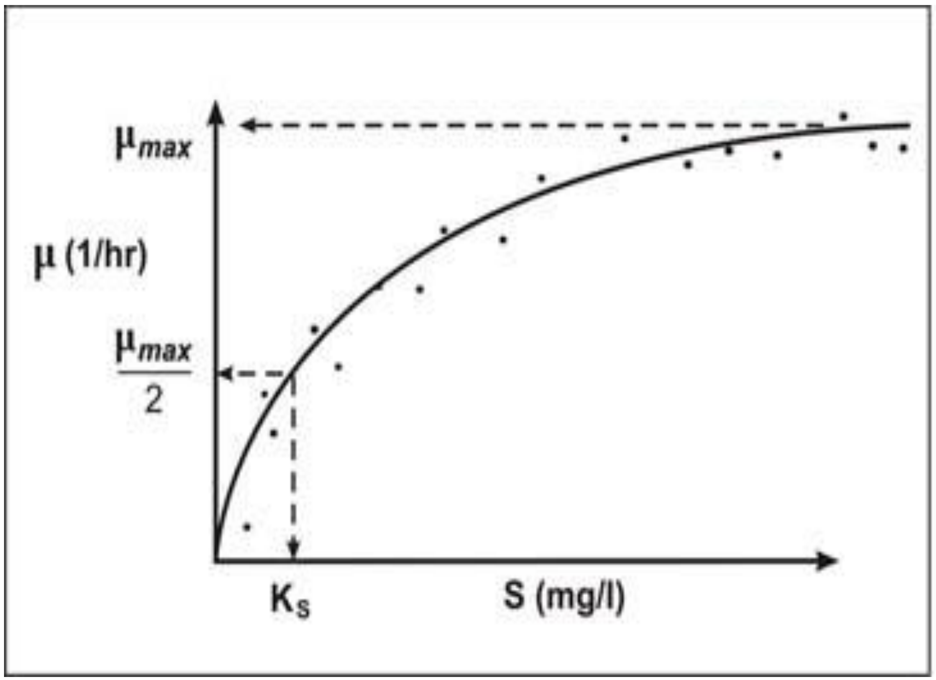
RAS, WAS & MLSS(Mixed Liquor Suspended Solids)



Monod Model

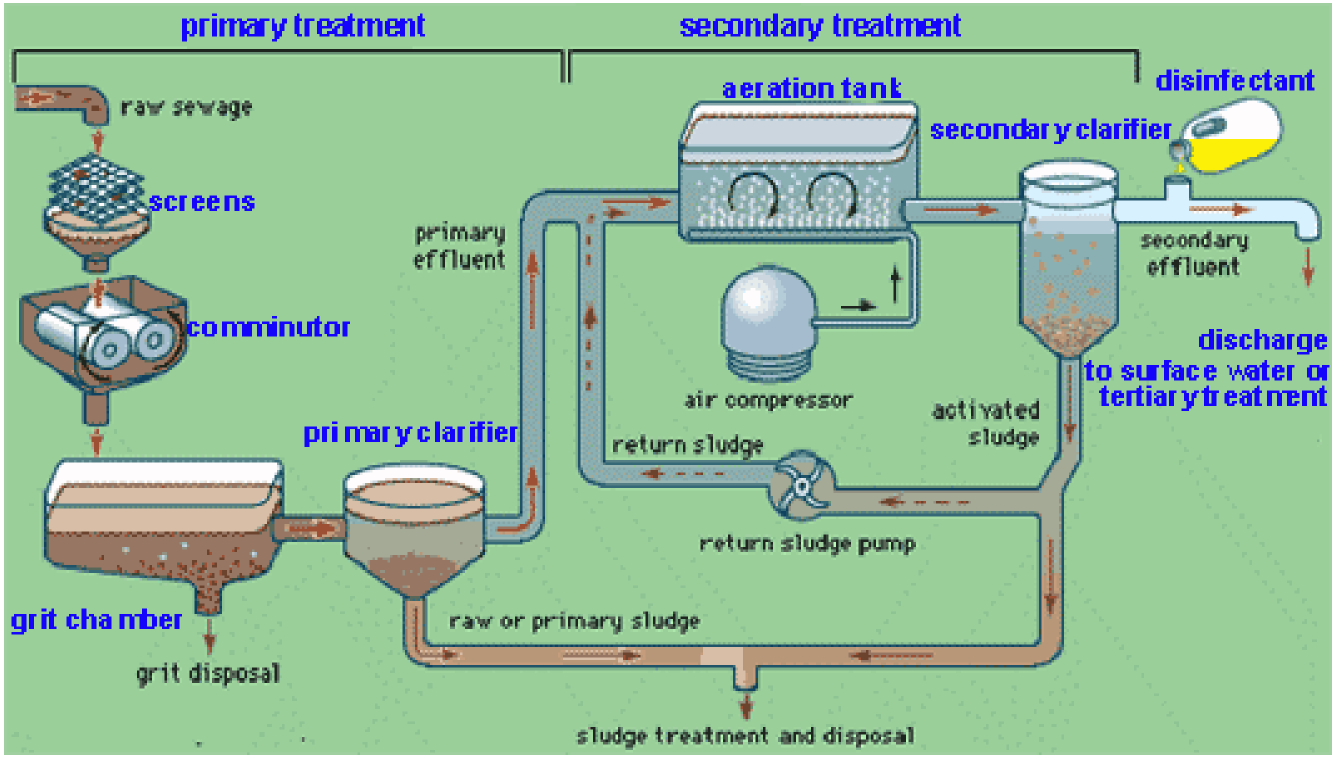
- Monod Kinetics is used for microbial growth calculations, and reactor sizing, in the activated sludge process.
- The pertinent equations are $r_g = dX/dt = \mu X = \mu_{max} SX / (K_s + S)$, where the terms have the usual meanings, S, substrate conc, X, microbe conc.
- The diagram below shows how K_s is determined from μ_{max} . Monod's equation is an empirical equation to determine r_g , the growth rate of microbes.

Monod Model



$$\mu = \mu_{max}\left(\frac{S}{S+K_S}\right) \quad (5)$$

wastewater treatment flow diagram



Aerobic vs Anaerobic Process

- In aerobic process, molecular oxygen present which is absent in case of anaerobic process.
- In aerobic process, stable oxidized end products like CO_2 & H_2O are generated, but in case of anaerobic process stable reduced end products like CH_4 & NH_3 are generated.
- In aerobic no byproduct recovery, but in anaerobic byproduct methane gas is useful.

Aerobic vs Anaerobic Process

- In aerobic appreciable microbial growth occurs, but in anaerobic no appreciable growth of microbes.
- In aerobic less skilled operation & in anaerobic more skilled/stringent operation is required.
- In aerobic low capital cost but high operating cost & in anaerobic high capital investment but low operating cost.

Aerobic vs Anaerobic Process

- Aerobic process is suitable for low BOD wastewater like sewage while anaerobic process is suitable for high BOD wastewater/ sludge coming from sugar mills and other agrochemical operations.

Reactor Configuration

- In environmental engineering, particularly in water & waste water treatment reactors used are of 3 types –

  i) Batch Reactor(BR)

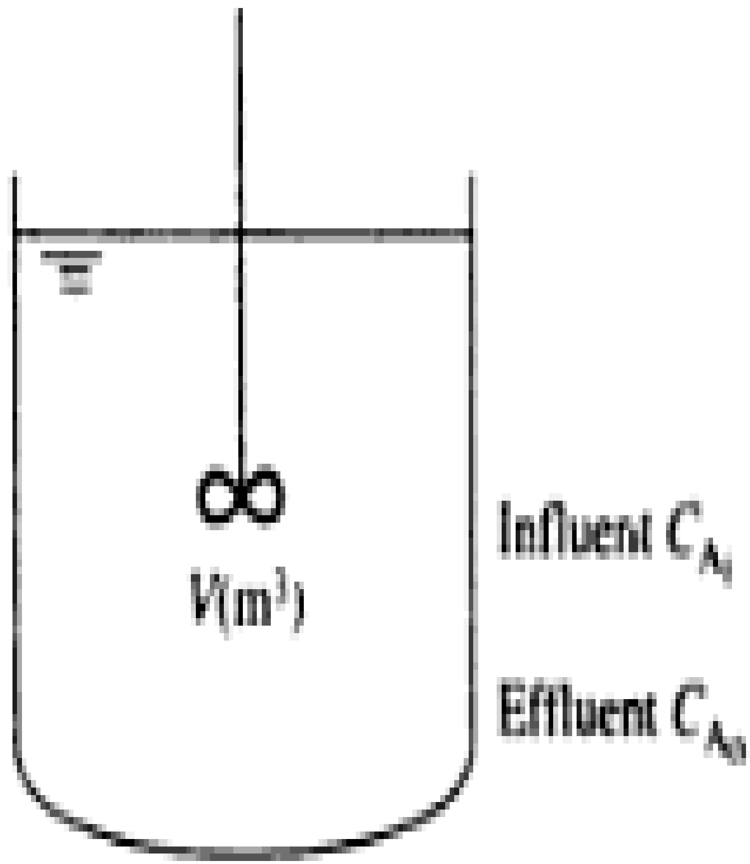
  ii) Continuously Stirred Tank Reactor(CSTR)

  iii) Plug Flow Reactor(PFR)

i) Batch Reactor(BR)

- In this case, the reactants or inputs enter into the reactor, remain for desired time & then discharged.
- Ex:- BOD test

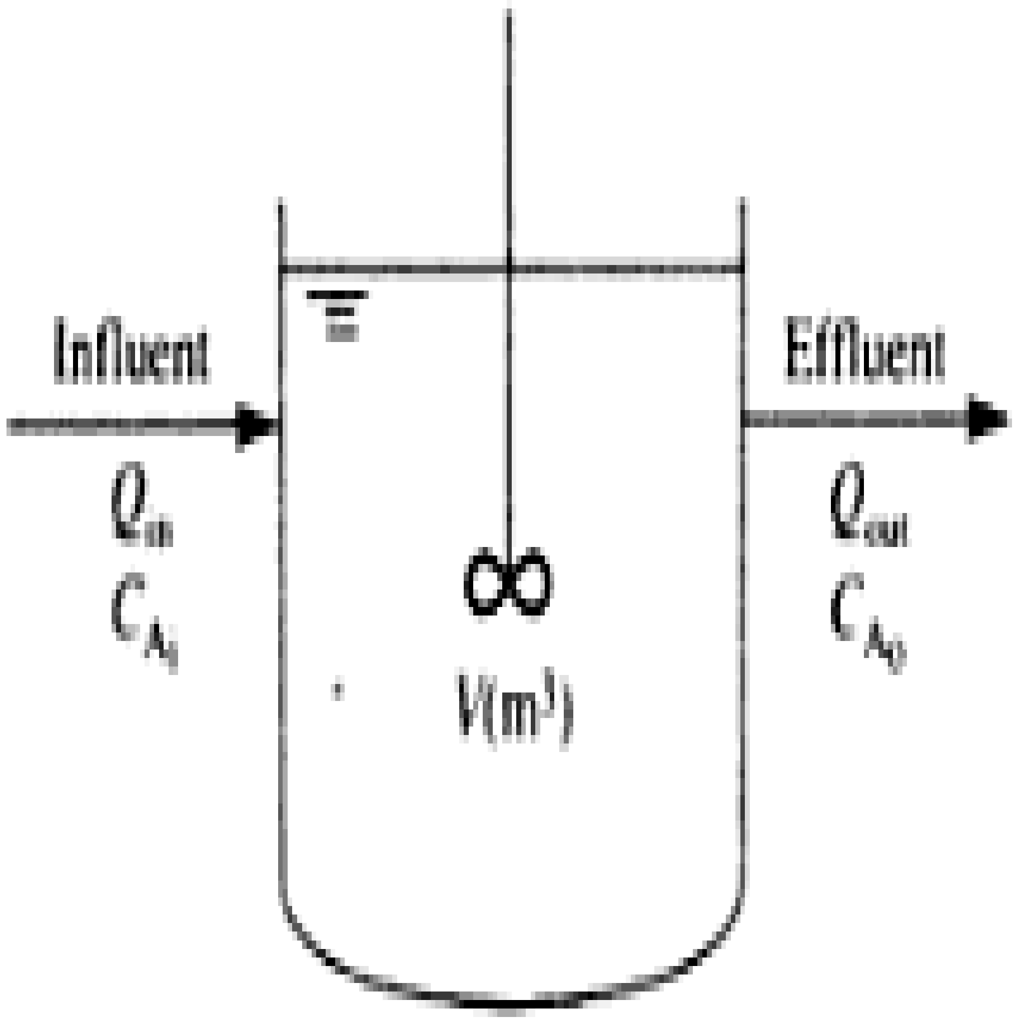
Diagram of BR



ii) Continuously Stirred Tank Reactor(CSTR)

- In this case, reactants continuously enter into the reactor & the products are continuously discharged from a well-mixed vessel.
- Ex:- Waste water treatment

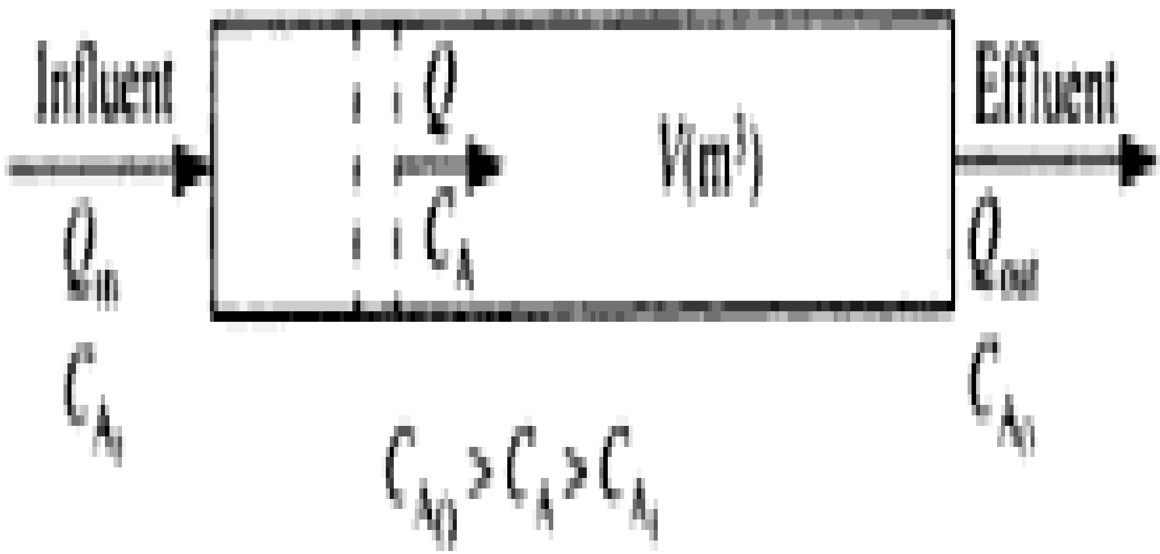
Diagram of CSTR



iii) Plug Flow Reactor(PFR)

- In this case, the reactants or inputs are entered at one end & products are discharged at the other end, after spending a minimum retention time in the system.
- Ex:- mixing of pollutant in river flow

Diagram of PFR



Soil Chemistry

- The order of 10 most abundant elements in soil & crustal rocks are –
- In soil :

  O > Si > Al > Fe > C > Ca > K > Na > Mg > Ti
- In Crustal rock :

  O > Si > Al > Fe > Ca > Mg = Na > K > Ti > P

Soil Chemistry

- The most common soil minerals are –

  Quartz - SiO_2

  Calcite - $CaCO_3$

  Gypsum - $CaSO_4.2H_2O$

  Gibbsite - $Al(OH)_3$

Soil Chemistry

- <u>Soil Salinity</u> :-

  A soil solution is considered saline, if the electrical conductivity (EC) is greater than 4000 micro-siemens/cm or µs/cm.

  This condition occurs, when evaporation exceeds precipitation.

  If this condition continues then, saltpan will occur.

Soil Chemistry

- General Composition of soil :-

1)Inorganic or Mineral matter–45% (Ca,Mg etc.)

2) Organic matter – 5% (Humus)

3) Soil water – 25%

4) Soil air – 25%

Soil Chemistry

- Types of soil in India :-

  1. Red soil
  2. Black soil
  3. Mountainous soil
  4. Desert soil
  5. Alluvial soil

  (fine grained fertile soil present in river bed)

Soil Chemistry

- The elemental properties of soil in relation to infiltration are –
  1. Bulk Density or Dry Density
  2. Particle Density
  3. Porosity
  4. Water content
  5. Degree of saturation

Soil Chemistry

1. Bulk Density(ρ_b)=M_d/V_t

= Dry mass of soil/Total volume of soil

2. Particle Density(ρ_m)=M_d/V_d

= Dry mass of soil/Dry volume of soil

3. Porosity(ϕ)= $(V_a+V_w)/V_s$

= (Volume of air + Volume of water)/Volume of soil

4. The water content (Θ) = V_w/V_s

= Volume of water/ Volume of soil

Soil Chemistry

5. Degree of saturation(s):-

It is a measure of wetness.

So, $S = V_w/(V_a+V_w)$

$= (V_w/V_s)/[(V_a+V_w)]/V_s$

$= \theta/\phi$

Soil Chemistry

- Soil Moisture Deficit (SMD) :-

  The Soil Moisture Deficit is the term used when soil moisture is below the Field Capacity (FC) of soil.

- Field Capacity (FC) :-

  It is the maximum % of volumetric soil moisture that a soil sample will hold freely against earth gravity. It varies from 5% for sandy soil to 30% for dry soil.

Atmospheric Chemistry

- Primary Pollutant :-

  The Primary Pollutants are those which are emitted by identifiable manmade sources.

  Ex:- SO_X, NO_X,CO

Atmospheric Chemistry

- <u>Secondary Pollutant</u> :-

  The secondary pollutants are those formed in the atmosphere by chemical or photochemical reactions of primary pollutants.

  Ex:- Acid rain, Photochemical Smog

- <u>Photochemical smog</u> :-

  It is basically the product of HC(Hydrocarbon)+NO_x+Sunlight

PAN

- PAN is a class of compounds, Peroxy- Acyl- Nitrates, that are formed by photochemical reactions at the ground level. It is a key ingredient of SMOG, is a respiratory inhibitor and an eye irritant. The commonest PAN is Peroxy-Acetyl- Nitrate.
- The reactions involving PAN formation are complex, and not totally well understood. However, the equations below give a rough pathway to the photochemical formation of PAN compounds.

PAN

- PANs are secondary pollutants which are present in photochemical smog. PANs are not directly emitted as exhaust from power plants or internal combustion engines, but they are formed from other pollutants by chemical reactions in the atmosphere. Free radical reactions catalyzed by UV light from the sun oxidize unburned hydrocarbons to aldehydes, ketones & dicarbonyl compounds whose secondary reactions create peroxyacyl (the most common is the peroxyacetyl) radicals, which combine with the NO_2 radical to form Peroxyacylnitrates (PANs); if the radical is peroxyacetyl, then peroxyacetylnitrate (PAN) is formed.

PAN

- The reactions involved, in a simplified manner, are as follows:
- NO_2 + hv -------> NO + O
- O + O_2 ---------> O_3
- O_3 + NO --------> NO_2 + O_2
- When the nascent oxygen combines with hydrocarbon (i.e. HC or RC), then acyl radicals, RCO , are formed:
- RC + O ----------> RCO

PAN

- Then these acyl radicals combine with oxygen molecule to form peroxy-acyl radicals
- RCO + O_2 ----->
  RCO_3

and finally, peroxy-acyl radicals RCO_3 combine with NO_2 to form RCO_3NO_2.

- RCO_3 + NO_2 ----------> RCO_3NO_2 , a peroxy-acyl nitrate
- If R is CH_3 (methyl group) then, $CH_3COOONO_2$ or $C_2H_3NO_5$ (peroxy-acetyl nitrate) is formed, which is called PAN.

Atmospheric Chemistry

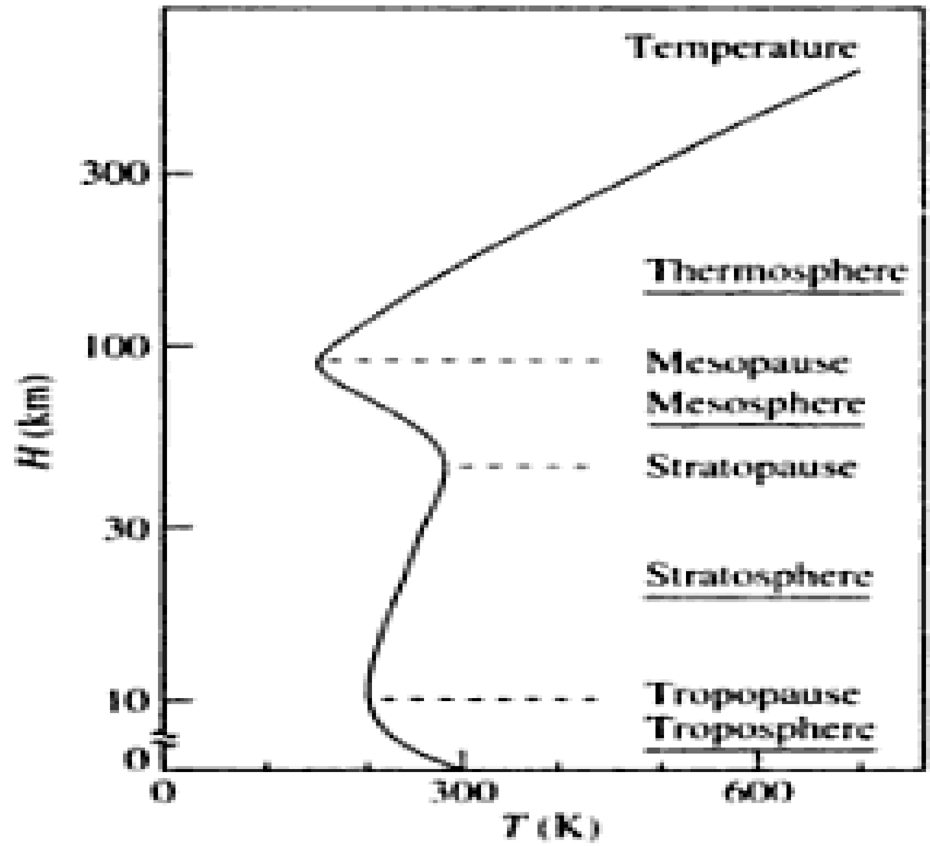


Figure 3.13 Vertical temperature profile of earth's atmospheric regions.

Atmospheric Chemistry

- Troposphere – 0-12 km
- Stratosphere – 12-50 km
- Mesosphere – 50-80 km
- Thermosphere – 80-700 km

Atmospheric Chemistry

- The **Troposphere** is mostly heated by transfer of energy from the earth surface and temperature decreases with altitude or height.
- In **Stratosphere** temperature increases with height due to increased absorption of UV radiation by Ozone Layer.

Atmospheric Chemistry

- In **Mesosphere** temperature decreases with height due to decreasing solar heating.
- In **Thermosphere** temperature increases with height due to absorption of highly energetic solar radiation which causes atmosphere particles in this layer to become electrically charged.

Air Pollution

- Criteria Pollutants:-
- The criteria pollutants as defined by USA, EC(European Community) & WHO includes CO,NO_2,SO_2,Pb,PM-10(Particulate Matter of dia less than 10μm)
- These are generally found in urban environment.

Air Pollution

- Non-Criteria Pollutants:-
- The non-criteria air pollutants are those for which emission limits from industry are set or fixed.
- These are more poisonous & hazardous w.r.t. criteria pollutants
- Ex:- Benzene(C_6H_6),Carbon disulphide(CS_2), Arsenic, Asbestos

Air Pollution

- Acid Deposition:-
- Rainwater has P^H approximately 5.7 & rainwater having P^H less than this will be treated as acid rain, which will be a reason for acid deposition on the earth.
- Hydrocarbon(HC),SO_X,NO_X emitted from industries & vehicles are the main source of acid deposition.

Air Pollution

- GHG(Green House Gases):-
- A GHG absorbs & emits radiation within the thermal infrared range having wavelength between 700nm to 1mm i.e.
- 700×10^{-9} m to 10^{-3}m
- The major GHG in order of their contribution are CO_2>CFCs>CH_4>N_2O(Nitrous Oxide)

Air Pollution

- Air Pollution Meteorology:-
- The meteorological factors are –
- Wind speed & direction
- Temperature & humidity
- Turbulence
- Atmospheric Stability
- Topographic effects on meteorology

Air Pollution

- <u>Scales</u>:-
- Air pollution emission can be measured in 3 scales-
- a) Microscale
- b) Mesoscale
- c) Macroscale

Air Pollution

- a) <u>Microscale</u>:-
- It is of the order of 1km & duration is minutes to hours.
- Ex:- Chimney gases

Air Pollution

- b) Mesoscale:-
- It is of the order of 100km & duration is hours to days.
- Ex:- Mountain valley wind

Air Pollution

- c) Macroscale:-
- It is of the order of 1000km & duration is days to weeks.
- Ex:- wind over oceans & continents

Air Pollution

- Wind Speed:-
- Wind speed at any height(z) can be determined using power law relationship i.e.
- $U_Z=U_{10}(Z/Z_{10})^P$

Air Pollution

- Where,
- U_Z is wind speed at height Z mtr
- U_{10} is wind speed at 10mtr height
- Z is height in mtr
- Z_{10} is 10 mtr height
- P is exponent depends on terrain & stability class

Air Pollution

- Q. Use power law velocity profile equation to determine U_{20},U_{50},U_{100},U_{200} if U_{10} is 5m/sec & p is 0.2.

Air Pollution

- <u>Lapse Rate</u>:-
- In the lower troposphere, the temperature usually decreases with altitude.
- The rate of temperature change or gradient is known as the lapse rate.
- Lapse rate can be ambient or adiabatic.

Air Pollution

- <u>Ambient Lapse Rate (ALR)</u> or
- <u>Environmental Lapse Rate(ELR)</u>:-
- The temperature change or gradient with respect to rising altitude is known as ambient lapse rate & it varies from day to day & day to night.
- This is the actual change of temperature with altitude for the stationary atmosphere.

Air Pollution

- Adiabatic Lapse Rate:-
- The temperature change of a parcel of air against rising altitude under adiabatic condition (i.e. occurring without the addition or loss of heat) is called the adiabatic lapse rate.

Air Pollution

- Adiabatic Lapse Rate can be of two types-
- i) Dry Adiabatic Lapse Rate(DALR)
- ii) Moist adiabatic lapse rate (MALR) or
- Saturated adiabatic lapse rate(SALR)

Air Pollution

- For dry air i.e. DALR value is 0.98^0C per 100mtr
  or approximately 1^0C per 100mtr
  or 10^0C per KM height
- For moist air i.e. MALR value is 0.55^0C per 100mtr or approximately 0.6^0C per 100mtr
  or 6^0C per KM height.

Air Pollution

- Atmospheric Dispersion:-
- For determining atmospheric dispersion, generally 5 models are used like –
- Gaussian model
- Numerical model
- Statistical model
- Emperical model
- Physical model

Air Pollution

- Out of the above models, Gaussian model is generally used.
- The various assumptions of Gaussian model are –
- i) There is no variation in wind speed & direction between the source & receptor.

Air Pollution

- ii) All discharges remain in the atmosphere.
- iii) Dispersion doesn’t occur in the downward direction.
- iv) Emission rates are assumed constant & continuous.

Equipment Selection & Design

- The Equipment Selection & Design is made on the basis of the types of compounds which are required to be removed.
- Generally, compounds can be of three types –
- a) Volatile Organic Compounds(VOCs)
- b) Inorganic Compounds
- c) Particulate matter

Equipment Selection & Design

- The major types of equipments which are used are –
- i) Incinerators
- ii) Absorbers
- iii) Adsorbers
- iv) Condensors
- v) Filters

Equipment Selection & Design

- vi) Scrubbers or wet collectors:-
- It is an apparatus using water or solution for purifying gases or vapours
- vii) Various particle collection devices like ESP(Electrostatic Precipitator)
- viii) Impingement separators:-
- By density difference, it separates solids from gases

Equipment Selection & Design

- ESP:- An **electrostatic precipitator** (ESP) is a highly efficient filtration device that removes fine particles, like dust and smoke, from a flowing gas using the force of an induced electrostatic charge minimally impeding the flow of gases through the unit.

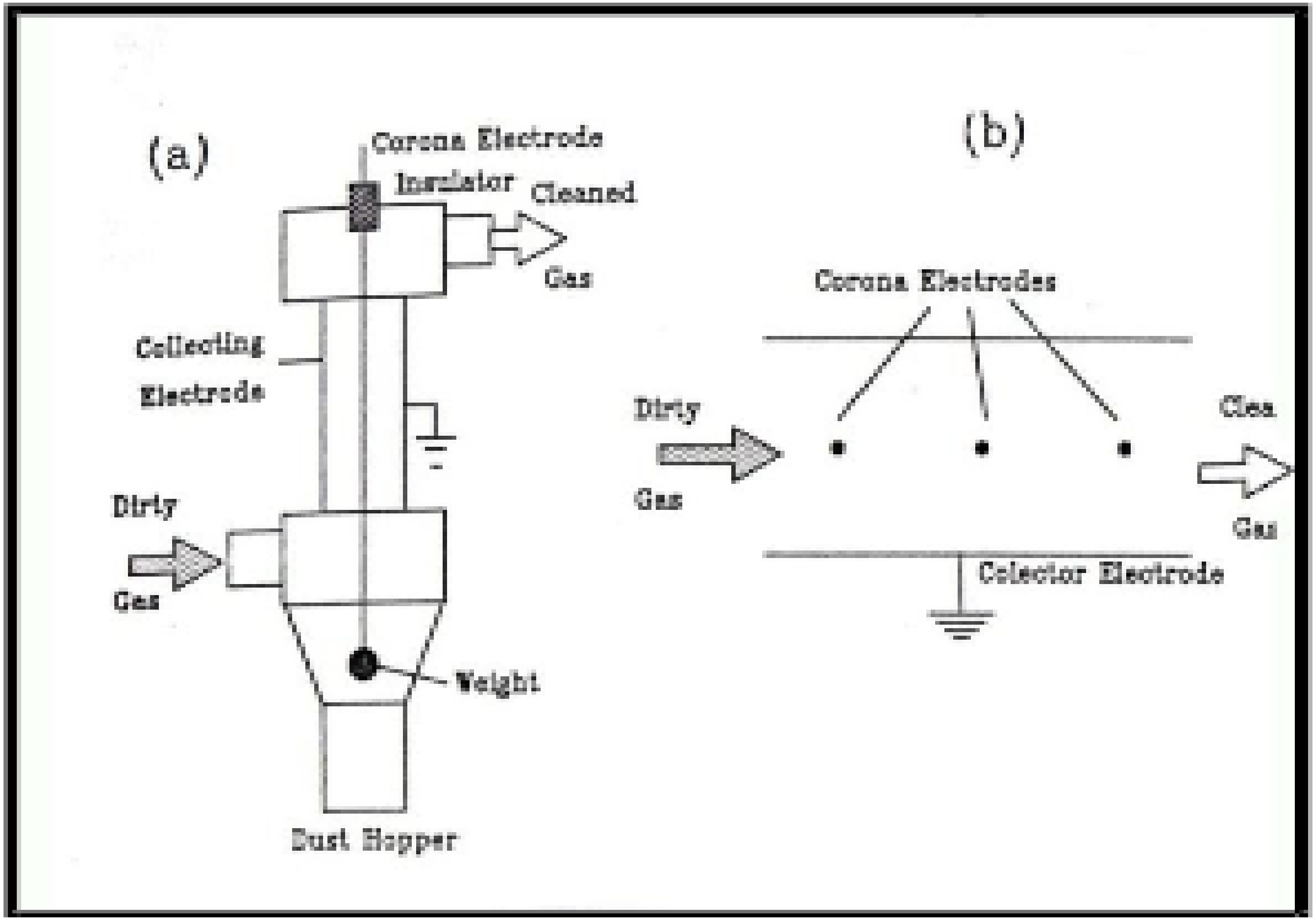
Equipment Selection & Design

- **<u>Basic Working Principle of ESP:-</u>**
- In high- voltage electrostatic field, affected by the electric field force, gas ionization takes place. There are tremendous amount of electrons and ions existing in the ionized gas. After the dust particles are combined with these electrons and ions, they will be polarized, most of them are negatively polarized. Under the action of the field force, negatively charged particles migrates towards the positive electrode and in turn release electrons and attach to the positive electrode.

Equipment Selection & Design

- When the particles agglomerate and the layers reaches a certain thickness on the plate, rapping system will start to work and the particles will be dislodged from the collecting plate by vibration and falling into the hopper. That ends the collection process.

Diagram



(a)
Corona Electrode
Insulator
Cleaned
Gas
Collecting
Electrode
Dirty
Gas
Weight
Dust Hopper
(b)
Corona Electrodes
Dirty
Gas
Clea
Gas
Colector Electrode

Equipment Selection & Design

- The efficiency of an ESP with plate collector is given by Anderson-Deutsch equation which can be expressed as follows:-
- Efficiency = $1 - e^{(-AW/Q)}$
- where, A = area of the plates in square mtr
- W= particle sedimentation velocity in an electric field in mtr/sec
- Q= Gas flow rate in m^3/sec

Problem

- A quantity of 50 m^3/sec of air flows from a cement manufacturing facility. It contains cement particles whose settling velocity is 0.12 mtr/sec. If 99% removal efficiency is required, calculate the surface area of the ESP or design an ESP.

Problem

- Calculate the percentage increase in area of the ESP plates, if the efficiency of the ESP unit is to be increased from 99% to 99.7%. Given the flow rate is $50m^3/sec$ & particulate velocity is 0.15mtr/sec.

Problem

- The drift velocity of fly ash particle is given by the empirical equation $w = 1.5X10^5\ d_p$, where d_p is particle size. Determine the plate area required to remove particles of dia 0.7µm with removal efficiency 95%. Flow to ESP is $5m^3$/sec.

Noise Pollution

- Sounds are mechanical waves of pressure which allow us to hear & listen.
- Sounds can be transmitted through solid, liquid & gas.
- Generally human beings can perceive sound frequencies between 20 Hz & 20 KHz.

Noise Pollution

- Noise is a sound, that is loud, unpleasant, unexpected or undesired.
- Sounds, particularly loud ones, that disturb people or make it difficult to hear wanted sounds, are called noise.
- Noise is a subset of sound.

Sources of Noise Pollution

- Sources can be classified into outside & inside.
- Outside include construction sites, road traffic, airport, factories etc.
- Inside include phones, tv, radio, home appliances etc.
- Main source is urbanization & increasing population.

Sources of Noise Pollution

Source	Sound in dB
Normal conversation	60
Alarm Clock	80
Car horn	120
Jet	130
Gunshot	140
Rocket Launching	180

Effects of Noise Pollution

- Sleep disturbance
- Lack of productivity
- Causes stress & depression
- Hormone imbalance
- Higher heart rate

Noise Control or Attenuation

- Noise has following medium.
- Source→Transmission Path →Receiver
- The acoustic treatment of above three can help in attenuation.

Ways to reduce Noise Pollution

- Wear ear plugs
- Avoid using multiple appliances at a time
- Keep vehicles & machines in proper condition
- Buildings can be designed with suitable noise absorbing material for the walls, windows, and ceilings.
- Social awareness programs should be taken up to educate the public about the causes and effects of noise pollution.

Physical Properties of Sound

- The various physical properties of sound are –
- Amplitude(A)
- Wavelength(λ)
- Time Period(T or P)
- Frequency(f)
- Speed of sound(c)

Physical Properties of Sound

- Amplitude is maximum or minimum pressure
- Wavelength is the distance between successive crest or trough
- Time period is the time gap between successive crest or trough
- Frequency is the number of complete pressure variations or cycles per second.
- Speed of sound is 340m/sec.

Noise Criteria

- The various noise criteria can be –
- L_{Aeq} (Equivalent Continuous Level)
- L_{AE} (Sound Exposure Level)
- L_{AN} (Sound Level Exceeded for N% of time)

Indian Standard for ambient noise level

Area code	Area	Daytime	Nighttime
A	Industrial Area	75dB	70dB
B	Commercial Area	65dB	55dB
C	Residential Area	55dB	45dB
D	Silence Zone	50dB	40dB

The above values are of L_{Aeq}.

Inverse Square Law of sound Propagation

- It states that, the sound intensity(I) is inversely proportional to the square of the distance (r) it propagates.
- $I = W/4\pi r^2$ i.e.
- $I \alpha 1/r^2$,
- where, W is Sound power of noise source in watt.

Formula

- The sound power level is measured in decibel(dB) i.e.
- $L_W = 10 \log(W/10^{-12})$
- where, L_W is sound power level in dB for 10^{-12} watt & W is sound power of noise source in watt.

Formula

- The sound pressure level is measured in decibel(dB) & is directly proportional to the square of sound pressure i.e.
- $L_P=10\log\{P^2/(P_0)^2\}$
- $= 20 \log (P/P_0)$
- where L_P is sound pressure level in dB,
- P is measured pressure in Pascal &
- P_0 is reference pressure = 20μPa

Problems

- Q.1. The sound from a voice shouting source is 0.001W. What is the sound power level?
- Q.2.If a sound source has a pressure of 2000μPa at 10mtr distance, calculate
- a) Sound Pressure Level in dB
- b) Sound Intensity in Watt/m^2
- c) Sound Power in Watt.

Problems

- Q.3.If two sound sources have equal pressure of 2000μPa, then determine the sound pressure in dB.
- Q.4. An air conditioner generates a noise level of 75dB for five minutes in every hour. If the background noise level is 55dB, then calculate the L_{Aeq}.

Waste Minimization

- Waste minimization is necessary :-
- i) To control pollution
- ii) To decrease the depletion rate of resources
- ii) To increase efficiency & hence profitability

Waste Minimization

- Elements of a waste minimization strategy:-
- It includes –
- i) Reduction at source
- ii) Recycle/ Reuse
- iii) Treatment
- iv) Disposal

Waste Minimization Hierarchy

Waste Reduction Techniques

- It has four major categories:-
- i) Inventory Management
- ii) Production Process Modification
- iii) Volume Reduction
- iv) Recovery

Waste Reduction Techniques

- i) <u>Inventory Management</u>:-
- Inventory means
  a <u>detailed</u> list of articles, goods, property.
- Inventory management includes –
- a) Inventory Control
- b) Materials Control

Waste Reduction Techniques

- ii) Production Process Modification:-
- It includes –
- a) Operational & maintenance procedures
- b) Materials Change
- c) Process equipment modification

Waste Reduction Techniques

- iii) <u>Volume Reduction</u>:-
- It includes –
- a) Source Segregation
- b) Concentration

Waste Reduction Techniques

- iv) Recovery:-
- It includes –
- a) on-site
- b) off-site

Life Cycle Assessment(LCA)

- LCA is an useful environmental management tool.
- Any product may have the following stages in it’s lifecycle –
- i) Raw material acquisition
- ii) Bulk material processing

Life Cycle Assessment(LCA)

- iii) Engineered & specialty materials production
- iv) Manufacturing & assembly
- v) Uses & services
- vi) Retirement or expired
- vii) Disposal

Life Cycle Assessment(LCA)

- LCA has the following phases –
- i) Planning
- ii) Screening
- iii) Data Collection
- iv) Data treatment
- v) Evaluation

Diagram


PACKAGING
DISTRIBUTION
LIFE CYCLE ASSESSMENT
MANUFACTURING
USAGE
MATERIALS
DISPOSAL

Environmental Impact Assessment

- Environmental Impact Assessment (EIA) is a process that requires consideration of the environment & public participation in the decision making process of project development.
- Environmental Impact Assessment (EIA) is an important management tool for ensuring optimal use of natural resources for sustainable development.

Environmental Impact Assessment

- The stages of EIA include –
- i) Screening
- ii) Scoping
- iii) EIS preparation
- iv) Review

Environmental Impact Assessment

- i) Screening:-
- By screening, it is to be decided which projects should be subject to environmental assessment.
- ii) Scoping:-
- It is the process which defines the key or important issues that should be included in the environmental assessment.

Environmental Impact Assessment

- iii) EIS preparation:-
- It is the scientific & objective analysis of the scale, significance & importance of impacts identified.
- iv) Review:-
- The review panel guides the study & then advises the decision makers.

Environmental Impact Assessment

- Origin of EIA:-
- All ecosystems including human beings have threshold of tolerance for pollution & disturbances, beyond which the system may suffer anything from temporary upsets to complete destruction. After second world war industrial & agricultural practices began to cause environmental damage which crossed the thresholds & lead to origin of EIA.

Environmental Impact Assessment

- EIA Procedure:-
- There are generally three options for establishing EIA procedures.
- i) Legislative Option i.e. Legal approach
- ii) Middle Ground Option i.e. within accepted planning & Procedures
- iii) Policy Option i.e. within the administrative policy of government

Environmental Impact Assessment

- Project Screening for EIA:-
- The success of EIA depends on effective coverage & application of projects. The various methods commonly used to select projects for EIA are –
- i) The use of positive (EIA required) & negative (EIA not required) list

Environmental Impact Assessment

- ii) The use of project criteria
- iii) The sensitive area criteria
- iv) Matrices
- v) Initial Environmental Evaluation(IEE)

Environmental Impact Assessment

- Initial Environmental Evaluation(IEE):-
- IEE is a mini EIA.
- It requires a description of the environment & the development & the identification of environmental impacts those are anticipated.

Environmental Impact Statement(EIS)

- EIS is a review document prepared for assessment in the EIA process.
- <u>Scope Studies of EIS</u>:-
- Scoping is the procedure for establishing the TOR(Terms Of Reference) for the EIS.

Environmental Impact Statement(EIS)

- In general, the objectives would be to identify the concerns & issues those need attention, necessary for public involvement & to prepare a detailed report for the investigation of specific issues associated with the development.

Environmental Impact Statement(EIS)

- <u>Preparation of an EIS</u>:-
- One of the important elements of any project is the preparation of documentation to communicate the findings & conclusions of the study.

Environmental Impact Statement(EIS)

- The value of the project is sharply diminished, if it’s findings don’t reach it’s requisite results or intended audiences.
- The important points to be considered are –
- i) Planning
- ii) Purpose
- iii) Audience
- iv) Structure

Environmental Impact Statement(EIS)

- Review of an EIS:-
- The functions of the review authority includes-
- i) The scope of the assessment i.e. which projects should be subjected to a full or partial EIS.
- ii) General or specific guidelines & advice on the methods of EIS.

Environmental Impact Statement(EIS)

- iii) Formulate the TOR(Terms Of Reference) & initiate a detailed EIS.
- iv) Ensure that, the EIS had been adequately completed within the TOR.

Solid Waste Management

- Solid waste is the unwanted or useless solid materials generated from combined residential, industrial and commercial activities in a given area.
- Management of solid waste reduces or eliminates adverse impacts on the environment and human health and supports economic development and improved quality of life.

Solid Waste Management

- It may be categorised according to its <u>origin</u> (domestic, industrial, commercial, construction or institutional); according to its <u>contents</u> (organic materials like plastics, rubber, food items & inorganic materials like glass, metal etc); or according to <u>hazard potential</u> (toxic, non-toxic, flammable, radioactive, infectious etc).

Solid Waste Management

- A number of processes are involved in effectively managing waste for a municipality.
- These include monitoring, collection, transport, processing, recycling and disposal.

Solid Waste Management

- The order or hierarchy of solid waste management includes –
- i) Waste prevention & minimization
- ii) Reuse & Recycling
- iii) Transformation
- iv) Landfill

Solid Waste Management

- Reuse:-
- A newly purchased product is put to another use after the first use is completed.
- Recycling:-
- It is the processing of used materials or waste into new products to prevent waste of potentially useful materials.

Solid Waste Management

- <u>Properties of MSW(Municipal Solid Waste)</u>:-
- The various properties of MSW includes –
- i) Physical Properties of MSW
- ii) Biological Properties of MSW
- iii) Chemical & Energy Properties of MSW

Solid Waste Management

- i) <u>Physical Properties of MSW</u>:-
- The various Physical Properties of MSW are –
- a) Particle Size Distribution
- b) Density & Moisture Content
- c) Field Capacity
- d) Shear Strength
- e) Hydraulic Conductivity

Solid Waste Management

- a) Particle Size Distribution:-
- Particle size is measured in terms of size of screens in mm through which wastes are passing.
- This distribution will provide the information of various materials present.

Solid Waste Management

- b) Density & Moisture Content:-
- Density is mass per unit volume, which is a useful physical parameter used for separating various wastes from each other before treatment.

Solid Waste Management

- The moisture content is expressed as mass of water vapour per unit mass of substance.
- Moisture Content(%) = $\{(a-b)/a\}X100$
- Where,
- ‘a’ is initial mass of sample &
- ‘b’ is mass of sample after drying

Solid Waste Management

- c) <u>Field Capacity (FC)</u>:-
- It is the maximum percentage of volumetric soil moisture that a MSW sample will hold freely against earth's gravity.
- FC can be calculated by –
- $FC = 0.6 – 0.55(W/4500+W)$
- Where, W is overburden weight in Kg.

Solid Waste Management

- d) <u>Shear Strength</u>:-
- Solid wastes when compacted usually have high shearing strength & hence don't flow on standing, but sludge has poor shearing strength & therefore very often sludge is co-disposed with MSW.

Solid Waste Management

- e) Hydraulic Conductivity:-
- Sludge in landfills tend to resist the movement of water through them due to low hydraulic conductivity, as sludge has high moisture content.

Solid Waste Management

- ii) Biological Properties of MSW:-
- Organic or biological matter in MSW is significant for the energy recovery by biodegradation.
- Biodegradation can be accomplished either by aerobic or anaerobic process.

Solid Waste Management

- The biodegradability of the organic fraction of MSW is given by –
- BF = 0.83 - 0.028LC
- Where,
- BF is Biodegradable Fraction
- LC is Lignin(organic) Content in % of dry weight
- High LC will give low biodegradability.

Solid Waste Management

- iii) <u>Chemical & Energy Properties of MSW</u>:-
- The various steps involved in this are –
- a) Proximate Analysis
- b) Ultimate Analysis
- c) Energy Content

Solid Waste Management

- a) <u>Proximate Analysis</u>:-
- It deals with the determination of moisture content(W%), volatile matter(VM%), non-combustible fraction (i.e. ash%) & Fixed Carbon(FC).
- FC can be found out by –
- FC=100 - W(%) - VM(%) - ash(%)

Solid Waste Management

- FC is the solid combustible residue that remains after the material is heated & the volatile matter is ejected.

Solid Waste Management

- b) Ultimate Analysis:-
- It is the elemental analysis of essential major elements like C,H,O,N,P,S in percentage mass.

Solid Waste Management

- c) <u>Energy Content</u>:-
- Heating value or calorific value of MSW may be defined as the amount of heat liberated in calorie, when a gram of MSW is burnt.
- It gives the amount of organic matter present in the MSW.
- Generally, terms like E, H_u, H_{wf}, H_{awf} are used to express energy content.

Solid Waste Management

- E is Energy Content
- H_u is LHV(Lower Heat Value) i.e. energy received from waste as collected from site
- H_{wf} is NHV(Normal Heat Value) i.e. energy received from water-free waste
- H_{awf} is HHV(Higher Heat Value) i.e. energy received from ash-water-free waste

Solid Waste Management

- $H_u = H_{awf} \times B - 2.445 \times W$
- Where,
- B is flammable fraction or combustible component
- W is moisture content fraction or water content

Solid Waste Management

- The energy content of MSW can be determined from following equations –
- i) Dulong Equation
- ii) Khan Equation

Solid Waste Management

- i) Dulong Equation:-
- H_{awf} =337(C)+1419{(H)-0.125(O)} +93(S) + 23(N)
- Where, C, H, O, S, N are the % by weight of each element present in the material.

Solid Waste Management

- ii) Khan Equation:-
- $E = 0.051\{F + 3.6(CP)\} + 0.352(PLR)$
- Where, E = Energy content,
- F = % of food material by weight
- CP = % of Cardboard & Paper by weight
- PLR = % of Plastic & Rubber by weight

Solid Waste Management

- Separation of MSW:-
- The different major components of MSW must be separated from one & the other in order to have suitable management of MSW.
- The component separation can be done at the household or at the industry i.e. at the source or at the transfer station or at the final destination, where mechanical sorting or separation is possible.

Solid Waste Management

- <u>Storage & Transport of MSW</u>:-
- It depends on types of collection facility available & materials present, which can be –
- i) Door Step Collection
- ii) Regular Roadside Collection
- iii) Dustbins at market places
- iv) Community Recycle bin

Solid Waste Management

- Integrated Waste Management:-
- The ideal integrated waste management plan might have following priorities –
- i) Minimize all components of waste fraction.
- ii) Recycle paper, cardboard, non-ferrous metals.
- iii) Reuse plastics, ferrous metals, glass.

Solid Waste Management

- iv) Compost food fraction of MSW.
- v) Incinerate the remaining food waste.
- vi) Landfill the remaining after proper treatment.

Land fill vs Open Dump

- A Sanitary Landfill is a carefully engineered tract of land, designed by engineers. The system consists of a large excavated area in the ground, with a thick lining of plastic over which there is a compacted clay liner. The bottom of the pit also has a liner that helps in preventing the liquid waste (that comes out from the solid waste mostly if rainwater is soaked in the landfill) from leaking through, as it could contaminate the water supply. This liquid waste that gets collected is called leachate. The compacted garbage (or refuse) is then added to the landfill in the form of organized layers (layers of garbage alternating with layers of soil).

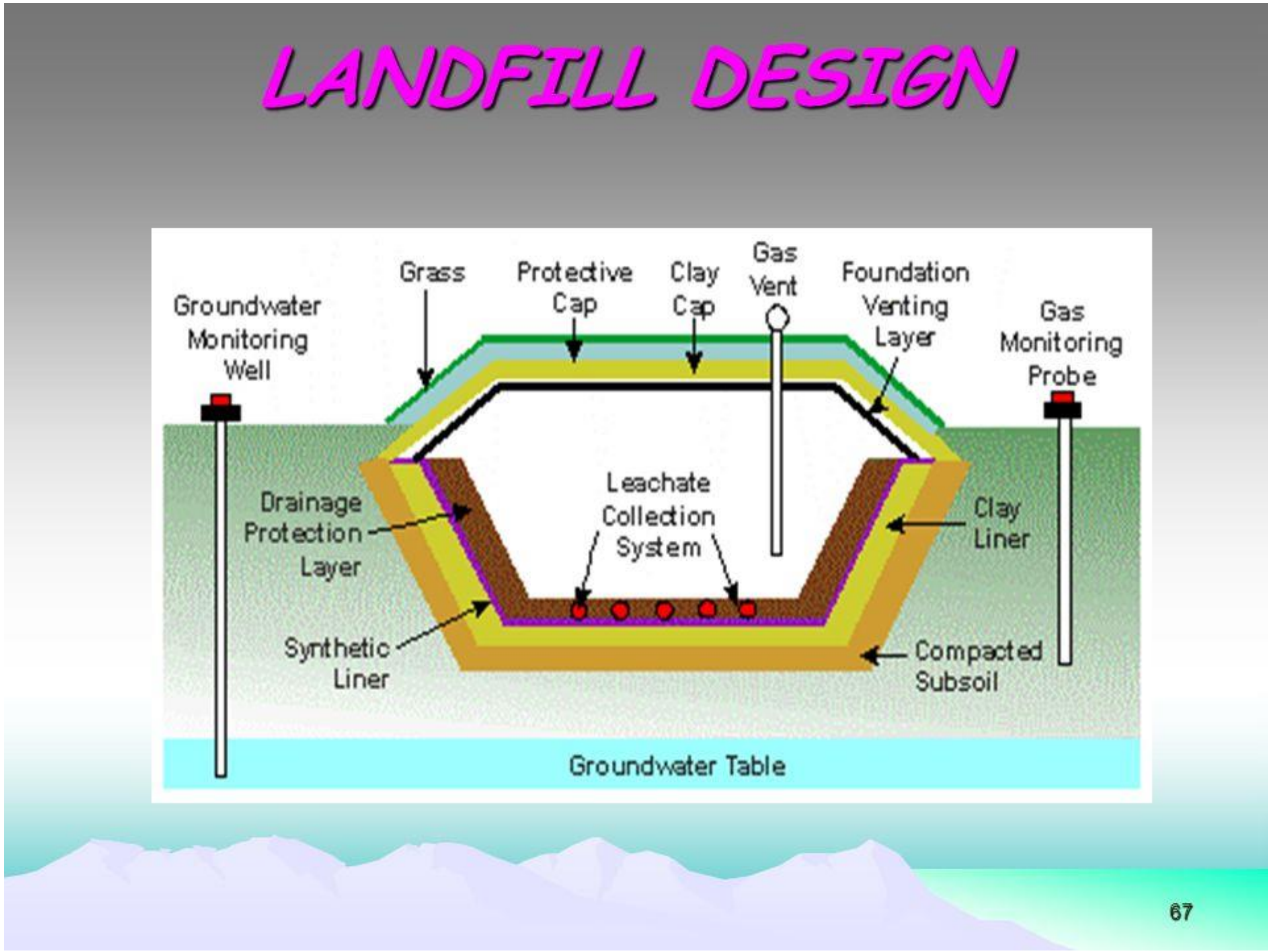
Land fill vs Open Dump

- This is done for the elimination of any unpleasant odors and to expedite the rotting or decomposition process. When the landfill is fully covered, it is further sealed by a layer of compacted clay. Moreover, a gas (methane) is often produced as the waste deteriorates due to which a system is required to collect and pump it. If this is not managed effectively, the methane gas can explode. The methane collected can be utilized to generate electricity.

Land fill vs Open Dump

- In most Western Countries, there are different types of landfills, mainly depending on the nature of waste materials. A landfill is built for each of the garbage types like household waste, hazardous chemicals or radioactive waste, construction waste, etc.
- An open dump, as the name suggests, is an open area typically outside city limits where the garbage is dumped; this usually results in very unhygienic conditions and often pollutes the groundwater nearby, from toxic chemicals leaching into the groundwater.

Diagram



LANDFILL DESIGN
Grass
Protective Cap
Clay Cap
Gas Vent
Foundation Venting Layer
Groundwater Monitoring Well
Gas Monitoring Probe
Leachate Collection System
Drainage Protection Layer
Clay Liner
Synthetic Liner
Compacted Subsoil
Groundwater Table
67

Solid Waste Management

- Leachate in Landfills:-
- Leachate is the contaminated water in landfills which arrive at the landfill site through external precipitation.
- The amount of leachate produced in a landfill depends on it’s water balance, which can be expressed as follows –
- LC = PR + SRT – SRO – EP – ST

Solid Waste Management

- Where,
- LC is Leachate,
- PR is Precipitation
- SRT is Surface Run To i.e. water outside the site entering the landfill
- SRO is Surface Run-off
- EP is Evapotranspiraton
- ST is Change in water storage

Solid Waste Management

- Q. Calculate the Landfill area requirement for 20 years for a city of population of about 5 lakhs. Assume MSW generation as 500gm per capita per day & density of MSW is 500kg/m^3.

Hazardous Waste Management

- Hazardous waste is defined as, any waste which because of it's physical, chemical quality, quantity and infectious characteristics can cause significant hazards to human health or the environment, when improperly treated, stored, transported or disposed.

Hazardous Waste Management

- A substance is hazardous, if it exhibits one or more of the following characteristics.
- i) Ignitable:- The substance causes or enhances fire.
- ii) Reactive:- The substance reacts with other materials & may explode.

Hazardous Waste Management

- iii) <u>Corrosive</u>:- The substance destroys tissues or metals.
- iv) <u>Toxic</u>:- The substance is a danger to health, water, food & air.

Hazardous Waste Management

Hazardous Category	Nature of Waste
H1	Explosive
H2	Oxidiser
H3A	Highly Flammable
H3B	Flammable
H4	Irritant
H5	Harmful

Hazardous Waste Management

- Generation of Hazardous Waste:-

Industry Type	Hazardous Substances
Battery	Cd, Pb, Ag, Zn
Electroplating	Co,Cr,Cu,Zn
Printing	As,Cr, Cu,Pb,Se
Textiles	Cr, Cu, Organics

Hazardous Waste Management

- Medical Hazardous Wastes :-
- These are the wastes generated from hospitals, medical colleges, nursing homes, clinical laboratories & operation theatres etc.

Hazardous Waste Management

- Medical hazardous wastes include –
- i) Expired or Obsolete medicines
- ii) Infectious dressing materials
- iii) Pathological wastes from medical laboratories & operation theatres
- iv) Wastes from dental clinics etc.

Hazardous Waste Management

- <u>Household Hazardous Waste</u>:-
- The household hazardous wastes come from kitchen, bathroom, garage, garden etc.
- It may include –
- i)Used or Exhausted batteries
- ii)Chemicals like dyes, perfumes
- iii)Pesticides, herbicides, used oils, lubricants etc.

Hazardous Waste Management

- Transportation of Hazardous Waste :-
- The data or information required for Transportation of Hazardous Waste are –
- i) Waste Generator
- ii) Composition of Waste
- iii) Physical Appearance
- iv) Method of Packaging

Hazardous Waste Management

- v) ADR/RID classification
- ADR means transport of dangerous goods by road
- RID means transport of dangerous goods by rail
- vi) UN Number(United Nation Number)

Hazardous Waste Management

- ADR/RID classification:-

Class	Item Description
1a	Explosive Items
1b	Items loaded with explosives
1c	Detonators & similar types of goods
2	Gases, Compressed, Condensed or dissolved under pressure
3	Flammable Liquids

Hazardous Waste Management

- The UN numbers range from UN0001 to about UN3500 and are assigned by the United Nations Committee of Experts on the Transport of Dangerous Goods.

Hazardous Waste Management

UN Number	Hazardous Item
1001	Acetylene Dissolved
1002	Compressed Air
1003	Liquefied air, refrigerated
1005	NH_3, dry, liquefied

Hazardous Waste Management

- <u>Treatment of Hazardous waste</u>:-
- i) Thermal Treatment (Incineration)
- ii) Chemical Treatment (Neutralization)
- iii) Physical Treatment (Filtration, Flocculation)
- iv) Disposal (Secure Landfill)

Hazardous Waste Management

- Incineration:-
- Incineration can be defined as controlled high temperature oxidation of primarily organic compounds to produce CO_2 & H_2O with non-objectionable by-products.

Hazardous Waste Management

- 3 T's of Incineration:-
- i) Time
- ii) Temperature
- iii) Turbulence

Hazardous Waste Management

- i) <u>Time</u>:-
- Adequate residence time for solids for complete destruction or breaking of bonds.
- It depends on feed rate, incinerator dimension & rotation speed.

Hazardous Waste Management

- ii) Temperature:-
- High enough temperature is required for destruction of hazardous waste.
- iii) Turbulence:-
- Sufficient turbulence with adequate air or oxygen for mixing of waste with oxygen.
- This depends on rotation speed & incinerator types.

Hazardous Waste Management

- Types of Incinerator:- (P-724-731,G.kiely)
- i) Rotary Kiln
- ii) Liquid injection
- iii) Plasma Arc Destruction
- iv) Wet Air Oxidation
- V) Fluidized Bed Combustion

Hazardous Waste Management

- i) Rotary Kiln:-
- This is most common type of incinerator.
- Here Chemical destruction of waste occurs.
- ii) Liquid injection:-
- This is for treating liquid organic waste.

Hazardous Waste Management

- iii) Plasma Arc Destruction:-
- In this case, electric arc of very high temperature is used.
- iv) Wet Air Oxidation:-
- It is an aqueous phase oxidation where materials are exposed to gaseous source of oxygen.

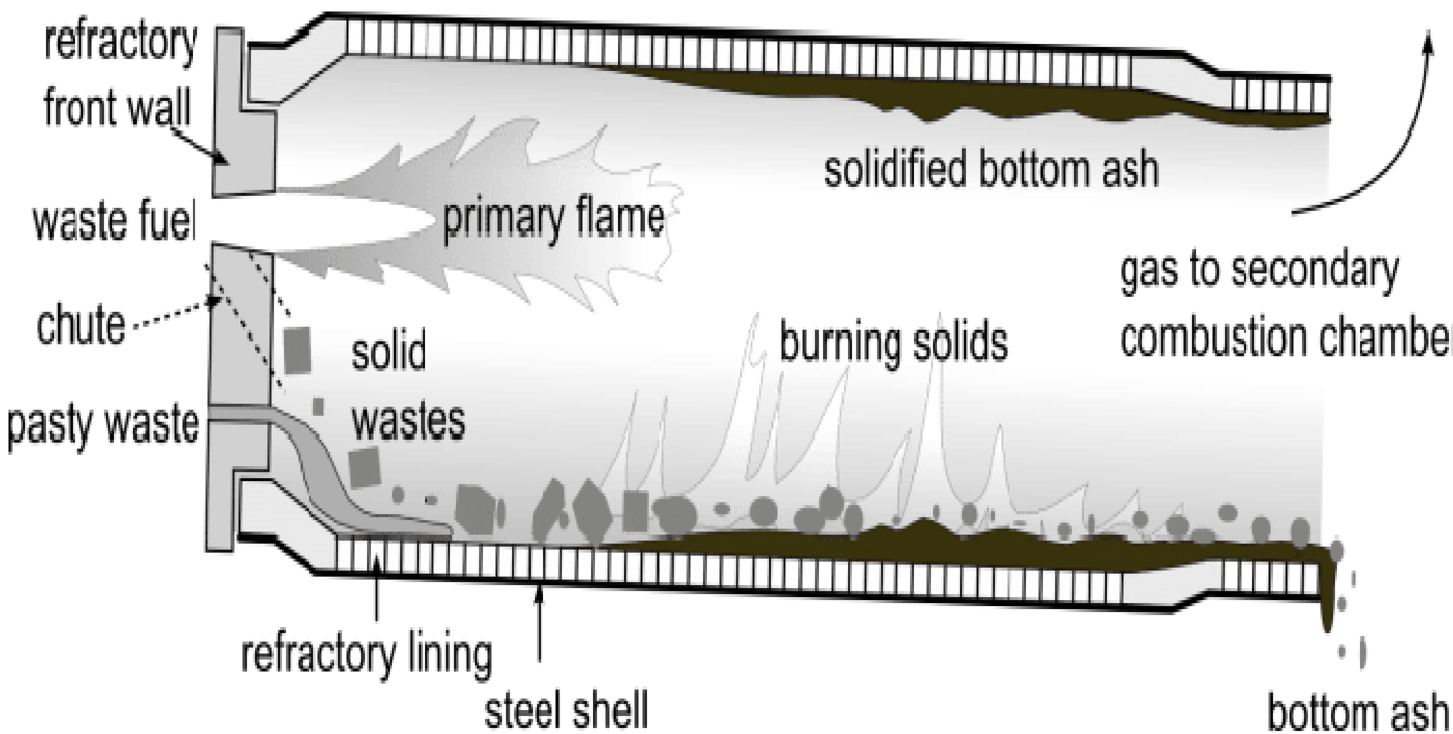
Hazardous Waste Management

- V) Fluidized Bed Combustion:-
- This is suitable for uniform types of waste.
- In this case, heat transfer is very fast & uniform.

Rotary kiln incinerator

- A rotary kiln incinerator is typically a slightly inclined rotating cylinder, with dimensions around 2 m in diameter and 10 m long, on a pilot plant scale. There is a firebrick or refractory lining inside the cylinder. The kiln can handle all sorts of wastes and hazardous wastes including solids, liquids, sludges and gases. Partially combusted gases are often passed through a secondary combustion chamber for complete combustion. By the nature of its design and construction, the three Ts of combustion are adhered here - good contact or residence time, fair degree of turbulence, and operating at a high enough temperature. A schematic diagram is below :

Rotary kiln incinerator



Hazardous Waste Management

- DRE(Destruction & Removal Efficiency):-
- Destruction and removal efficiency (DRE) is the efficiency of the unit (kiln) in destruction and removal of a particular targeted organic compound.
- In incineration DRE of above 99% is required.

Hazardous Waste Management

- DRE can be calculated by using the following formula –
- DRE= $\{(W_{in} - W_{out})/W_{in}\} \times 100$
- Where,
- W_{in} is mass feed rate of specific organic component to the incinerator
- W_{out} is mass emission rate of same organic component from the incinerator

Hazardous Waste Management

- CE(Combustion Efficiency):-
- Combustion efficiency is a measurement of how well the fuel being burned or is being utilized in the combustion process.

Hazardous Waste Management

- CE can be calculated by using the following formula –
- CE = $\{(C_{CO2} – C_{CO})/C_{CO2}\} \times 100$
- Where,
- C_{CO2} is concentration of CO_2 in the emitted gas
- C_{CO} is concentration of CO in the emitted gas

Hazardous Waste Management

- Q. Find out CE(Combustion Efficiency) & DRE(Destruction & Removal Efficiency) of an incinerator from the following data –
- i) Input of phenolic waste is 18.2% & outlet phenol is 0.04%
- ii) Outlet gas concentration of CO is 0.1% & CO_2 is 25.7%

Environment & Human Health

- Env. Conditions Affecting Health:-
- i) Cleanliness of working area
- ii) Proper Lighting arrangement
- iii) Sufficient Temperature & Ventilation
- iv) Noise control
- V) Dust control
- Vi) Proper Working space & seating arrangements

Environment & Human Health

- Factors affecting Health:-
- Physical factors like unhygienic living conditions, lack of education & overcrowding in small areas lead to health problems.
- Chemical factors like improper or excess use of pesticides, herbicides and exposure to toxic, hazardous and radioactive substances lead to health problems.
- Climate changing factors

Environment & Human Health

- Diseases of human and Their Control:-
- Interaction of the agents like micro-organisms with the hosts like human beings and the environment can lead to various diseases.

Communicable Diseases & Their Control

- Following <u>three factors</u> are important in this case.
- sufficient strength of micro-organisms,
- lower immunity of the person &
- favouring environment for the transmission of agents

Communicable Diseases & Their Control

- Prevention can be done by -
- Enforcing immunization laws
- Providing health education to all
- Implementing good hand washing procedures.

Common Diseases

- Hepatitis is inflammation of the liver and often caused by viral infection.
- Typhoid is an acute illness associated with fever can be caused by bacteria salmonella typhi & spread to other people by contaminated water.

Common Diseases

- Malaria is caused by a parasite called plasmodium which is transmitted to human beings by the bite of infected female anopheles species mosquitoes.
- Dengue fever is an infection caused by dengue viruses.

Role of IT in Env. & Human Health

- IT or Information Technology, is one of the fastest growing recent technologies & as technology is advancing, the role of IT is increasing day by day.
- IT is used in the development & application of computational tools to acquire, store, organize, achieve, analyze & visualize various data which can be used for observation & protection of env. & human health.

Role of IT in environment

- A large amount of information is easily available through remote sensing technology, GIS(Geographic Information System) & GPS(Global Positioning System) which can be used for various environmental purposes.
- This data and knowledge about global environment can be used for mapping & monitoring various natural resources, thereby helping in various environmental studies.

Role of IT in environment

- GIS helps in detecting the existence of species of flora & fauna & counting the numbers of animals like tiger, elephant etc.
- MoEF(Ministry of Env. & Forest) & GOI(Govt. of India) have established ENVIS (Environmental Information System) in 1982 in different organizations for providing important information.

Role of IT in Human Health

- IT helps in the development of biotechnology, gene engineering, research & developments in drug technologies.
- IT plays a major role for a better human health in the fields like bioinformatics and online medical transcription.
- IT can be used for audio, visual & data communications for medical consultation, nursing & medical education.

Role of IT in Human Health

- IT helps in spreading awareness about endemic, epidemic & communicable diseases.
- Using Remote sensing & GIS, areas which are prone to diseases like malaria, dengue etc. can be identified & accordingly steps for prevention or spreading of these diseases can be taken.

E-Waste

- E- waste or Electrical/Electronics waste is an environment killer.
- Today’s electronic gadgets, tomorrow’s electronic wastes.
- 'E-waste' means waste from electrical and electronic equipments; whole or in part or rejects from their manufacturing and repair process which are intended to be discarded as waste.

E-Waste

- E-waste is the term used to cover all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of re-use.
- It is also referred to as WEEE (Waste Electrical and Electronic Equipment) or electronic waste or e-scrap in different regions.

E-Waste

- Electronic waste or e-waste describes discarded electrical or electronic devices & used electronics which are destined for reuse, resale, recycling, or disposal are also considered e-waste.
- Informal processing of e-waste in developing countries can lead to adverse human health effects and environmental pollution.

RoHS and WEEE directives

- Companies selling electrical and electronic goods in the European Union must conform to the EU legislation for electrical and electronic equipment (EEE). The two most important directives are:
- The Waste Electrical and Electronic Equipment Directive (WEEE), which sets out the responsibilities of EEE producers for the collection and recycling of their products at the end of their lifecycle.

RoHS and WEEE directives

- The Restriction of Hazardous Substances Directive (RoHS), which bans the use of certain hazardous substances (such as lead, mercury, cadmium, hexavalent chromium and some polybrominated flame retardants) in EEE.
- WEEE and RoHS Directives are complex pieces of legislation that apply to a similar range of products.

RoHS and WEEE directives

- Each directive imposes obligations and outcomes that EU Member States must achieve. However, neither directive dictates how the Member States must fulfill their obligations. Therefore, when exporting to Europe, U.S. exporters need to be mindful that national rules for implementing each directive will differ from country to country.

Why E-Waste Management

- It is the fastest growing portion of municipal waste & its management will prevent -
- Pollution of ground water.
- Acidification of soil.
- Emission of toxic fumes and gases.
- Release of harmful gases into the air.

Sources/Types of E-Waste

- 1. Waste generated from the products used for data processing such as computers, computer devices like monitor, speakers, keyboards, printers etc.
- 2. Electronic devices used for entertainment like TV, DVDs, and CD players.
- 3. Equipment or devices used for communication like phones, landline phones, fax etc.

Sources/Types of E-Waste

- 4. Household equipment’s like vacuum cleaner, microwave ovens, washing machines, air conditioners etc.
- 5. Audio, visual components such as VCRs, Stereo equipment etc.

E-Waste Composition(Approx.)

- Monitors - 10% ,
- Television -10%,
- Computers,Televisions, Fax, Printers etc.-15% ,
- DVD/VCR Player, CD Player, Radio etc.- 15% ,
- Refrigerators -20% ,
- Washing Machine, Dryers, AC, Vacuum Cleaners etc.- 30%

Is E-Waste hazardous?

- E-Waste in itself is not hazardous.
- However, the hazardous constituents present in the e-waste render it hazardous & when such wastes are dismantled & processed, they pose hazard to health and environment.

Reasons of E-waste generation

- Advancement in technology.
- Changes in style, fashion and status
- Products nearing the end of their useful life
- Not taking precautions while using them

Components of E-Waste

- EEE contains various materials including hazardous, valuable and scarce metals.
- Common hazardous materials found in e-waste are heavy metals (such as mercury, lead, cadmium etc.)
- E-Waste also contains many valuable materials (such as iron, copper, aluminum and plastics) and
- precious metals (like gold, silver, platinum and palladium) that can be recycled.

Components of E-Waste

- In fact, up to 60 elements from the periodic table can be found in complex electronics, and many of them are recoverable, though it is not always economic to do so presently.
- From the resource perspective, e-waste is a potential “urban mine” that could provide a great amount of secondary resources for remanufacture and recycling.

How E-Waste handled currently in India & across the world?

- Around 90% of the e-waste generated in India are handled by the informal sectors.
- Incineration & Landfilling are used currently for majority of e waste.
- Incineration i.e. E- Waste are destroyed by burning which produces harmful gases.
- Land filling which often leads to contaminate water and soil.
- Very less percentage of e-waste is recycled.

EFFECTS OF E-WASTE ON THE ENVIRONMENT

- Emissions from E-Waste create environmental damage.
- Toxic chemicals from e-waste enter the "soil-crop- food pathway,“ and these are non-biodegradable and cause soil pollution.
- E-Waste dumping yards and nearby places are polluted and cause health hazards.

EFFECTS OF E-WASTE ON HUMAN BODY

- Elements present in e-waste affect human body.
- **Lead** damage to central and peripheral nervous systems , blood systems and kidney damage and affects brain development of children.
- **Chromium** leads to asthmatic bronchitis & DNA damage.

EFFECTS OF E-WASTE ON HUMAN BODY

- **Cadmium** leads to toxic irreversible effects on human health & accumulates in kidney and liver. causing neural damage
- **Mercury** leads to chronic damage to brain and respiratory system.
- **Plastics including PVC -** Burning produces dioxin which can cause reproductive and developmental problems, Immune system damage & Interfere with regulatory hormones etc.

DISPOSAL OF E-WASTE

- We should ensure safe disposal of these e-waste, because –
- 1. Land fill disposal allows heavy metals to leach into ground water.
- 2. Incineration makes hazardous materials pollute air.
- 3. Disposal to water is dangerous and cause water and soil contamination.

Methods of Recycling

- <u>Disassembly/Dismantling </u>:
- It is the systematic removal of components , parts or a group of parts or a subassembly from a product in e-waste.
- <u>Upgrading </u>:
- It includes comminuting(breaking) and separation of materials using mechanical/physical or metallurgical processing .

Methods of Recycling

- Materials recovery :
- The materials are recovered by recycling facilities. The plastic, glass, metals can be recovered by sorting them before mixing them with other waste.

ADVANTAGES OF RECYCLING E-WASTE

- Assets recovery
- Reduction of need for landfills
- Resale and reuse
- Creation of jobs

ADVANTAGES OF RECYCLING E-WASTE

- E waste has emerged as one of the fastest growing waste streams world wide today.
- Electronic gadgets, without proper disposal can cause environmental harm
- Reuse and Recycle are more beneficial than simple disposal.

How to Dispose E-waste

- Donate working older equipment to schools colleges or government entities in need.
- If computers are out of order then return it to the manufacturers. (HCL and Wipro in India has best take back service)
- Send waste goods to authorized recycling facility for proper disposal.

Probable Solutions

- Need for stringent health standards and environmental protection laws in India
- Extended producer responsibility
- Import of waste under license
- Producer-public-government cooperation
- Awareness program, following safer and efficient methods

Probable Solutions

- Choosing safer technology and cleaner substitute
- Monitoring of compliance rules
- Reduction of waste at source
- Recognition to the unorganized sectors in India.

Probable Solutions

- Designing of products using environment friendly raw items can make a change.
- Government should take steps to reduce e-waste disposal.

E- Waste (Management & Handling) Rules 2011

- E- Waste (Management & Handling) Rules 2011 were notified in 2011 and had come into force since 1st May, 2012.
- In order to ensure effective implementation of E-Waste Rules, Government of India modified the above one on 23.03.2016 which has been effective from 01-10-2016.

E- Waste (Management & Handling) Rules 2011

- These rules are applicable to every producer, consumer or bulk consumer, collection centre, dismantler and recycler of e-waste involved in the manufacture, sale, purchase and processing of electrical and electronic equipment or components.

E- Waste (Management & Handling) Rules 2011

- Two categories of electrical and electronic equipment namely –
- (i) IT and Telecommunication Equipment and
- (ii) Consumer Electricals and Electronics such as TVs, Washing Machines, Refrigerators Air Conditioners including fluorescent and other mercury containing lamps are covered under these Rules.