

RSPCB-JEE/JSO

B.Sc / M.Sc / B.Tech / M.Tech / Chemistry / Environmental Science / Textile

ENVIRONMENTAL ENGINEERING SCIENCE

(COVERAGE OF COMPLETE SYLLABUS)



HAND WRITTEN NOTES
ZONE TECH PUBLICATIONS

Air Pollution :-

Air pollution can be defined as the presence of one or more air contaminants (pollutants) such as dust, mist, gas, fumes, vapours etc. in outdoor atmosphere in sufficient quantity, of such characteristics & of such duration, that it becomes injurious to human, plant, animal life, property etc. & also interfere with comfortable enjoyment of life or property.

Sources of air pollution :-

Air pollutants can be classified as

(i) Natural pollutants

Ex:- Natural fog, Bacteria, product of volcanic eruption, Pollen grains.

(ii) Aerosols:-

Ex:- dust, smoke, fumes, mist, etc.

(iii) Gases:-

Ex:- oxides of Nitrogen, oxides of Sulphur, O_3 , CO etc.

Note:-

CO_2 gas is not considered as an air pollutant.

Aerosols:-

Aerosols refer to the dispersion of solid & liquid particles in microscopic size in gaseous media.

• It can be defined as equilibrium system in which the dispersion medium is a gas & a dispersed phase is solid & liquid.

• The term Aerosol is used during the time when it is suspended in the air, after settling or deposition the term aerosol no longer applies.

Various types of Aerosols:-

(i) Dust:-

- Dust is made up of solid particles ^{larger} predominately size than the colloidal particles & capable of temporary suspension in air or other gases.
- Dust is produced by crushing, grinding etc of organic & inorganic material.
- Size of dust particles - (1 to 1000 μm)

(ii) Smoke:-

- Smoke consists of finely divided particles produced by incomplete combustion of fuel or material.
- It consists pre-dominantly of carbon particles.
 - size - (0.5 - 1 μm)

(iii) Mist:-

- This term refers to a low concentration dispersion of liquid particles of large size.
- It consists of water droplets suspended in atmosphere.
 - size - (< 10 μm)

(iv) Fog:-

- If mist concentration is high in to obscure (अधिका) visibility then it is called as Fog.
- It means Fog is a special condition of mist in which the concentration of liquid particles is very High & size is very less.
 - It refers to the dispersion of water or Ice in atm. near earth surface reducing the visibility.
 - size - (0.4 - 1 μm)

(v) Fumes:-

These are fine solid particles generated by ~~condensation~~ ^{condensation} from gaseous state after volatilization from melted substance.

- Fumes are accompanied by chemical reaction such as oxidation.

• size - (0.03 - 0.3 μm)

hases:-

(i) SO₂ :- (Sulphur-di-oxide) :-

- This is one of the principle constituents of air pollutants.
- The main sources of Sulphur-di-oxide (SO₂) is combustion of fuel specially coal.
- It is most abundant atmospheric contaminants in city. The major contributors of SO₂ are refineries, chemical plant, municipal incineration plant.

(ii) oxide of Nitrogen (NO_x) :-

- NO_x are the second most abundant atmospheric contaminant next to SO₂.
- The Highest Concentration of NO_x is gaseous imition occurs in the effluent from industries where nitric acid is produced.
- The next Highest Concentration is in automobile exhausts.
- There are 7 oxides of Nitrogen such as N₂O, NO, NO₂, NO₃, N₂O₃, N₂O₄, N₂O₅. Out of this these only NO (Nitric oxide) & NO₂ (Nitrogen-di-oxide) are considered as pollutants.

(iii) CO (Carbon mono-oxide):-

- CO is an odourless & colorless gas & its major origin is incomplete combustion of carbonaceous material & petroleum product.
- It is highly toxic gas & it is generally classified as Asphyxiant (breathing problematic gas)
- Cheap source of CO in atm. is combustion of fuel in automobile.

(iv) HF (Hydrogen fluoride):-

The major source of HF are the manufactures of phosphate fertilizers, aluminium industries brick & pottery plants etc.

- Hydrogen fluoride is more important in term of injury to vegetation & animals than in term of injury to human beings.

(v) Hydrogen Sulfide & Mercaptane:-

- H_2S is a foul smelling gas.
- The source of H_2S is natural emission include anaerobic bi-logical decay processes on length in mances (उसकी आवाज) & in oceans.
- Volcanos & natural water springs emit Hydrogen Sulfide at some extent.
- Major source of H_2S is Kraft pulp industry.
- Other Sulphur compound like Mercaptane are important because of their strong odour.
- Source of Mercaptane pulp industry, petroleum refinery, chemical manufacturing plant etc.

(vi) Aldehydes:-

Aldehydes are produced by the combustion of gasoline, diesel, oil, fuel oil & natural gases.

These are formed in the air because of photochemical reaction.

Primary & Secondary Air pollutants:-

1. Primary Air pollutants:-

These are those which are emitted directly from identifiable sources.

Ex:- Siner particles, Coarse particles, SO_2 , NO_x , CO, Halogen compounds, organic compounds, radioactive compounds.

2. Secondary Air pollutants:-

These are those which are produced in the air by interaction amongst two or more primary pollutants, or by reaction with atmospheric constituent with or without photo-activation.

Ex:- ozone, formaldehydes, PAN (per-oxi-peroxy acyl nitrate), photochemical smog, H_2SO_4 .

Smog:-

The term smog is formed by two words smoke & fog.

• Smog can be of 2 types

(i) photochemical smog

(ii) Coal industry smog (Modern smog) / Traffic smog

(i) Photochemical Smog:-

It is formed by oxidation of Hydrocarbons & Nitrogen oxide using photochemical reaction.

• Its main constituents are NO_2 , Hydrocarbons, Carbon-mono oxide & Ozone.

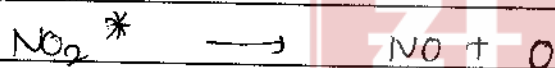
• It reduces visibility, causes eye irritation, damage to the vegetation & cracking of rubber.

(a) Nitrogen-di-oxide - Photochemical reaction:-

• Ultra violet length energy is absorbed by NO_2 & the highly energetic molecule (NO_2^*) is formed.



• These highly energetic molecule (NO_2^*) dissociates into Nitric oxide & oxygen.



• This atomic oxygen reacts quickly with molecular oxygen (O_2) to form ozone.



In the presence of Hydro-carbon other reactions take place & form aldehydes, per-oxides & per-oxi-acetyl nitrate (PAN).

• In the presence of water vapour nitric acid (HNO_3) may form.

(b) Sulphur-di-oxide - photochemical Reaction:-

• Ozone may be formed in atmosphere as a by product during photo-chemical oxidation of SO_2 to H_2SO_4 .

• The process efficiency of this process is very low.

Factors affecting photo-chemical Reaction:-

① Light Intensity:-

② Reactivity of Hydro carbon

③ Ratio of Hydro carbon to Nitric oxide

④ Presence of light absorber

⑤ Metro Meteorological Variables

Note:-

The main Conisquent of photo chemical smog are ozone & PAN.

14-10-23

2) Traffic smog / modern smog:-

Traffic smog is a type of air pollution which is derive from vechile exhaust or emission from internal combustion engines and industrial fumes that react in atmosphere with sunlight to form Secondary pollutants, that also combine with primary pollutant or emission to form photo. chemical smog.

3) Coal Induce smog:-

Coal induce smog mainly consist of sulphur compound.

Effect of Air pollution on Human.

① Sulphur di-oxide - (SO_2):-

- SO_2 is an irritating gas which effects on mucous membrane when it is inhaled.
- It leads to bronchial spasms & Asthmatic patient are badly affected.

② CO (Carbon-Mono-oxide) :-

- CO has a strong affinity for combining with Hemo-globin (HB) in the blood & formed carboxy-Hemoglobin (COHB).
- It reduces the ability of Hemoglobin to carry oxygen to the body tissues.
- CO has about 200 times more affinity than the oxygen so that low level of CO results in High level of COHB.
- CO also affects the Central nervous system of the body.

③ oxides of Nitrogen (NO_x) :-

- Out of several oxides of Nitrogen, only 2 are thought to affect human health.
- It causes eye & nose irritation & it creates dis-comfort.

④ Hydrogen Sulfide & Mercaptane :- (H₂S)

- H₂S is a foul smelling gas.
- Its smell is like that of rotten egg. (EIST EGG)
- Exposure of Hydrogen Sulfide for short duration can result in fatigue of smell sense.

Note:-

Mercaptane are added to natural or manufactured gas supplies to check the leakage.

⑤ Ozone (O₃) :-

- Ozone is a gas which is irritating in nature.
- It's affects the respiratory system.
- It can reach much deeper into the lungs than the oxides of Sulphur.

⑤ Fluorides :-

- Fluorine gas is a cumulative poison but Hydrogen fluoride (HF) is less harmful to human beings.

⑥ Lead (Pb) :-

- The main source of lead in urban atmosphere is automobile exhausts. It damages gastric system, liver, kidney.
- It causes child abnormality, brain abnormality, abnormality in fertility etc.
- The mental development of children gets badly affected.

⑦ Hydro-carbon Vapour :-

- The effect of formaldehyde is irritating.
- It causes eye & respiratory irritation due to formation of photochemical smog.
- Cancer

→ Carcinogenic Causing Agent :-

polycyclic organic compound, Incomplete combustion of Hydrocarbon,
3,4-Benzopyrene

Radio active Isotopes :-

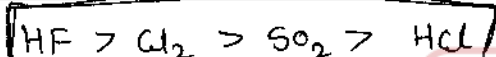
Some radio active isotopes like iodine-131, potassium-40, phosphorus-32, cobalt-60, radium-226, Carbon-14, Sulphur-35, Calcium-45, Uranium, strontium-90 etc. are found in ambient air & these isotopes badly affect human health.

Effect of Air pollution on Animals:-

- Animals are affected by air pollution.
- They are not affected significantly by direct inhaling.
- There are 3 pollutants which are most responsible for damage to livestock (animals) such as fluorine, Arsenic, lead ---

Effect of Air pollution on plants:-

SO_2 , HF , Cl_2 , HCl , NO_2 etc... affects the plants



Air pollution damage various Material:-

Material	pollutants	Effects
1. Metals	SO_2 , Acid gases	• Corrosion; loss of metal etc.
2. Building material	SO_2 , Acid gases, particulate matter	• De-colorization, leaching
3. paint	SO_2 , H_2S	• De-colorization
4. Textile	SO_2 , H_2S	• De-colorization
5. Textile dies	Ozone, NO_2	• Fading
6. Rubber	Oxidant & ozone	• Cracking, weakness
7. leather	SO_2 , Acid gases	• Disintegration, powdered surface
8. paper	SO_2 , Acid gases	• Embrittlement
9. Ceramics	Acid gases	• Surface staining

Control of Air pollution:-

- The Air pollution in atmosphere can be controlled by natural processes & by Engg. systems.

1. Natural processes:-

• There are some natural processes which act as air pollution removal mechanism in the atmosphere. Such as -

- (i) Dispersion
- (ii) Settling
- (iii) Wash-out
- (iv) Rain-out
- (v) Adsorption

2. Engineers Systems:-

• There are two approach for air pollution control

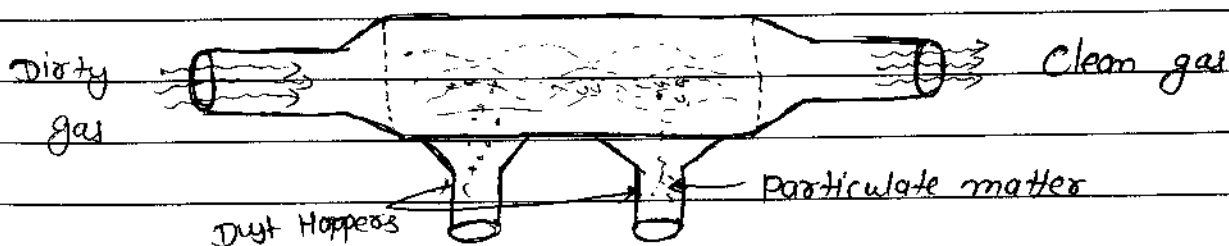
- (i) Dilution
- (ii) Control at Source.

(i) Dilution:-

Tall chimneys or stage stacks discharge the contaminants or air pollutants at higher level from the ground surface, where they get diluted into atmosphere.

(ii) Control at Source:-

- Gravitational settling chamber



- Gravitational settling chamber in air pollution control system provide an large area to minimize Horizontal velocity &

to allow the time for settling for particulate pollutants.

- It is used to remove particulate air pollutants only.
- Usual velocity through settling chamber is 0.5 to 2.5 m/sec.
- Simple to design & maintain & low pressure loss.
- Require large area for installation & has low collection efficiency.

• Theoretically it should be able for settling of particulate size 5-10 μm but in actual they are not able to remove particles of size less than $5 \mu\text{m}$.

• Centrifugal gas collector:-

- Centrifugal collector employ a centrifugal force instead of gravity force to separate particles from the gas stream.
- There are two types of centrifugal gas collector
 - (a) Cyclone Collectors
 - (b) Dynamic precipitators

(a) Cyclone Collectors:-

- Large diameter collectors have good collection efficiency for particles 140-50 μm in dia.
- The efficiency of this unit may be as high as 90% for the particles of 5-10 μm in dia.

(b) Dynamic Precipitator:-

- A dynamic precipitator imparts a centrifugal force to the particles which are present in incoming gas stream, by the action of rotating vanes.
- This unit function as an erosion fan as well as dust collector.
- It is 7 times more efficient than the cyclone precipitator.

• Wet scrubber or collector:-

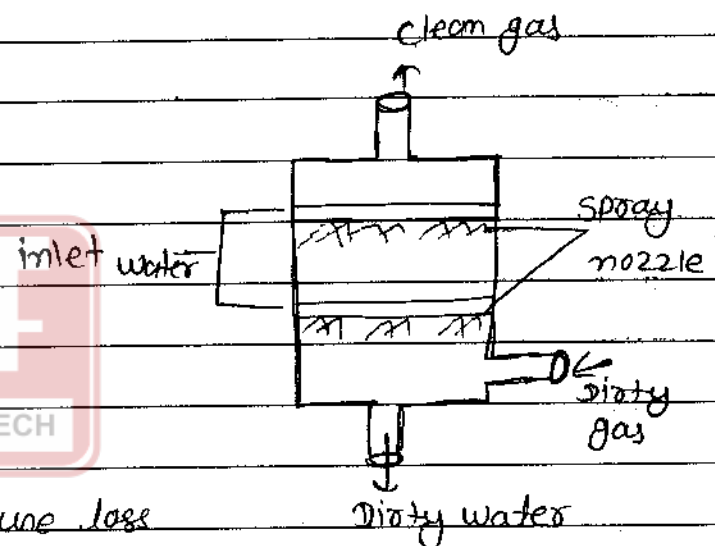
wet scrubbers remove the particulate matter from incoming gaseous stream by allowing the gaseous to flow up against a falling water stream.

• The most commonly used wet scrubbers are

- Spray tower
- wet cyclone scrubber
- Venturi-Scrubber

① Spray tower:-

- Spray towers are low cost scrubbers. That can be used to remove gases as well as particulate air pollutant.
- This unit cause very less pressure loss and can handle large volume of gas.



② Wet cyclone scrubber:-

- It is a simple wet cyclone scrubber high pressure nozzle spray are located in various places within the cyclone chamber which generates a fine spray that intersect the small particles in the gas.
- The efficiency approaches 100% for droplets of 100 μm where as 90 - 98% removal efficiency is achieved for the droplets of size 5 to 50 μm .

③ Venturi-Scrubber:-

- It can efficiently remove gaseous as well as particulate air pollutant.

Q1) Electrostatic Precipitator :-

In electrostatic Precipitator the emitted gas is passed through a highly ionized field or high vortical field. & there in that zone a particulate pollutant can get electrically charge with a result that ~~detected~~^{they} are separated out from the gaseous stream with the help of electrostatic forces.

Q2) ESP is extensively use in thermal power plant, pulp & paper industries, mining & metallurgical industries, Iron & steel plant, chemical industries etc.

Advantage :-

- Very small size particle (above $1 \mu m$) in wet or dry state can be captured is in easily.
- more than 99% efficiency can be achieved but usual range of efficiency is 95-99%.
- In ESP there are few moving parts hence its maintenance cost is very less.
- ESP can be operated at high temp. upto $300-450^{\circ}C$.

Fabric filter :- / Bag filters :-

In fabric filters the gas stream is passed through a woven or felted fabric which filters out particulate matter.

Applications :- / Advantages :-

- Has a high collection efficiency for wide range of particle.
- Very simple in design has ability to handle large volume of gas, at relatively high speed.
- Reasonable pressure drop & power requirements.
- Fabric filters are useful or particularly use in Cement, Kinds, Foundries (leather industries), steel furnishes, floor meals etc.

Control of pollution & removal of gaseous pollutant :-

Gaseous pollutant can be controlled by following devices.

i) Adsorption unit :-

- (a) Fixed bed adsorber
- (b) Moving bed adsorber
- (c) Fluidized adsorber

In adsorption unit, the gaseous stream is passed through the beds of a porous material containing adsorbent material such as Activated carbon, Activated Alumina, Magnesium silicate gel, Fuller (भुल्लाने मिट्टी) Earth, molecular sieve (dihydrated zeolite).

ii) Absorption unit :-

- (a) Spray tower
- (b) Tray or plate tower
- (c) Packed tower

iii) Condensation Unit :-

The principle of Condensation unit states that a compound will condense at a given temp. if its partial pressure is increased until it is equal to or greater than its vapour pressure.

There are 2 basic types of Condensation unit

- (a) Surface condensation
- (b) Contact condensation

iv) Combustion or Incineration unit :-

Combustion as a process is used to purify polluted gas, only when the admix pollutants are oxidizable to inert gases.

- Hydrocarbons & Carbon mono oxides can be easily burnt, oxidizes & removed

(a) Direct flame Combustion

(b) Thermal combustion

(c) Katelite combustion:-

- It can be used when material in the waste gas are too less to make direct flame insulation visible.

- The following Katelitics are used in katelatic combustion

i) Vanadium pentoxide (at High temp.) $\rightarrow$ remove SO_2

ii) platinum Metals - for removing NO_x .

iii) Activated Alumina - for removing Hydro carbons

iv) Pd-II, Cu-II $\rightarrow$ for oxidation CO & CO_2

Control of Air pollutant in Auto mobile:-

- Emission from petrol engine contain greater concentration of Hydrocarbon, CO where as Diesel engine contain greater concentration of NO in addition with thick smoke & particulate pollutants.

- Katelite converters helps in oxidation of Hydrocarbons & CO to CO_2 .
- They also convert NO into Nitrogen.
- Generally platinum & palladium (pd) Katelitics is used in Automobiles Katelite converter.

Dispersion of Air pollutant into the Atmosphere:-

① Lapse Rate:-

- In the troposphere the temp. of ambient air normally decreases with increase in altitude or Height.
- This rate of change (decrease) of temp. is called as Lapse rate.
- There are following types of Lapse Rate.

① Environmental Lapse Rate:- [ELR] / Ambient Lapse Rate

- The lapse rate of Ambient air is known as Environmental lapse rate. Generally ELR is taken as $6.5^{\circ}\text{C}/\text{KM}$.
- The ELR can be determine by sending up a balloon equiped with thermometer & self recording Mechanism. The Lapse rate obtained is known as probing Lapse Rate / Ambient Lapse Rate / Environmental Lapse Rate.

② Adiabatic Lapse Rate (ALR)

- When a parcel of air which is hotter & lighter than the surrounding air, then naturally it tends to rise up until it reaches at a level at which its own temp. & density becomes equal to that of ambient air. This rate of decrease in temp. with increase in Height is known as Adiabatic Lapse Rate (ALR).

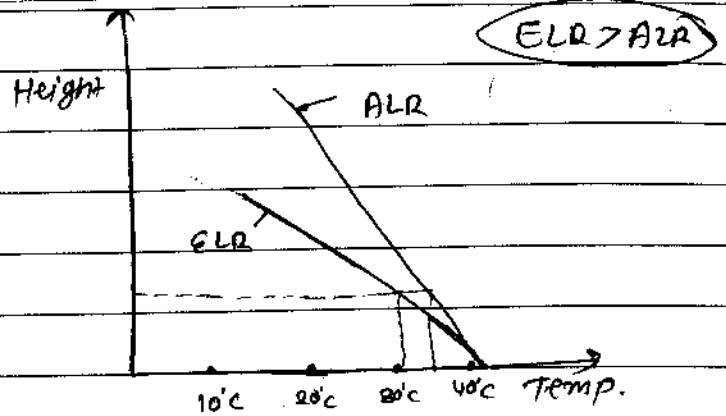
- There are dry & wet adiabatic lapse rate

$$\begin{aligned} \text{Im} \left\{ \begin{array}{l} \text{dry adiabatic lapse rate} - 9.8^{\circ}\text{C}/\text{km} \\ \text{wet adiabatic lapse rate} - 6^{\circ}\text{C}/\text{km} \end{array} \right. \end{aligned}$$

③ Super adiabatic Lapse Rate:-

When ambient lapse rate (ELR) is more than Adiabatic lapse rate then ELR is known as Super adiabatic lapse rate.

- In this case air parcel will always remain warmer & descending parcel always remain cooler than surrounding air. Hence rising of the parcel will continue to lift up.

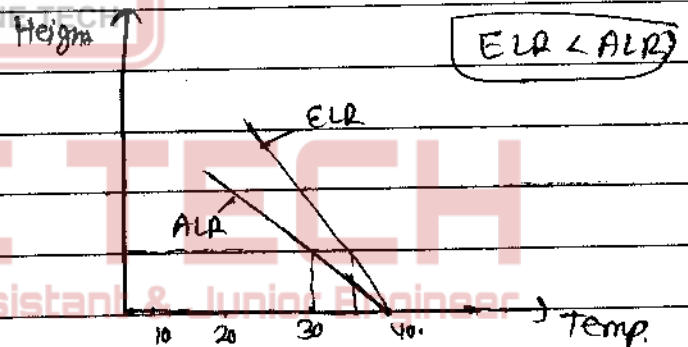


- Dispersion of pollutant will be rapid due to rapid vertical mixing of the air making the environment unstable.

ii) Sub-adiabatic lapse rate:-

- When ELR is less than ALR then ELR is known as Sub-adiabatic lapse rate.

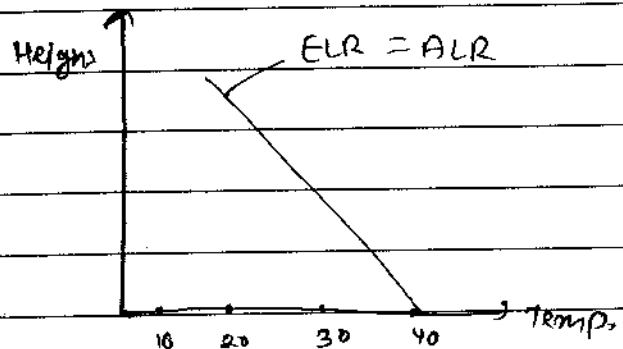
$$\boxed{ELR < ALR}$$



- In this condition atm. remains Stable.

iii) Neutral Lapse rate:-

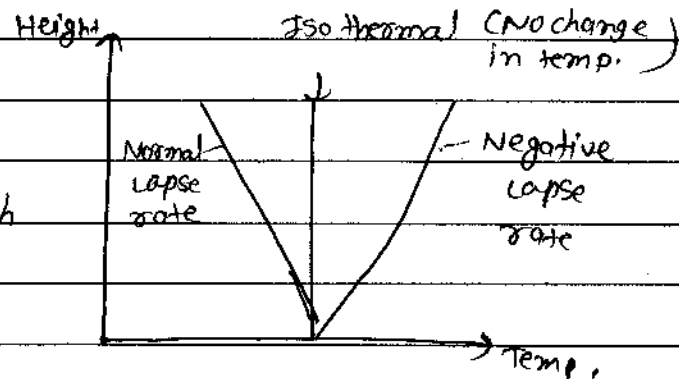
$$ELR = ALR$$



(iv) Negative lapse rate or Inversion:-

- when the temp. of environment increases with increase in Height or elevation then ELR is known as Negative Lapse rate & this condition is known as Inversion.

- It occurs under the condition usually referred to as inversion, An inversion is a state in which the warmer air lies over the colder air below.



- There are 2 type of inversion

(a) Radiation Inversion:-

It is also known as surface inversion.

- In radiation inversion the formation of fog is occurred when air is wet & particulate matter stops their uprise lifting.
- Radiation inversion is associated with sunlight.

(b) Subsidence Inversion:- For Assistant & Junior Engineer

- This is associated with a high pressure system & which is caused by characteristic sinking or subsidence motion of the air in a high pressure area surrounded by low pressure area.

Ex:- cyclone.

Plume Behaviour:-

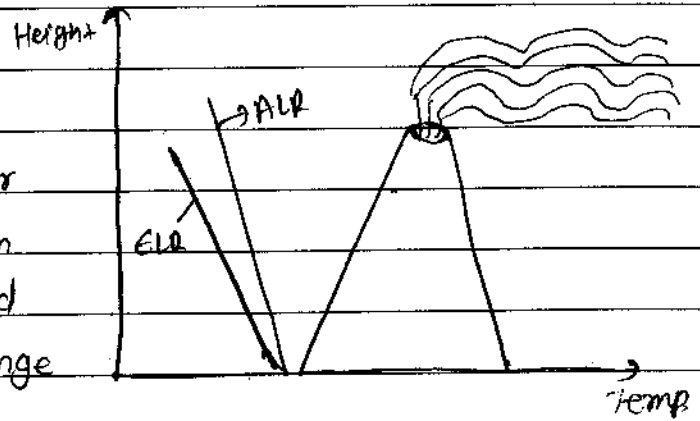
Plume is defined as the path taken by continuous discharge of gaseous pollutant emitted from a stack or chimney.

- The shape of plume & concentration distribution of gaseous pollutant depends upon localized air stability.

① Different types of plumes:-

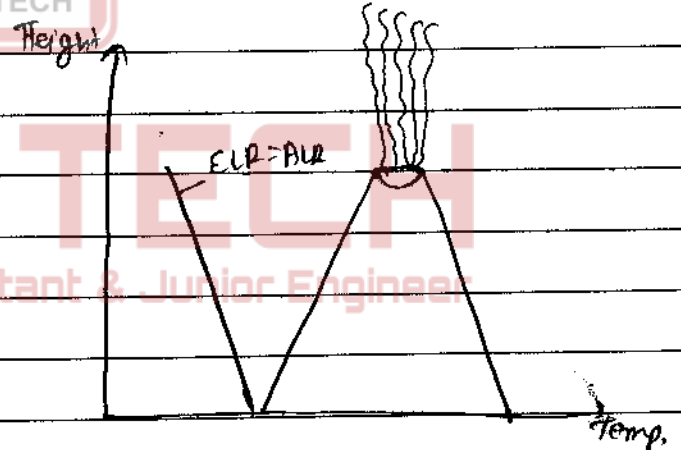
(1) Looping Plumes:-

- This is common type of plume behaviour which is occurred under Super adiabatic lapse rate condition with light to moderate wind speed on a hot afternoons when large thermal eddies are present.



- The plume was wavy (लहरदार) behaviour. since it occurs in a highly unstable ground.
- High turbulence helps in rapid dispersion of the pollutant but high concentration touch the ground.

② Neutral plume:-

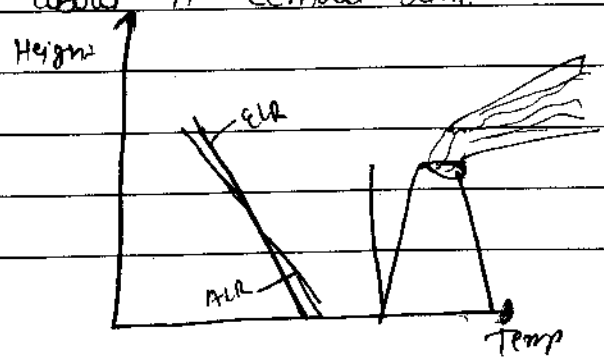


③ Coning plume:-

Coning plume occurs on cloudy day or nights with strong wind (wind velocity $> 32 \text{ kmph}$) when the lapse rate nearly neutral.

- The plume is vertically symmetrical about its central line.

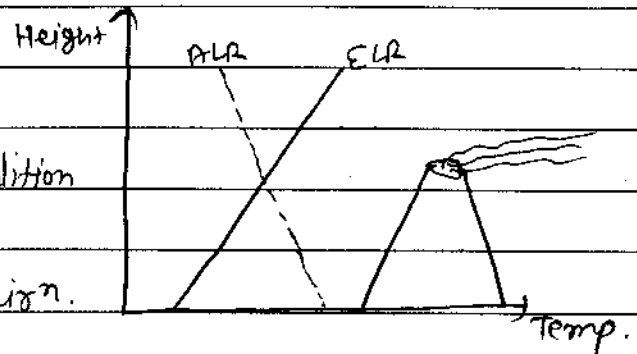
$V > 32 \text{ kmph}$



④ Fanning plume :-

It occurs under extreme inversion condition in the presence of light wind.

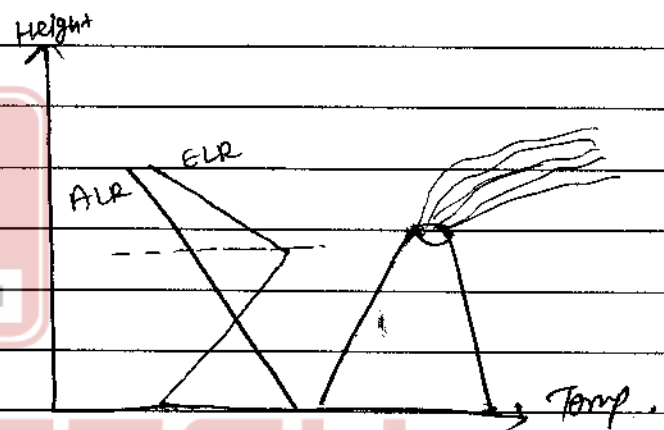
- The most of vertical dispersion is suppressed by extreme stable condition due to inversion & the plume fans out in the horizontal dirⁿ.



⑤ Lofting plume :-

Plume is said to be lofting when a strong super adiabatic lapse rate exist above the inversion.

- In such a condition, the downward movement & mixing is prevented by surface inversion. But the upward mixing will be quite turbulent & rapid due to super adiabatic condition.

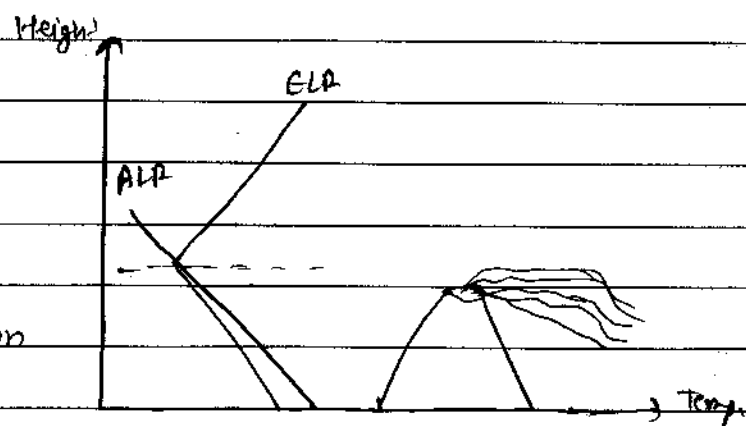


- The plume will not reach at the ground in this condition.
- This condition is most favourable for the dispersion of pollutant.

⑥ Fumigating plume :-

- The condition for fumigation are just opposite to the condition of lofting plume.

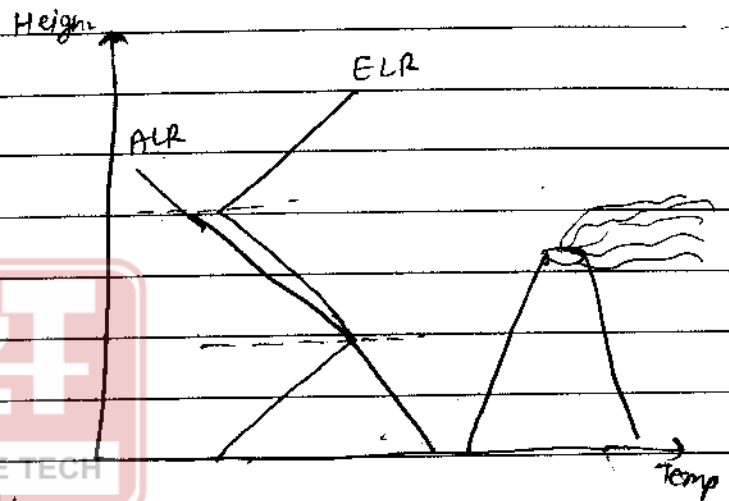
- Fumigation takes place when an inversion layer occurs at a short distance above the top of the stack & super adiabatic condition exist below it.



- It is worst or bad condition for the dispersion of the pollutant because pollutant can not escape above the top of the stack & they are brought down readily (sinking) near the ground surface due to high turbulence.

⑦ Trapping plume:-

- This condition is achieved when the plume is caught or trapped b/w two inversion layers hence the emitted plume neither go up nor down.
- The dispersion of effluent is severely affected by the atmospheric condition b/w two stable regions.
- It is also a bad condition for the dispersion of pollutant.



Design of Stack Height:-

- Central board for prevention & control of water pollution recommended following provisions for the height of chimney.

(1) Height of chimney for emission of particulate matter

$$h = 74 (Q_p)^{0.27}$$

(2) Height of chimney for emission of SO_2

$$h = 14 (Q_s)^{1/3}$$

(3) Min. values

The board has further recommended that the height of chimney or stack calculated on the basis of particulate matter & SO_2 emission.

by above 2 equations, should not be less than following

i) for chimney adopted for industries in general [except thermal power plant] $\Rightarrow$ $h_{min} = 30M$

ii) for thermal power plant having capacity 200 - 500MW
 $h_{min} = 220M$

iii) Thermal power plant having capacity more than 500MW
 $h_{min} = 275M$

h = Height of stack in meter

Q_p = particulate matter emission Tonnes/hour

Q_s = SO_2 emission kg/hr

Note: -

The height of chimney should be max. of above 3 criteria

Q. A factory uses 1.5 ML oil (fuel oil) per month. The exhaust gases from the factory contain following quantities of pollutants per ML/per year.

offw
particulate matter - 4 tonnes/year

SO_2 - 20 tonne/year

ML = million liter

NO_x - 5 tonne/year

Hydro-carbon, CO & others - 3 tonne/year

Calculate safe Height of chimney for safe dispersion of pollutant.
for particulate matter

$$\begin{aligned} \Rightarrow h &= 74 (Q_p)^{0.27} \\ &= 74 \left(\frac{4}{365 \times 24} \right)^{0.27} \\ &\Rightarrow 14.32 \end{aligned}$$

$$Q_p = 4 \times (1.5 \times 12) \text{ tonnes/year}$$

$$\Rightarrow 72 \text{ t/year}$$

$$= 72 / 365 \times 24$$

$$= 0.008 \approx 0.01 \text{ tonne/hr}$$

For particulate matter

$$h = 74 (Q_p)^{0.27}$$

$$= 74 (0.01)^{0.27}$$

$$= 21.34$$

$$Q_s = 20 \times (1.5 \times 12) \text{ tonne/year}$$

$$= 360 \text{ t/year}$$

$$= \frac{360}{1000 \times 365 \times 24}$$

$$\Rightarrow \frac{360 \times 10^3}{365 \times 24}$$

$$= 41.09 \text{ M}$$

For SO_2

$$h = 14 (Q_s)^{1/3}$$

$$= 14 (41.09) = 47.7 \text{ M} \approx 50 \text{ M}$$

So, required height of stack is 50 M.

Best Institute For Assistant & Junior Engineer

Air Quality Modeling :-

Air quality models use mathematical & numerical techniques to simulate the physical and chemical processes that effect air pollutants as they disperse & react in the atmosphere.

Purposes:-

- Establishing emission control legislation, i.e. determining the max. allowable emission rates that will meet fixed air quality standards
- Evaluating proposed emission control techniques & strategies i.e. evaluating the impacts of future control.
- Selecting locations of future source of pollutants (ex. industries) in order, to min. their environmental impacts

- planning the control of air pollution episodes i.e. defining immediate intervention strategies.
- ~~Assen~~ Assessing responsibility for existing air pollution levels, i.e. evaluating present source-receptor relationship

Factors to be considered in Modeling :-

5 major physical processes are simulated.

- i) Pollutant advection
- ii) diffusion
- iii) Deposition
- iv) chemical reaction (i.e. transformation)
- v) Emission

Types of Air Quality Modeling :-

① Dispersion / Diffusion Modeling :-

Uses mathematical formulations to characterize atmospheric processes that disperse a pollutant emitted by a source

Ex :- Gaussian plume model.

② Photochemical Modeling :-

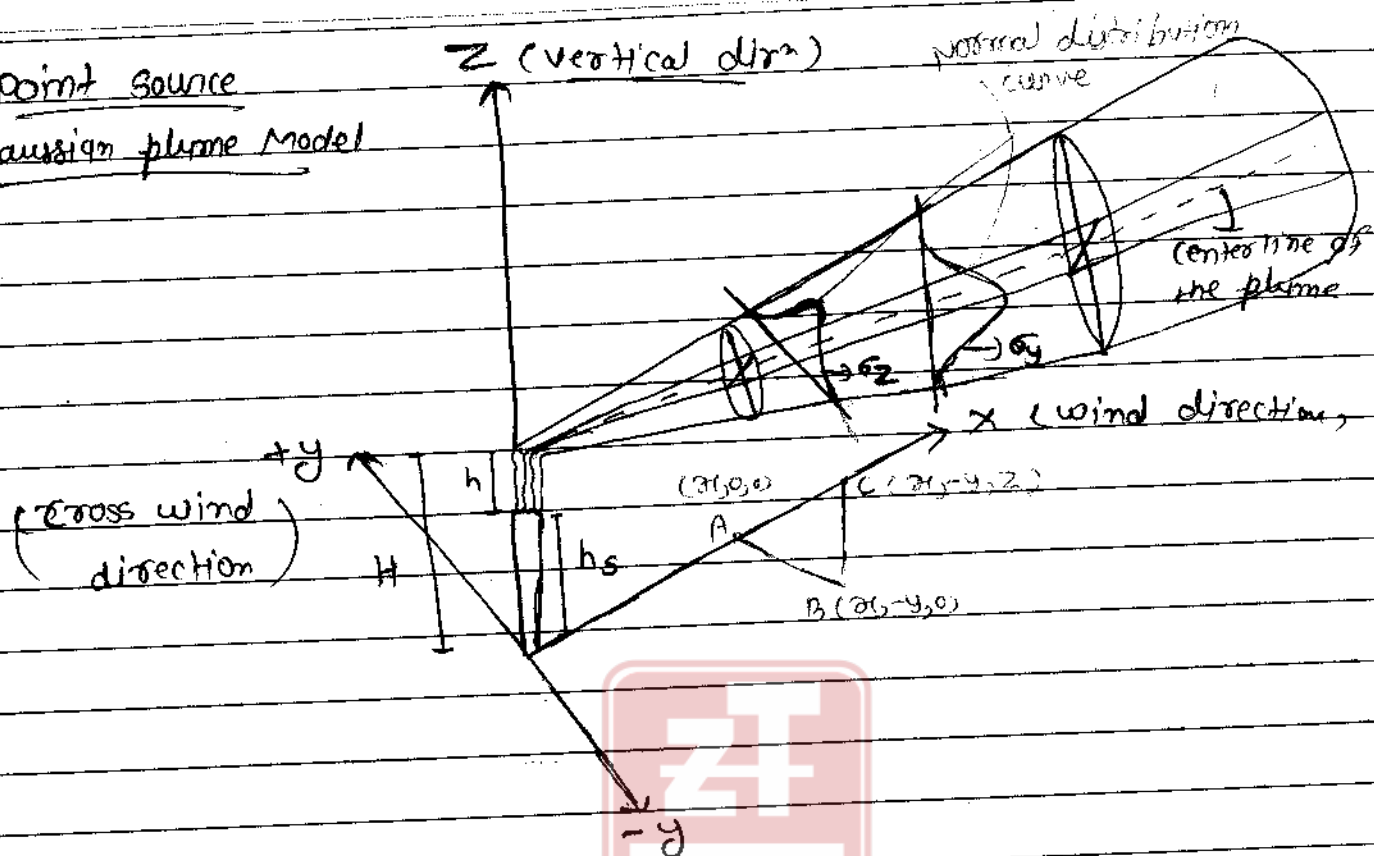
Long-range air quality models that simulate the change of pollutant concentrations in the atmosphere due to the chemical & physical processes in the atmosphere.

③ Receptor modeling :-

Mathematical or statistical procedure for identifying & quantifying the source of air pollutants at a receptor location.

Ex :- chemical Mass Balance method.

point source Gaussian plume Model



H = effective stack Height

h_s = Stack Height

h = plume rise

σ_z & σ_y = standard deviation

Factors affecting the dispersion of pollutant:-

① Wind speed:-

- wind speed generally increase with height.
- For buoyant sources, plume rise is affected by wind speed, the stronger the wind, the lower rise.

② Turbulence:-

- Turbulence is another factor which affects the wind dirn & hence the concentration of air pollutant.
- It is highly irregular motion of the wind.
- More will be the turbulence dispersion will be more.

(3) wind dirⁿ :-

- The total concentration of air pollutant is inversely proportional to the increase of wind angle dirⁿ with respect to receptor.

Ass

Assumptions :-

- Plume spread results primarily by molecular diffusion.
- Time required for the pollutant to travel to the receptor is neglected ; steady state is assumed
- Normal distribution of horizontal & vertical pollutant concentrations in the plume.
- There is no diffusion in x dirⁿ.
- ~~Uniform~~ In Line Source no diffusion in ^{any} ~~all~~ dirⁿ.] Imp
- Uniform continuous emission rate.
- Wind speed is constant.
- Terrain is Flat.
- pollutant dispersion follows normal statistical distribution
- Shape of plume is conical
- pollutant are non-reactive or inert.

- At any point P there is a contribution to the concentration $C(x, y, z)$

$$C(x, y, z) = \frac{Q}{U} \frac{1}{2\pi\sigma_y\sigma_z} e^{\left(\frac{-y^2}{2\sigma_y^2}\right)} \left[e^{\left[\frac{-(z-H)^2}{2\sigma_z^2}\right]} + e^{\left[\frac{-(z+H)^2}{2\sigma_z^2}\right]} \right]$$

Imp $\log_e C \propto H^{-2}$

Q = mass emission rate

C = pollutant concentration at point P (x, y, z)

U = wind speed at effective stack height

- If only concentrations at ground level are required

$$C(x, y, 0) = \frac{Q}{U} \frac{1}{\pi \sigma_y \sigma_z} e^{\left(\frac{-y^2}{2\sigma_y^2}\right)} \cdot e^{\left(\frac{-H^2}{2\sigma_z^2}\right)}$$

Note:-

It should be noted that max. concentration occurs when

$$\sigma_z = \frac{H}{\sqrt{2}}$$

- If only concentrations at ground level on the center line of the plume (along x-axis dirn) are required then the equation is simplified further since both $z=0$, $y=0$.

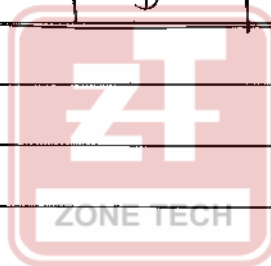
$$C(x, 0, 0) = \frac{Q}{U} \frac{1}{\pi \sigma_y \sigma_z} \cdot e^{\left(\frac{-H^2}{2\sigma_z^2}\right)}$$

Pascal stability classes:-

Pasquill stability y classes	Atmospheric stability	Temp. gradient dT/dz ($^{\circ}\text{C}/100\text{m}$)
A	Extremely Unstable	< -1.9
B	Moderately Unstable	-1.9 to -1.7
C	Slightly unstable	-1.7 to -1.5
D	Neutral	-1.5 to -0.5
E	Slightly Stable	-0.5 to 1.5
F	Stable	> 1.5

Stability Classification:-

Surface wind speed (at 10m), M/S	Day time Isolation			Night time conditions	
	Strong	Moderate	Slight	Thin overcast or $\geq 4/8$ low cloud cover	$\leq 3/8$ cloud cover
< 2	A	A-B	B	-	-
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
> 6	C	D	D	D	D



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NOISE POLLUTION

11-11-21

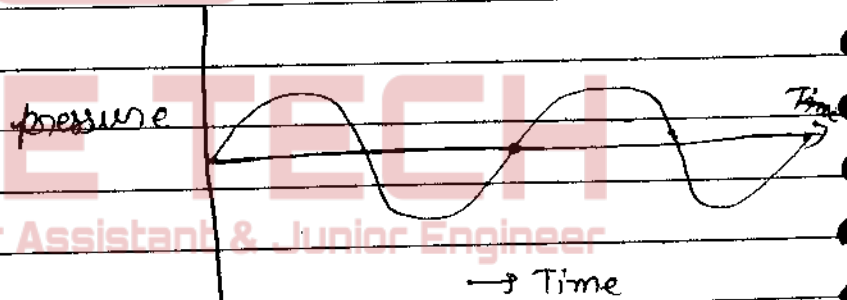
NOISE

Noise can be defined as that the unwanted sound which produce undesirable psychological effect in an individual by interfering with one's social activity such as work, rest, recreation, sleep etc.

- The noise of sufficient intensity & duration can induce health problem such as permanent & temporary hearing loss, general annoyance, irritation, disturbance, headache, insomnia, mental torcher, fatigue, nausea, high blood pressure, High pulse-rate etc.

Characteristics of sound & its measurement :-

Alternative Compression & Rarefaction of surrounding air produces sound wave which propagate in the form of sinu-soidal path.



- The time b/w two successive peaks or Troughs is known as time period ' T '. & its inverse, which is represent the no. of times a peak arrives in one second is known as frequency ' f '.
- Frequency is measured in Hz.

$$f = \frac{1}{T}$$

- The distance b/w 2 successive peaks or troughs is known as Wave length ' λ '. (λ)

$$\lambda = \text{Velocity} \times \text{Time}$$

$$\lambda = c \times \frac{1}{f}$$

$c = \text{velocity}$

$$T = \frac{1}{f}$$

Amplitude :-

- The amplitude 'A' of the sound wave is the height of peak sound pressure which is measured above or below the zero pressure line.
- The equivalent pressure of sound waves is represented by root mean square pressure (P_{rms})

$$P_{rms} = \sqrt{\frac{1}{T} \int_0^T p_{rms}^2 \cdot dt}$$

Power of Sound (W) =

- It is defined as the rate of doing work by a travelling sound wave in the dirⁿ of propagation of wave.
- The power of sound is measured in watt.

Sound intensity (I) :-

- It is defined as the sound power averaged over the time, per unit area normal to the dirⁿ of sound wave.

$$I = \frac{W}{a}$$

W = power of sound

a = A unit area $\perp$ to the sound wave

- Sound Intensity in the form of pressure

$$I = \frac{p_{rms}^2}{\rho \cdot c}$$

p_{rms} = rms sound pressure in pascal

ρ = density of air or medium

c = velocity of sound wave in m/s

$$p_a = N/m^2 \quad \left\{ \begin{array}{l} 1 \text{ Mpa} = 10^6 \text{ N/m}^2 \\ 1 \text{ Mpa} = 1 \text{ N/mm}^2 \end{array} \right.$$

level of sound / Noise :-

- The sound pressure of the faintest sound (शुद्ध शिः) that can be heard by a normal healthy individual is $20 \mu\text{Pa}$
- The $20 \mu\text{Pa}$ sound pressure is considered as reference sound pressure so, Now

$$\text{Sound level (L)} = \log_{10} \left(\frac{Q}{Q_0} \right) \text{ Bel} \rightarrow (B)$$

or

$$L = 10 \log_{10} \left(\frac{Q}{Q_0} \right) \text{ Decibels (dB)}$$

Here Q = measured quantity sound of pressure or sound power or sound intensity

Q_0 = reference std. sound pressure or std. sound power or std. sound intensity

<u>Imp</u>	std. sound pressure = $20 \mu\text{Pa}$
	std. sound power = 10^{-12} watts
	std. sound intensity = $\frac{10^{-12} \text{ watt}}{\text{area } \text{m}^2}$

(i) Sound pressure level (L_p) :-

$$L_p = 10 \cdot \log_{10} \left(\frac{P_{rms}}{20 \mu\text{Pa}} \right)^2$$

(dB)

or

$$= 20 \cdot \log_{10} \left(\frac{P_{rms}}{20 \mu\text{Pa}} \right)$$

(ii) Sound power level (L_w)

$$L_w (\text{dB}) = 10 \cdot \log_{10} \left(\frac{W}{10^{-12}} \right)$$

(iii) Sound intensity level (L_i)

$$L_i (\text{dB}) = 10 \cdot \log_{10} \left(\frac{I}{\left(\frac{10^{-12}}{a} \right)} \right)$$

Q# Addition of Sound levels:-

$$① \text{ } 50 \text{ dB} + 50 \text{ dB} = ?$$

$\Rightarrow$

$$L_p = 20 \cdot \log_{10} \left(\frac{P_{rms}}{20 \mu\text{Pa}} \right)$$

$$50 \text{ dB} = 20 \cdot \log_{10} \left(\frac{P_{rms}}{20} \right)$$

$$\frac{P_{rms}}{20} = \text{Anti log} \left(\frac{50}{20} \right)$$

$$P_{rms} = \text{Anti log} \left(\frac{50}{20} \right) \cdot 20$$

$$\boxed{(P_{rms})_{50} = 6324.55 \mu\text{Pa}}$$

$$(P_{rms})_{50 \text{ dB} + 50 \text{ dB}} = \sqrt{(6324.55)^2 + (6324.55)^2}$$

$$\Rightarrow 8944.26 \mu\text{Pa}$$

Now

$$(L_p)_{50 \text{ dB} + 50 \text{ dB}} = 20 \cdot \log_{10} \left(\frac{P_{rms}}{20} \right)$$

$$= 20 \cdot \log_{10} \left(\frac{8944.26}{20} \right)$$

$$\Rightarrow 53 \text{ dB} \checkmark$$

$$② \text{ } 60 \text{ dB} + 60 \text{ dB} = ?$$

$$P_{rms} = \text{Antilog} \left(\frac{60}{20} \right) \cdot 20$$

$$\boxed{(P_{rms})_{60 \text{ dB}} \Rightarrow 20000 \mu\text{Pa}}$$

$$(P_{rms})_{60 \text{ dB} + 60 \text{ dB}} = \sqrt{(20000)^2 + (20000)^2} = 28284$$

$$L_p = 20 \cdot \log_{10} \left(\frac{28284}{20} \right)$$

$$\Rightarrow \textcircled{63 \text{ dB}}$$

Average of sound pressure level :-

For n^{th} sound pressure level (L_n) p_{rms} is given as

$$(L_p)_{\text{avg}} = 20 \cdot \log \left[\frac{1}{N} \left\{ \sum_{n=1}^N 10 \left(\frac{L_n}{20} \right) \right\} \right]$$

Ex: calculate avg. sound pressure level for 4 measurement readings such as 40, 50, 62, 72 dB with respect to 20 μPa .

$$= (L_p)_{\text{avg}} = 20 \cdot \log \left[\frac{1}{4} \left\{ 10 \left(\frac{40}{20} \right) + 10 \left(\frac{50}{20} \right) + 10 \left(\frac{62}{20} \right) + 10 \left(\frac{72}{20} \right) \right\} \right]$$

$$\Rightarrow 20 \cdot \log \left[\frac{1}{4} \cdot (100 + 316.2 + 1258.9 + 3981.07) \right]$$

$$\Rightarrow \underline{63 \text{ dB}}$$

Octave Band Analysis :-

- A noise can be fully categorised by breaking it into components of frequency which is called as Spectra.
- An octave band is the frequency interval b/w given frequency & twice of that frequency.
- Normally 8-11 octave bands are considered for any classification.

1 st	octave Band	→	22 Hz	—	44 Hz
2 nd		→	44 Hz	—	88 Hz
3 rd		→	88 Hz	—	176 Hz
⋮					
11 th		→			

Note:-

- Narrow band analysis is used instrument testing.
- Octave band analysis is used to control community noise pollution & for identification of violators.

Noise rating system:-

1. The L_N Concept:-

The parameter L_N is a statistical measurement indicating how frequently a particular sound level is exceeded.

- The value of L_N will be represented the sound pressure level that exceed for $N\%$ of the gauging time.

→ for example the given 70dB value of L_{50} will represent that the sound level will exceed 70dB for 50% of mean measuring time.

Example

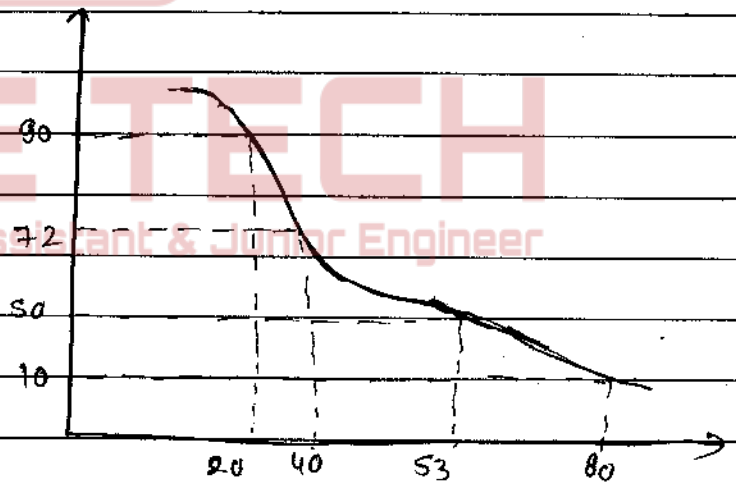
(% of time
≥ stated value)

$$L_{10} = 80\text{dB}$$

$$L_{50} = 53\text{dB}$$

$$L_{72} = 40\text{dB}$$

$$L_{90} = 20\text{dB}$$



→ sound level (dB)

Cumulative Distribution curve

Equivalent sound level / The L_{eq} Concept:-

- The equivalent sound level is defined as the constant sound level over a giving time, expends the same amount of

Energy which is expended by fluctuating sound level over the same time

$$L_{eq} = 10 \log_{10} \sum_{i=1}^n \left(10^{\frac{L_i}{10}} \right) \cdot t_i$$

n = total no. of sound samples

L_i = sound level of i^{th} sample

T_i = Time duration of i^{th} sample (it is expressed as fraction of total sample time)

Noise Abatement & Control :-

The noise reduced by automobiles & trains is biggest nuisance in modern life.

It can be abated by construction of walls of both side of railway lines & roads due to which noise can be reduced

$$\text{Noise Path Loss Reduction (dB)} = 10 \cdot \log_{10} \left[\frac{20H^2}{\lambda^2 R} \right]$$

λ = wavelength of sound

R = distance b/w barrier & receiving point

H = Height of barrier wall

Ambient air quality standard in respect of noise :-

Area Code	Category of Area/Zone	Limits (dB)	
		Day time	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silent Zone	50	40

Note: -

- ① Day time shall be ^{mean} from 6AM - 10PM
 • Night time mean from 10PM - 6AM

dB (Leq*) $\rightarrow$ waited avg. of diff. sound levels

Sound level & Human response :-

Common sounds	Noise level (dB)	Effect on Human
1. Air raided siren	140	painfully loud
2. Jet take off (200ft), thunderclath, Auto horn (3feet)	120	• Max. vocal effort
3. Pile driven	110	—
4. Garbage truck	100	—
5. Heavy truck (50ft) & city traffic	90	• Very annoying, Hearing damage after 8 hrs.
6. Alarm clock (2ft), Hair drier	80	Annoying
7. Noisy restaurant, freeway traffic, Mens voice (3ft)	70	Telephone use become difficult
8. Air conditioning unit (20feet)	60	• Intrusive
9. Light auto traffic (100 ft)	50	• Quite
10. Living room, bedroom & quite office	40	—
11. Library, Soft whisper (15ft)	30	Very quite
12. Broadcast studio	20	very quite

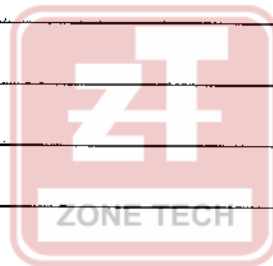
High intensity noise & Human Health Hazard :-

Noise level (dB)	Health hazard
80	Annnoying
90	Hearing damage (8 hr)
95	Very annoying
110	Stimulation of reception in skin
120	pain threshold
130 - 135	Nausea, vomiting, & dizziness
140	pain in ear, prolong exposure causing intensity
150	burning of skin, significant change in pulse rise
160	other minor, permanent damage if prolonged
180	Eardrums rupture, measure permanent damage
194	lungs damage

Noise pollution Standards :-

Category of Vehicle	Noise limit 'm decibal (dB)
1. Motor-cycle, scooter & three-wheelers	80
2. passenger car	82
3. passenger car or commercial vehicle up to 4 MT (metric tonne)	85
4. passenger or commercial vehicle above 4 MT - 12 MT	89
5. greater than 12 MT	91

Equipment	Noise limit
1. Window A.C. of 1-1.5 ton	68 dB
2. Air Cooled coils	60
3. Refrigerators	46
4. Diesel generator for domestic purpose	85-90
5. Compactors, rollers, front loader, Concrete mixers, Cranes, vibrators, & Saws	75



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Solid waste Management

27

• Types of solid wastes:-

- Municipal solid waste
- Industrial solid waste
- Hazardous waste
- bio-medical waste
- E-waste

• Waste generation:-

Material flow and waste generation

• Solid waste - A Consequent life

• Evolution of solid waste management

• The development of solid waste management

• Integrated solid waste management

• Planning for integrated waste management, operation of solid waste management

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Classification of solid wastes :-

- Solid waste are the organic & inorganic waste materials such as product packaging, grass clippings, furniture, clothing, bottle, kitchen refuse, paper, appliances, paint cans, batteries etc.
- Solid waste is a Hetrogeneous mass of wastes from the urban communities as well as a more homogeneous accumulation of agricultural, industrial & mineral wastes.
- Solid waste are classified on the basis of source of generation and type.

Types of solid waste	Description	Sources
Food waste (garbage)	waste from the preparation, cooking & serving of food. Market refuse, waste from the handling, storage & sale of produce and meats and vegetables	
• Rubbish	Combustible (primary organic) paper, cardboard, cartons wood, boxes, plastic, rags, cloth, bedding, leather, rubber, grass, leaves, yard trimmings	Households, institutions & Commercial such as hotels, stores, restaurants,
	Non combustible (primary inorganic) metals, tin cans, metal foils, dirt, stone, bricks, ceramics, crockery, glass bottles, other mineral refuse	market, etc.

Ashes and Residues	Residue from fires used for cooking and for Heating buildings, cinders, clinkers, thermal power plants	
Bulky waste	Large auto parts, tyres, stoves refrigerators, other large appliances, furnitures, large crates, trees, branches, palm fronds, stumps, flotsage	
Street waste	Street sweepings, Dirt, leaves, catch basin dirt, animal dropping, contents of litter receptacles dead animals	Streets, sidewalks, valleys vacant lots etc.
Dead animals	Small animals: cats, dogs, poultry etc. large animals: Horses, cows etc.	
Constructions and demolition waste	Lumber, roofing and sheathing scraps, scrap residues, rubble, broken concrete, plaster, conduit pipe, wire insulation etc.	Construction and demolition sites, remodeling, repairing sites
Industrial waste & Sludges	Solid waste resulting from industry processes and manufacturing operations, such as food processing waste, boiler house clinkers, wood plastic & metal scraps and shavings etc.	Factories, power plants treatment plants, etc.

	Effluent treatment plant sludges of industries & Sewage treatment plant sludges, coarse screening, grit & septic tank.	
Hazardous wastes	pathological waste, explosives, radioactive material, toxic waste etc.	Households, hospitals, institutional stores, industry etc.
Horticulture wastes	Tree-trimmings, leaves, waste from parks and gardens etc.	Parks, garden, roadside trees, etc.

Classification of Solid waste :-

1. Based on Source:-

(i) Residential:-

(ii) Commercial

(iii) Institutional

(iv) Industrial

(v) Agricultural

} Municipal

2. Based on Type:-

(कचरा)

(i) Garbage

It contains ~~put~~ putrescible (rotting) organic matter, which produce an obnoxious (अपहोती) odour & attracts rats & other vermin.

(ii) Ashes & residues

• Since ashes and residues are almost entirely inorganic, they are valuable in landfills.

(iii) Bio-degradable & Non-bio degradable:-

- Bio-degradable waste is a form of waste, originating naturally from plant or animal sources, which may be degraded by other living organisms (by biological actions).
- Bio-degradable waste usually can be found in municipal solid waste such as green waste, food waste, paper waste, & biodegradable plastics. Some of the sources contain human waste, sewage, slaughterhouse waste etc.
- Waste that cannot be decomposed or degraded by the biological process is known as "Non-biodegradable wastes". Most of them include the inorganic waste that is non-biodegradable.

(iv) Hazardous wastes:-

(v) Combustible & Non-combustible waste

(vi) Bulky waste

(vii) Street waste

(viii) Dead animals

(ix) Farm waste

(x) Abandoned vehicles

(xi) Construction & demolition waste

(xii) Sewage waste

(xiii) E-waste

(xiv) Plastic waste

Important point:-

① Refuse:-

- Refuse is a term which represents a dry waste or solid waste of the society.
- The usual density of refuse varies $300 - 600 \text{ kg/m}^3$
- The density of Indian refuse is generally higher than that of the developed countries. Hence Indian refuse can be

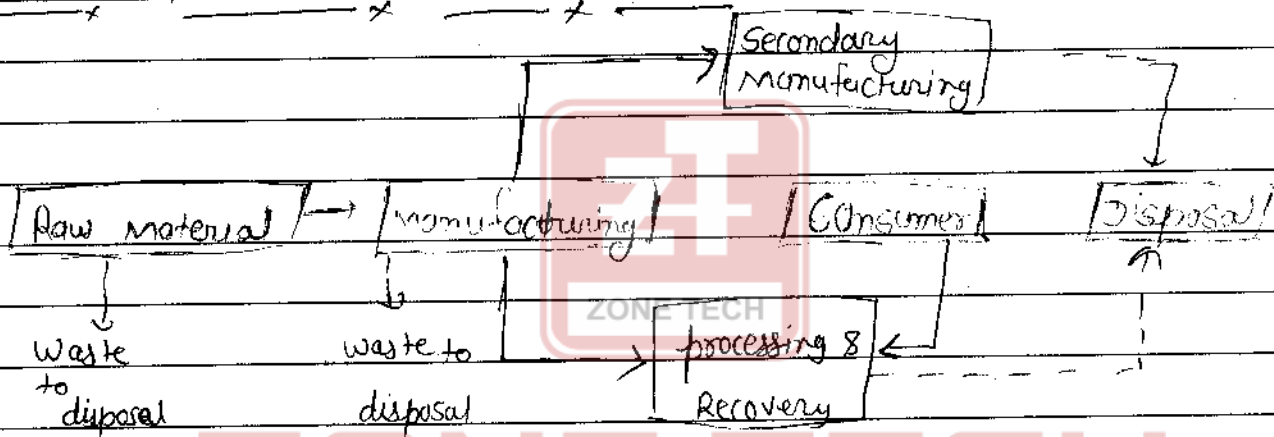
carried efficiently & economically by mechanical transport.

- The calorific value of Indian refuse is much smaller because its moisture content is high.
- The community refuse can be referred as municipal solid waste.

② The density of garbage varies from $450 - 900 \text{ kg/m}^3$

The density of ashes & residues varies from $700 - 850 \text{ kg/m}^3$.

Material flow & waste generation :-



Solid waste : A consequence of life :-

- Improper disposal causes plague because of breeding and other disease.
- Improper landfilling of solid waste causes water pollution.
- Improper landfilling of solid waste causes air pollution by release of greenhouse gases.
- Plastic dumped in oceans causes harm to marine environment.
- Increasing use of plastic packaging of goods due to technology advancement.

Consequences : Recent years:

- cloud burst in Mumbai (2005)
- Blast in the Bhuvan steel factory at Noida, caused due to imported scrap from Iron

- Reduction in the migratory birds due to consumption of contaminated food.
- Animals dying on streets and farmland due to consumption of plastic bags.
- Fire in Mumbai & Delhi dumpsites.
- The area of the dump yard in Chennai has doubled over the last decade & clogging of the drains due to indiscriminate of solid waste and construction debris in another major reason for floods (2015)

Evolution & Development of solid waste management : OLD INDIA

• Manusmriti :-

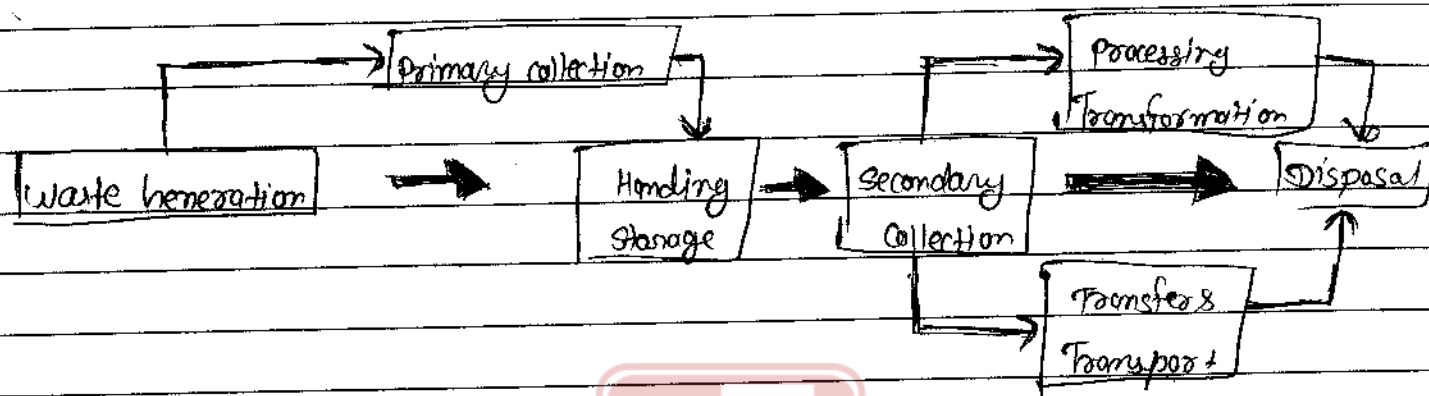
- 1st systematic treatment of Hindu Law, also prohibited the throwing of garbage, dust, rubbish, pieces of meat etc. on the highway & in water bodies & made it punishable.
- Kautilya in his Arthashastra has mentioned that maintaining sanitation of habitate was essential and inviable.
- Ayurveda also emphasized on the wholesomeness of water and pure air as the pollution of both causes many type of diseases.

NEW INDIA :-

- Surat (hujrat) plague
- Municipal Solid waste (Management and Handling) Rules 1987
- PIL at Supreme Court 1999 (Dr. Amrita Patel)
- Revise Municipal Solid waste (Management & Handling) Rules 2000
- Jawaharlal Nehru National Urban Renewal Mission (JNNURM) 2006 - hywahaati
- Swachh Bharat Mission 2014 - 2 Oct. 2014
- Plastic Waste Management Rules, 2011 & Revised in 2016
- Bio-Medical waste (Management & Handling) Rules, 1998 & Amended 2003, 2011, & Bio-Medical Waste Management Rules, 2016

- E-waste Management Rules, 2011 & revised in 2016
- Battery (Management & Handling Rules) 2001

Functional Element of Solid waste management System:-



- Solid waste management (SWM) is associated with the control of waste generation, its storage, collection, transfer & transport, processing & disposal in a manner that is in accordance with the best principles & principles of public health, economics, Engineering, conservation, aesthetics, public attitude & other Environmental considerations.

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Waste Generation:-

- Waste generation from households, commercial areas, industries, institutional, street cleaning and other municipal services.

Waste Storage:-

- Storage is a key functional element because collection of wastes never take place at the source or at the time of their generation.
- Onsite storage is of primary importance due to aesthetic consideration public health and economics involved.
- Some of the options for storage are plastic containers, conventional dustbins (of households), used oil drums, large storage bin.

(for institutions & commercial areas or servicing depots), etc.

Waste collection:-

- This includes gathering of wastes & hauling them to the location, where the collection vehicle is emptied, which may be a transfer station a processing plant or a disposal site.

• Transfer Station:-

Intermediate station where wastes from smaller vehicles are transferred to larger ones and also segregated.

Transfer & Transport:-

- This functional element involves the transfer of wastes from smaller collection vehicles, where necessary to overcome the problem of narrow access lanes, to larger ones at transfer stations.
- The subsequent transport of the wastes, usually over long distances, to disposal sites.

Processing:-

- Processing is required to alter the physical & chemical characteristics of wastes for energy & resource recovery & recycling.
- The important processing techniques include compaction, thermal volume reduction, manual separation of waste components, incineration & composting.

Recovery & Recycling

- This includes various techniques, equipment & facilities used to improve both the efficiency of disposal system & recovery of usable material and energy.
- Recovery involves the separation of valuable resources from the mixed solid wastes, delivered at transfer stations or

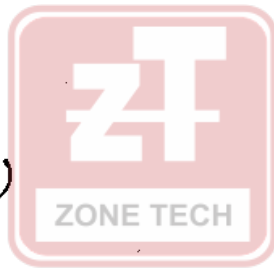
processing plants.

- It also involves size reduction and density separation by air classifiers, magnetic devices for iron & screens for glass.
- Certain recovered materials like glass, plastics, paper, etc. can be recycled as they have economic value.

Waste disposal:-

• Most common method for solid waste disposal.

- i) open dumping
- ii) Sanitary landfill
- iii) Composting
- iv) Shredding (pulverization)
- v) Incineration
- vi) Pyrolysis



20-10-23

Selection criteria for waste processing technology:-

Reference

- National green tribunal order dated 25 May & 1 Aug. 2016 in the matter of OA No. 199 of 2014 (Almitra H. Patel v/s Union of India)
- The selection of appropriate technology is one of the most key consideration for successful solid waste management system. A wrong selection of waste processing technology can cause failure of entire waste management system leading to bad economics & environmental cost.

Selection of Best available technology for waste processing :-

• The waste processing technology can be divided into 2 category.

1. Biological treatment
2. Thermal treatment

1. Biological treatment :-

- Biological treatment is completes by allowing M.O. to degrade waste components by creating conducive environment for the growth of M.O.
- In biological treatment, the biodegradable organic portion of waste is broken down into gaseous product such as CO_2 , CH_4 , S_2S etc. & water molecules. water molecule leaving behind carbon rich by product which is called as Composed
- The biological activities depends upon several criteria such as
 - (i) C/N ratio
 - (ii) pH value
 - (iii) moisture content
 - (iv) oxygen supply
- The biological process for waste treatment can be further divided into 2 category.

- (a) Aerobic process (in the presence of oxygen)
- (b) Anaerobic process (in the absence of oxygen)

2. Thermal treatment :-

- Thermal process of treatment is applied to destroy harmful potential of the waste with their Energy recovery.

MSW - Municipal Solid waste

- In this process the waste component are insubminated in controlled oxygen supply so that maximum heat energy can be recovered by causing air pollution.
- The heat energy can be utilized for generating electricity through boiler.

II Important waste processing technologies:-

① Aerobic Composting:-

- Composting is the process of aerobic decomposition of bio-degradable organic matter in warm, moist environment by the action of bacteria, yeast, fungi & other M.O.
- Imp. In India MSW has initial C/N ratio of around 30:1 which is ideal for decomposition.
- Imp. The M.O. involved in stabilization of O.M. utilized of 30 part of Carbon for 1 part of Nitrogen.
- Imp. Compositing required 25 m^2 area for per ton of MSW (only for windrow Composting for 21 days Composting & maturity yard for 30 days composting)

② Vermi-Composting:-

- Vermi-Compost is the end product of the breakdown of OM by particular species of Earth worms.
- Vermi compost is a nutrient rich, natural fertilizer & soil conditioner which is cultured on a specially made Vermi-bed.
- The Earth worms are generally used: *Eudrilus eugineae*, *Eisenia foetida*, *Lumbricus rubellus*.
- Vermi-Compost can treat any organic waste except oil, spicy, salty, Hard & diet do not have excessive acidity & alkalinity.

- preferred C/N ratio $\rightarrow 30 : 1$
- preferred Moisture Content $\rightarrow 40 - 45\%$
- Vermi-Composting can be done in a tank of size $4m \times 1m \times 5m$ for waste input of 10 kg/day of semi-decomposed waste.

③ Bio-Methanation or Bio-waste derived Fuel :-

- It is a process based on Anaerobic digestion in which m.o. break down bio-degradable O.M. in the absence of oxygen. It produces methane & CO_2 rich bio-gas for energy production hence it is a renewable energy source.
- The nutrient rich solids left after digestion can be used as fertilizers.
- preferred C/N ratio $\rightarrow 25 - 30 : 1$
- Moisture Content $> 50\%$
- Area required for bio-Methanation - $25m^2$ /tonn of MSW

④ Incineration :-

- Incineration of MSW involves Combustion of waste leading to vol. reduction 90-95% & recovery of heat energy.
- Basically it is a burning furnace for waste material & converts MSW into ash, gaseous & particulate matter & Heat energy.
- It requires high temp. of the order of $800 - 1000^\circ C$, sufficient air (O_2) & mixing of gaseous stream.
- The Min. temp. of burning of carbonous OM without waste to avoid the release of smoke & emission of diox, is $850^\circ C$.
- Depending on the nature of waste & operating characteristic of combustion reactor, the gaseous product derive

from the Combustion of MSW may include — CO_2 , water, (H_2O & flue gas), oxygen (O_2), NO_x , SO_2

- Min. Moisture content $< 45\%$.

- Min. calorific value $> 1500 \text{ Kcal/kg}$ of MSW.

⑤ Pyrolysis / Plasma pyrolysis :-

- Plasma pyrolysis or plasma gasification is a waste treatment technology in which waste matter is gasified in a oxygen starved environment, to decompose the waste matter into its basic molecular structure.

- The process demands high electric energy for creating high temp. by an electric arc gasifier.

- In this process does not combust the waste material as insulator do.

- In pyrolysis relatively high voltage, high electricity is passed b/w 2 electrodes, spaced apart, creating an electric arc where the temp. as high as 13871°C is reached.

- The temp. from 1M arc can be reached upto 4000°C at this temp. most of type of waste are broken into basic elemental components in a gaseous form & complex molecule. depending on the input waste.

⑥ Production of Refused derive fuel / Palletization :-

- It is basically a processing method for mixed MSW which can be very effective in preparing & increased fuel feed for thermal process like incineration or industrial furnaces.

- It is a fuel produce by shredding of MSW & stream

treatment for reducing moisture content.

- RDF includes organic components such as plastic bio-degradable material (plaster, Bricks, logs) & non-combustible material such as glass & metal are not included in RDF.
- If moisture content is more than 35-40%, then it is required to dry the waste.
- RDF is an alternative process & it is potential based technology.

Criteria for Selection of waste processing Technology:-

Primary Criteria for Selection of waste processing Technology

1. Quantity of waste generation
2. Characteristics of waste (physical & chemical property)
3. Based on land availability
4. prevailing environmental conditions
5. climatic condition and terrain
6. Social acceptance
7. Market for the products
8. Capital investment
9. Siting criteria
10. Environmental norms.

- Vermi-composting and Biogas plants are capable of handling effectively up to 30 Tonn/ per day & suitable for small towns.
- Aerobic composting plants are found operational up to 500 Tonn/day.
- The waste to energy plants are found cost-effective for processing waste 500 Tonn/day & above.

IWP - Integrated waste plant

BM - Biomethanation

VC - Vermi-compositing

CC - chemical conversion

RDF = Refused derive fuel

Table-1 options for Integrated Technologies as per waste quantity generation

S.No	population range	waste gen. TPD	Composition	Technological options
1.	Above 2 Million	>1100 TPD	Biodegradable 35 - 50%.	IWP comprising - BM+CC+RDF. W to E plant for power, based on: gasification, pyrolysis, incineration & mass ~~for~~ burning. RDF to Cement industry plastic to fuel oil
2.	1M - 2M	550-1100 TPD	Biodegradables 40-55%.	IWP comprising - BM+CC+RDF W to E plant for power, where wastes exceeds 500 TPD based on: gasification, pyrolysis, Incineration & mass burning RDF to Cement industry plastic to fuel oil
3.	1 Lakh - 10 Lakh	30-550 TPD	Biodegradables 40-55%.	IWP - BM, CC + RDF as feed stock to power plant / cement industry. Plastic to fuel oil
4.	50K - 1 Lakh	10-30 TPD	Biodegradables 45-60%.	BM, VC or CC RDF
5.	<50K	<10	45-65%.	BM, VC/CC and RDF
6.	Hill towns state capitals		30-50%.	BM, CC/RDF as feed stock, plastic to fuel oil

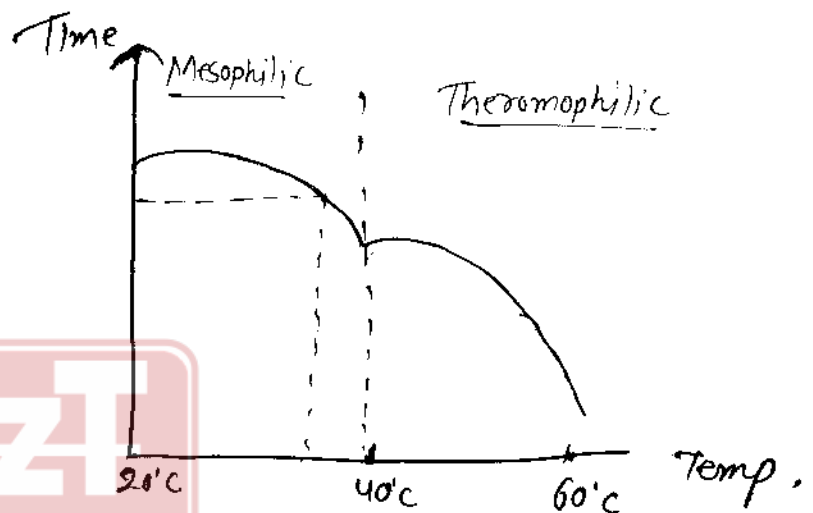
Table-2 Indicative Land Requirements for different Composting Technologies

Parameters	Windrow	Static	In vessel	Vermicomposting
General	Simple technology	Eff. for farm & municipal use	Large-scale systems for commercial applications	Suitable for quantities less than 50 TPD generation of mixed MSW
Amount of waste treated	1 ton - 500 ton per module	1 ton - 500 ton per module	1 ton - 200 ton per module	1 ton - 50 ton
Land Requirement	8 ha - 500 TPD	5 ha - 500 TPD (less land required given faster rates & eff. pile vol ^m)	4 ha - 500 TPD (very limited land due to rapid rates & continuous operations)	2 ha - 50 TPD
Time	8 weeks	5 weeks	3 weeks (3-5 days in vessel 3 weeks to mature)	8 weeks
Ambient Temp.	No Temp. Sensitive	Not temp. Sensitive	Not temp. Sensitive	30-40°C ideal range: 35-37°C
Energy Input	Moderate	Moderate (2-3 hr aeration)	High	Low
Financial Implications	Moderate	Costly	Very costly	Modest, purchase of exotic earthworms suitable for MSW composting are expensive

Table-3 - specifications for various type of waste processing Technologies.

S.No.	Method	MSW characteristics	C/N ratio	pH Control	Temp. required	Moisture Content
1.	Composting	Sorted organic fraction of MSW, preferable with same rate of decomposition	B/W 25-50 initially. Release of ammonia & impeding of biological activity at lower ratios	7-7.5 (optimum) Not above 8.5 to 14M nitrogen loss in the form of ammonia gas	50-55°C for first few days & 55-60°C for the remainder composting period. Biological activity reduces significantly at higher Temp.	55% (Optimum)
2.	Incineration	MSW with calorific value as high as possible; volatile matter >40%; fixed carbon <15%; inert <35%.	Calorific value. As high as possible >1200 kcal/kg	—	850°C - 1400°C	As min. as possible <45%
3.	Pyrolysis	—	—	6.5-8.5 (optimum)	700°C - 900°C	—
4.	Gasification	—	—	—	>1000°C	—
5.	Biomethanation	Sorted organic fraction with higher the putrescibility better is the gas yield; fibrous OM is undesirable as the anaerobic MO. do not break down woody materials such as lignin	25-30 (preferable)	Acidogenic bacteria through the production of acids reduces the pH of the tank. Methanogenic bacteria operates in a stable pH range 6.5-7.5	Mesophilic bacteria are optmally around 35-45°C or at ambient temp. b/w 20-45°C. Thermophilic bacteria act optimally around 50-52°C at elevated temp. up to 70°C. Mesophiles are more tolerant to changes in environmental conditions & hence more stable, but thermophilic act faster.	>50% Implications on feed, gas production, system type, system efficiency

6. Vermicomposting	Any organic waste which are not appreciably oily, spicy, salty or hard & that do not have excessive acidity & alkalinity	30:1 (preferred). Brown matter (wood products, saw dust, paper etc.) is rich in carbon & green matter (food scraps, leaves etc.) in Nitrogen	Slightly alkaline state preferable correction by adding small dose of calcium carbonate	30 20-30°C
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21-10-23

Characteristics of Municipal solid waste :-

1. Density

- The density of waste (mass per unit volume, kg/m^3) determines the storage & transportation volume requirements.
- MSW density in India is typically around $450 - 500 \text{ kg/m}^3$.

Typical Density (kg/m^3) values Asian countries :-

Components	Range	Typical
Food waste	130-480	290
paper	40-130	89
plastic	40-130	64
Yard waste	65-225	100
glass	160-480	194
Tin cans	50-160	89
Aluminium	65-240	160

Method for Bulk Density Measurement :-

• Material and Apparatus :-

- wooden box of 1m^3 capacity
- wooden box of 1ft^3 capacity
- Spring balance weighing upto 50 kg

• procedure :-

- A composite sample of MSW collected from diff. parts of the heap should be taken in the smaller 1ft^3 box and weighed with the help of a spring balance.
- After weighing, contents of this smaller box (1ft^3) should be emptied into the bigger 1m^3 box.
- This is repeated until the larger box is filled to the top.
- Once the larger box is filled, the weight of the waste is noted.
- The waste should not be compacted by pressure
- Repeat the entire procedure thrice & take the avg. weight to arrive at the weight per cubic meter (1m^3).

Impact of Density on Waste Transportation Choices :-

- Compacter bins & refuse compactors are cost effective in case of low density waste. But this are not cost effective in case of high density waste.

True A compaction ratio as high as 2.5:1 is achievable :-

2. Particle size

- The size and distribution of the waste material is important consideration in the recovery of materials, especially with mechanical means such as trommel screen & magnetic separator
- Size of waste components :-

(i) $S_c = 1$

(ii) $S_c = \frac{L+W}{2}$

(iii) $S_c = \frac{L+W+H}{3}$

(iv) $S_c = (L \cdot W)^{1/2} \quad / \quad 2\sqrt{L \cdot W}$

(v) $S_c = (L \cdot W \cdot H)^{1/3} \quad 3\sqrt{L \cdot W \cdot H}$

3. Field capacity:-

31

- It is the total amount of moisture that can be retained in the waste sample subjected to the downward pull of gravity
- It is very important for determining the formation of leachate in landfill.

~~But~~ water in excess of the capacity will be released as leachate.

4. Moisture Content:-

- Moisture content $\% = \frac{\text{wet weight} - \text{dry weight}}{\text{wet weight}} \times 100$
- ~~Notes~~ A typical range of moisture content is 20-45%, representing the extremes of waste characteristics in an Arid climate & in the wet season of a region having large precipitation.
- Values greater than 45% are however not uncommon.
- Moisture increase the weight of MSW & therefore the cost of collection & transportation also increase.

5. Calorific value:-

- Calorific value of waste is defined as the amount of heat generated from combustion of a unit weight of the waste, expressed as kilojoule per kilogram (KJ/kg) or (Kcal/kg).
- The calorific value is determined experimentally using a bomb calorimeter, in which the heat generated from the combustion of a dry sample is measured at a constant temp. of 25°C.
- Determining calorific value of waste is important to determine the potential for recovering RDF from waste & its utilization in cement, power, and waste to energy plants.

6. Bio-Chemical characteristics:-

• Chemical characteristics:-

- These include p^H : Nitrogen, phosphorus & potassium (N-P-K), total

organic carbon : C/N ratio & calorific value:

- Biochemical characteristics:

These include carbohydrates, proteins, natural fiber, and bio-degradable factor.

- Toxicity:-

Toxicity profile of MSW includes heavy metals, ~~per~~ persistent organic pollutants, pesticides & insecticides.

- Toxicity characteristics leaching procedure (TCLP) is used for ascertaining the toxicity profile of MSW.

Quantification of waste generation:-

- An assessment states that the per capita waste generation is increase by about 1.3% per year.
- with an urban growth rate of 3.0 - 3.5% per year, the annual increase in waste quantities may be considered at 5% year per year.

Quantification of waste - 1996

- The characterization studies carried out by National Environmental Engineering Research Institute (NEERI).
- MSW contains large organic fraction (30-40%) ; ash and fine earth (30-40%) paper (3-6%) along with plastic, glass & metal (Each less than 1%).
- The calorific value of refuse range b/w 800-1000 Kcal/kg and C/N ratio b/w 20 to 30.
- Study revealed the quantum of waste generation varies b/w 0.2 - 0.4 kg/capita/day in the urban centers & goes up to 0.5 kg/capita/day in Metropolitan cities.
- The study was carried out in 42 cities of varying sizes.

Quantification of waste : 1999-2000

- The study conducted by CPCB through Environment protection Training & Research Institute (EPTRI) in 1999-2000 in ~~200~~ 210 class I cities & 113 class II towns.
- class I cities generated 48,134 tons/day (TPD) of MSW while class II towns generated 3401 TPD of MSW.
- The study revealed that waste generation rate in class I cities was approximately 0.34 kg/capita/day while the waste generation rate in class II towns was found to be 0.14 kg/capita/day.

2010-2011

- The survey conducted by the Central Institute of Plastics Engineering and Technology (CIPET) at the instance of CPCB has reported generation of 50,592 TPD of MSW in 2010-2011 in the same 59 cities.

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2004-2005

- NEERI's assessed 59 cities (35 Metro cities & 24 Megacities).
- Studies have revealed that waste generation rate varies from 0.12 - 0.60 kg/capita/day.
- Per Total Compostable Matter — 40-60% ✓
- recyclable fraction — 10-20% ✓
- Moisture Content — 30-60% ✓
- C/N ratio — 20-40 ✓

6,897 TPD - in Raj - waste

2014 - 15

- As per epew CPCB, 1,43,449 TPD of MSW was generated for 34 states & Union territories during 2013 - 2014.
- The avg. rate of waste generation in India, based on this data is 0.11 kg/capita/day.
- out of the total waste generated, approximately 1,17,644 TPD (82%) of MSW was collected and 32,871 TPD (22.9%) was processed or treated.

Solid waste management status in Recent Years:-

- Total quantity of solid waste generated 1,60,038.9 TPD. out of which collected waste (1,52,749.5 TPD) = 95.4%.
- Quantity of ba waste is treated $\rightarrow$ 79,956.3 TPD (50%)
quantity of waste if land filled $\rightarrow$ 29,427.2 TPD (18.4%)
- Total waste generated remains unaccounted $\rightarrow$ 50,655.4 TPD (31.7%)

per capita solid waste generation:-

Year	solid waste generation (gm/capita/day)
2015-16	118.68
16-17	132.78
17-18	98.79
18-19	120.54
19-20	119.26
20-21	119.07

- The trend of % solid waste generation has been calculated for last 6 year & marginal decrease trend is observed in per capita solid waste generation over the last 6 year.

observed

The trend of solid waste processed is ↑ increasing over the last 6 years.

In 2015-16, 19% waste was processed but in 2020-21 49.96% was processed.

The trend for solid waste landfilling is observed that it is decreasing.

2015-16 - 54%.

2020-21 - 18.4%.

Trend in gap in solid waste management

Year	Gap in solid waste management (%)
2015-16	40.99
16-17	79.78
17-18	9.38
18-19	30.35
19-20	25.82
20-21	31.70

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Solid waste Management trend state wise

Per capita generation in 2020-21		Urban ULB	
Max. Delhi	Min. Assam	Town/cities/urban local bodies in state & UT	
Lakshdeep	Meghalaya	ULB - 4437	
Mizoram	Bihar	Towns - 3043	
		7968 - class I & II (Towns & cities)	
Waste process 2020-21		In Raj. - 196 (Town & cities)	
Max. Chhattisgarh	Min. Bihar	ULB - 196	
Odisha	Arumachalpradesh	class I & II - 79	
Hoo	Assam		

Reffered from annual report 2020-21 on emplimentation of
Solid ~~bas~~ waste management rule 2016 (CPCB dehli)

Disposal of Solid waste:-

- Disposal on or inside the earth is only fisible method for long term handling of the following:
 - (i) Solid waste that are collected & ^{has} no further use
 - (ii) Residual matter remaining after solid waste have been processed
 - (iii) Residual matter remaining after recovery of conversion products & energy has been accompletes.

Methods of Disposal:-

1. Open dumping
2. Sanitary landfill
3. Composting
4. Shreuding / ~~pub~~ phubisation
5. Incineration
6. Pyrolysis

Note:-

- Sanitary landfill is the method of disposal of the waste which is most commonly used for municipal waste.
- Land farming & deep well injection (sevence boring) is used for industrial waste.

1. Disposal is refused by open dumping:-

- It is an oldest method of disposing solid waste
- Simple method

- collected solid waste is disposed in low lane area located far away from the city.
- It is not eco friendly
- This method is still in practice in semi-urban areas & rural areas.

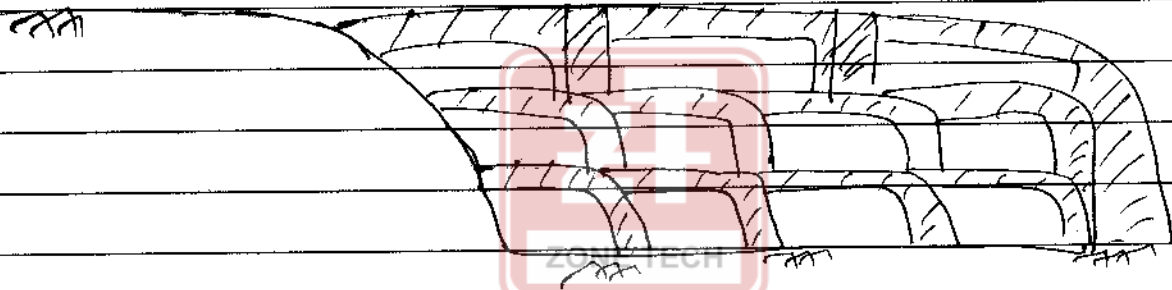
2. Disposal of refuse by Sanitary landfills:-

- The important aspects in the implementation of sanitary landfills include

- Site selection
- Land filling method & operations
- occurrence of gases & leachate
- Movement & control of landfill gases & leachate

- In this method refuse is carried & dump into low lane areas under & Eng. operation, designed & operated according to acceptable standard.
- It involves a control disposal of solid waste on or in the upper layer of earth surface
- The refuse is dump & compacting in a layer of 0.3-0.6m after the days work.
- When the depth of filling becomes about 1.5m, it is covered by earth layer of 15-30cm thickness.
- Filling is done by a grid pattern.
- Before dumping the second layer compaction is done by movement of bulldozers & Trucks.
- A min. clearance distance of 6m from surrounding area should be left during filling operations of low laying areas.

- Insecticides like DDT, Dieldrin, etc. should be sprayed to prevent mosquito breeding.
- final cover about 0.6m of earth is laid & compacted at the top of filled up layer length in order to finish the complete operation & prevent rodents (etc) from burrowing into the refuse.
- The filled up refuse gets stabilized due to decomposition of organic matter & get in ~~event~~ converted into stable compounds.



Steps involved in refuse stabilization:

- The entire period of refuse stabilization can be divided into distinct phases.
- i) Aerobic bacteria & fungi, which are dominant, deplete the available oxygen to oxidise into organic matter. as a result of aerobic respiration, temp. of landfill increases.
- ii) Anaerobic & facultative bacteria develop to decompose the organic matter & H_2 & CO_2 gases are evolved through acidogenesis process.
- iii) Methanogenic bacteria develop to cause evolution of Methane gas.
- iv) Methanogenic activity gets stabilized.
- v) Methanogenic activity subsides, representing depletion of organic matter & ultimately the system returns to

aerobic condition with in the landfill.

Note:-

The refuse in a well managed landfill, generally gets stabilized with in a period of 2-4 months & settle down by 20-40% of its original heights. Hence the filled up land can be used for developing for green land, parks, ground or recreation spot.

Advantages:-

- This method is most simple & economical.
- Separation of diff. kind of refuse is also not required in this method
- No residue or by product left out in this method hence no further disposal is required.
- Low lying area or water logged area can be easily reclaimed & put to better use.

Disadvantage:-

- Low lying depression or dumping site may not always be available.
- There is a continuous evolution of foul gases near the fill site specially during the time of dumping of the refuse. These gases may often be explosive in nature.
- In case of sanitary landfill there is a problem of leachate.

Accountance of gases & leachate in landfills:-

- The following event occurs when solid waste is dumped in a sanitary landfill.

vi) biological decay of organic matter:-

vii) chemical oxidation

viii) Evolution of gases

ix) Movement of liquid

x) Dissolving & leaching, organic & inorganic material by water

xi) Uneven settlement caused by consolidation

xii) movement of dissolved material by concentration gradient & osmotic.

gases in landfill:-

• Air, ammonia, CO_2 , CO, H_2 , H_2S , PCH_4 , N_2 , O_2 ,

• CH_4 & CO_2 are principal gases produced by anaerobic decomposition.

• The movement of gases can be controlled by constructing air bands, barriers, by gas recovery, by landfill sealant.

• The compacted clay is most commonly used sealant for landfill.

leachate in landfill:-

• leachate is defined as the liquid which is percolated through the solid waste & has extracted dissolved & suspended material from it.

• In most of landfill the liquid portion of leachate is composed of the liquid produced from the decomposition of organic waste & the liquid that has entered in the landfill from the external source such as surface drainage, rainfall, underground water & water from underground springs.

• Under normal conditions leachate is found in the bottom of landfill.

- The use of clay liners or synthetic liners like geotextile has been most favourable method for reducing & eliminating the percolation of leachate.
- An important method to control the production of leachate is to eliminate the infiltration of surface water from the landfill which is major contributor to the total vol^m of leachate.
- For this an impervious clay layer over the top of fill at a downward gradient, can be provided with adique drainage & surface infiltration.

landfilling methods at sanitary landfilling site:-

- ① Area method
- ② Trench method
- ③ Depression method

① Area Method:-

- Area method is used when the terrain is unsuitable for trench excavation specially the water table is high.
- Entire landfill site is divided into no. of sub-areas by constructing embankment & roads.

② Trench method:-

- It is suitable to the areas where an adequate depth of covered material is available at sight & the water table is well below the surface.

③ Depression method:-

- At location where natural & artificial depression is found, depression method is suitable in this condition.

Composting:-

- In India the Composting is practised in rural areas on the mixture of night soil & refuse.
- There are 2 methods which are generally adopted here.
 1. Indore process
 2. Bangalore Method

1. Indore Method:-

- In this method manual turning of piled ^{up} mass is done for its decomposition under aerobic condition.
- It is an aerobic method.
- In this method layers of vegetable waste & night soil are alternatively piled in depth of about 7.5 cm - 10 cm each to a total depth of 1.5 m in a trench or above the ground to form a mound which is called a windrow.
- The mixture is ~~kept~~ kept for 2-3 months.
- This compost mass is then left for another 1-1.5 months without any turning, after which the compost becomes ready for use.
- The entire process takes about 4 months.

2. Bangalore method:-

- It is an anaerobic process.
- In this method the vegetable waste & night soil are piled up in layers in an underground earthen trench of about 10 x 1.5 x 1.5 m.
- The mass is covered at a ~~step~~ top by the layer of earth about 15 cm depth.

- And it finally left over decomposition
 - Total time of process is 4-5 months (depending upon the season)
 - The fully stabilized a brown color odourless powdered mass is obtained called as Humus.
- ~~But~~ This method is widely adopted for Municipal Authority in India.

Disposal of refuse by pulverisation:-

- All the operation like Shredding, grinding, separation of waste are carried out mechanically.
- ~~The element~~ In this method, refuse is ~~pub~~ pulverised in a grinding machine so as to reduce its volume.
- The pulverised refuse become practically odourless & unattractive to the insects.
- This pulverised refuse contains fertilising elements like potash, phosphate, Nitrogen etc.

HAZARDOUS WASTE:-

Procedure for management of hazardous and other waste:-

- ① For the management of hazardous and other wastes, an occupier shall follow the following steps, namely.
- (a) Prevention
 - (b) Minimization
 - (c) Reuse
 - (d) Recycle
 - (e) Recovery, utilization including co-processing
 - (f) Safe disposal

• Storage of hazardous and other wastes:-

- The occupiers of facilities may store the hazardous & other wastes for a period not exceeding 90 days & shall maintain a record of sale, transport, storage, recycling, recovery, pre-processing, co-processing & utilization of such wastes & make these records available for inspection.

Provided that the State Pollution Control Board may extend the said period of 90 days in following cases, namely.

- Small generators (up to 10 tonnes per annum) up to 180 days of their annual capacity.
- Actual users and disposal facility operators up to 180 days of their annual capacity.
- occupiers who do not have access to any treatment, storage, disposal facility in the concerned state, or
- the waste which needs to be specifically stored for development of a process for its recycling, recovery, pre-processing, co-processing or utilization.
- In any other case, on justifiable grounds up to 180 days.

Manifest System (Movement Document) for hazardous & other waste to be used within the country only -

Copy no. with colour code	Purpose
Copy 1 (white)	To be forwarded by the Sender to the State Pollution Control Board after signing all the 7 copies
Copy 2 (Yellow)	To be retained by the Sender after taking signature on it from the transporter & the rest of the 5 signed copies to be carried by the transporter
Copy 3 (Pink)	To be retained by the receiver (actual user or treatment storage & disposal facility operator) after receiving the waste & the remaining 4 copies are to be duly signed by the receiver.

Copy (4) Orange	To be handed over to the transporter by the receiver after accepting waste.
Copy (5) Green	To be sent by the receiver to the State Pollution Control Board
Copy (6) Blue	To be sent by the receiver to the Sender
Copy 7 (Grey)	To be sent by the receiver to the state Pollution Control Board of the Sender in case the Sender is in another state.

SCHEDULE I

List of processes generating hazardous wastes.

SCHEDULE II

List of waste constituents with concentration limits

Class - A

Based on leachable concentration limits [Toxicity Characteristic Leaching procedure (TCLP) or Soluble Threshold Limit Concentration (STLC)]

Note:-

- The testing method for list of constituents at A1 - A61 in class-A, shall be based on Toxicity Characteristic Leaching procedure (TCLP) & for extraction of leachable constituents, USEPA Test method 1311 shall be used.
- The testing method for list of constituents at A62 - A79 in class-A, shall be based on Soluble Threshold Limit Concentration (STLC) & waste Extraction Test (WET) procedure given in appendix II of section 66261 of title 22 of California Code regulation (CCR) shall be used.

- In case of ammonia (A16), cyanide (A11) & chromium VI (A64) extractions shall be conducted using distilled water in place of the leaching media specified in the TCLP/SLC procedures.

Class-B

Based on Total Threshold Limit Concentration (TTLC)

Class	Constituent	Concentration in mg/kg
(1)	(2)	(3)
B1	Asbestos	10000
B2	Total Petroleum Hydrocarbons (TPH) (C5 - C36)	5000

Class-C

Based on Hazardous characteristics

Class C1 → Flammable

Class C2 → Corrosive

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 $12.5 \leq pH \leq 2$ (CA)

- It corrodes steel (SAE 1020) at a rate greater than 6.35 mm per year at a test temp. of 55°C

Note:-

For the purpose of determining corrosivity method - Bureau of Indian Std. 9040 C, for pH NACE TM 0169 : laboratory corrosion Testing of Metals and EPA 1110A method for corrosivity towards steel (SAE 1020).

Class C3 :- Reactive & explosive

- It is normally unstable and violent change without detonating.
- It forms potentially explosive mixture with water.

- If it is mixed with water it generates toxic gases, vapours, fumes.
- It is a cyanide or Sulphide Bearing waste.
- Working pH 2 - 12.5

Class C-4: Toxic

Concentration	Effect
2500 mg/kg	Acute oral LD50
4300	Acute dermal LD50
10000 parts/million	acute Acute inhalation LC50

- It has an acute toxicity with 50% mortality within 96 hr for zebra fish at a concentration of 500 mg/L in dilution water & test conditions as specified in BIS test method 6582-2001.

Class - C5

Substance or waste liable to Spontaneous Combustion

Class - C6

Substance or waste which in contact with water emit flammable gases.

Class - C7 - Oxidizing

Class - C8 - organic peroxides

Class - C9 poisons (Acute Acute)

Class - C10 Infectious Substance

Class - C11 liberation of toxic gases in contact with air & water

Class - C12 - Eco-toxic

Class - C13 - Capable

SCHEDULE - III

PART-A

Base No.	Description of Hazardous waste
A1	Metal & Metal Bearing wastes
A2	Wastes containing principally inorganic constituents, which may contain metals & organic materials
A3	Waste containing principally organic constituents, which may contain metals & inorganic materials.
A4	Waste which may contain either inorganic / organic constituents

PART-B

Same as part A But B contain scrap matter.

PART-C

Code	Characteristic
H1	Explosive
H3	Flammable liquids
H4.1	Flammable Solids
H4.2	Substances or waste liable to Spontaneous Combustion
H4.3	Substances or waste which, in contact with water emit flammable gases
H5.1	oxidizing
H5.2	organic peroxides
H6.1	poisons (acute)
H6.2	Infectious substances
H8	Corrosives
H10	liberation of toxic gases in contact with air or water
H11	Toxic (delayed or chronic)
H12	Eco-toxic
H13	capable

SCHEDULE - IV

List of commonly recycleable hazardous wastes:-

SCHEDULE - V

part - A

Specifications of used oil suitable for recycling

S.No.	Parameter	max. permissible limit
1	Polychlorinated biphenyls (PCBs)	$< 2 \text{ ppm}$ ($< 0.25\%$)
2	Lead	100 ppm
3	Arsenic	5 ppm
4	Cadmium + Chromium + Nickel	500 ppm
5	Polycyclic aromatic hydrocarbons (PAH)	6 %

PART - B

Specification of fuel derived from waste oil

S.No.	Parameter	max. permissible limit
6	Total halogens	4000 ppm
7	poly Sediment	0.25 %
8	Sulphur	0.5 %
9	water Content	1 %

- The detection limit is 2ppm by gas liquid chromatography (GLC) using Electron capture detector (ECD)

SCHEDULE - VI

Hazardous & other wastes prohibited for import

- Arsenic, Beryllium, Mercury, selenium, Thallium

PLASTIC WASTE MANAGEMENT

1. Plastic waste a Global Concern:-

- on an avg. production of plastic globally crosses 150 million tonnes per year due to increase in plastic waste by packaging films, wrapping materials, shopping, garbage bags, fluid containers, clothing, toys, household & Building material.
- It is estimated that approximately 70% of plastic packaging is converted into plastic waste in short span.

Per capita plastic Consumption in 2014-15 (in kg)

Global Avg. - 28

US - 109

China - 38

India - 11

Europe - 65

Brazil - 32

The recycling of virgin plastic material can be done 2-3 times only, because after every recycling the plastic material deteriorates due to thermal pressure and its life span is reduced. Hence recycling is not a safe & permanent solution for plastic waste disposal.

- only 60% of the plastic produced is recycled, balance 9400 tonnes of plastic is left unattended in environment causing, land, air & water pollution.
- 70% of plastic packaging products are converted into plastic waste in a short term span.
- There are 8 million tonnes of plastic waste entering the ocean every year.
- The total plastic in the ocean amounts to 150 M tonnes.
- Plastic packaging account for 62% of all items recovered in coastal clean up efforts.

- In 2014, there was 1kg of plastic in the ocean for every 5 kg of fish and by 2050 there will be more plastic than fish.

Some important points about plastic

- Plastic are made from oil with a highly polluting production process. A single bottle can take upto 1000 years to break down.
- Asia is the world leader in plastic pollution.
- Philippines alone dumped over 1 Billion pound plastic in sea/ocean.
- 83% of our drinking water contains plastic.
- Plastic Consums lead to cancer, effects on hormone levels & heart damage.
- Plastic have been found in the blood of even new born babies.
- over 600 marine species are affected by plastic. Nearly 45000 marine animals have ingested plastic & 80% were injured & killed.
- As plastic travel with oceans currents, an island of trash called the 'Great Pacific Garbage Patch' has been created.
- Burning of plastic results into formation of a class of flame retardants called Halogens.

2. Plastic waste generation in India:-

- Acc. to the report for year 2017-18, Central Pollution Board has estimated that India generates approximately 9.4 Million tonnes per annum plastic waste (26000 ton/day), & out of this approximately 5.6M per annum (15600 ton/day) plastic waste is recycled & 3.8M ton per annum (9400 ton/day) plastic waste is left uncollected or ~~labeled~~ littered.

- Out of 60% recycled plastic -
 - 70% is recycled at registered site
 - 20% is recycled by Unorganized Sector
 - 10% of the plastic recycled at home
- This states are the 38% higher than the 28% of global avg.
- One of the major reason for this 50% of plastic discarded as waste after single use.

3. Plastic Waste Management :-

- The 7 types of plastic

(i) Polyethylene Terephthalate (PETE or PET)

(1)

(ii) High Density Polyethylene (HDPE)

(iii) Polyvinyl chloride (PVC)

(2)

(3)

(iv) Low-density polyethylene (LDPE)

(v) Polypropylene (PP)

(4)

(5)

(vi) Polystyrene or Styrofoam (PS)

(vii) Miscellaneous plastic (include: poly-carbonate, polylacte)

(6)

(7)

- plastic are generally 2 types:-

• Thermoplastics:-

Thermoplastics or Thermo-softening plastics are the plastics which soften heating & can be molded into desired shape such as PET, HDPE, LDPE, PP, PVC, PS etc.

• Thermosets:-

Thermosets or thermosetting plastics strengthen on heating, but

Can not be remoulded or recycled such as sheet, molding compounds (SMC) fibre Reinforced plastic (FRP), Bakelite etc. are the example of the same.

Plastic waste management Rule:-

Most favoured option $\rightarrow$ Reduce - Reuse - Recycle - Recovery - Land fill

Reduce:-

Some of these steps may include

- (1) Discourage the use of disposal plastics
- (2) Minimize buying water
- (3) Minimize use of plastic cutlery
- (4) Purchase second hand item
- (5) Support a bag Tax or ban

Note:-

- Sikkim:- First state to ban plastic bottles & Disposable foam products
- Operation Blue mountain in Nilgiris, Tamil Nadu - is associated with plastic waste.
- Maharashtra - Ban on plastics.
- Himachal Pradesh - Sustainable plastic waste management plan.

• Reuse

• Recycle

• Benefits of Recycling

- $\rightarrow$ Reduce Environmental pollution
- $\rightarrow$ Energy saving: 40 - 100 MJ/kg
- $\rightarrow$ Economic Benefits
- $\rightarrow$ Reduce demand for virgin polymer
- $\rightarrow$ Preferred to Land filling
- $\rightarrow$ Generates Employment
- $\rightarrow$ Reduce depletion of fossil fuel reserves.

- Conservation of non-renewable fossil fuels - plastic production uses 8% of the world's oil production, 4% as feedstock and 4% during manufacture.
- Reduced consumption of energy
- Reduce amount of solid waste going to landfill
- Reduced emissions of carbon-dioxide (CO_2), NO_x & SO_2 .

Difficulties in Recycling:-

- Hard to separate from non-plastic (no 'magnet' equivalent)
- Differing composition of plastic resins means they are largely incompatible
- Degradation of polymer chains on recycling
- Recycled polymer is of lower quality than virgin polymer.
- Low value of recovered plastics
- Identification of reuse & recycling opportunities

Methods of Recycling:-

1. Mechanical Recycling
2. Feedstock Recycling
3. Plastic to Road Construction
4. Plastic to Toilet / pavement Blocks
5. Recycling of Multi-layered plastic

Note:-

Plastic men of India:- Rajagopalan Vasudevan, Tamil Nadu.
Award - Padam Shri

1. Mechanical Recycling

Techniques for Separation & Sorting of plastic waste:-

- Air classifier (also known as a Zig Zag Separator)

- A technique used for separating of light films or concentrating paper mill. or separate dust from remained material.

2. Air Tabling :-

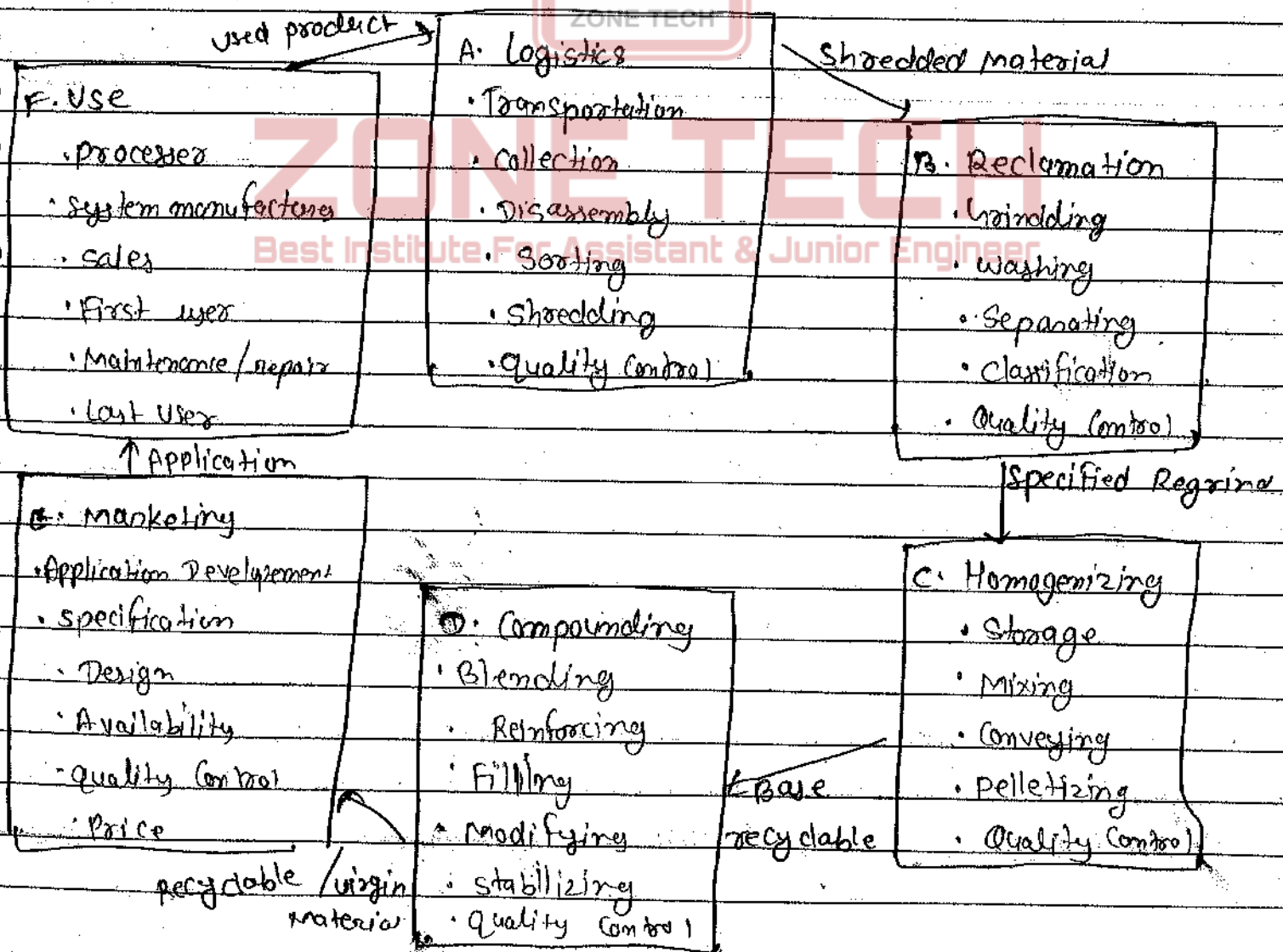
- Density Concentrating Technique.
- Useful for diff. size, shape particles

3. Ballistic Separator :-

- Separate solid waste at the inlet, depending on size, density & shape

4. Dry & wet gravity Separation (or Sink float Tank)

- Used in the recycling of plastic bottles & their caps.



5. Foam Flotation:-

- It is an intensive rinsing process with the addition of either fluid or steam & it has the ability to extract large volumes of fluid making it an effective choice for recycling.

6. Electrostatic Separation (or Triboelectric Separation)

- There are sensor based separation technologies also available

1. Plastic Color Sorting

- In this technique, ultra-violet light is used in combination with excellent digital camera technology to identify materials as small as 0.04mm. This range of plastic color sorting machines cover material throughputs of 300-1800 kgs/hr.
- The machine throughputs are dependent upon material type and quantity of contamination.
- The sorting accuracy is typically up to 99.99%.

2. Near Infrared (NIR)

- When materials are illuminated they mostly reflect light in the near infrared wavelength spectrum.
- Min. particle size - 50mm

Extrusion & palletisation:-

plastic extrusion is a high-volume manufacturing process in which raw plastic is melted and formed into a continuous profile.

- Extrusion products items such as pipe/tubing, rods, fencing, window frames, plastic film & sheeting, thermoplastic coatings & wire insulation.

- This process start by feeding plastic material from a hopper into the barrel of the extruder.

2. Feedstock Recycling:-

① Depolymerisation:-

- It is a de-polymerization process in which the bonds of polymer are break down to obtain monomers

Avg. Feedstock & Output with Thermal Depolymerization

Feedstocks	oil	bricks	solids (mostly carbon)	water (steam)
plastic bottles	70%	16%	6%	8%
medical waste	65%	10%	5%	20%
Tires	44%	10%	42%	4%
Sewage sludge	26%	9%	8%	57%
paper (cellulose)	8%	48%	24%	20%

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Segregated MSW received
from Municipal Corporation

Recyclables like plastic
films, PP, LDPE, HDPE
etc.

Dry fraction for
RDF

Wet
fraction

Plastic Segregated
from MSW by using ADS

Shredder for
size reduction of
plastics

Beaters for
dislodging
dust and

step cleaning
for final
cleaning

Intermediate
Storage
Hopper

oil to storage
and dispatch

Random Depolymerisation
Reaction

Condenser

has generated 15
used as fuel in

Feeder

Active
element

⑤ Plastic to fuel (Pyrolytic Conversion Technologies)

- steps in pyrolysis to convert scrap plastic to fuel sources.

i) Segregation & Pre-Treatment

- size reduction, moisture removal & Segregation

ii) Conversion

- Convert plastic to gas

iii) Distillation

gas is collected in condensation chamber & is converted in the form of liquid fuel.

iv) Acid removal process

v) Separation / final blending / refining

output	Percentage of overall output
Char	Ranges on avg. from 2% - 13%
natural gas	8 - 10%
fuel / goil	80 - 90%

⑥ plasma pyrolysis Technology (PPT)

- The intense and versatile heat generation capabilities of plasma pyrolysis technology enable it to dispose of all types of plastic waste including polymeric, biomedical & hazardous waste in a safe & reliable manner.
- The temp. of primary chamber 8500°C
- The waste material dissociates into CO , H_2 , CH_4 , higher HC etc.
- Later waste into the Secondary chamber where these gases are combusted in the presence of excess air.
- The inflammable gases are ignited with high voltage spark.
- The temp. of Secondary chamber $- 10500^{\circ}\text{C}$
- The hydrocarbon, CO & H_2 are combusted into CO_2 & water.

3. Plastic to Road Construction

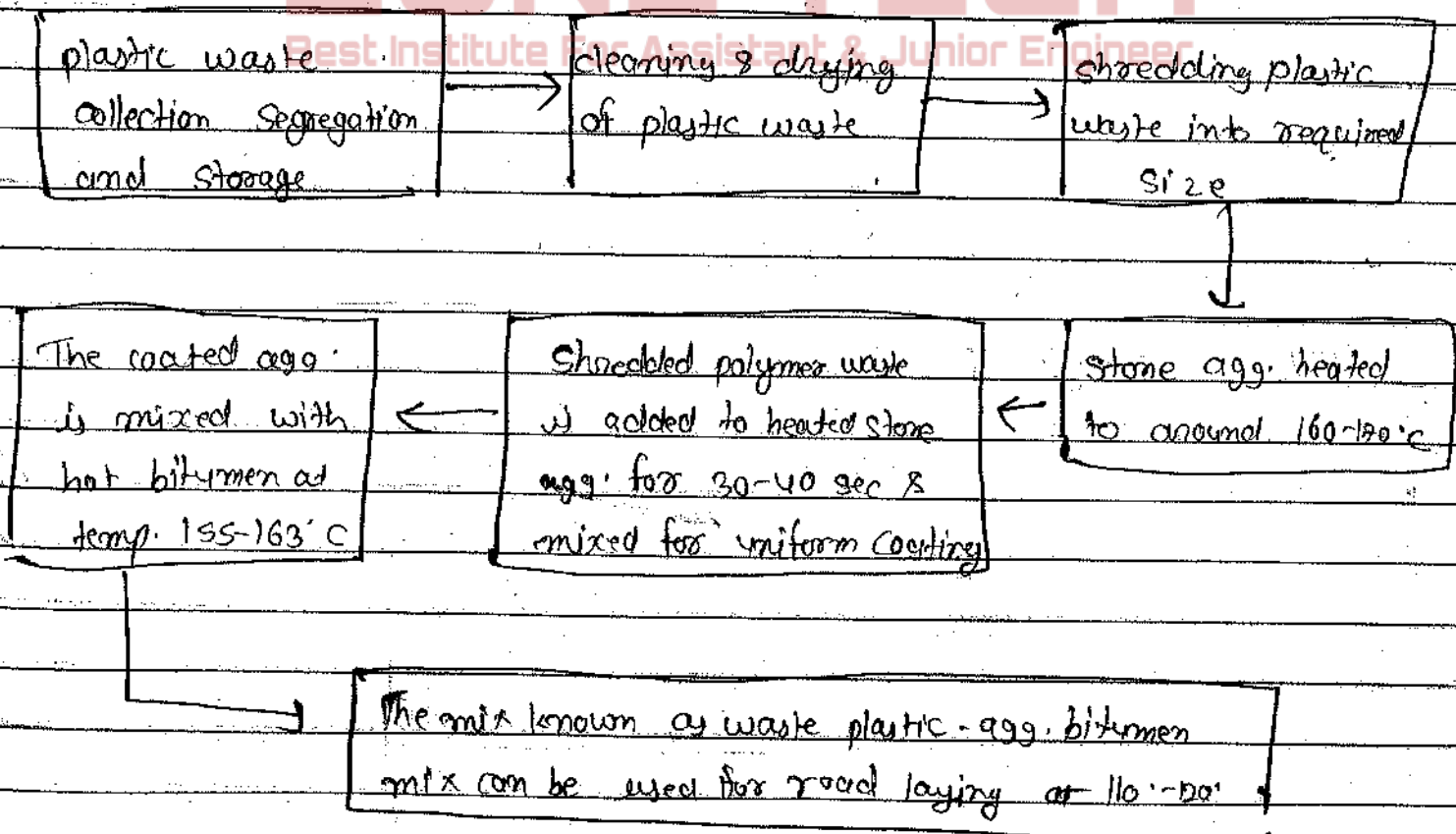
(A) Methodology

- Collected
- Segregated
- Cleaned
- Shredded
- The Shredded waste plastic shall pass through 4.75mm sieve & be retained on 1mm sieve.
- The Bitumeam to plastic ratio 10:1

(B) Plastic as a 'binder'

- Shredded plastic waste + hot stone (150-170°C) with uniform mixing.
- Plastic melts and spreads over the stone agg. in its molten state, giving a thin coating at the surface and acting as a binder.

Flowchart of plastic Bitumeam Road Process



4. plastic to Toilet (Plastone) / Pavement Blocks

- The cost of JHHL (Individual Household latrine) construction with plastone structure around 30% of the cost of cement wall structure.

plastic to pavement Block

- Each plastone blocks consume 300 plastic carry bags & 4-6 PET bottles.

Application of Recycled plastic

① PETE or PET

PET - Polyethylene Terephthalate used for many bottles application because they are inexpensive, lightweight, and shatter-resistant.
Recycled products - mineral / drinking water bottles, Cosmetic Bottles.

② HDPE - High Density polyethylene used for in bottles, carry bags, milk pouches, recycle bins etc.

Recycled products:-

Tubes, sewer pipes, pallets, boxes, buckets, toys, bottles for detergents, construction, cable insulation, packaging of food products etc.

③ PVC - Polyvinyl chloride

used for pipes & fitting, Tarpsaulins, Medical Apps etc.

Recycled products:-

Flexible packaging, bin liners, carrier bags, tubes, agricultural mulch film, agricultural sheet, construction film, Cling-film, heavy duty, sacks etc.

4. LDPE - Low Density polyethylene

used in plastic bags, various containers, dispensing bottles, wash bottles, tubing etc.

Recycled products :-

Flexible packaging, bin liners, carrier bags, tubes, agricultural mulch film, agricultural sheet, construction film, cling film, heavy duty sacks

5. PP - Polypropylene

used in - Auto parts, industrial fibers, food containers, etc.

Recycled products :- pipes, pallets, boxes, furniture, car parts, pots of yoghurt, buckets, butter, margarine, fibers, milk crates etc.)

6. PS - Polystyrene

used in food service packaging, disposable cups, tray pitchers, refrigerators, liners etc.

Recycled products :- Cloth Hangers, park Benches, flower pots, Toys, spoons, cutlery, picture frames, seedling containers, etc.

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7. Others

Others (usually, mixed plastic waste, used in Thermoset plastics, multilayer & laminates, Bakelite, polycarbonate, etc.)

Recycled products :-

CDs, pallets, floors, roofs, furniture, sheeting, Benches, shoe, soles etc.

- E-WASTE MANAGEMENT -

- In 20th Century the information & communication revolution has brought inorms change in the way we organize our lives, economy, Industry & Institution.
- The rapid growth of technology, upgradation of technical innovations & a high rate of obsolescence in the electronic Industry have lead one of the fastest growing waste stream in the world. which consists electric & electronic equipments such as - Refrigerators, Washing machine, Computers, T.V., mobiles, I pads etc.
- Many of which contains toxic material

Composition of E-waste:-

It consist of ferus & Non-ferus metals, plastic, glass, & wood etc.

• Iron & Steel — 50%.

plastic — 21%.

Non-ferus metals — 13%.

mercury, Arsenic, lead etc.

E-waste generation In India :-

3 billion electronic & electrical equipment become waste in 2010.

- Globally about 20-50 million tonn of e-waste are disposed in each year.
- which accounts for 5% of municipal solid waste. Acc. to CAH report over 7.2 Million tonn of Industrial Hazardous waste, about 4 lakh tonn of electronic waste, 1.5M tonn of plastic waste, 1.7M tonn medical tonwaste, 48M tonn Municipal waste are generated in our country in 2010.

- CPCB has estimated about 8 lakh tonne waste in 2012.
- 10 states of our country contribute about 70% of total E-waste generated in our country.
- About 65 cities generate more than 60% of total E-waste in India.

Top 10 cities $\rightarrow$ Mumbai, Delhi, Bangalore, Chennai, Kolkata, Ahmedabad, Delhi, Hyderabad, Pune, Surat & Nagpur

- Main source of E-waste in India are - govt., public & private sectors - 70%.

- Individual Home hold - 5%.

- Rest been contribute by the manufacturing.

T.V. - 68%.

Desktop, Server - 27%.

Imports - 2%.

mobile - 1%.

Environmental Concern & Health Hazards:

- E-waste highly complex to handle
- Pollutants & their occurrence in waste may be highly toxic & Hazardous

pollutants	occurrence
liquid crystal	Display
Lithium	mobile, telephones, photographic equipment, video equipment, batteries
Mercury	Components of copper machine, steam irons, batteries in clocks, pocket calculator, switches, etc.
Nickel	Alloys, batteries, relays, semi-conductors, pigment
PCB (poly chlorinated biphenyl)	Transformer, capacitor, softening agent for paint, glue & plastic

- Selenium photo-electric cells, pigments, photo-copier, fax-machine
- Silver Capacitor, switches, batteries, resistors, zinc
- Zinc steel, bars, alloys, disposal & rechargeable batteries
luminescent substance
- Arsenic Semi-conductors, diode, micro-wave, LED, solar cells
- Beryllium Electron tubes, filter of plastic & rubber, lubricant additive
- Brominated flame - retardant Casings, circuit board, cables, & PVC
proofing agent cables
- Cadmium batteries, pigments, solders, alloys, circuit board,
computer batteries, monitor, cathode ray tube (CRT)
- Chrome dies & pigments, switches, solar
- Cobalt Insulator
- Copper Conductor cables, copper ribbons, coils, circuit, pigment
- Lead Rechargeable batteries, solar, transistor, lithium batteries,
PVC, stabilizers, lasers, LED's, Thermo-electric elements

Many of these substances are toxic & cancer causing compounds.

Storing of E-waste in landfills & Incineration of E-waste are
Environmental & Health hazard

Reuse & recycle recycling is only for can be done for
limited span & it may be hazardous in unorganized
Sector

E-waste

E-waste management & Handling rule - 2011

BIO-MEDICAL WASTE

Bio-Medical waste management rules - 2016 (Amended in 2018 & 19)

ABBREVIATIONS

HCF	Health care facility
BMW	Bio Medical waste
CBWTF	Common Bio Medical waste Treatment facility
NHSRC	National Health System Resource Centre
AYUSH	Ayurveda Yoga Unani, Sidha and Homoeopathy
CPCB	Central pollution Control Board
SPCB	State pollution Control Board
MS	Medical Superintendent
CMO	Chief medical officer
SMD	Senior medical officer
PMO	Principal medical officer
CHC	Community Health center
PHC	primary Health center
MO J/C	medical officer in charge
PPE	personal protective equipment
IEC	Information Education & Communication
ETP	Effluent Treatment plant
SMTAC	State Monitoring and Technical Advisory Committee
DMTAC	District
DOT	District Quality Team
ANM	Auxiliary Nurse Midwife
HCW	Health Care Worker
WHO	World Health Organization
C&D	Construction & Demolition
E-waste	Electronic waste
EEG	Electrical & Electronic Equipment
PRO	Producers Responsibility Organisation

In accordance Bio-Medical waste Management rules 2016, categorise the bio-medical waste generated from the health care facility into 4 categories.

1. Yellow category
2. Red "
3. White "
4. Blue "

waste generated from the healthcare facility

- Bio - medical waste - (15%)
- General waste - (85%)
- Other waste

• Yellow Category :-

- Human Anatomical waste
- Animal Anatomical waste
- Soiled waste
- Discarded or Expired medicine
- Chemical waste
- Chemical liquid waste

- Discarded linen, mattresses, bedding contaminated with blood or body fluid, soiled routine mask & gown
- microbiology, biotechnology & other clinical laboratory waste (pre-treated)

• Red category :-

- wastes generated from disposable item such as tubing, bottles, intravenous tubes & sets, catheters, urine bags, syringes without needle, fixed needle syringes with their needles cut, vacutainers & gloves.

• White Category:-

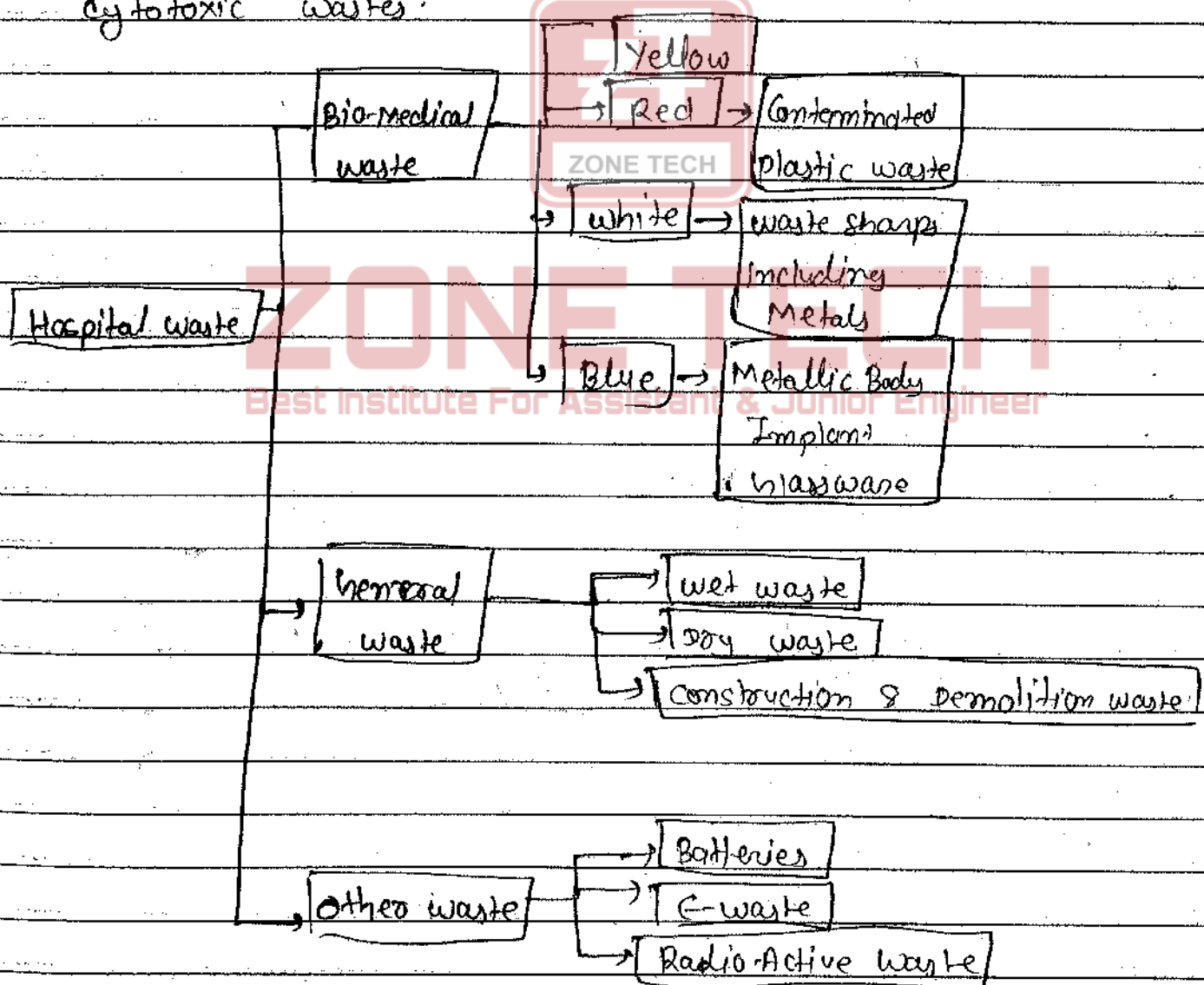
waste sharp including metals

Needles, Syringes with fixed needles, needles from needle tip
Cutter or burner, scalpels, blades or any other contaminated
Sharp object that may cause puncture and cuts.

This includes both used, discarded & contaminated metal sharps

• Blue Category:-

Broken or discarded & contaminated glass including medicine
vials and ampoules except those contaminated with
cytotoxic wastes.



Steps involved in - Bio-Medical waste Management:-

- The management of bio-medical waste can overall be summarized in the following steps:
 - i) waste segregation in color coded and barcode labeled bags / containers at source of generation
 - ii) pre treat laboratory & High infectious waste
 - iii) Intra-mural transportation of Segregated waste to Central Storage area
 - iv) Temporary storage of bio-medical waste in Central Storage area
 - v) Treatment & Disposal of bio-medical waste through CBWTF or Captive facility.

• First 5 Steps

- Segregation
 - Collection
 - Pre-treatment
 - Intramural
 - Transportation
 - Storage
- is the exclusive responsibility of Health care facility
- While treatment & Disposal is primary responsibility of CBWTF operator. except for lab and Highly infectious waste should be pre-treated by HCF.

- Bio-Medical & General waste shall not be mixed.
- Storage time of waste should be as less as possible so that waste storage, transportation and disposal is done, within 48 hrs.

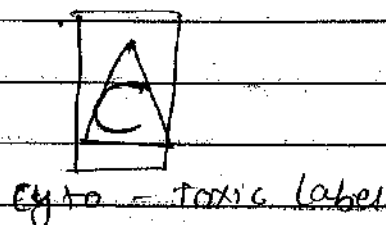
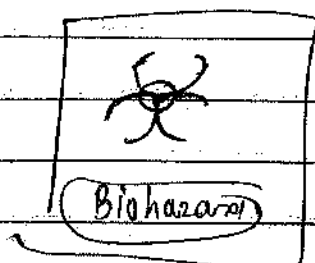
- If CBWTF facility is available at a distance of 75 km from the HCF, bio-medical waste should be treated and disposed only through such CBWTF operator.

Bio-medical waste Segregation:-

Category	Color & Type of Container
i) Yellow category	yellow coloured non-chlorinated plastic Bags.
<u>Note:-</u>	
Chemical waste (Yellow-e) comprising of un-used, residual or date expired liquid chemicals including spent hypo of x-rays should be stored in yellow container	
ii) Red category	• Red coloured Non-chlorinated plastic Bags having thickness equal to more than 500 μ & thick containers
iii) White category	• white colored translucent puncture proof, leak proof, Tempos proof containers
iv) Blue category	puncture proof boxes or containers with blue colored marking

Bio-medical waste collection:-

- Time of Collection - within 48 hrs.
- Packaging - Barcode are insert as per ^{CP CB} ~~CBC~~ guidelines.
- Labelling



Segregation, Treatment & Disposal of BW

(1) Yellow Category:

cas Human Anatomical waste:-

Treatment & disposal

HCF linkage with CBWTF

• Pre-treatment

Auto-claving or Micro-waving or Hydroclaving or stabilization method prescribed in WHO Blue book 2014.

• Handled over to CBWTF or CTF

• For HCF without linkage CBWTF :-

• This waste should be dispose through plasma pyrolysis unit or Twin chambered Compact Incinerator with 2 Sec retention time in secondary Combustion Chamber.

• Disposal of waste in deep burial pit should not be practiced unless the hospital is located in rural or remote isolated areas

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(2) Animal Anatomical waste:-

Treatment & disposal :-

• Same as human Anatomical waste.

(3) Soiled waste:-

Treatment & disposal:-

with CBWTF

• The waste must be handled over without treatment at HCF

• without CBWTF

Same as upper human Anatomical waste

⑥ Expired & Discarded Medicine:-

Treatment

• For HCF having linkage with CBWTF

- as per BMW rules 2016, all the expired & discarded medicine including cytotoxic drugs either returned back to the manufacture or handed over to CBWTF to be disposed of through incineration at temp. $\geq 1200^{\circ}\text{C}$

• For HCF having own treatment & disposal facility:-

- sent back to manufacturer or can be disposed through nearest common biomedical waste or Hazardous waste incinerator with prior intimation to SPCB/PCC.
- This waste can be disposed through twin chambered captive incinerator.

ZONE TECH

⑦ Chemical waste:-

• For HCF having linkage with CBWTF

• No pre treatment is required

• Hand-over to CBWTF for final disposal by Incineration

For HCF having own treatment & disposal facility

or upper case

⑧ Chemical waste

Segregation:-

• liquid waste generated due to use of chemical in production of biological & used of discarded disinfectants, silver X Ray film developing liquid, discarded formalin, infected secretions, aspirated body fluid, liquid from laboratories, and floor washings, cleaning, house-keeping etc.

Type of bag & Container:-

Not applicable since this liquid waste containing waste chemicals is collected & pre-treated prior to disposal through Effluent Treatment plant.

Treatment & disposal:-

• pretreatment is necessary

• Handed over to CBWTF as yellow (B) chemical waste

• Depending on the type of chemical pre-treatment should may be neutralization or precipitation followed by disinfection.

g) Discarded Linen, mattresses, beddings contaminated with Blood, body fluids, routine mask and gown.

Treatment & Disposal:-

• Disinfected the waste with non-chlorinated chemical & hand over to CBWTF for final disposal by Incineration.

• The waste mattresses & Cutting → CBWTF → Incineration
or

Cutting → Disinfection (by non-chlorinated chemical) → RDF plants

(H) Microbiology, Biotechnology & other Clinical laboratory waste

Treatment & Disposal:-

• For HCF having linkage with CBWTF

waste → pretreatment → CBWTF

(autoclave / Microwave / Hydroclave / non-chlorinated

pre-treatment disinfectants)

non-chlorinated disinfectants like - Aldehydes, lime based powders or solution, ozone gas, ammonium salts, and phenolic compounds.

② Red Category:-

Treatment & Disposal:-

for HCF having linkage with CBWTF:-

- Vacutainers / vials with blood samples should be pre-treated & disposed as yellow (h) category waste.
- No onsite treatment of Red category waste is required. All such waste is needed to be sent to CBWTF for final treatment & disposal.

for HCF having own treating unit & disposal facility:-

- All the recyclable waste generated from HCF must be sterilised using

→ autoclaving

→ Microwaving

→ hydro-claving

followed by shredding or mutilation or combination of sterilisation & shredding.

③ White Category:-

Treatment & Disposal:-

for HCF having linkage with CBWTF

- waste handed over to CBWTF without any alteration or onsite treatment.

for HCF having own treatment & disposal facility:-

Method of disinfection	Treatment	options for final disposal
• Autoclaving	Shredding : or Mutilation : or Encapsulation in Cement concrete	Concrete pit ; or
• Dry heat sterilization	Encapsulation in Metal container	sanitary landfill or steel foundry
• Autoclaving cum Shredding as single unit operation	None	

⑤ Blue Category:-

① Glassware

Treatment & Disposal:-

For HCF having linkage with CBWTF

- Dispose of the empty glass bottles by handing over to CBWTF without any onsite treatment.

For HCF having own treatment & disposal facility:-

The waste glass bottles / broken glass has to be sterilized or disinfected (either autoclaving or microwaving or hydroclaving or by sodium Hypochlorite solution) followed by soaking & washing with detergent prior to sending it for recycling.

② Metallic Body Implants:-

Treatment & Disposal:-

For HCF. Handled to CBWTF or disinfection.

* Standards for Treatment & Disposal as per BMW Rules, 2016

③ Standards for Incineration:-

① operating Standards:-

- Combustion efficiency (CE) shall be at least 99.00%.

Ans

$$C.E. = \frac{\% CO_2}{\% CO_2 + \% CO} \times 100$$

- The temp. of primary chamber $\rightarrow 8000^\circ C \pm 500^\circ C$
Secondary " $\rightarrow 10500^\circ C$
- retainance time 2 Sec.

mg = milligrams $\rightarrow$ 10 gm

(B) Emm Emission Standards:-

S.No.	Parameter	Standards	
		Limiting Concentration in mg/cm ³ in unless stated	Sampling Duration in Minutes, unless stated
1.	Particulate matter	50	30 or 1 Nm ³ of sample vol ^m , whichever is more
2.	NO, NO ₂ expressed as NO ₂	400	30 or online sampling or grab sample
3.	HCl	50	30 or 1 Nm ³ of sample vol ^m , whichever is more
4.	Total Dioxins & Furans	0.1 mg TCO/Nm ³ (at 11% O ₂)	8 hr or 5 Nm ³ of sample vol ^m , whichever is more
5.	Hg & its compounds	0.05	2 hr or 1 Nm ³ of sample vol ^m , whichever is more

Operating & Emission Standards for Disposal by plasma pyrolysis or Gasification

(A) Operating standards:-

- Combustion efficiency $\rightarrow$ 99.99%

$$CE = \frac{\% CO_2}{\% CO_2 + \% CO} \times 100$$

- Temp. of the combustion chamber after plasma gasification shall be $10500 \pm 500^\circ C$ with gas residence time of at least 2 sec with min. 3% oxygen in stack gas.

- Stack height should be min 30m.

Standards for Autoclave:-

• Gravity Flow Autoclaving

	Combination ①	Comb ②	Comb ③
Temp.	* ~~121~~ 121°C	* ~~135~~ 135°C	* ~~149~~ 149°C
pressure	* ~~13.5~~ 13.5 PSI	* ~~31~~ 31 PSI	* ~~52~~ 52 PSI
Time	* ~~60~~ 60 sec/M	* ~~45~~ 45 M	* ~~30~~ 30 Min

• vacuum autoclave:-

- Min. 3 va pre-vacuum pulse to purge to autoclave of all air.

	Comb ①	Comb ②
Temp.	* ~~121~~ 121°C	* ~~135~~ 135°C
pressure	15 PSI	31 PSI
Time	45 M	30 M

Standards of Microwaving:-

- It shall be not used for cytotoxic, hazardous or radioactive wastes, contaminated animal carcasses, body parts & large metal items.
- Indicator — Bacillus atrophaeus spore using vials or spore strips with at least 1×10^4 spores per detachable strip.

Standards for Dry Heat Sterilization:-

- Temp. * 185°C
- residence time - 150 minutes in each cycle, which sterilization period of 90 minutes.

Standard for liquid waste:-

parameters	permissible limit
pH	6.5 - 9.0
Suspended solids	100 mg/l
oil & grease	10 mg/l
BOD	30 mg/l
COD	250 mg/l
Bio-assay test	90% survival of fish after 96 hr in 100% effluent

Standard for Deep Burial:-

- Yellow (a), (b) & (c) wastes namely human anatomical, animal anatomical & soiled waste are permitted for deep burial only in rural or remote areas where there is no access to common bio-medical waste treatment facility after obtaining authorization from SPCB/PCCW.
- A pit or trench should be dug about 2m deep. It should be half filled with waste, and then covered with lime within 50cm of the surface, before filling the rest of the pit with soil.
- It must be ensured that animals do not have any access to burial site.
- The ground water table level should be min. 6m below the lower level of deep burial pit.

WATER TREATMENT :-

Chapter - 1 :- Water Quality Parameters

Parameters

Physical	Chemical	Bio-chemical
- Suspended solids - Color - Turbidity - Odour & Taste - Temp.	- Dissolved solids - pH - Alkalinity - Hardness - Chlorides content - Fluorides - Nitrogen - BOD & COD - TOC - Metals	- Non-pathogenic m/o - Pathogens → Bacteria → Virus → protozoa → Helminths

SN	Characteristic	Requirement (Acceptable limit)	Permissible Limit in the Absence of Alternate source
1.	Color, Hazen units, max.	5	15
2.	Odour	Agreeable	Agreeable
3.	pH value	6.5 - 8.5	No relaxation
4.	Taste	Agreeable	Agreeable
5.	Turbidity, NTU, max.	1	5
6.	Total dissolved solids, mg/l max.	500	2000
7.	Aluminium, mg/l	0.03	0.2
8.	Ammonia	0.5	No relaxation
9.	Anionic detergents	0.2	1

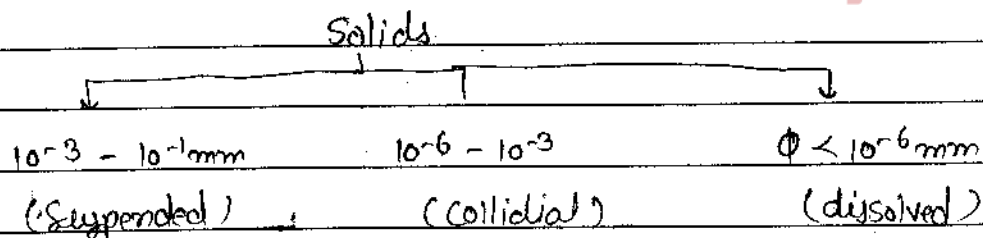
10. Barium	0.7	No relaxation
11. Boron	0.5	1
✓12. Calcium	7.5	200
13. Chloramines	4	No relaxation
✓14. Chloride	260	1000
15. Copper	0.05	1.5
✓16. Fluoride	1	1.5
17. Free residue chlorine	0.2	1
18. Iron	0.3	No relaxation
19. Mg	30	100
20. Mn	0.1	0.3
21. Mineral oil, mg/l	0.5	No relaxation
✓22. NO ₃ (Nitrate)	45	No relaxation
23. phenolic Compounds	0.001	0.002
24. Selenium.	0.01	No relaxation
25. Silver	0.1	No relaxation
✓26. Sulphate	200	400
27. Sulphide	0.05	No relaxation
✓28. Total alkalinity as Calcium carbonate	200	300
✓29. Total hardness	200	600
✓30. Zinc	5	15
31. Cadmium	0.003	No relaxation
32. Cyanide	0.05	"
33. Lead	0.01	"
34. Mercury	0.001	"
35. Molybdenum	0.07	"
36. Nickel	0.02	"
37. pesticides		
37. polynuclear	0.0001	No relaxation

38. polychlorinated biphenyls	0.0005	No relaxation
39. Total arsenic	0.01	0.05
40. Total Chromium	0.05	No relaxation
41. Trihalomethanes		
(i) Bromoform	0.1	No relaxation
(ii) Dibromochloromethane	0.1	"
(iii) Bromodichloromethane	0.06	"
(iv) Chloroform	0.2	"
42. Radioactive materials		
(i) Alpha emitters Ba/L	0.1	No relaxation
(ii) Beta emitters Ba/L	1.0	No relaxation
43. BOD	0	0

Physical Characteristics :-

① Suspended Solids:-

The solids are classified as Suspended solids if the size is (10^{-3} to 10^{-1} mm)



For measurement of suspended solid Thurimetric Test is conducted.



~~For~~ Suspended solids & dissolved solids are combined known as dispersed solids.

• Acc. to EPA (Environmental protection agencies) ^{In} drinking water the Suspended solid content should not be more than 30 mg/lit.

② Turbidity:-

If large amount of suspended solids are present in water, it will appear turbid.

- Turbidity depends upon fineness & concentration of suspended solids present in water.
- It is measure of the resistance which is offered by the water against the passage of the light.

Measurement:-

① Based on absorption principle:-

- Ⓐ Turbidity Rod
- Ⓑ Jackson Turbidity meter
- Ⓒ Bayliss Turbidity meter

② Based on scattering principle:-

- Ⓐ modern Nephelometer.

• The std. scale of turbidity measurement is silica scale.

• Std. unit of turbidity

- NTU	(Nephelo turbidity unit.)
- FTU	(Formazine ' ' ')
- JTU	(Jackson ' ' ')
- STU	(Silica ' ' ')

• NTU is based on formazine scale, where as JTU is based on silica scale.

• Jackson Turbidity meter can not be measure the turbidity less than 25 ppm. Hence it is not suitable for drinking water. ∴

- Bayliss Turbidimeter is very accurate instrument. which is prepared preferred when turbidity of sample less than 5 ppm. In Bayliss Turbidimeter white opal glass & blue cobalt tube are used.

③ Color:-

Humic acid - yellowish color

Magnise oxide - dark brown / Blackish

Iron oxide - Reddish

Measurement:-

- Equipoment - Tintometer (color match matching Technique)
- color is expressed in TCU (True color unit) or Hazen unit.
- 1 TCU is equal to the color produced by 1 mg/l of platinum in the form of chloro platinate ion in 1 lit of distilled water.
- Std. scale - Platinum scale
- If 1.245 gm of potassium chloro platinate & 1 gm of cobalt chloride are dissolved in 1 lit of distilled water, the dilution will have 500 hazen units
- The intensity of color is also measured on Hazen scale, Bungers scale & Cobalt scale.
- Bungers scale is used in Nessler Nessler tube.

④ Taste & odour:-

- Sulphur — Rotten egg like taste & odour
- Algae — bad taste & odour

Measurement:-

- Instrument — Osmoscope
- Unit — TON (Threshold odour no.)
- 1 TON is numerically equal the vol^m of Sample of water in ml required to be added to 100 cm³ (ml) in odor free water, when the mixture just start giving a ~~Tipit~~ Typical smell in fresh water Sample.

Acceptable limit — 1 TON

permissible limit — 3 TON

⑤ Temperature:-

10-25°C

Chemical Characteristic:-

① Total Dissolved Solids:-

- Dissolved solid Contains ster surface electric charge due to which water offers electric conductivity.
- The concentration on TDS can be calculated by measuring the electrical conductivity of water.
- To check conductivity we use dilutionic tester.

$$\boxed{\text{TDS (mg/lit)} = 0.65 \times (\text{EC in } \mu\text{mho/cm at } 25^\circ\text{C})}$$

• limit — 500 — 2000 ppm

② pH :-

$$\text{pH} = -\log_{10} [\text{H}^+]$$

$$\text{pOH} = -\log_{10} [\text{OH}^-]$$

• H⁺ ion concentration moles/lit.

$$p^H + p^{OH} = 14$$

• p^H is measured by potentiometer

→ Acid indicators — Methyl orange (Red -
 [light red → To dark red]
 working range — 2.2 - 4.4

→ Basic Indicator — phenolphthalein
 [pink → colorless]
 working range → 8.6 - 10.3

Q. $p^H_A = 3.2$

$p^H_B = 6.2$

which is more acidic & How many times.

⇒ $p^H_A \rightarrow -\log_{10}(H^+)$

$p^H_A \rightarrow -\log_{10}(H^+)$

$3.2 \rightarrow -\log_{10}(H^+)$

$(H^+)_A = 10^{-3.2}$

$(H^+)_B = 10^{-6.2}$

$\frac{[H^+]_A}{[H^+]_B} = 10^{-3.2 + 6.2}$

$\Rightarrow 10^{+3} \Rightarrow \underline{1000}$

$[H^+]_A \rightarrow 1000 \times [H^+]_B$

③ Alkinity :- / Alkalinity :-

- Alkinity is the ability of water to neutralize acids or H^+ ion concentration.
- It is the quantity of ions in water that will react to Hydrogen ion.

Major Source:- OH^- , CO_3^{2-} , HCO_3^-

$\text{OH}^- \rightarrow$ Caustic Alkalinity

$\text{CO}_3^{2-} \rightarrow$ Carbonate Alkalinity

$\text{HCO}_3^- \rightarrow$ Bi-carbonate Alkalinity

Minor Source:-

HSiO_3 , HPO_4^{-2} , HS^- , H_2BO_2

• Alkalinity Titration:-

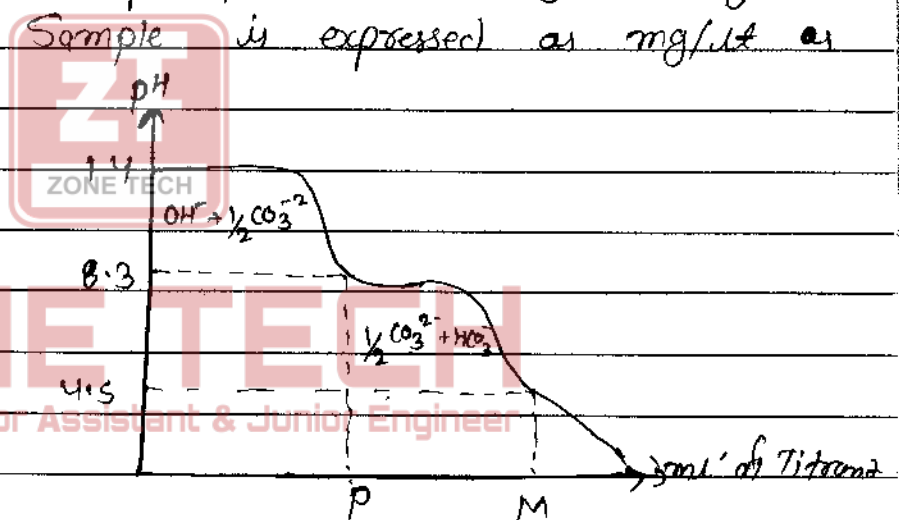
Titrant $\rightarrow 0.02\text{N H}_2\text{SO}_4$

Color Indicator $\rightarrow$ phenolphthelene & Methyl orange

Alkalinity of water Sample is expressed as mg/Lt as CaCO_3 .

P - phenolphthelene Alkalinity

M - Methyl orange



Results:-

① $P = M$

alkalinity is due to OH^- only.

② $P = 0$ / T.A. = M

alkalinity is due to HCO_3^- only

③ $P = M/2$ or T.A. = 2P

alkalinity is due to CO_3^{2-} only.

④ $P < M/2$

alkalinity is due to HCO_3^- & CO_3^{2-} .

⑤ $p > 7$

alkalinity is due to OH^- & CO_3^{2-}

permissible limit $\rightarrow 200 - 600 \text{ mg/l as CaCO}_3$

Q: If water sample contains 420 mg/l CaCO_3 , 120 mg/l HCO_3^- & 51 mg/l of hydroxide. then calculate total alkalinity of water in mg/l as CaCO_3 .

$$\Rightarrow \begin{array}{lcl} 420 \text{ mg} - \text{CO}_3^{2-} & \xrightarrow{420/60} & 7 \text{ g.eq} \\ 120 \text{ mg} - \text{HCO}_3^- & \xrightarrow{120/61} & 1.97 \text{ g.eq} \\ 51 \text{ mg} - \text{OH}^- & \xrightarrow{51/17} & 3 \text{ g.eq} \end{array}$$

Total alkalinity in g.eq. $\rightarrow 11.97 \text{ g.eq. (7+2+3)}$

Total alkalinity in mg/l as CaCO_3

$$\text{g.eq} = \frac{\text{given quantity}}{\text{eq. wt.}}$$

$$11.97 = \frac{\text{given quantity}}{50}$$

So

$$= 11.97 \times 50$$

$$\Rightarrow 598.5 \text{ mg/l}$$

④ Hardness :-

The concentration of multivalent cations (specially Ca^{+2} , Mg^{+2}) represent the hardness of water

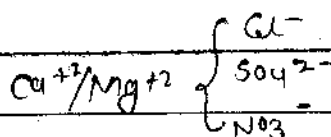
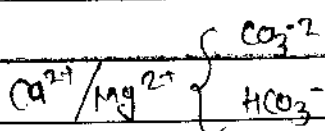
Major source $\rightarrow \text{Ca}^{+2}$, Mg^{+2}

Minor $\rightarrow \text{Fe}^{+2}$, Mn^{+2} , Ba^{+2} , Al^{3+}

Hardness

Carbonate Hardness

Non-carbonate Hardness



- It can be removed by simple boiling of water
- Temporary Hardness

- It can't be removed by simple boiling of water
- Permanent Hardness

Measurement :-

Method :- EDTA method [Ethylenediamine Tetraacetic acid]

• It is also called Versenate solution

Color Indicator :- EBT [Eriochrome Black T]

wine red $\longrightarrow$ Blue

Titrent :-

0.01 M EDTA

$$\text{Total Hardness in mg/lit as CaCO}_3 = \frac{50}{20} [\text{Ca}^{2+}] + \frac{50}{12} [\text{Mg}^{+2}]$$

mg/lit
↓

- Hardness is expressed in degrees (°) of Hardness as per clark scale.
- As per clark scale one grain of CaCO_3 dissolved in 1 gallon of water produced 1 degree of Hardness.

$$1 \text{ grain} = 64.8 \text{ mg}$$

$$1 \text{ gallon} = 4.546 \text{ lit}$$

$$1 \text{ degree of Hardness as CaCO}_3 = \frac{64.8}{4.546}$$

$$\approx 14.25 \text{ mg/lit as CaCO}_3$$

- Acc. to French scale the 1 degree of Hardness as CaCO_3 is equivalent to 10 mg/lit of Hardness as CaCO_3 .
- Clark scale is also known as English Scale.

- 1 degree of Hardness as CaCO_3 acc. to German scale is equivalent 17.85 mg/Lt as CaCO_3

Hardness in mg/Lt as CaCO_3	Type of water
< 75 ppm	Soft
75 - 200	Moderate soft / Moderate Hard
200 - 300	Hard
> 300	Very Hard

Hardness & Alkalinity relationship:-

$$C.H = \begin{cases} T.H. \\ \text{min} \{ \text{Alkalinity} \} \end{cases}$$

$$T.H. = C.H + N.C.H$$

① $T.H. > \text{Alkalinity}$

$$C.H. = \text{Alkalinity}$$

$N.C.H$ is present

② $\text{Alkalinity} > T.H.$

$$C.H. = \text{Total Hardness}$$

$N.C.H.$ is not present

Q. If $T.H. = 300 \text{ mg/Lt}$

$$\text{Alkalinity} = 280 \text{ mg/Lt}$$

Find $C.H$ & $N.C.H$

$$\Rightarrow C.H = \begin{cases} 280 \\ \text{min} \{ 300 \} \end{cases}$$

$$C.H = \text{Alkalinity}$$

$$C.H = 280$$

$$N.C.H = T.H - C.H = 300 - 280$$

$$\Rightarrow 20 \text{ mg/Lt}$$

③ Fluoride :-

- upto 2 mg/L fluoride helps to prevent dental cavities.
- During formation of permanent teeth it combined chemically with tooth on enamel, resulting in harder, stronger teeth. which are more resistance to decay.
- Excess value ($\geq 1.5 - 2 \text{ ppm}$) results in decolorization of teeth which is called as mottling of teeth.
- Greater than 5 mg/L causes deformation of bones. This is called as bone fluorosis.
- permissible limit — $1 \rightarrow 1.5 \text{ ppm}$

④ Nitrogen Content :-

Nitrogen forms	Indication	Measurement	Permissible value
1. Free ammonia	Recent pollution	By Simple boiling of water	0.15 mg/L
2. Organic Ammonia (Albuminoids)	decomposition has been started	oxidizing agent (KMnO ₄) added & boiling water	0.30 mg/L
3. Nitrite	partly decomposed condition	Color matching agent (Nephthamine, Sulphonic acid)	0
4. Nitrate NO ₃ ⁻	old pollution	Color matching agent (phenoldi-Sulphonic acid + potassium Hydroxide)	$\pm 45 \text{ ppm}$

• Free Ammonia + Organic ammonia are combinedly known as Kjeldahl ammonia.

• If Nitrate concentration is more than 45 mg/l then it causes Methemoglobinemia infants (small babies 6 months).

• The US ^{Environment} protection agency has establish max. contaminant level level (MCL) for Nitrate in public drinking water Because of Health concerns.

• The MCL for Nitrogen can be expressed as unit of Nitrate or as unit of Nitrogen (N) (NO_3^-)

• The MCL expressed as unit of Nitrate is 45 mg/l which is equivalent as unit of Nitrate of Nitrogen to 10 mg/l .

⑦ Chloride Content :-

• Chloride in water is mostly derived from Natural mineral deposit, Agricultural or irrigation Discharge.

• Chloride are estimated by mercurimetric method in which raw water is titrated with std. Silver nitrate (AgNO_3) using potassium chromate (K_2CrO_4) as an Indicator.

• Argentometric method is also use to determine chloride content.

• permissible limit $\rightarrow 250 - 1000 \text{ mg/l}$ or ppm

⑧ Phosphorus :-

• Phosphorus is not toxic & do not represent direct Health threat. But —

- i) It facilitate rapid growth of Aquatic plant.
- ii) It interface with water treatment plant (WTP)

• Even a low concentration of 0.2 mg/l interface with water Treatment process.

Bio-logical Characteristic:-

① Pathogens:-

- These are disease causing or harmful Micro ^(M.O.) organisms.
- No

② Non-Pathogens:-

- These are non Harmful M.O.

③ Aerobic :-

- These M.O. decomposed the O.M. in the presence of oxygen

④ Anaerobic

- These M.O. decomposed the O.M. in the absence of oxygen

⑤ Facultative

- These M.O. decomposed the O.M. in the presence as well as absence of oxygen.

⑥ Disinfection:-

- The process of killing pathogens.

⑦ Stabilization:-

The process of killing all types of M.O.

② Coliforms:-

The coliforms are non-pathogenic M.O. which are used as an indicator for identification of pathogens.

Coliforms test:-

- ① Membrane filter Test (Latex):- ✓
- ② MPN Test (Most Probable no.)
- ③ C.I test (Coliform Index test)

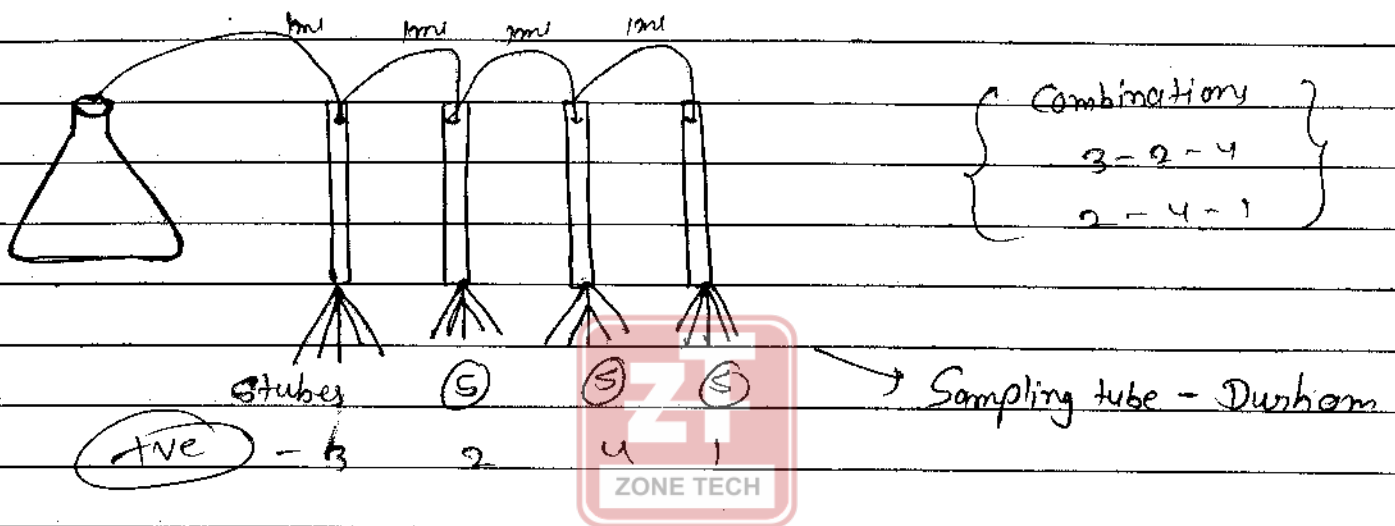
① Membrane filter Test:-

- Water sample ~~poor~~ poured on a ~~sterile~~ sterile membrane filter.
- Membrane is then put in contact with nutrients (M-endo medium) that permits the growth of only coliforms colony.
- After incubation (in the absence of sunlight) for 20 hrs no. of visible colony are counted in 100ml of sample.

② MPN Test:-

- It is also known as multiple tube fermentation test.
- This method determine the quality of water by quantifying the no. of Coliforms in 100ml of water.
- MPN Test involves a series of test tubes containing fermentative growth of Lactous, in which water sample are added in definite proportion.
- we can detect coliforms in the water sample by observing the fermentation tube for production of gases & acids.

- A color change fermentation broth (2451) (from red to yellow) indicate the production of acids.
- The MPN test is conducted in diff. stages
 - (i) primitive test
 - (ii) confirmed test
 - (iii) Complete test



water-borne disease:

Cause for by virus Infection:-

Cryptosporidiosis, poliomyelitis, Hepatitis

Cause by bacteria

Typhoid, fever, colera, bacillary dysentery

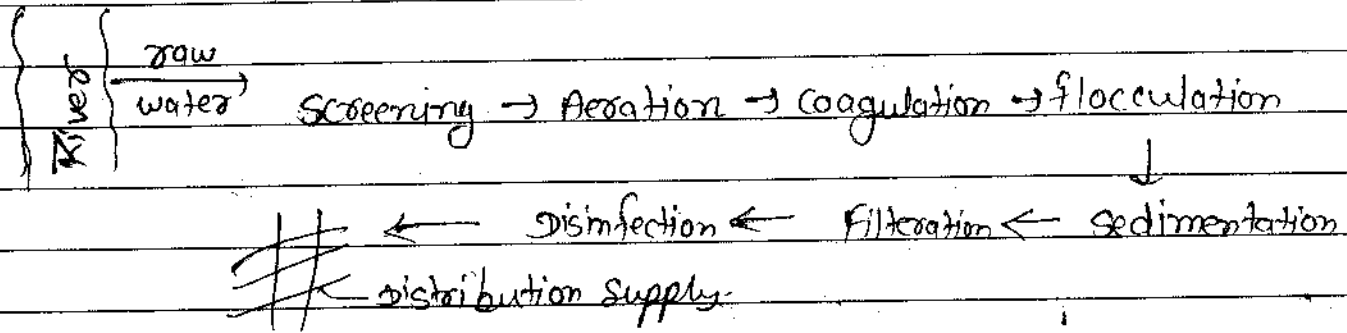
Cause by Helminths (parasite worms)

Echinococcosis, Schistosomiasis

Cause by protozoa

Amoebic Dysentery, Giardiasis

Chapter - 2 Treatment of water:-



① Screens:

Screens are used to remove large floating impurities such as branches of tree, paper, bag, dead animals etc. from the water.

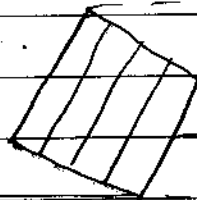
There are 2 types of screen

- i) Coarse Screen
- ii) Fine Screen

i) Coarse Screen:-

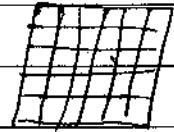
Coarse screen are in the form of bars, which are space 20-100 mm c/c.

- It is kept inclined at $3-6^\circ$ to 1° H for increasing the flow area to reducing flow velocity. Because smaller velocity helps in reducing the smaller sediments or light weighted impurities.



(ii) fine screen:-

fine screens are in the form of wire mesh with opening size 10mm.



Note:-

In case of stored water micro strainer or ~~formed~~ screen are useful for screening & it reduce the load on filter.

② Aeration:

- water is brought in intimate contact with the air, this process is known as aeration. It is used to remove undesirable gases like CO_2 , S_2S .
- It is also used to add oxygen for oxidation of undesirable substance like algae, decomposing organic compound etc.
- It remove Iron & Mn from the water.
- It is more often use for ground water as surface water is already in contact with atmosphere.

• Different types of Aerators:-

(a) Spray nozzle:-

Remove 90% CO_2 & 99% S_2S .

(b) Cascade aerators:-

Remove 20-45% CO_2 & 35% S_2S .

(c) Diffused air aerators:-

(d) Trickling bed or Tray Tower:-

This is used mostly for removal of Iron & Mn.

- During the aeration KMnO_4 may be mixed with water.

③ Sedimentation:-

Most of suspended impurities present in water to have specific gravity greater than that of water.

- In still water these impurities will tend to settle down under the action of gravity, this process is known as sedimentation.

Theory of Sedimentation:- (Stoke's law)

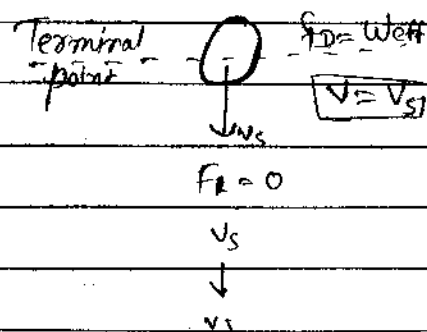
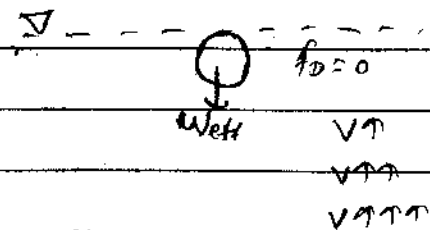
- When a solid particles settle down in a liquid medium, its downward settlement is opposed by drag force offered by the water.
- The effective weight of particle (Actual wt. - buoyancy force) causes particle to accelerate in the beginning, till it attains a sufficient velocity which the drag force becomes equal to eff. wt. of particle. After attaining this velocity particle first falls down with this velocity, this velocity is known as settling velocity or Terminal velocity (V_s).
- Stoke's considered spherical particle in this analysis.

F_D = drag force

W_{eff} = effective wt. ($W - F_B$)

V_s = settling velocity

$$F_D = \frac{1}{2} C_D \rho_w A \cdot v^2$$



At terminal pt. :-

Eff. wt. = Drag force

$$W_{eff} = F_D$$

$$W - F_B = F_D$$

$$\gamma_s \cdot V - \gamma_w \cdot V = \frac{1}{2} C_D \cdot \rho_w \cdot A \cdot v^2$$

$$\frac{4}{3} \pi R^3 (\gamma_s - \gamma_w) = \frac{1}{2} C_D \cdot \frac{\gamma_w}{g} \cdot \pi R^2 \cdot v_s^2$$

$$\frac{4}{3} \pi R \frac{\gamma_w}{g} (\frac{\gamma_s}{\gamma_w} - 1) = \frac{1}{2} C_D \cdot \frac{\gamma_w}{g} \cdot v_s^2$$

$$\frac{4}{3} \cdot \frac{\pi}{2} (G-1) = \frac{1}{2} \cdot \frac{C_D}{g} \cdot v_s^2$$

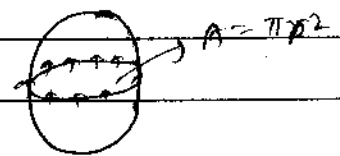
$$v_s = \sqrt{\frac{4}{3} (G-1) \cdot \frac{Dg}{C_D}} \quad (1)$$

particle size

RSD

Unit wt. $\rightarrow \gamma_s$

$$V = \frac{4}{3} \pi R^3$$



Stoke's law is valid for laminar condition of settling

particle size	Condition
① $D < 0.0002 \text{ mm}$	Settling is affected due to brownian motion of the particle.
② $D \leq 0.2 \text{ mm to } 0.0002 \text{ mm}$	Laminar condition
③ $D > 0.2 \text{ mm}$	Turbulent condition

For laminar Condition: $Re \leq 1$

$$\text{Coefficient of drag} = C_D = \frac{24}{Re}$$

$$Re = \text{Raynold's No.} = \frac{\rho v D}{\mu}$$

from eq. ①

$$V_s^2 = \frac{4g}{3} \frac{(h-1) \cdot D \cdot \mu R_e}{24}$$

$$V_s^2 = \frac{4g}{3} \frac{g}{18} \frac{(h-1) \cdot D \cdot \rho_w V_s D}{\mu}$$

$$V_s = \frac{(h-1) \rho_w g D^2}{18\mu}$$

Ans

$$V_s = \frac{(h-1) \rho_w D^2}{18\mu}$$

Sedimentation tank :-

There are 2 types of Sedimentation tank

① Quiescent type (Fill & Draw type)

Detention Time - 24 hrs.

Sludge removal time - 6-12 hrs

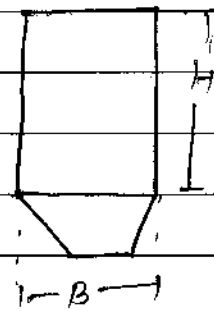
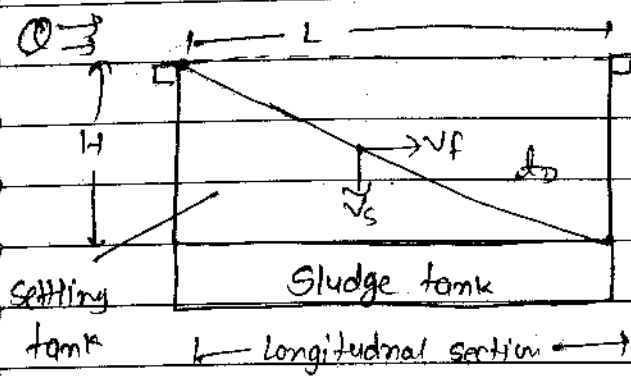
Min. No. of Unit required - 3

② Continuous flow type tank :-

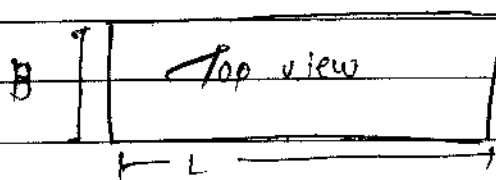
(a) Horizontal flow type tank - or Rectangular Tank :-

(b) Vertical flow type tank or Circular Tank

③ Horizontal flow type / Rectangular Tank :-



(C/S view)



H = Depth of settling zone

L = length of sedimentation tank

B = width of sedimentation tank

Q = Design discharge $\Rightarrow \frac{1}{8} B A D D$

t_d = Detention time

V_s = Surface overflow rate / Settling velocity

V_f = Horizontal flow velocity

Best Institute For Assistant & Junior Engineer

(i) Vol. of tank (V) $\Rightarrow \frac{V \Rightarrow L \cdot B \cdot H}{8}$

$$V = Q \cdot t_d$$

(ii) Surface area or plan area (A_p)

$$\left\{ \begin{array}{l} A_p = B \times L \\ A_p = \frac{V}{H} \\ A_p = \frac{Q}{V_s} \end{array} \right.$$

(iii) Cross-Sectional Area (A_{cs})

$$\left\{ \begin{array}{l} A_{cs} = B \cdot H \\ A_{cs} = \frac{V}{L} \\ A_{cs} = \frac{Q}{V_f} \end{array} \right.$$

$$\text{civ) } \boxed{V_s = \frac{H}{t_d}} \quad \text{or} \quad \boxed{V_f = \frac{L}{t_d}}$$

Design data:-

• Detention time $\rightarrow$

(i) $t_d = 4 - 8$ hrs. for plain sedimentation

(ii) $t_d = 2 - 4$ hrs. for sedimentation with coagulation & flocculation

• ~~Surface~~ Surface overflow rate or settling velocity (V_s)

(i) $\text{SOR} = 15 - 30$ ~~15000 - 18000~~ lit/day/m^2 of Surface Area
for plain sedimentation

(ii) $\text{SOR} = \frac{24\text{K} - 30\text{K}}{24\text{K} - 30\text{K}}$ lit/day/m^2 for sedimentation with coagulation

• Horizontal flow velocity (V_f)

$$\boxed{V_f = 0.3 \text{ m/min}}$$

• L/B ratio = 4 to 5

• Depth of sludge zone = $[0.8 - 1.2 \text{ m}]$

• Design discharge

$$Q = \text{max. Daily Discharge} = 1.8 \times \text{Avg. Daily discharge}$$

(b) Circular tank:-

$$\text{No. of tanks} = N = D^2 [0.785H + 0.11D]$$

H = depth of tank

D = dia of tank ($D \neq 60 \text{ m}$)

Sedimentation with Coagulation & Flocculation:-

- If fine suspended particles are present in water, they are not easily settle down & due to which the efficiency of tank is decreased.
- The solids which are not coarse more so if they are colloidal then it passes along the water through the sedimentation tank.
- For the settlement of colloidal particles agglomeration is essential.
- The agglomeration of particle required -

(i) The particle destabilization to permit attachment when contact occurs.

(ii) Agglomeration of destabilized particles.

- Coagulation is defined as the addition of chemical to a colloidal suspension which results in particle destabilization by the reduction in forces which tend to keep the particle apart. The added chemical is known as Coagulant.
- Coagulation is a fast mixing process.
- The theory of coagulation is known as 'Diffused Double layer' theory.
- The choice of best coagulant for any particular water is determined by Jar test.
- Mechanism of Coagulation:-

(i) Ionic layer compression

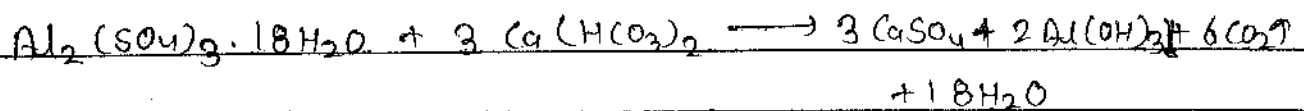
(ii) Adsorption & charge neutralization

(iii) Sweep coagulation

(iv) Inter particle bridging.

Some Commonly used coagulant:-

(a) Alum ($\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$)



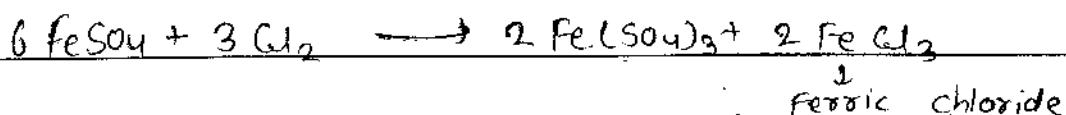
- Alum reacts with bicarbonate alkalinity to form a gelatinous precipitate of Aluminium Hydroxide $\text{Al}(\text{OH})_3$ which attracts the fine suspended particles, thus grow in size & finally settle down readily. This reaction introduces permanent hardness & water becomes corrosive due to CO_2 .
- Normal dose of Alum $10-30 \text{ mg/lit}$.
- Eff. working pH range $6.5 - 8.5$.

(b) Copperas ($\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$)

- It is added to the water in conjunction with Lime.
- Lime ^{can be} added either before or after the added of copperas & finally a gelatinous precipitate of ferric hydroxide $[\text{Fe}(\text{OH})_3]$ is formed.
- Normal dose $\longrightarrow 10-30 \text{ mg/lit}$
- Effective pH range $\longrightarrow 8.5$ & above
- It is not used for colored water.

(c) Chlorinate Copperas

Ferric Sulphate



- When chlorine is added it reacts with copperous & form

Ferric Sulphate & Ferric Chloride. which are combinedly known as Chlorinated Compound.

- Both compounds reacts with Lime & form a gelatinous precipitate of Ferric Hydroxide.
- Eff. pH range $\rightarrow$

for Ferric chloride $\rightarrow 3.5 - 6.5$ & > 8.5

for Ferric sulphate $\rightarrow 4-7$ & > 9

(d) $\text{Na}_2\text{Al}_2\text{O}_4$ (Sodium Aluminat) Aluminate:-

- It reacts with Ca & Mg present in water & results in the precipitate of Ca & Mg aluminate.
- It also reduces temporary & permanent hardness.
- It does not required Alkalinity.
- It is costlier than Alum.
- It is used for boiler feed water in which a very low concentration of Hardness is allow.
- working pH range $\rightarrow 6 - 8.5$

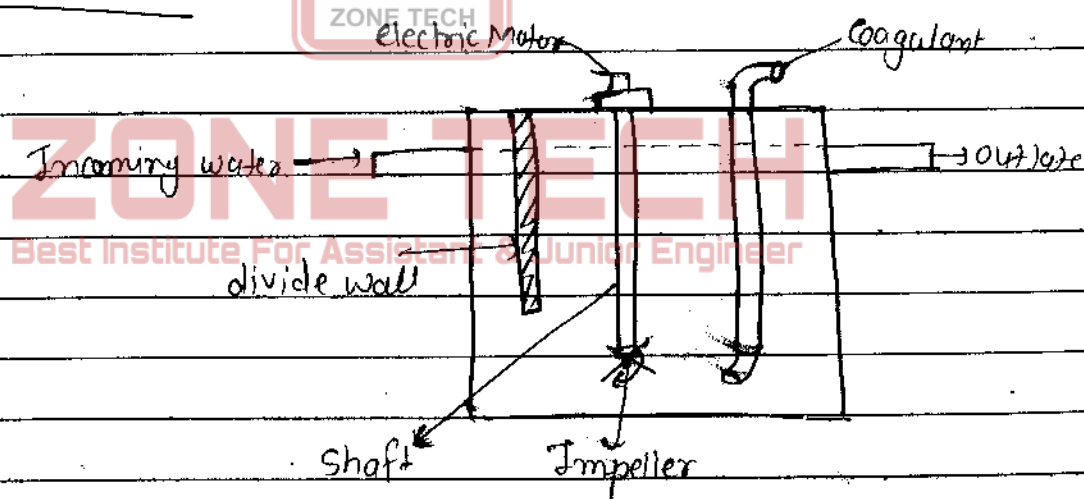
(e) Lime:-

- Lime is a Unique coagulant in case where phosphorus & removal is required & where it may be desire to remove Ammonia.

~~Comparison~~ ^{Comparison} b/w Aluminium Salt & Iron salt:

- Iron salt produce Heavy flocks.
- Time required for flock formation is smaller for iron salt.
- Iron salt work in a large pH range.
- Iron salt impart corrosiveness.
- Iron salt cause reddish brown staining on floor & equipment.
- Iron salt produce Iron bacteria. Hence these are not used for water treatment.
- Iron salt are used in sewage treatment. whereas Aluminium Salt are used in water treatment.

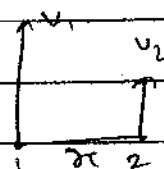
Mixing basin (Flash mixer) :-



- Coagulation is a fast mixing process which is carried out in a basin known as flash mixer.
- The intensity of mixing depends upon temporal mean velocity gradient (G).

detention timing in Coagulation $\rightarrow$ 30-60 Sec

- The unit of $G \rightarrow$ per second or Sec^{-1}



$$G = \left(\frac{v_1 v_2}{x} \right)$$

$$G = \sqrt{\frac{P}{\mu V}}$$

$$G = \sqrt{\frac{C_D \cdot 8 A V_r^3}{2 \mu \cdot V}}$$

P = power in watt

μ = viscosity of medium ($\frac{Ns}{m^2}$)

V = vol^m of Tank in m^3

$$P = F_D \cdot V_r$$

$$\therefore F_D = \frac{1}{2} C_D \cdot 8 \cdot A \cdot V_r^2$$

Flocculation :-

• It is basically a slow mixing process in which a destabilized particle are brought into intimate contact to promote agglomeration.

• The rate of flocculation depends upon

(a) Turbidity

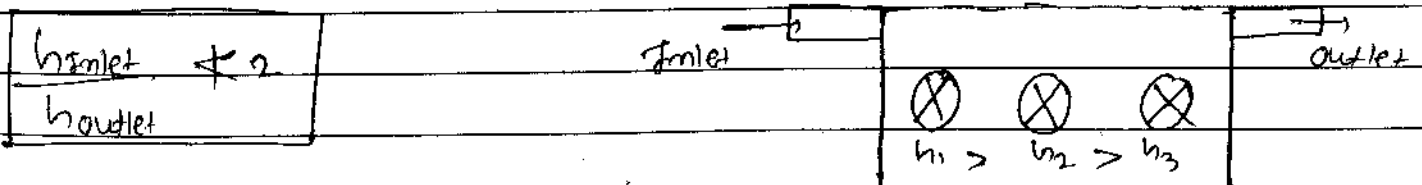
(b) Types of Coagulant & its dose.

(c) Temporal mean velocity gradient.

• The size & density of a floc depends upon the detention time & temporal mean velocity gradient (G). respectively.

$$\underline{G \uparrow} \left\{ \begin{array}{l} t_d \uparrow \Rightarrow \text{size} \uparrow \\ G \uparrow \Rightarrow \text{density} \uparrow \end{array} \right\}$$

• To obtain large & dense floc tapered flocculation is adopted.



• detention time of flocculation tank - 10-30 min

$$G \cdot t_d \Rightarrow 10000 - 100000$$

④ Filtration:-

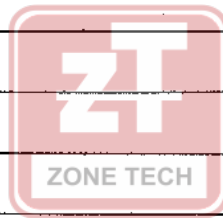
Filtration is a polishing step which ~~is an~~ removed suspended Solids (remaining), dissolved Solids, organic matter, color, M.O. etc.

Filters are classified as

- ① Slow Sand Filter
 - ② Rapid Sand Filter
 - ③ Pressure Filter
- } gravity filter

• Mechanism involved in filtration:-

- ① Mechanical straining
- ② Sedimentation
- ③ Electrolytic change
- ④ Biological action



ZONE TECH

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* Biological Action:-

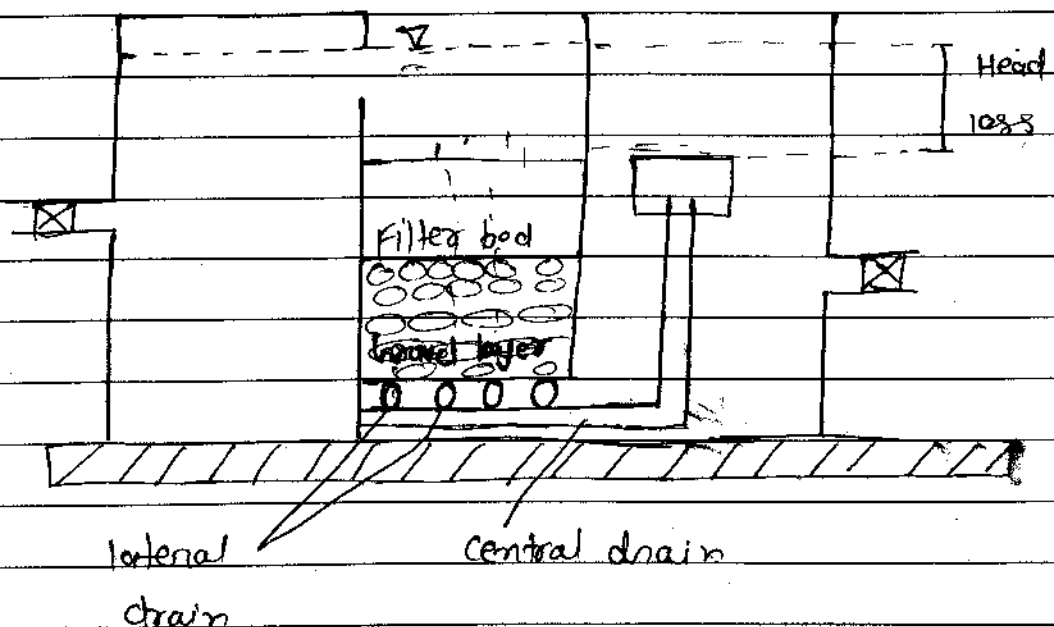
• The set bed or filter bed has been identify as 3 zone of purification.

- i) The surface coating which is known as Schlemmdeck layer
- ii) Orotropic Zone existing a few mm below schlemmdeck layer
- iii) Heterotropic Zone which extend around 300mm into the filter bed.

When a new filter put in Commission (operation) & raw water is passed, during the first 2 weeks the upper layer of Sand grains gets coated with a reddish brown sticky deposit of partially decomposed organic matter together with Iron, Mn, Al & Silica.

- This coating absorb organic matter & after 2-3 weeks these exist in upper layer of sand.
- A film of alga, bacteria & protozoa is formed. This skin is called as Schizmundek layer.
- After a few mm below the Schizmundek layer otic ototropic zone exist. In this zone growing plant life breaks down organic matter, decomposed the blackton & used available nitrogen, phosphorus & CO_2 , providing oxygen in the place.
- A few mm ototropic zone the Hittotropic zone exist which extend 300mm into the bed this zone bacteria multiple to very large no. & break down the organic matter.

SLOW SAND FILTER



- depth of tank 2.5m - 3.5m
- plan area of each unit 100-200m²
- Filter medium $\rightarrow$ Sand, Anthracite or granite
- Eff. size of medium (D_{10}) $\rightarrow$ 0.2 to 0.4mm
- Cu (coefficient of uniformity) $\rightarrow$ 1.8 to 3
- Rate of filtration $\rightarrow$ 100-200 lit/hr/m² filter area.
- Bacterial removal efficiency $\rightarrow$ 98-99%
- Depth of water layer $\rightarrow$ 90-110cm
- Depth of filter medium $\rightarrow$ 90-110cm
- Depth of gravel layer $\rightarrow$ 60-90cm
- Design life $\rightarrow$ almost 10-15 years

Cleaning of Filter:-

Cleaning should be done when head loss become 0.7 - 0.8 times of filter bed.

- For cleaning of slow sand filter the top layer is scrapped & 1.5-3cm layer of sand is removed in each cleaning.
- then filter is washed with good water.
- frequency of cleaning 1-3 months.

Total area (m ²)	Required No. of unit (operational + stand by)
up to 20	1+1 = 2
20 - 250	2+1 = 3
250 - 650	3+1 = 4
650 - 1200	4+1 = 5
> 1200	5+1 = 6

$$\text{Total filter area} = \frac{\text{Design discharge}}{\text{Rate of filtration}} \rightarrow \frac{\text{lit/hr}}{\text{lit/hr/m}^2} = \text{m}^2$$

• Rate of filtration $\rightarrow 2000 - 6000 \text{ lit/hr/m}^2$ filter ^{area}
(30 times of rate of filtration of slow sand filter)

• Bacterial removal efficiency $\rightarrow 80 - 90\%$

• Plan area required to each unit is less than 100m^2

• Depth of sand layer $\rightarrow 60 - 90\text{cm}$

• Depth of gravel layer $\rightarrow 75\text{cm}$

~ The base material is gravel which is provided in 5-6 layers

1 layer (i) 3 to 6mm particle size

2 layer (ii) 6 to 12mm "

3 layer 12 - 20mm "

4 layer - 20 - 40mm "

Cleaning of filter:-

• Cleaning is done by back washing.

• The entire process take 15-30 minit.

• Amount of water required for back washing is 2-5% of total filtered water.

• Back washing frequency 24-48 hrs.

• Rate of back washing 6-16 times of rate of filtration.

Min. no. of filter units required:-

$$N = 1.22 \sqrt{Q}$$

Q = design discharge in MLD

let

$$Q = 5,000,000 \text{ lit/day}$$

$$Q = 5 \text{ MLD}$$

problem associated with Rapid Sand Filter:-

① Air binding:-

Reason - Negative head (Vacuum)

② Mud wall formation:-

Reason - Atmospheric Dust

③ Cracking of filter:-

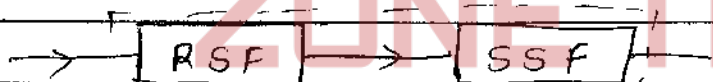
Reason - Alternate wetting & Drying

④ Bumping of filter:-

Reason - High rate of Back washing

Note:-

① Roughing filter or Double Filtration:-



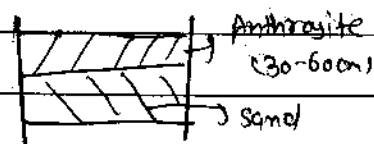
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The rate of filtration can be increased without compromising the quality of water, by providing roughing filter.

- In this filter RSF is provided before SSF.
- This process is known as double filtration.

② Dual Media Filter (DMF):-

- To increase the rate of filtration dual media filter is used in which the layer of anthracite particle is provided and below which sand layer is provided.



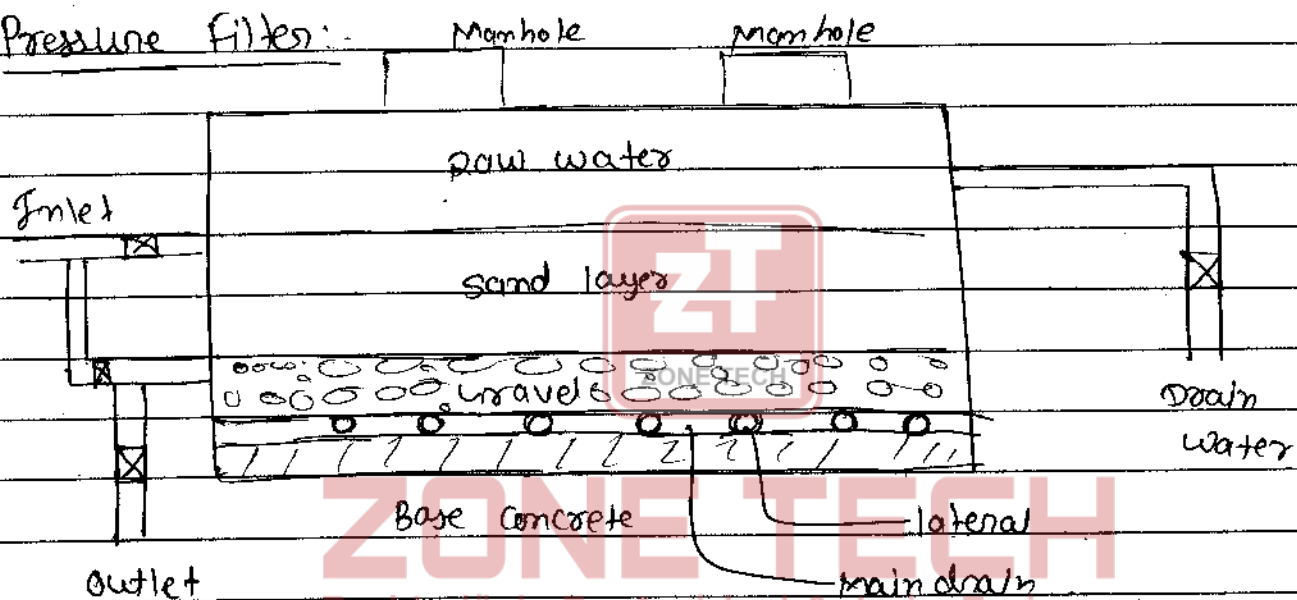
③ Multi-media Filter (MMF) :-

- In this filter more than 2 filter mediums are used.

③ Rate of Filtration

$$\text{MMF} > \text{DMF} > \text{RSF} > \text{SSF}$$

Pressure Filter :-



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- Pressure filter is similar to rapid sand filter but its entire unit is inside a closed chamber.
- Rate of filtration $\approx 6000 - 15000 \text{ lit/hr/daym}^2$
- It is used for the treatment of water at industrial plant & in swimming pool water treatment.

③ Softening process :-

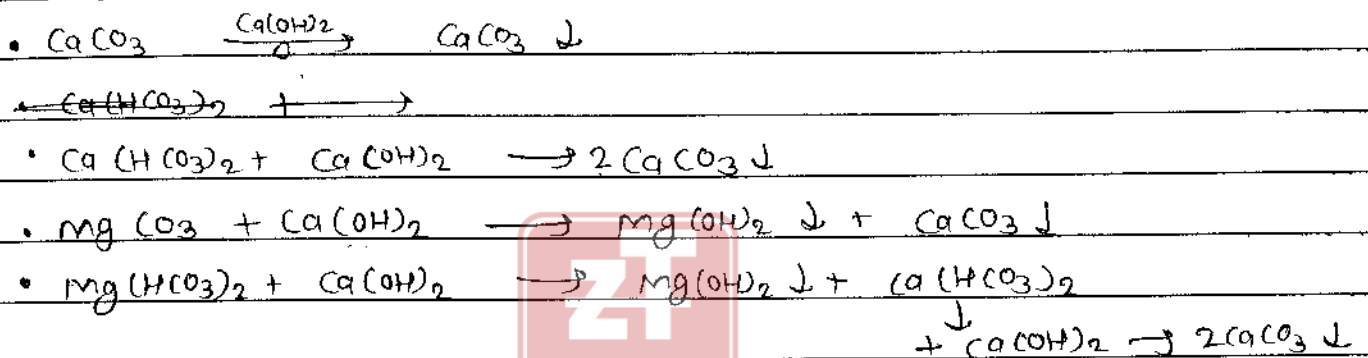
- The removal of hardness from the water is known as softening.

Methods:-

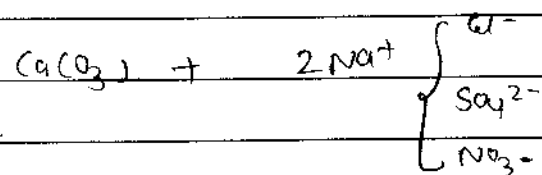
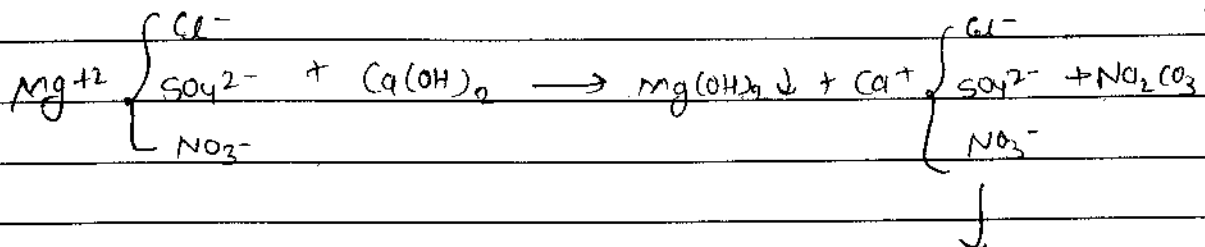
- ① Lime - soda process
- ② Zeolite method / Ion-exchange / base-exchange / kation exchange
- ③

① Lime soda process:- Ca(OH)_2 & Na_2CO_3

Lime removes entire carbonate Hardness.



• Soda remove non-carbonate Hardness of Calcium:



• Lime converts non-carbonate of Mg into Non-carbonate of Ca.

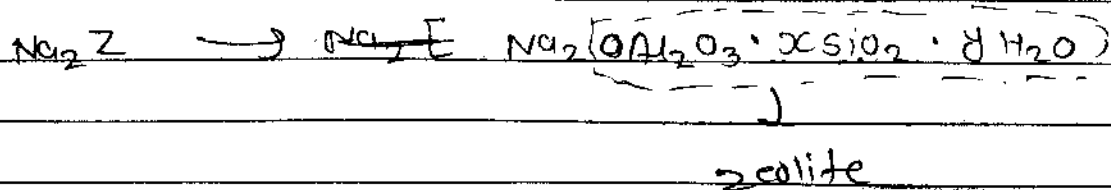
Quantity calculation:-

- To remove 1 mol of CaCO_3 Hardness, required amount of lime of 1 mol. $\Rightarrow$
- To remove 1 mol of $\text{Ca}(\text{HCO}_3)_2$ Hardness, required amount of lime of 1 mol.
- To remove 1 mol of MgCO_3 Hardness, required amount of lime of 1 mol.
- To remove 1 mol of $\text{Mg}(\text{HCO}_3)_2$ required 2 mol lime
- To remove 1 mol of Ca-non carbonate $\rightarrow$ 1 mol soda ~~1 mol Na_2CO_3~~
- To remove 1 mol of Mg-non carbonate required 1 mol lime & 1 mol soda.

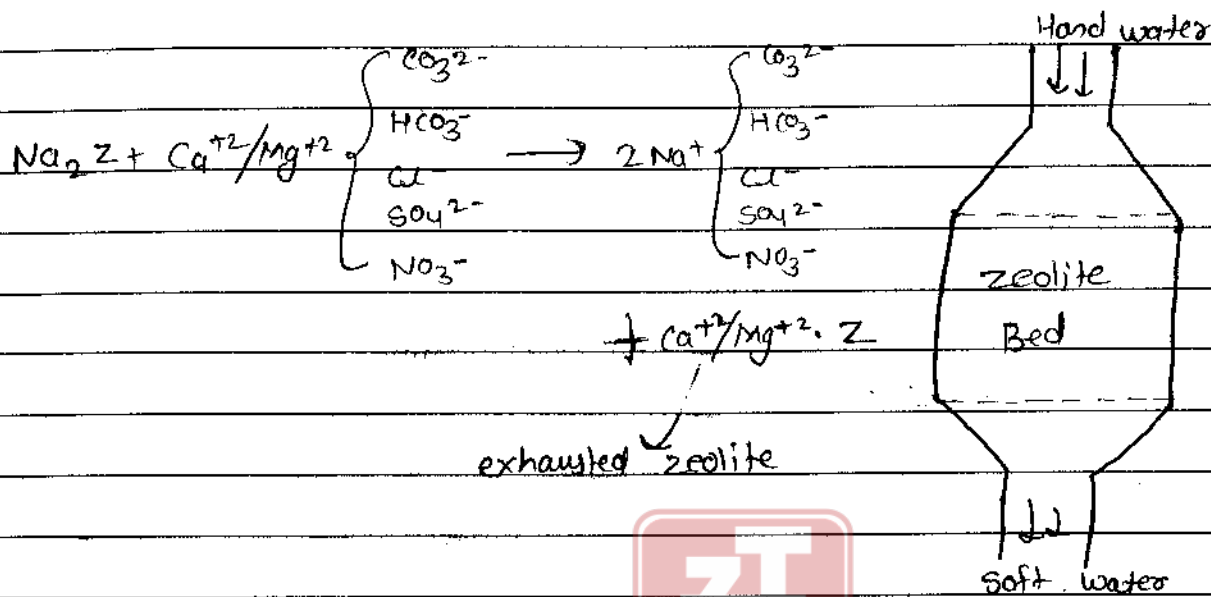
Important Point:-

- Lime also helps in removing CO_2 from the system.
- Lime soda process reduces the corrosion of pipe.
- It also help in killing the Bacteria.
- It also remove Iron, & Mn.
- The main disadvantage of this process is the production of sludge in huge quantity.
- By this process zero (0) Hardness can not be received,
- It can remove the hardness upto 50 mg/lit .

Zeolite method:-



The unit of this process is quite similar to that of pressure filter in which a zeolite bed is provided



Zeolite removes all types of ~~possible~~ hardness from the water. But in this case exhausted zeolite is formed in the zeolite bed. for the regeneration of sodium zeolite, 5-10% of brine solution is passed through the bed.

Imp. Zeolite process results in zero hardness.

- No sludge is formed
- No problem of incrustation of pipe as in Lime-soda process.
- It is not suitable for turbid water.
- It leaves sodium bicarbonate (NaHCO_3) in water which causes foaming when it is feeded to the boiler.

⑥ Disinfection:-

Disinfection may be defined as the process of destruction or inactivation of Harmful M.O. in water by physical process by chemical process.

Methods of disinfection:-

① Physical method:-

(a) boiling

(b) Ultra-violet rays (most suitable for swimming pool water treatment)

② Chemical method:-

(a) oxidizing agent (Cl_2 , Br_2 , Iodine, O_3 , KMnO_4 , H_2O_2)

(b) Metals [Ag , Cu]

(c) acids or alkalis

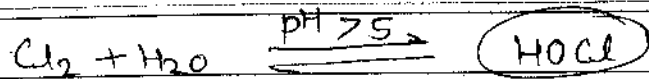
* Disinfection by chlorine:- (Major method)

Disinfection of water by chlorine is known as Chlorination.

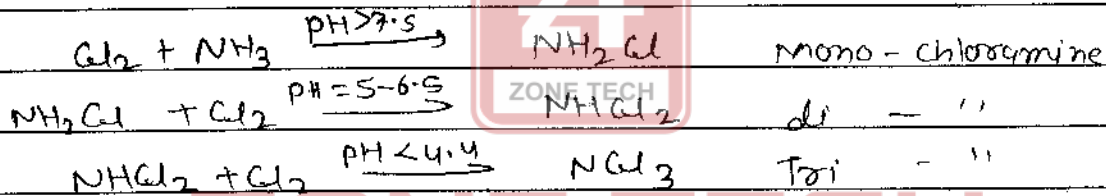
Chlorine reacts with water (~~when~~ when $\text{pH} > 5$) and forms Hypochlorous Acid (HOCl)

Hypochlorous Acid is a strong oxidizing agent. But very sensitive to the pH of water. If $\text{pH} > 8$ then HOCl dissociates into OCl^- (hypochlorite ion).

OCl^- is an oxidizing agent but very less eff. than the HOCl .



- To maintain HOCl in water the pH should be lie in b/w 5-7.
- Cl_2 , HOCl & OCl^- are combinedly known as free form of chlorine.
- Chlorine reacts with ammonia which is present in water & forms chloramines.
- These chloramines are also oxidizing agent.



- These chloramines are known as combined form of chlorine & they retain in water for greater duration hence they act as safeguard against future recontamination.

• The form in which the chlorine is added in the water:-

- free chlorine (liquid or gas)
- Hypochlorides (Bleaching powder)
- Chloramines
- Chlorine-di-oxide (ClO_2)

• The disinfection by bleaching powder is known as Hypochlorination.

Types of Chlorination:-

① Plain chlorination:-

When no other treatment is given into the water except chlorination. then it is called as plain chlorination.

- It is used for relatively clean water which have turbidity 20-30 mg/lit.

② Pre-chlorination :-

- Applying chlorine before filtration or before sedimentation coagulation, known as pre-chlorination.
- 0.1 - 0.5 mg/lit chlorine dose is required before filtration & before sedimentation coagulation 5-10 mg/lit chlorine is required.
- Pre-chlorination is always followed by Post chlorination to ensure safety.

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③ Post chlorination:-

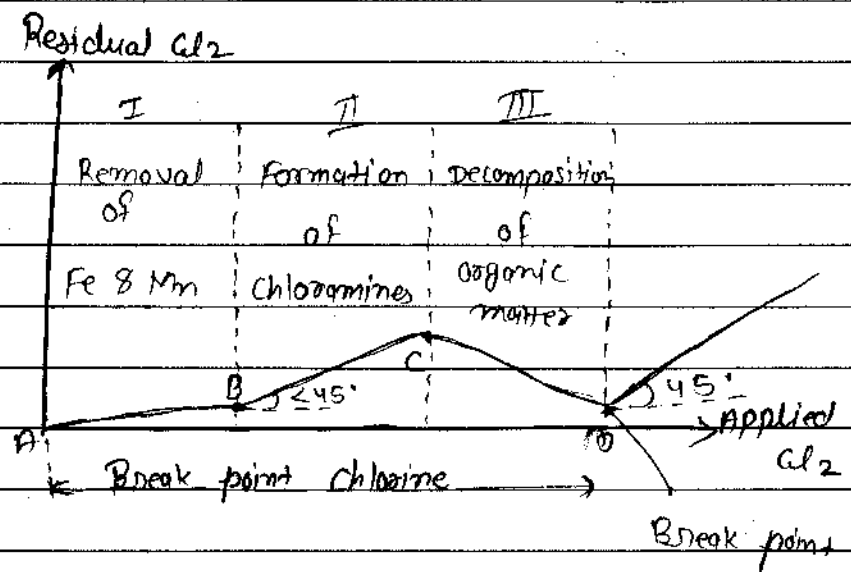
Applying chlorine at the end of when all treatment is completed, is called as post-chlorination.

- The normal dose of chlorine should be such that 0.2 mg/lit should be left after a contact period of 10 minit.
- This process is also known as chlorination.

④ Double chlorination:-

(Pre chlorination & post chlorination are combinedly known as Double chlorination.)

⑤ Break point Chlorination:-



- During disinfection process amount of residual chlorine is less in the beginning (Stage I). During which Fe & Mn, nitrite etc. are oxidize.
- In II stage Chloramines & Combined form of chlorine are formed.
- Combined chlorine residual chlorine will gradually increase as demand for disinfection is satisfy. The amount of residual would be slightly less than applied chlorine Because some bacteria killing takes place.
- And point C or at the beginning of III stage a bad smell start coming out due to decomposition of organic matter & hence the residual chlorine decreased suddenly at the end of III stage (point D) the bad smell suddenly disappeared, this implies that the oxidation of organic matter has been completed.
- Any further chlorine addition simply appears as free chlorine. This point D is called as Break point & this process of addition chlorine up to point D is known as Break point Chlorination.

⑥ Super chlorination:-

When excess chlorine ($5-15 \text{ mg/lit}$) is added into water during epidemic such that it gives a residual ~~gives~~ of ($1-2 \text{ mg/lit}$) beyond the Break point is called as Super chlorination.

⑦ Di-chlorination:-

Removal of excessive chlorine content from the water is known as di-chlorination.

* De-chlorinating agent:-

- Sodium ~~thio~~ sulphate ($\text{Na}_2\text{S}_2\text{O}_3$) $\rightarrow$ Cheapest
- Activated carbon
- Sulphur di-oxide - SO_2

* Testing of chlorine residual:-

- ① Orthotoludine Test
- ② DPD Test [Diethyl - Phenylene - Diamine]
- ③ Chlorotex Test
- ④ starch Iodide Test

Q. A water supply scheme serve a population of 10,000 at the rate of 50 lpcd, for the chlorine dose of 2 ppm calculate the required amount of Bleaching powder with 20% available chlorine.

$$\Rightarrow 10,000 \times 50 \Rightarrow 500,000 \text{ lpcd/day} \quad \text{Total water treated}$$

$$\text{Chlorine} \rightarrow 2 \text{ ppm} = 2 \text{ mg/lit}$$

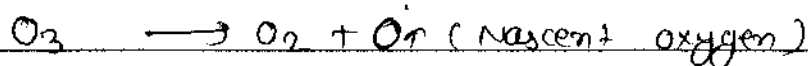
$$\text{Total quantity of chlorine required} = 2 \times 500,000 \Rightarrow 1,000,000 \text{ mg/day}$$
$$\Rightarrow 2 \frac{1}{2} \text{ kg/day}$$

Bleaching powder with 20% chlorine

1 kg chlor bleaching powder = 200 gm bleachlorine

1 kg chlorine = $\frac{2000 \times 1000}{200} \Rightarrow 5 \text{ kg/day}$ bleaching powder

Disinfection by Ozone (O_3) $\rightarrow$ Minor method



- Nascent oxygen is a powerful oxidizing agent.
- It removes organic organic matter as well as M.O. from the water.
- Normal dose $\rightarrow 2-3 \text{ ppm}$ or $2-3 \text{ mg/lit}$
- Ozone is very unstable hence it doesn't ensure the safety against against future recontamination.
- It is less efficient ~~less~~ in chlorine in killing bacteria

Disinfection with $KMnO_4$:- (Minor method)

- It is a popular disinfectant for well water supply in the rural areas which is contaminated with lesser amount of bacteria. $KMnO_4$ is mixed with water in a bucket & add well. It formed pink color in water. If pink color disappeared this implies that the biological content is present. Hence more $KMnO_4$ is added until the pink color stands.
- The treated water is not used for ~~48~~⁴⁸ hrs.
- It removes 98% bacteria But it removes 100% Colera Causing Bacteria.
- The water treated with $KMnO_4$ is not useful/suitable

for cleaning the floors & utensile (दाढ़ी) Because with passes of time it produces dark Brown precipitate.

Minor Treatment methods:-

① Treatment with activated carbon

• Due to adsorption property it removes test color & odour.

It removes Phenolic impurities.

• It is added before or after coagulation But before filtration.

• Normal dose $\rightarrow$ 5-20 mg/lit

• Its over dose is not harmful.

② Treatment with Copper Sulphate - ($\text{CuSO}_4 \cdot 7\text{H}_2\text{O}$)

• It checks the growth of algae & kills the algae to some extent.

• Copper Sulphate is added just at the entry of distribution system.

• Normal dose $\rightarrow$ 0.5 - 0.75 mg/lit

③ Flouridation:- Flouridation (addition of Flourine)

Agents:-

Sodium Flouride $\rightarrow \text{NaF}$

Sodium silicis Flouride $\rightarrow \text{Na}_2\text{SiF}_6$

Hydro silicis acid $\rightarrow \text{H}_2\text{SiF}_6$

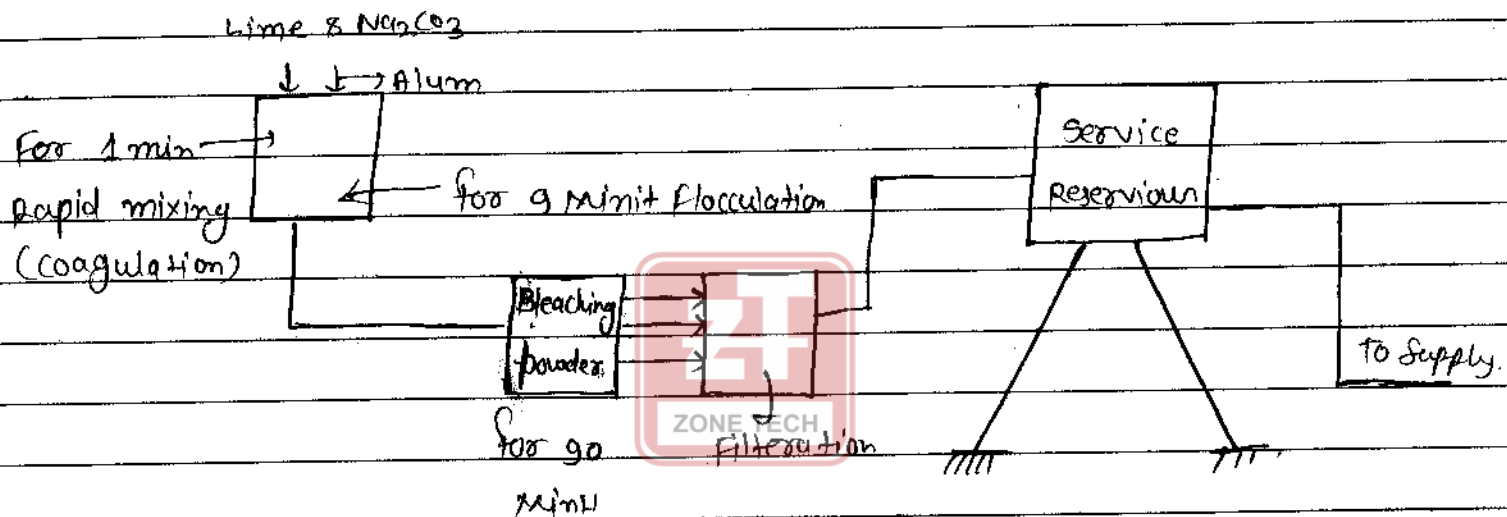
④ De-Flouridation:-

removal of Flourine.

Method:-

- Prashanti Method (It is based on activated Alumina)
- Nalgonda ~~Na₂CO₃~~ Technique
- Ion exchange method
- Reverse osmosis process

→ Nalgonda Technique.



→ Reverse Osmosis (R.O.) →

In this process water is passed through a semi-impermeable membrane which permits the flow of clean water ~~thru~~ through it & it blocks the flow of salt & fluoride.

De-Selenation:-

Methods:

- (i) R.O.
- (ii) Electro-dialysis

WASTE WATER

- ① Characteristics of waste water
- ② Treatment

Chapter - 1 (Characteristic of waste water)

Important Terms & definitions:-

* Seewage:-

Seewage indicates the liquid waste from the community

- It originated from latrines, urinals ~~toilets~~ kitchen, bathroom, Industrial activities etc.
- It also includes the storm water that may be admitted into sewer.
- Seewage is extremely putrescible.
- Its decomposition produce large quantity of gases.
- It contain large quantity of pathogens.
- It classified as domestic seewage & Industrial seewage.

* Sanitary Seewage:-

Domestic seewage & Industrial seewage are

collectively known as sanitary seewage.

It is ~~ext~~ extremely foul in nature

* Night soil:-

It is the term which is used to indicate human & animal stools.

* St Sullage:-

It indicates the waste water which is originated from bathroom & kitchen, wash basin, surface cleaning & washing area.

- It doesn't create bad smell.

* Sewer:-

It is a conduit or drain through which the sewage is carried to point of discharge or disposal.

~~The~~ Sewers are designed for gravity flow.

* Sewage Sewerage System:-

The term sewerage indicates the entire process of collection, treatment & disposal of the sewage.

- There are 3 types of Sewerage System.

1. Separate System:-

Separate ~~single~~ set of conduit is used to carry sanitary sewage & storm water.

2. Combined System:-

Sanitary sewage & storm water is carried in a single conduit.

- In case of combined system egg egg shape sewer preferred.

3. partially separate system:-

In this system a part of storm water which is originated from roof & courtyard of a building is carried with the Sewage in a separate conduit while Surface runoff carried in open drains.

Characteristics of waste water:-

① Color:-

Fresh sewage - Grey color
Septic Sewage - Dark gray / Black

② pH:-

Fresh sewage $\rightarrow > 7$ (Basic in nature / alkaline)
Septic sewage $\rightarrow \leq 7$ (Acidic in nature)

③ Temperature:-

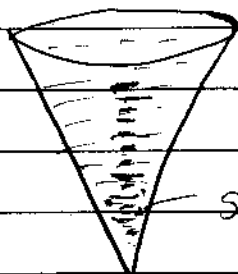
The avg. temp of municipal sewage in India is 20°C .

④ Solids:-

Municipal sewage consist of 99.99% water & remaining 0.01% of solids.

In municipal sewage solids are categorised as ^{settleable} settleable & non-settleable solids.

Settleable solids are measured by 'Imhoff Cone'.



Settleable Solids (mg/lit)

- In Imhoff cone sewage is allowed to stand for detention period of 2 hrs. & the quantity of the solids settle down in the bottom of Imhoff cone gives approx. value of settleable solids in (mg/lit).

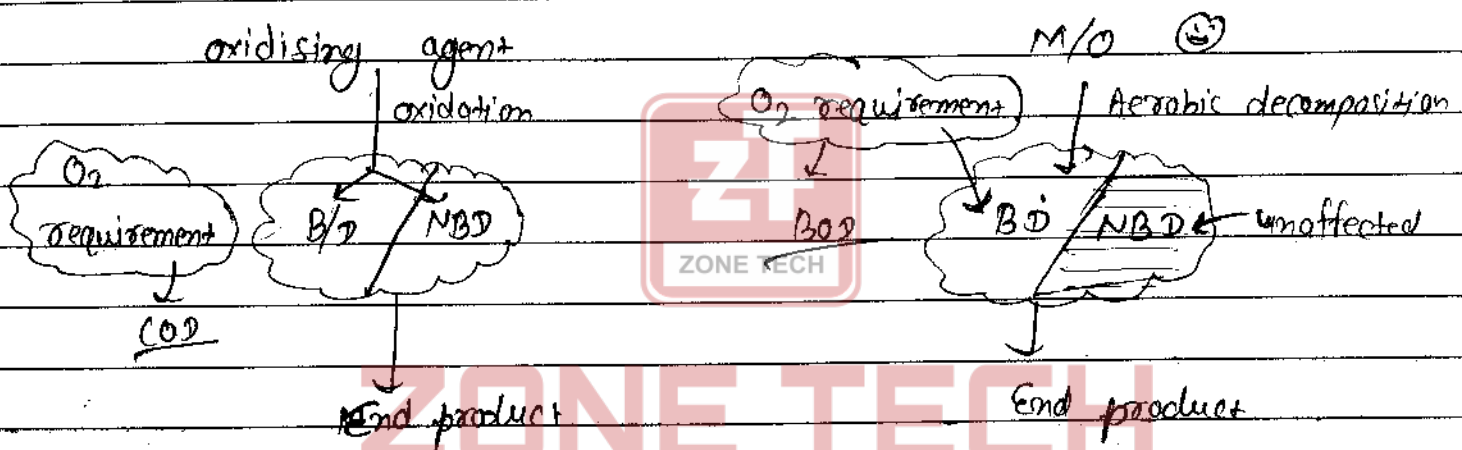
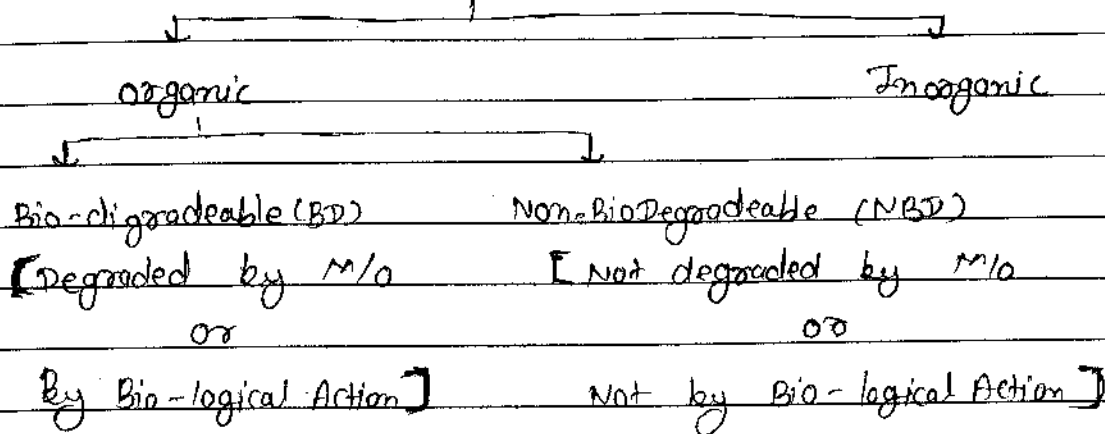
Some Important chemical parameters:-

① Dissolved oxygen:-

- Dissolved oxygen is one of the most important parameter which controls the biological activity & treatment of sewage.
- It depends upon temp.
 - with Increase in temp. dissolved oxygen content in a water body, reduces.
 - In a water body the dissolved oxygen content is max. & in day time due to photosynthesis process.
 - The max. quantity of dissolved oxygen that remain mixed in the system at a particular temp. is called as Saturation dissolved oxygen.
 - For the survival of aquatic life (animal & plant) the dissolved oxygen in a water body should not be less than 4 ppm.
 - D.O. is determined by Winkler method, in which water or sewage sample is titrated with Iodine Complex.
 - The order of D.O. in a water body is 10 mg/lit.

② Chemical Oxygen Demand (COD) :-

Solids



The amount of oxygen required to oxidise BD as well as NBD organic matter is called as Chemical Oxygen Demand (COD)

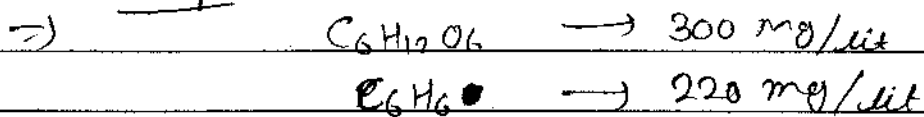
COD is determine By using a strong oxidising agent potassium di-chromate ($K_2Cr_2O_7$). Hence it is also known as Di-chromate Demand.

THOD (Theoretical oxygen Demand) :- THOD

If the chemical formula & exact quantity of all organic matter present in waste water is already known then exact quantity / amount of oxygen required to oxidise this

organic matter, can be computed by using chemical oxygen reaction, this comp computed oxygen demand is known as theoretical oxygen Demand.

Q. Sewage Sample Content 300 mg/lit glucose & 220 mg/lit Benzene then calculate theoretical oxygen Demand of Sample.



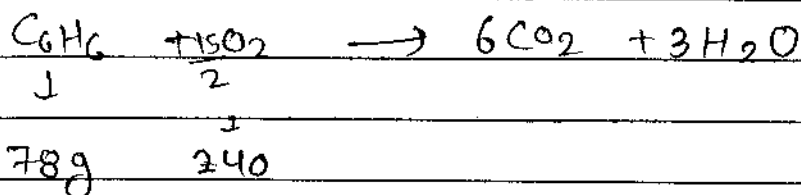
For glucose



$\therefore$ To oxidise 1 mol of glucose required oxygen = 6 Moles
 $\quad \quad \quad 180 \quad \quad \quad = 192 \text{ g}$

To oxidise 300mg $= \frac{192}{180} \times 300$

For Benzene



$\therefore$ To oxidise 1 mol of Benzene required oxygen = $\frac{15}{2}$
 $\quad \quad \quad 78 \quad \quad \quad = 240$

$\quad \quad \quad 220 \quad \quad \quad = \frac{240}{78} \times 220$

$\Rightarrow 676.9 \text{ mg/lit}$

Sample THOD = $320 + 676.9 \Rightarrow 996.92 \text{ mg/lit}$

Total organic Carbon (TOC)

• It is another way to represent organic matter in the form of carbon.

a. If a waste water content 200 mg/lit Benzene then Calculate TOC for the sample.

→ $C_6H_6 \Rightarrow 6 \text{ Mol carbon}$

for 1 Mol of Benzene TOC = 6 Mol

for 78g Benzene TOC = 72g

for 200 mg/lit Benzene TOC = $\frac{72}{78} \times 200$

$\Rightarrow 184.6 \text{ mg/lit}$

Note:-

• for all practical purpose $THOD = COD$

• But in general COD is less than THOD

Bio-chemical oxygen Demand (BOD) :-

• The amount of oxygen required to decompose Bio-degradable organic matter only by aerobic process, is known as Bio-chemical oxygen demand.

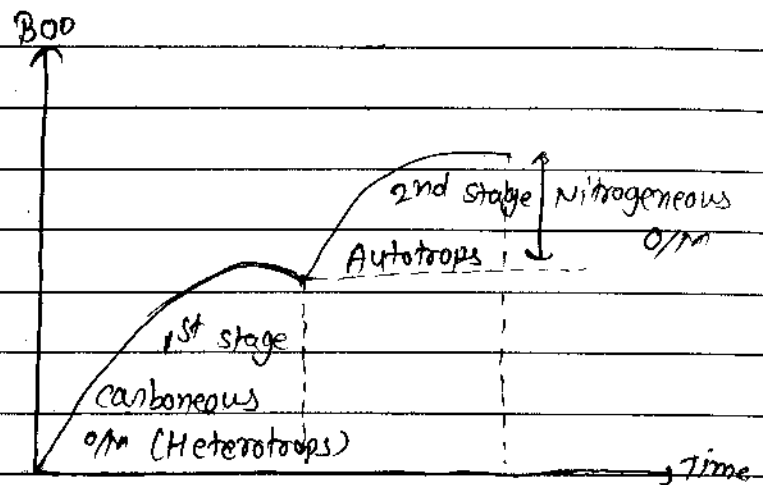
• There are 2 type of organic matter

(1) Carboneous organic matter

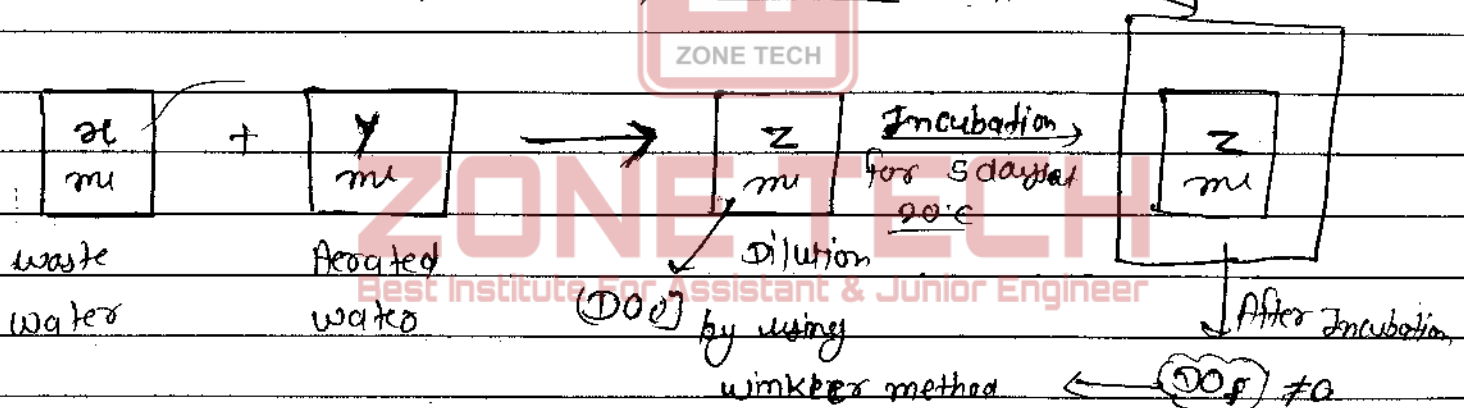
(2) Nitrogenous organic matter

• During aerobic decomposition the oxygen demand of waste water is satisfied into 2 stages.

- In first stage carbonaceous matter is oxidised by heterotrophs
- In further stage the nitrogenous organic matter is oxidised by autotrophic matter.



BOD Measurement (Dilution Aero Test) : - ~~☒~~ Sunlight not Allowed



$$B.O.D. \frac{5 \text{ days}}{20^\circ C} = (D.O_i - D.O_f) \cdot D.F$$

Dilution factor, $D.F = \frac{z}{x}$

Let

$D.O_{ww}$ = Dissolved oxygen of waste water

$D.O_{Aw}$ = Dissolved oxygen of Aerated water

$$\boxed{DO_i = \frac{DO_{ww} \cdot x + DO_{aw} \cdot y}{x + y}}$$

Volume of BOD bottle = 300ml

(BOD)_{5 days/20°C} = std. BOD → (Related to 1st stage BOD only)

2nd stage BOD → (Nitrification)

(BOD)_∞ & L₀ → ultimate BOD

BOD_{5/20°C} or std. BOD → 68% of (BOD)_∞

Reaction Kinematics:-

Deoxygenation rate

$$\frac{dL_t}{dt} \propto -L_t$$

$$\frac{dL_t}{dt} = -KL_t$$

$$\int_{L_0}^{L_t} \frac{dL_t}{L_t} = -K \int_0^t dt$$

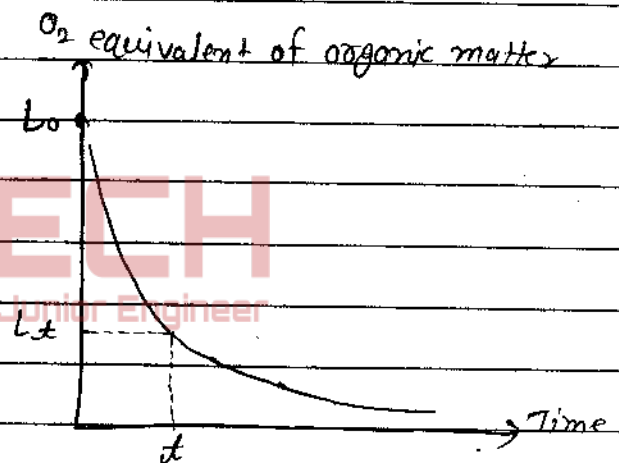
$$\Rightarrow [\ln]_{L_0}^{L_t} = -K[t]_0^t$$

$$\Rightarrow \left(\ln \left[\frac{L_t}{L_0} \right] = -Kt \right) \quad \text{--- (1)}$$

$$2.303 \log_{10} \left(\frac{L_t}{L_0} \right) = -Kt$$

$$\log_{10} \left(\frac{L_t}{L_0} \right) = \left(\frac{-K}{2.303} \right) \cdot t$$

$$\log_{10} \left(\frac{L_t}{L_0} \right) = -K_d \cdot t \quad \text{--- (2)}$$



$$K_D = \frac{K}{2.303} = 0.4341K$$

- K & K_D are deoxygenation constant. At base e & At base 10 respectively.

Using eq. ①

$$\log_e \frac{L_t}{L_0} = -Kt$$

$$\frac{L_t}{L_0} = e^{-Kt}$$

$$L_t = L_0 \cdot e^{-Kt}$$

Using eq. ②

$$\log_{10} \frac{L_t}{L_0} = -K_D t$$

$$\frac{L_t}{L_0} = 10^{-K_D t}$$

$$L_t = L_0 \cdot 10^{-K_D t}$$

BOD of 't' days

$$(BOD)_{t \text{ days}} = L_0 - L_t$$

$$= L_0 - L_0 \cdot e^{-Kt}$$

$$(BOD)_t = L_0 [1 - e^{-Kt}]$$

$$(BOD)_t = L_0 - L_t$$

$$= L_0 - L_0 \cdot 10^{-K_D t}$$

$$(BOD)_t = L_0 (1 - 10^{-K_D t})$$

- The rate of deoxygenation depends upon temp. It means with increase in temp. deoxygenation rate increases.
- The BOD of any 't' days depends upon temp. But ultimate BOD is a constant parameter. Do not depends on Temp.

$$K_D \text{ at any Temp } T_c / K_D T_c = K_{D 20^\circ C} \times [1.047]^{T_c - 20^\circ C}$$

Type of water	K_D 20°C $\rightarrow$ per day
① Tap water	< 0.05 per day
② Surface water	0.05 to 0.1
③ Municipal sewage	0.1 to 0.15
④ Treated Sewage	0.05 to 0.1

If deoxygenation value is less than 0.2 then we considered as K_D otherwise 1

①. following observation were made on 3% dilution of waste water :

- (1) D_0 of aerated water $\rightarrow 3 \text{ mg/lit}$
- (2) D_0 of Sample $\rightarrow 0.6 \text{ mg/lit}$
- (3) D_0 of dilution Sample After 5 days $\rightarrow 0.8 \text{ mg/lit}$
- (4) Deoxygenation constant $\rightarrow 0.303/\text{day}$ $0.1/\text{day}$

Calculate Std. BOD, Ultimate BOD & BOD of 3 days at 37°C

$$\Rightarrow D_{01} = \text{Dilution} = 3\%$$

$$D_{0ww} = 0.6 \text{ mg/lit}$$

$$D_{0Aw} = 3 \text{ mg/lit}$$

$$D_{0f} = 0.8 \text{ mg/lit}$$

for 100ml dilution, 3ml is sewage sample & 97ml is aerated water

$$x = 3 \text{ ml}$$

$$y = 97 \text{ ml}$$

$$Z = 100 \text{ ml}$$

$$D.F. = \frac{100}{3} = 33.33$$

$$DO_i = \frac{x \cdot DO_{ww} + y \cdot DO_{aw}}{x+y}$$

$$= \frac{3 \times 0.6 + 97 \times 3}{100}$$

$$\Rightarrow \frac{1.8 + 291}{100} = \frac{292.8}{100} \Rightarrow 2.928$$

$$\begin{aligned} (BOD)_{5\text{days}} &= (DO_i - DO_f) \cdot DF \\ &= (2.928 - 0.8) \cdot 33.33 \\ &\Rightarrow \underline{70.93 \text{ mg/lit}} \end{aligned}$$

$$\begin{aligned} \text{ultimate BOD} &= \frac{\text{std. BOD} \times 100}{68} \\ &\Rightarrow \frac{70.93 \times 100}{68} \Rightarrow \underline{104.3 \text{ mg/lit}} \end{aligned}$$

Method

$$\begin{aligned} (BOD)_5 &= BOD_u (1 - 10^{-K_d t}) \\ \boxed{(BOD)_5 = 70.93 (1 - 10^{-1.5})} \\ (BOD)_5 &= \frac{70.93}{(1 - 10^{-1.5})} = 104.3 \text{ mg/lit} \end{aligned}$$

BOD at 3 days

$$BOD_{3\text{day}/33^\circ\text{C}} = BOD_u (1 - 10^{-K_d 33^\circ\text{C} \cdot t})$$

$$\begin{aligned} K_d 33^\circ\text{C} &= K_d 20^\circ\text{C} \times [1.047]^{37-20} \\ &\Rightarrow 0.1 [1.047]^{17} \\ &\Rightarrow \underline{0.218 \text{ per day}} \end{aligned}$$

$$(BOD)_3 = 103.7 (1 - 10^{-0.218 \times 3})$$

$$\Rightarrow \underline{80.7 \text{ mg/lit}}$$

Note:-

$$(1) THOD \geq COD > BOD_u > BOD_5 \text{ or std. BOD}$$

$$(2) \frac{BOD_5}{COD}$$

• For Domestic sewage water its ratio 0.4 - 0.8

$$(3) \frac{BOD_5}{COD} \geq 0.6 \text{ Biological treatment is feasible.}$$

$$(4) \frac{BOD_5}{COD} \approx 0.2 \text{ can not be decomposed easily by biological action.}$$

physical & chemical treatment desired.

$$(5) \frac{BOD_5}{COD} = 0 \text{ It have toxic substance.}$$

$$(6) \frac{BOD_5}{COD} = 0.3 \text{ to } 0.6 \text{ waste need Acclimatization for biological treatment.}$$

$$(7) \frac{BOD_5}{COD} < 0.3 \text{ . waste water is treated with methods other than biological methods}$$

Population Equivalent :-

The avg. std. BOD production rate of domestic sewage is 80gm per capita per day.

- The no. of persons which produced the amount of BOD at the rate of 80gm per capita per day which is equal to that produce by Industrial Sewage, is called as population equivalent

Population Equivalent : -
$$\frac{\text{BOD per day of Industrial waste}}{\text{Avg. BOD production Rate}}$$

Relative Stability :- (S)

$$S = \frac{\text{O}_2 \text{ available in sewage effluent}}{\text{O}_2 \text{ requirement for } 1^{\text{st}} \text{ stage BOD}}$$

$$S = 100 [1 - (0.794)^{t_{20^\circ\text{C}}}]$$

or

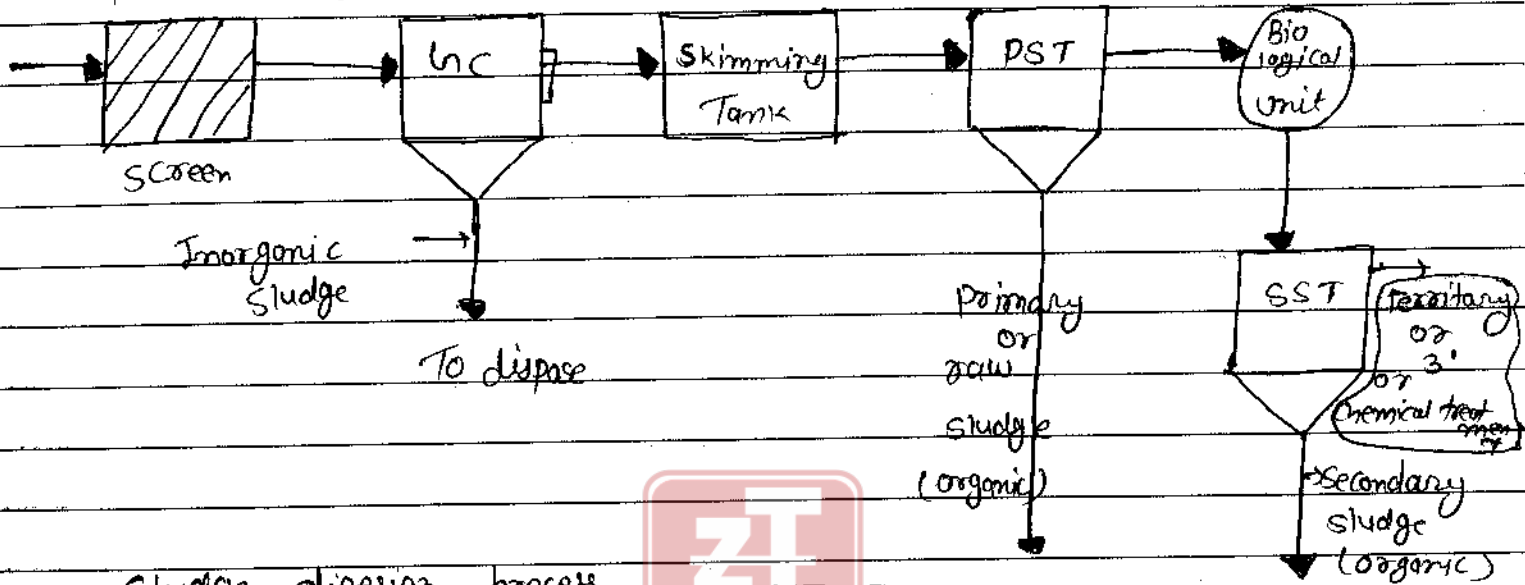
$$S = 100 [1 - (0.63)^{t_{37^\circ\text{C}}}]$$

- $t_{20^\circ\text{C}}$ or $t_{37^\circ\text{C}}$ is the time in days for a sewage sample to decolorise a sample of methyl blue solution. When sewage sample is incubated at 20°C & 37°C respectively.
- The decolorisation of color is caused by the enzymes produced by anaerobic bacteria.
- The sooner decolorization takes place, the earlier anaerobic condition developed which means lesser availability of oxygen.

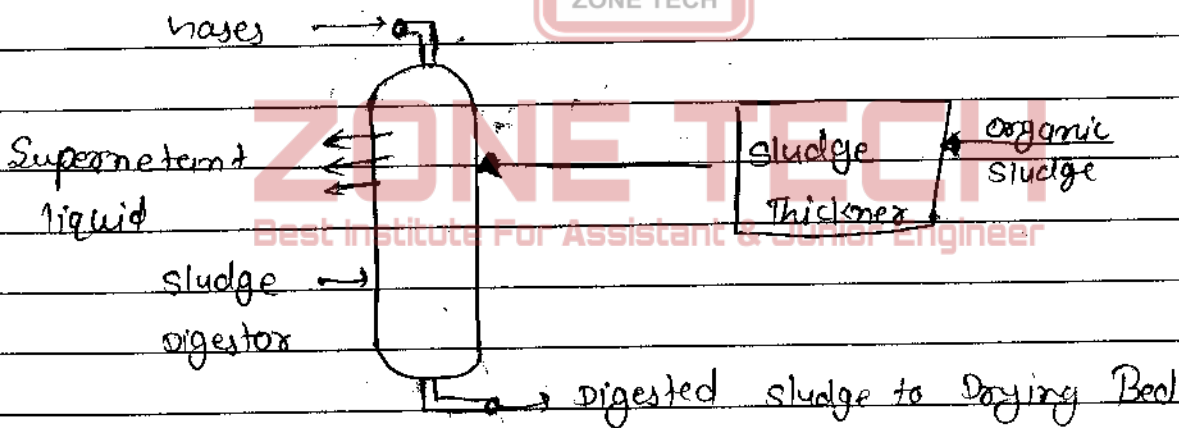
Treatment of waste water:-

primary sedimentation or 1st treatment

Preliminary Treatment



Sludge digestion process



S.No.	Treatment	Purification effect	Unit	BOD removal (%)	SS removal (%)	Bacteria removal (%)
1.	Preliminary	(a) removal of floating material like dead animal, tree branches, paper, Bag etc.	Screen	5-10%	2-20%	10-20%
		(b) Removal of Heavy settleable inorganic solid	Inc chamber or Distritus tank	10-20%	20-40	10-20
		(c) removal of oil & grease	Skimming Tank (or)	20-30	20-40	10-20

Valluvaculator

2.	Primary	Removal of Suspended Settleable organic matter	PST (or) Septic tank (or) Imhoff tank	30-35 20-30 30-40	60-65 40-60 60-65	25-75 25-75 25-75
3.	Secondary	Removal of fine, non-settleable solids	Intermittent sand filter (or) Slow Rate Trickling Filter (SRTF) (or) High Rate Trickling Filter (HRTF) (or) Activated Sludge process (ASP) (or) Oxidation pond	90-95 90-95 65-95 75-95 85-90	85-95 70-92 65-95 85-90 85-90	95-98 90-95 80-95 90-98 90-98
3.	Tertiary	Removal of pathogens	Chlorination	100	100	100

Specific gravity of Municipal sewage - slightly greater than 1

① Grit chamber:-

Grit chambers are generally long narrow channels or tanks that are designed to slow down the flow velocity for removal of grit from the waste water.

Grit is the Heaviest material in waste water which includes Sand, coffee grounds, gravel, cinders, cooking pieces, glass piece, egg shell. Specific gravity (2.4 - 2.65)

• Detention time - 45 - 90 sec (generally 60 sec or 1 min)

• At least 2 unit should be provided.

• Horizontal flow velocity - 15 - 30 cm/sec

• Surface overflow rate - 2.160 m³/m²/day

• Length → 10 - 18 m

• Depth → 1 - 1.5 m



• The length of channel is generally increased by 20% as an allowance for inlet & outlet turbulence.

• Velocity Control device:-

In case of rectangular grit chamber proportional weir is used. & In case of parabolic grit chamber parshall flume flume is used as velocity control device.

② Detritus tank:-

These are nothing But grit chamber which are designed for small flow velocity (0.09 m/s) & High detention time 3 - 4 min.

③ skimming tank:-

Skimming tanks are used to remove oil & grease from the sewage.

- At high temp. it is very difficult to remove oily substance from the sewage. Hence in India the skimming tank is generally not adopted.
- To increase the efficiency of skimming tank chlorine gas is added into sewage.
- Vacuumators may also be used to remove oil & grease.

④ PST (Primary Sedimentation tank)

In PST organic

Suspended solids are removed.

- They have specific gravity normally 1.2

width = 6M, not greater than 7.5M

L/B ratio = 4-5

Horizontal flow velocity = 0.3 M/min

detention time = 2 - 2.5 hrs

depth = 2.5 - 3.5 M

⑤ Secondary Treatment (a) Biological treatment:-

- The decomposition of organic matter by action of m.o. is known as biological degradation.

There are 2 types of biological stabilization

(a) aerobic stabilization

(b) anaerobic stabilization

• Aerobic process:-

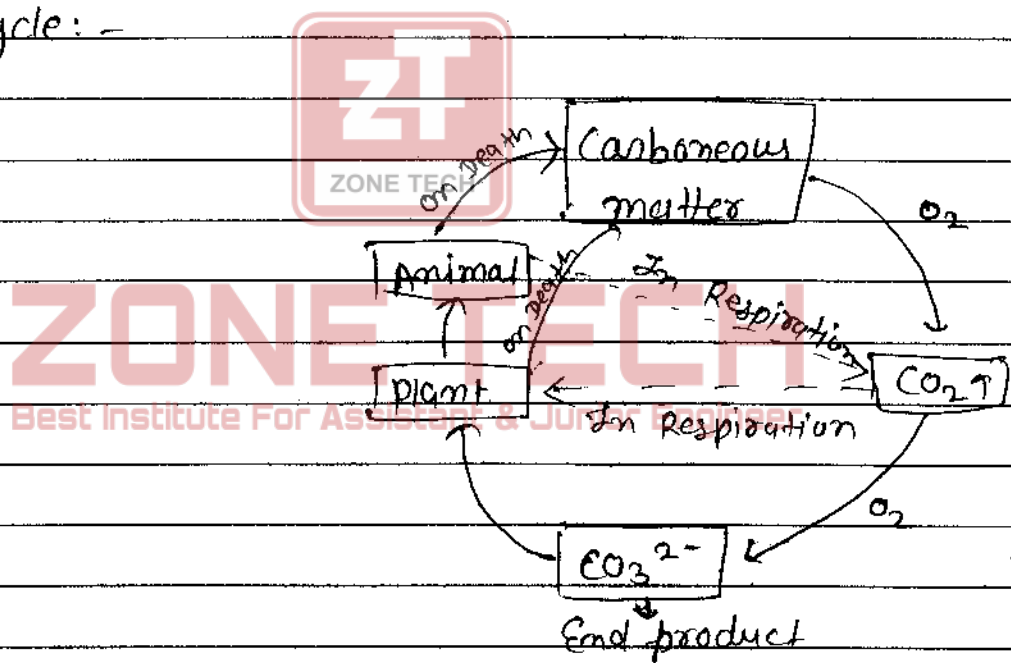
In this process organic matter is get

stabilized by the MnO in the presence of oxygen. This process produced reasonably stable end product with relatively low energy content. This process provides high degree of stabilization.

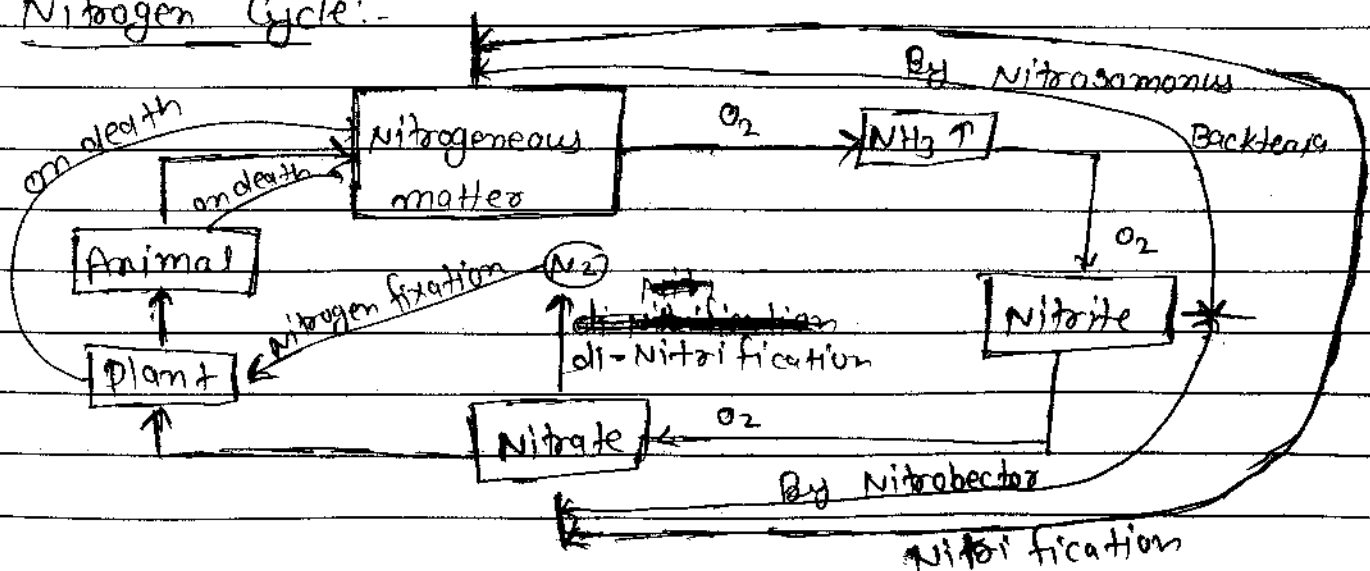
- In this process large amount of sludge is formed which required further treatment.
- The considerable amount of OM is synthesis by to new microbial cells

Aerobic cycle :-

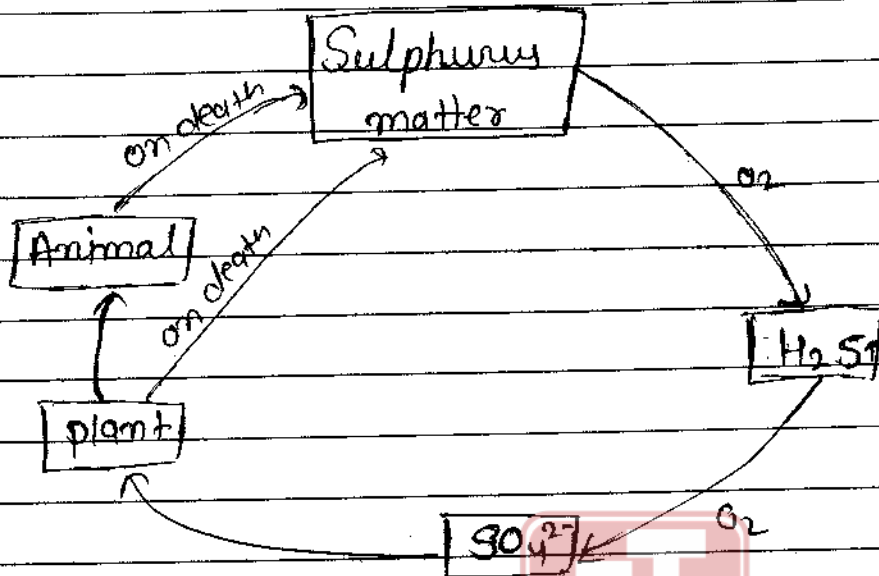
Q) Carbon cycle:-



⑥ Nitrogen Cycle:-

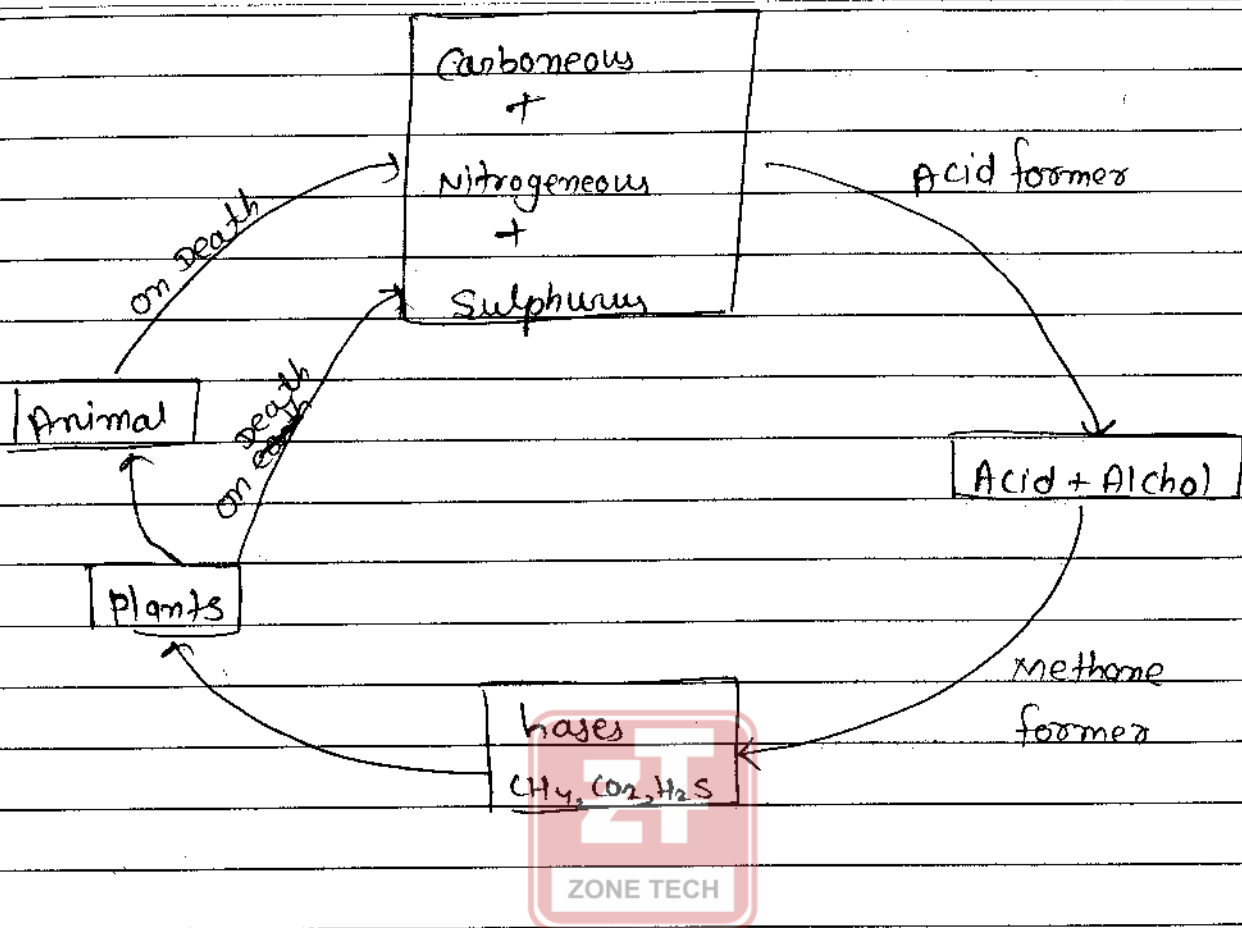


③ Sulphur Cycle:-

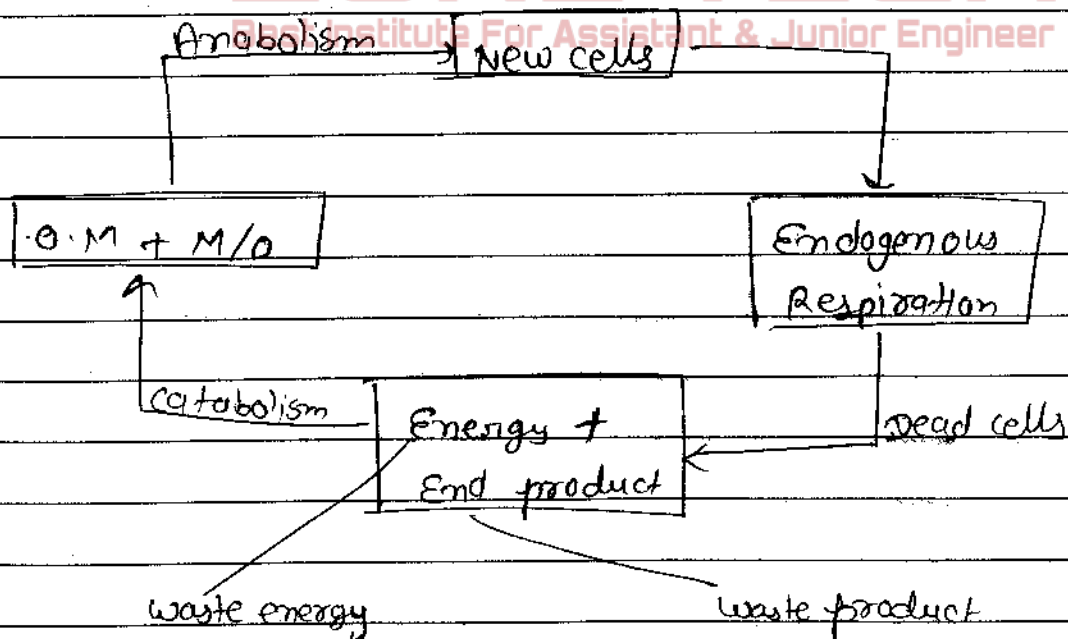


Anaerobic process:-

- In this process the organic matter is stabilised by M.O. in the absence of oxygen.
- The end product of anaerobic process considerable amount of Energy. Because of slower release of energy in anaerobic process the stiffness of new cell is very much less, then in aerobic reaction. This process provides lower degree of stabilization.
- Anaerobic process is much slower than aerobic process in this process less amount of sludge is formed.
- It is a multi stage process in which acid forms M.O. convert the O.M into volatile substance of low molecular mass (Acid & Alcohol) in further stage acid & alcohol are converted into gases like CH_4 , H_2S , CO_2 , etc. By CH_4 formed M.O.



Biological Growth:-



- The process in which o/m. is broken down produce energy is known as catabolism.
- The process in which produced material is used for the synthesis of new micro cells, is known as Anabolism.

Unit based on Aerobic treatment:-

1. Trickling filter
2. ASP (Activated sludge process)
3. Rotating biological Contractor (RBC)
4. Oxidation Pond.

Unit based on An-aerobic treatment:-

1. Septic tank
2. Imhoff tank
3. Up flow Anaerobic sludge blanket reactor (UASBR)
4. Raw sludge digester.

System of Biological Growth:-

1. Attached growth System:-

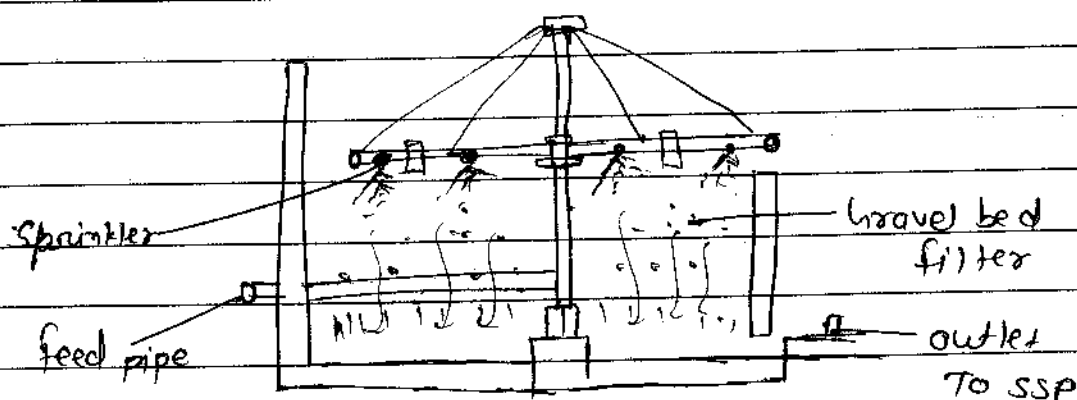
In this system bio mass (M.O.) attached to a medium the waste water containing a organic matter is passed through the medium

2. Suspended growth System

- In this system bio-mass in a suspension which contain o/m.

Biological Treatment Unit:-

1. Trickling Filter:-

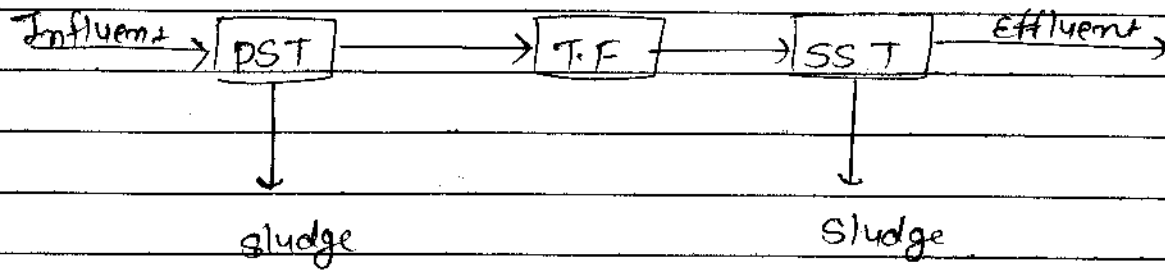


- Trickling filter is an aerobic attached growth system. The decomposition of organic matter and the purification of waste water is carried out by M.O. which are attached to a medium.
- In trickling filter, a bio mass layer is formed on the medium surface which is known as slime layer.
- With the passage of time the thickness of slime layer is increased.
- In the bottom portion of slime layer endogenous respiration takes place due to deficiency of food (O/M) so that the bond b/w slime layer and medium weakens.
- Finally the slime layer is sloughed off from the medium and removed in SST.

Types of trickling filter:-

1. Std. Rate trickling filter (SRTF)
2. High Rate trickling filter (HRTF)

1. Std. Rate Trickling filter (SRTF):-



- In case of std. rate of Trickling filter, recirculation of waste water effluent is not carried out

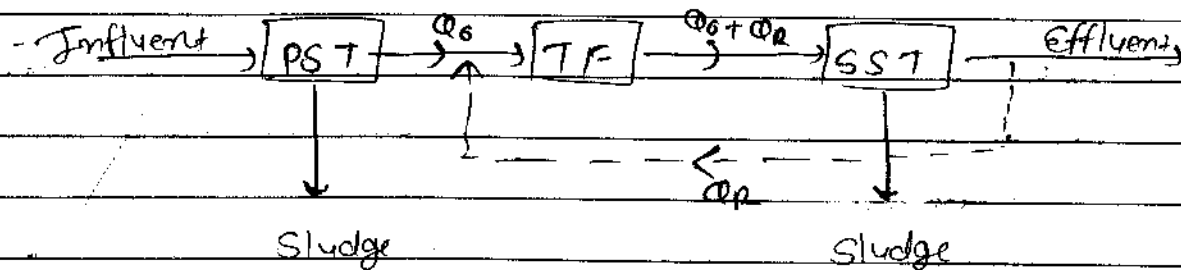
$$Q_R = 0$$

Recirculation Ratio

$$R = \frac{Q_R}{Q_0} = 0$$

2. High Rate trickling filter (HRTF):-

A. Single stage HRTF

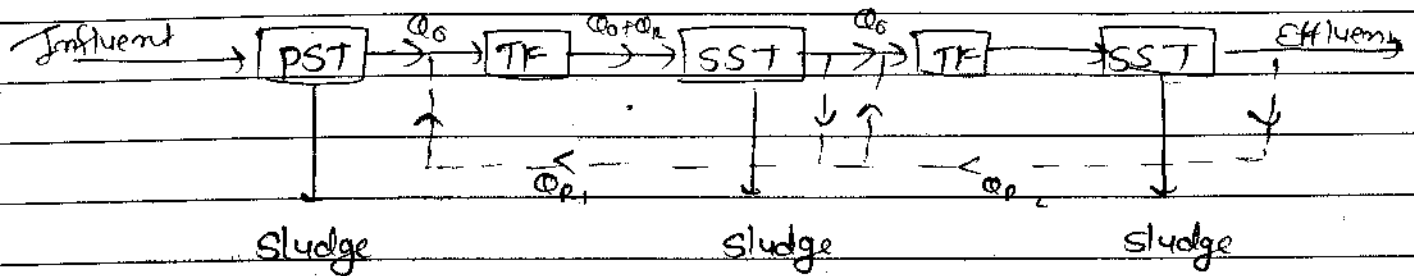


Recirculation contains are large quantity of m/o

→ Recirculation Ratio

$$R = \frac{Q_R}{Q_0}$$

(B) Double stage HRTF :-



Recirculation
Ratio

$$R_1 = \frac{Q_{R1}}{Q_0}$$

$$R_2 = \frac{Q_{R2}}{Q_0}$$

For (1) BOD removal efficiency:

2nd stage HRTF > 1st stage HRTF > SRTF

For (2) Nitritification efficiency

SRTF > HRTF

(3) As per IS code BOD removal efficiency

(i) For SRTF

$$m(y.) = \frac{100}{1 + 0.0044 \sqrt{u}}$$

u = organic loading rate (K_g of BOD₅/ha-m/day)

or

volumetric loading rate

(ii) For HRTF

$$m(y.) = \frac{100}{1 + 0.0044 \sqrt{\frac{y}{VF}}}$$

$Y =$ kg of BODs per day

$N =$ vol^m of filter (ha-m)

$F =$ Recirculation factor

$$F = \frac{1+R}{(1+0.1R)^2}$$

Imp For SRTF

$$R = 0$$
$$C = 1$$

Operational travel in SRTF:-

1. clogging and ponding of filter:-

Reasons:-

due to high growth of alkinity

Remainig

Treating the Sewage with Copper Sulphate

2. Excessive flying Beeding:-

• chlorination

3. odour problem

- Due to H_2S and other gases

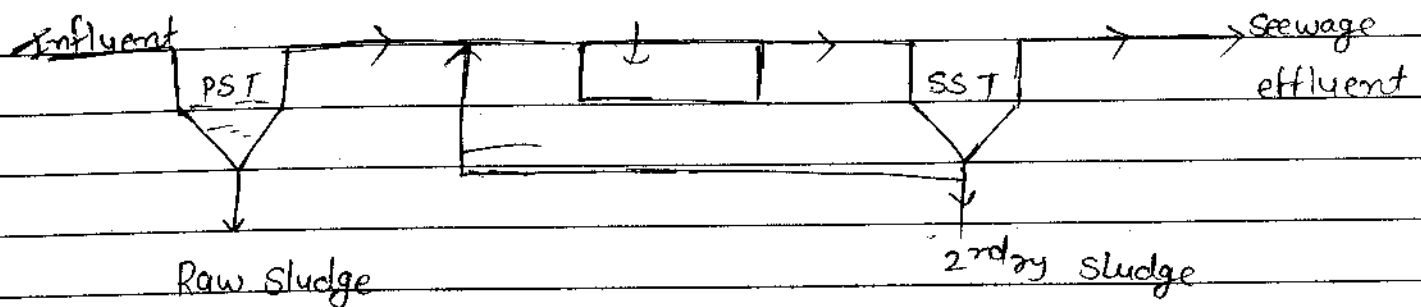
Remain:-

By providing proper ventilation to the filter and by maintaining Aerobic Condition in the filter.

- For proper ventilation trickling filter should be elevated structure & the wall of trickling filter should be honey comb.

Activated sludge process (ASP) :-

Reactor (Aeration tank)



The sewage effluent from PST is normally utilized in this process. It is mixed with 20-30% own vol^m of activated sludge which contain large quantity of highly active aerobic M/O.

The mixture enters in an Aeration tank where the M/O & organic matter are ultimately together with a large quantity of 4-8 hr. Under these condition the moving organism will oxidizing O/M the suspended & colloidal matter then to coagulate suspended & colloidal matter from a precipitate will settle down readily in SST.

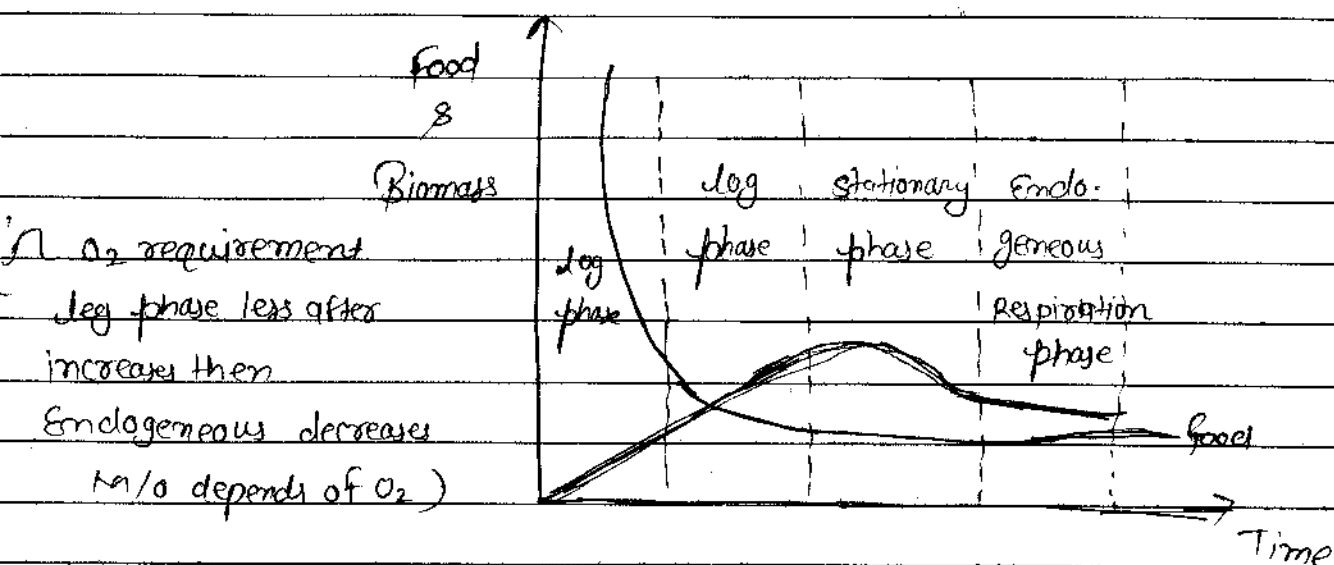
This settle sludge is known as activated sludge & the effluent obtained from a properly sludge process is of high quality which have lower BOD. Then that of trickling filter ASP is a suspended growth aerobic process.

BOD removal efficiency = 80-95%.

Bacterial removal efficiency = 90-95%.

Less land area is required.

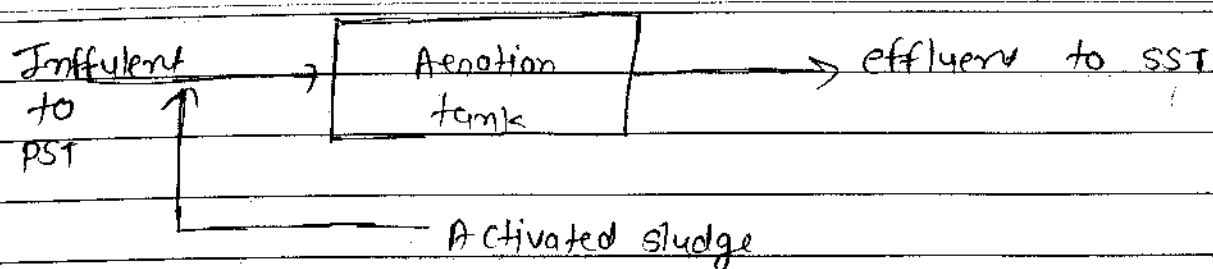
Reaction Kinematic of ASP :-



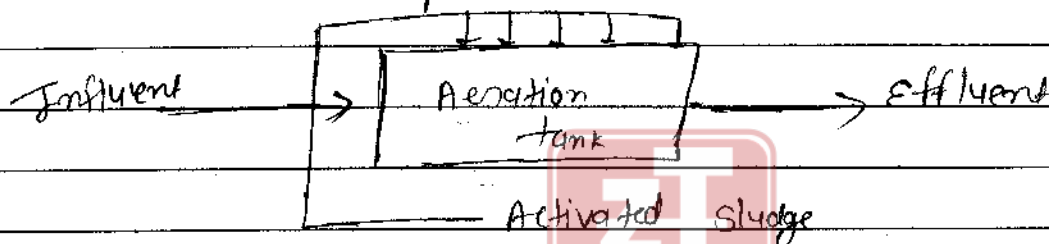
- The M/O 1st become activated to the environment & food which is provided to them. during this Biomass growth rate is not to be too much, this phase is known as lag phase.
- In lag phase bacterial cells reproduces by cell division at very high rate hence biomass growth rate will be high.
- In stationary phase the production of new cells is roughly offset due to limited availability of food & Endogeneous respiration. In this phase Biomass growth since to be constant.
- Endogeneous respiration predominate in last stage due to which biomass growth rate decrease & can up reach up to Zero (O_2).

Modification of Basic ASP :-

In Basic ASP (conventional ASP) the recirculate Activated Sludge is added to inlet & of the aeration tank as w single dose this regime flow which is employ to the aeration tank is plug flow not mixed flow.



The other type of flow regime which is called as complete mix flow which it introduce the rapid dispersion of incoming Sewage the throughout the tank and it is adopted in extend aeration process ASP.



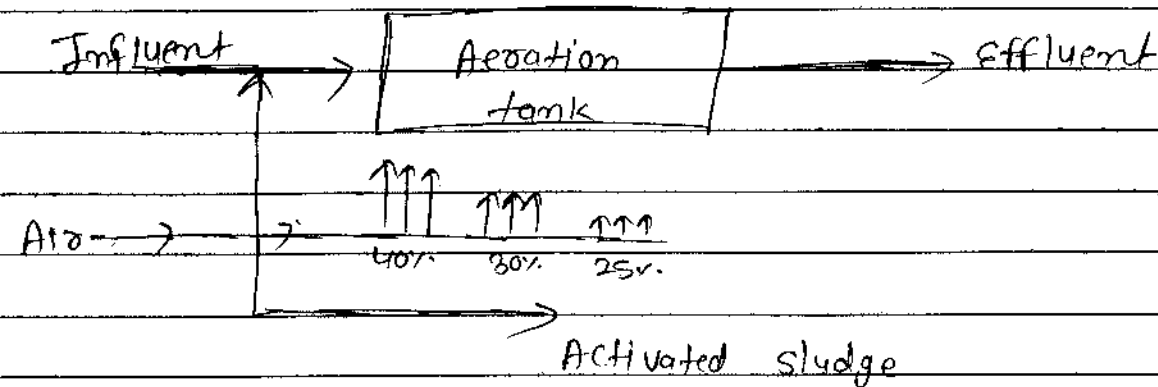
In plug flow, the F/m (Food/Biomass) or oxygen demand will be highest at inlet point and will then progressively decrease.

- In the complete mix process F/m ratio & oxygen demand will be uniform throughout the tank.
- The plug flow regime is achieve in such ASP, by providing a long narrow channel of length equal to 5-50 times the width.
- In complete mix process Aeration is done in square or circular aeration tank.

The plug flow is adopted for the plants having Capacity upto 300 MLD. where as Complete mix is adopted for the plants having capacity upto 25 MLD.

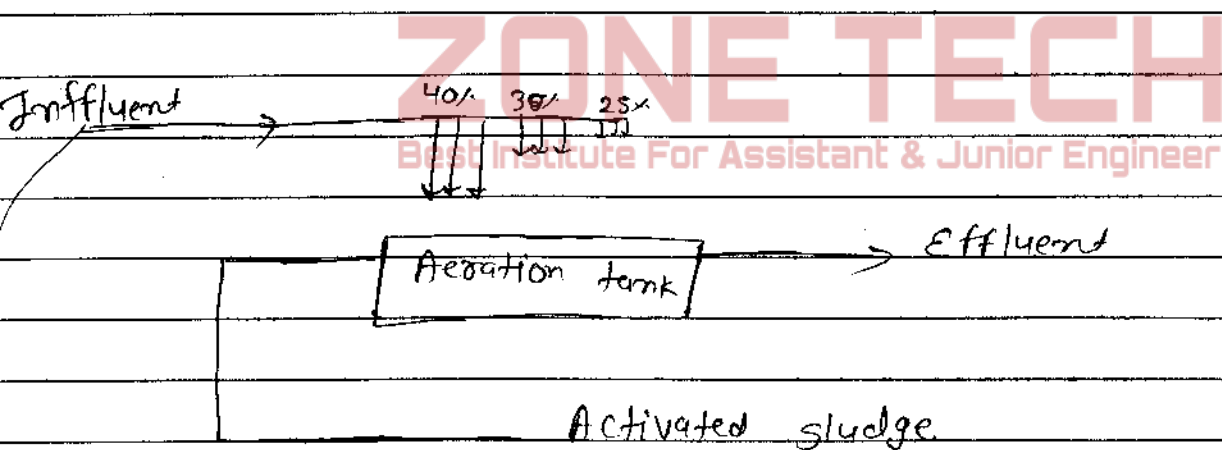
Importance Modification of ASP :-

1. Tepered Aeration process



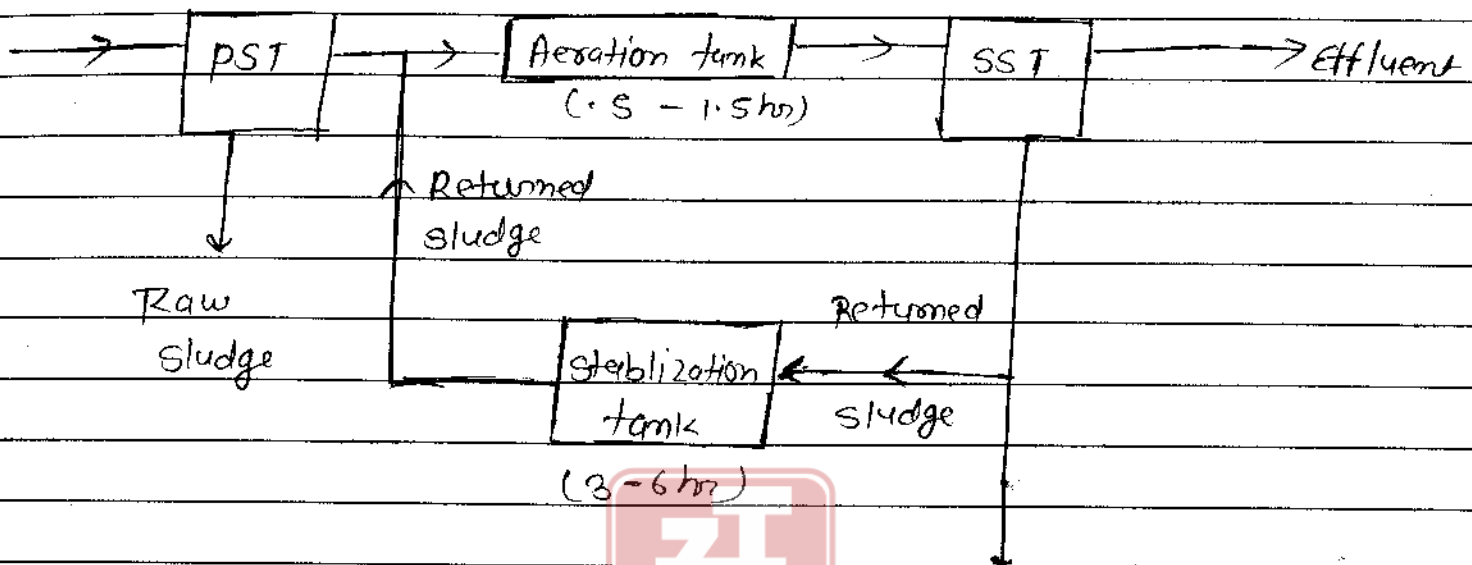
- It is a plug flow process
- This process insure optimal application of air throughout the tank.

2. Stepped Aeration Process



- In this process sewage is introduce along the length in several steps while wriiten Sludge is introduce inlet point. This process is adopted for the plant having capacity upto 1000 MLD

3. Contact Stabilization process



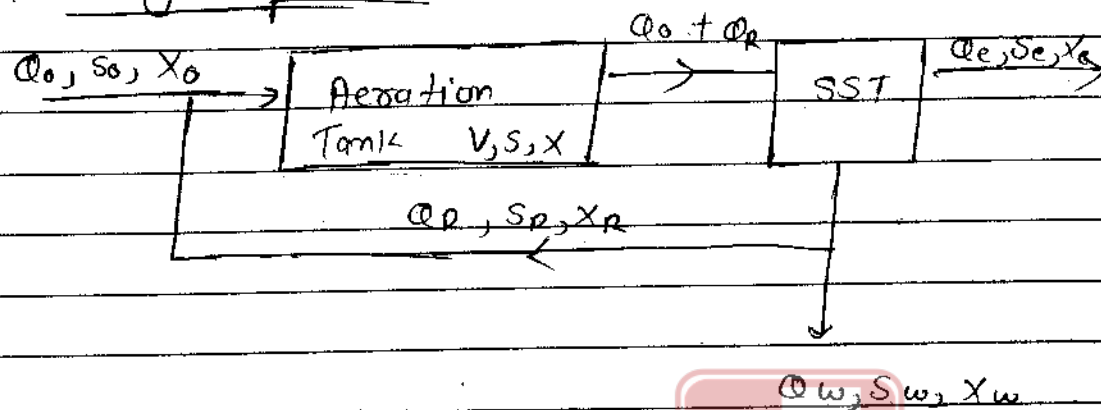
- This process is adopted for the plant having capacity upto 40MLD.

4. Extended Aeration Process (E.A)

- The flow regime extended Aeration Process is complete mix process.
- Generally primary sedimentation tank (PST) is generally avoided in this process.
- As its name suggest the Aeration period is quite large and extended to at least 12-24hr.
- This process permit low organic loading rate & high MLSS concentration & low F/M ratio.
- BOD removal efficiency = 95-98%.
- The plants however offers high aeration time so that effluent can send directly to ~~drawing~~ bed drying.

without sludge digestion process. This process is suitable for the plant having capacity ≤ 4 MLD.

Design parameter:-



Q = Discharge (MLD)

S = BOD application rate (mg/lit)

X = MLSS concentration ratio

MLSS = Mixed liquor Suspended Solids (living + dead cells)

MLVSS = Mixed liquor volatile S.S. (living cells)

MLVSS $\approx 80\%$ of MLSS

1. Hydraulic retention time / Aeration time (HRT)

$$HRT = \frac{V}{Q_0}$$

2. volumetric loading rate or organic loading rate

$$Q_0 = \text{lit/day}$$

$$S_0 = \text{mg/lit}$$

$$= \frac{Q_0 S_0}{V} \quad (\text{kg of BODs/day}) / \text{m}^3$$

3. Food of Biomass ratio

$$\frac{F}{M} = \frac{Q_0 S_0}{V \cdot X}$$

4. Sludge Age (θ_c)

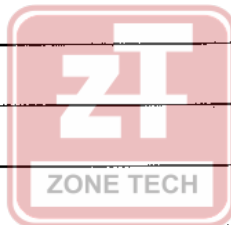
- It may be defined as the avg. time for which partical of MLSS remains under aeration it is also called as mean cell residence time or solid retention time.

$$\theta_c = \frac{V \cdot X}{Q_e \cdot X_e + Q_w \cdot X_w}$$

$$\theta_c = \frac{V \cdot X}{(Q_0 - Q_w) \cdot X_e + Q_w \cdot X_w}$$

X_e - negligible

$$\theta_c = \frac{V \cdot X}{Q_w \cdot X_w}$$



5. Sludge volume Index (SVI)

- The term sludge vol^m index is used to indicate physical state of sludge produce in a biological Aeration system. It represents of concentration of sludge in the system hence the state the rate of return sludge required to maintain the desire level of MLSS the F/M ratio in Aeration tank to achieve desire degree of purification.
- The 1 lit sample of mix is allow to settle for 30 min. settled sludge vol^m = "Vob ml" (observed vol^m) This vol^m of ml/lit is of mixed liquor will represent the quantity of sludge in ml/lit.
- The above sample after remixing the settled solid to further tested to laboratory for MLSS by the std.

processes for the measuring the suspended solid in sewage.
let the concentration of suspended solid is " X_{ob} " mg/L

$$SVI = \frac{V_{ob}}{X_{ob}} \text{ ml/mg}$$

generally SVI is represented ml/gm so that other

$$SVI = 10^3 \times \frac{V_{ob}}{X_{ob}} \text{ ml/gm}$$

Using mass Balancing equation

$$(Q_0 + Q_R) X = Q_0 X_0 + Q_R X_R$$

$$Q_0 X + Q_R X = Q_0 X_0 + Q_R X_R$$

$$Q_0 (\underbrace{X - X_0}_{\text{Negligible}}) = R (X_R - X)$$

$$\text{Recirculation ratio} = R = \frac{Q_R}{Q_0} = \frac{X}{X_R - X}$$

Inte

$$A = X_R \text{ mg/Lit}$$

$$= X_R \times \frac{10^{-3} \text{ gm}}{10^3 \text{ ml}}$$

$$= X_R \times 10^{-6} \frac{\text{gm}}{\text{ml}}$$

$$SVI = \frac{1}{A}$$

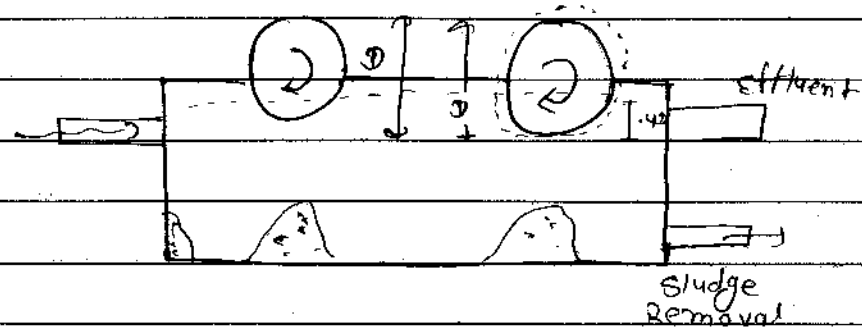
$$= \frac{1}{10^{-6} X_R} = \frac{10^6}{X_R}$$

$$X_R = \frac{10^6}{SVI}$$

$$R = \frac{Q_R}{Q_0} = \frac{X}{\frac{10^6}{SVI} - X}$$

Inte generally $SVI = 50 - 150 \text{ mg/gm}$

③ Rotating Biological Contractor :-



- A RBC is a cylindrical media which is made up of closely mounted thin circular plates of 3-3.5m in dia. & 10mm thickness.
- RBC are usually made up to 8m length. RBC are rotated at speed of 1-2 RPM.
- RBC are kept immersed in waste water by 40% of their dia.
- It is an aerobic ^{attached} ~~suspended~~ growth system.

Stabilization Unit :-

- Stabilization units are those units in which there is no need of separate sludge digestion process.
- A stabilization unit is that unit in which the treatment of waste water & sludge digestion process are done simultaneously in a common treatment basin (tank).
- Stabilization units are of 2 types
 - (1) Aerobic
 - (2) An-aerobic

Aerobic stabilization unit (Oxidation pond) :-

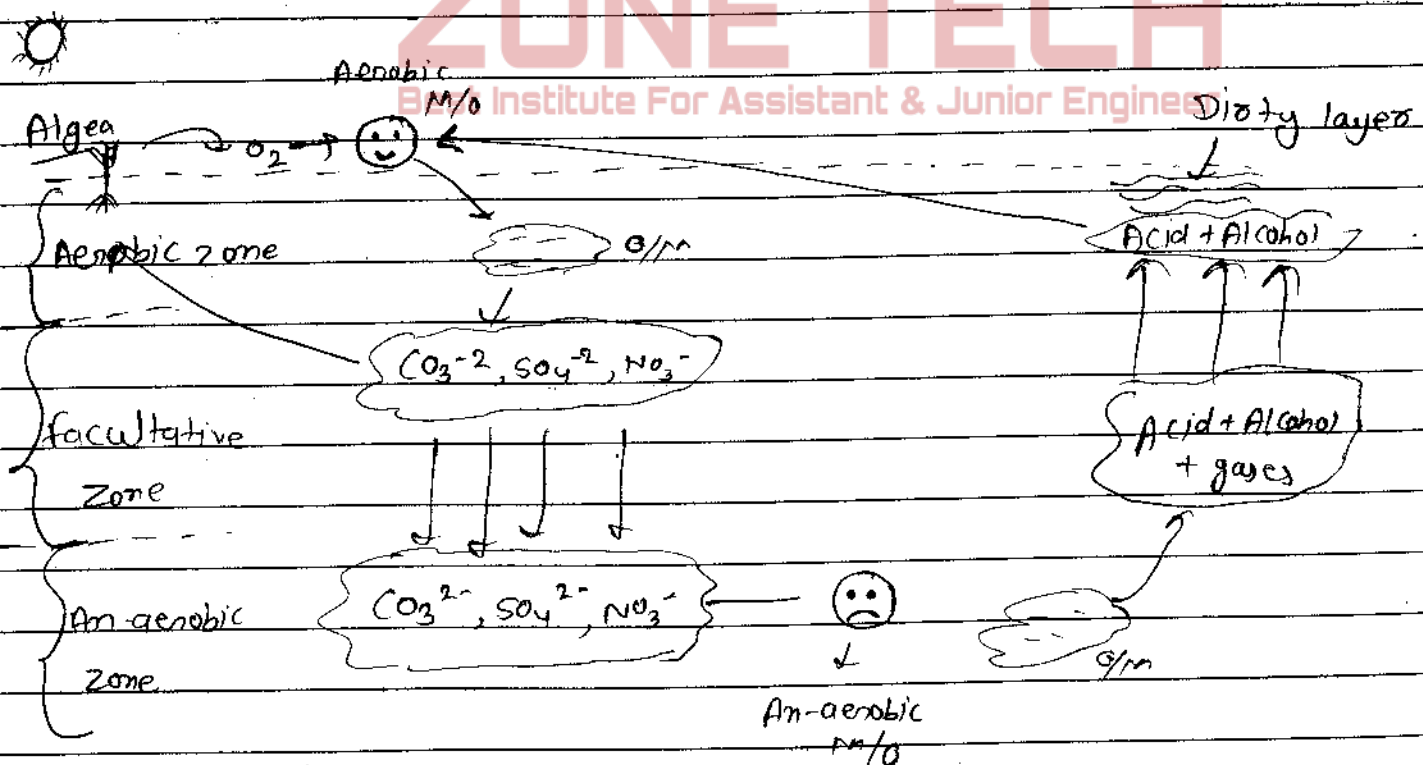
oxidation ponds are open earthen basins, specially designed & constructed to treat sewage & Bio-degradable industrial waste water. Such ponds provide comparatively long detention period during which time the waste gas stabilize by the action of natural forces.

• Ponds are generally following types.

1. Aerobic pond - ($< 0.5\text{m}$ depth)
2. An-Aerobic pond - depth ($2.5 - 5\text{m}$)
3. facultative pond -

• The actual oxidation pond used for domestic purpose is actually facultative in nature which have 3 zones.

• Aerobic Zone at the Surface, Anaerobic zone at the bottom & in b/w two zones facultative zone exist.



① Algae $\xleftrightarrow[\text{Relationship}]{\text{Symbiotic}}$ Aerobic M/O

② Aerobic M/O $\xleftrightarrow[\text{Relationship}]{\text{Symbiotic}}$ Anaerobic M/O

Design parameters:-

- Depth $\rightarrow 1-1.5 \text{ m}$
- Detention time $\rightarrow 15-30 \text{ days}$
- L/B ratio $\rightarrow 3$
- Length should not be greater than 750 m
- Area of Each unit $5-1 \text{ Hect.}$
- Pathogenic bacteria removal efficiency 99.9%
- BOD removal efficiency $80-90 \%$
- Organic loading rate depends upon the latitude of the place.

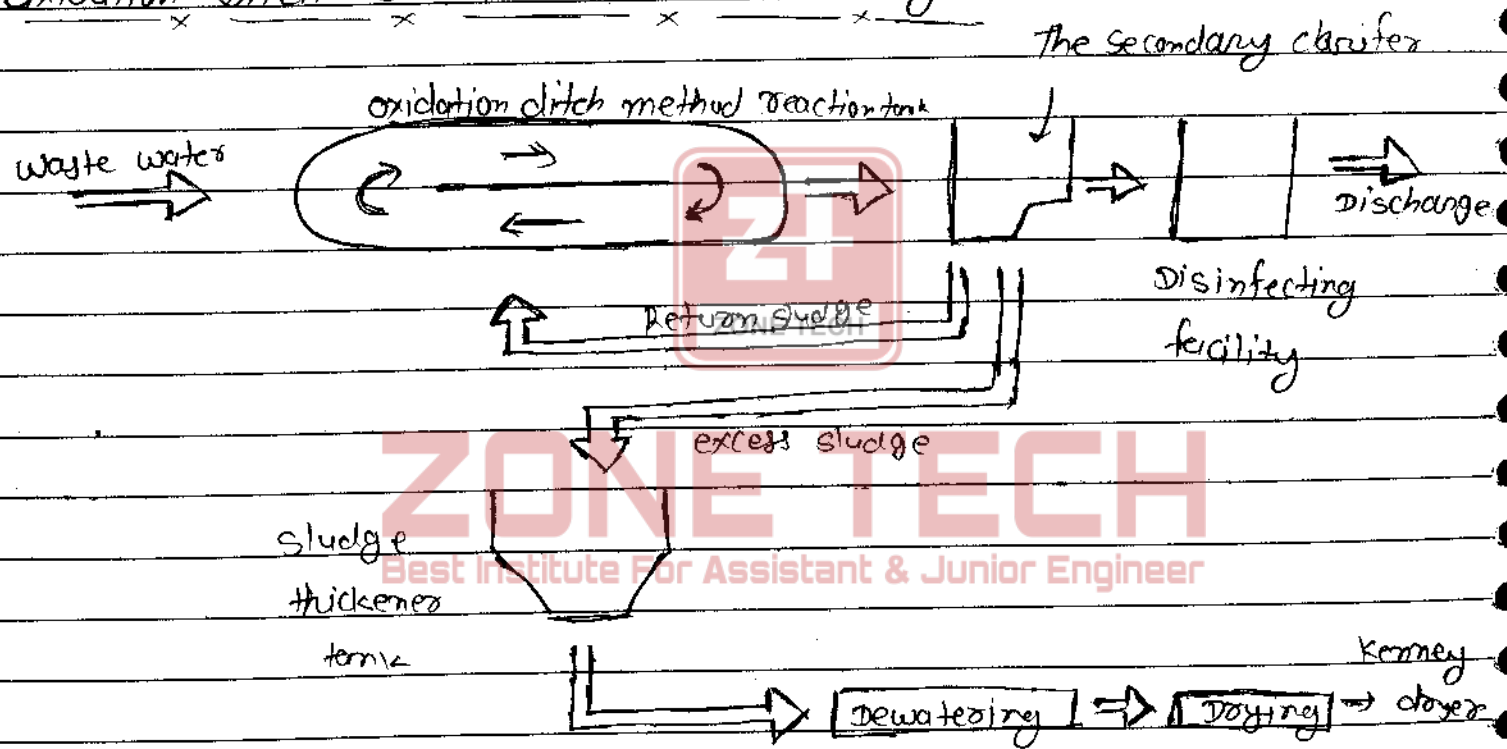
Im Bhanat Latitude (N)	Organic loading Rate kg of BODs / hac. / day
36°	150
32°	175
28°	200
24°	225
20°	250
16°	275
12°	300
8°	325

- The effluent from oxidation pond is not disposed in river because it contains large quantity of algae, It is better to

use for effluent irrigation.

- Sludge accumulation rate 2-5 cm/year.
- Min. depth of water = 0.3m
- Oxidation pond is generally used for small communities in which STP works without electricity.
- It is very economical

Oxidation Ditch or Extended Aeration Lagoon:-



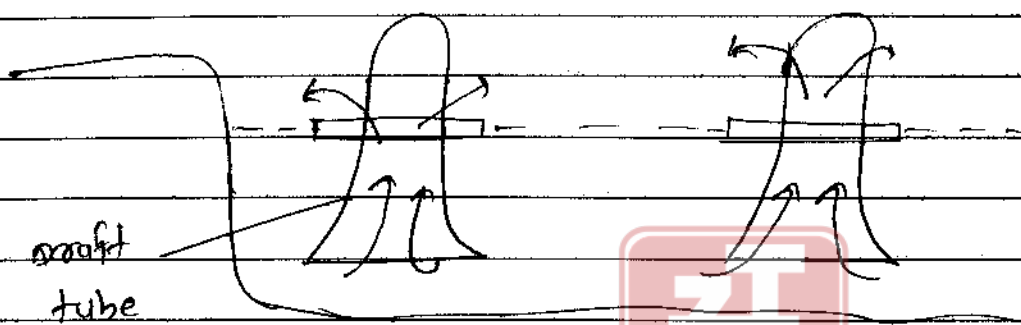
- The conventional activated sludge plant has been modified to eliminate PST & Sludge digester, In this process which is called extended aeration.
- This process provides an aeration tank with a longer aeration time.
- The construction of an oxidation ditch includes the construction of no. of ditches which are placed together side by side having depth of about 1-1.5m.

• Mechanical

Mechanical aerated lagoons

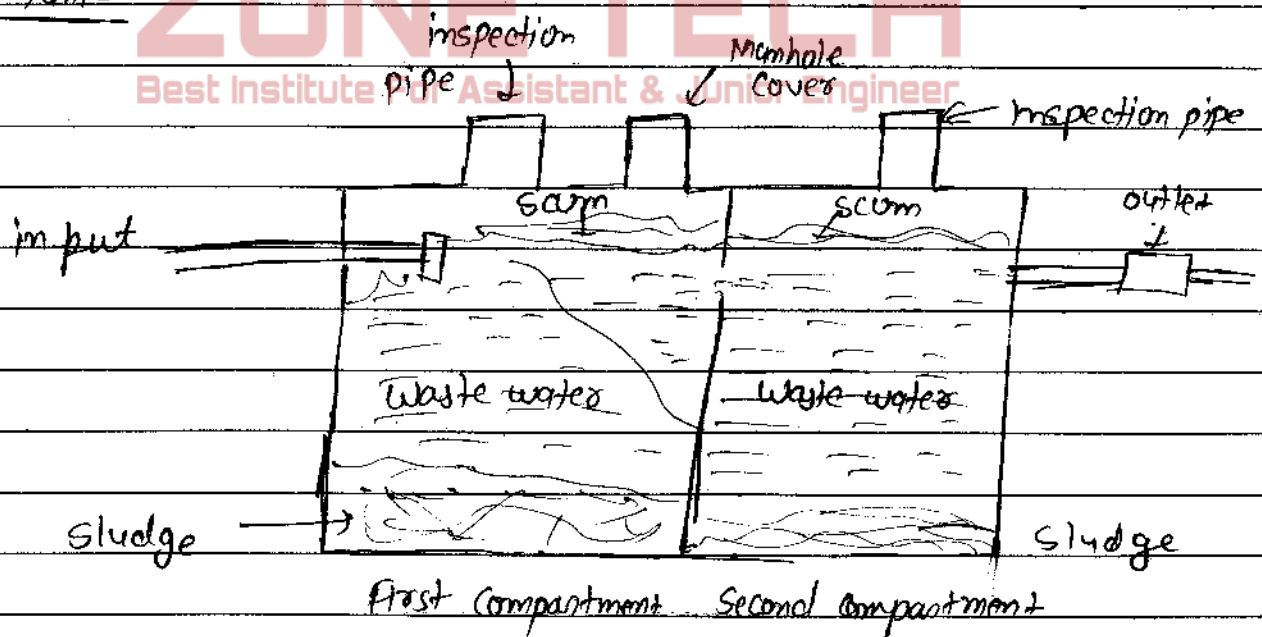
• A mechanical aerated lagoon is a deeper oxidation pond in which aeration is done by mechanical method.

• Detention period - 4-10 hrs



An-aerobic stabilization unit

① Septic tank:-



Design data:-

- Flow of sewage $\rightarrow$ 40-70 lpcd
- If sludge is allow, flow of sewage 90-150 lpcd.
- Detention time - 12-36 hrs.
- Sludge accumulation rate - 30 lt/capta/year
- L/B ratio $\rightarrow$ 2-3
- width should not less than 0.75 m
- Cleaning period - 6 months - 1 year
- Min. liquid capacity - 1000 lt.
- Depth $\rightarrow$ 1.2 - 1.8 m
- fore board $\rightarrow$ 0.3 m
- effluent from septic tank is disposed either in soakpit or in Dispersion trench, Depending upon the percolation rate.
- Soakpit is adopted when percolation rate is not greater than 15-30 minit & dispersion trench is adopted when percolation rate not greater than 60 minit
- The percolation is defined as the time required in minute for the seepage of water through the ground by 2.5 cm.
- The max. rate of effluent application is

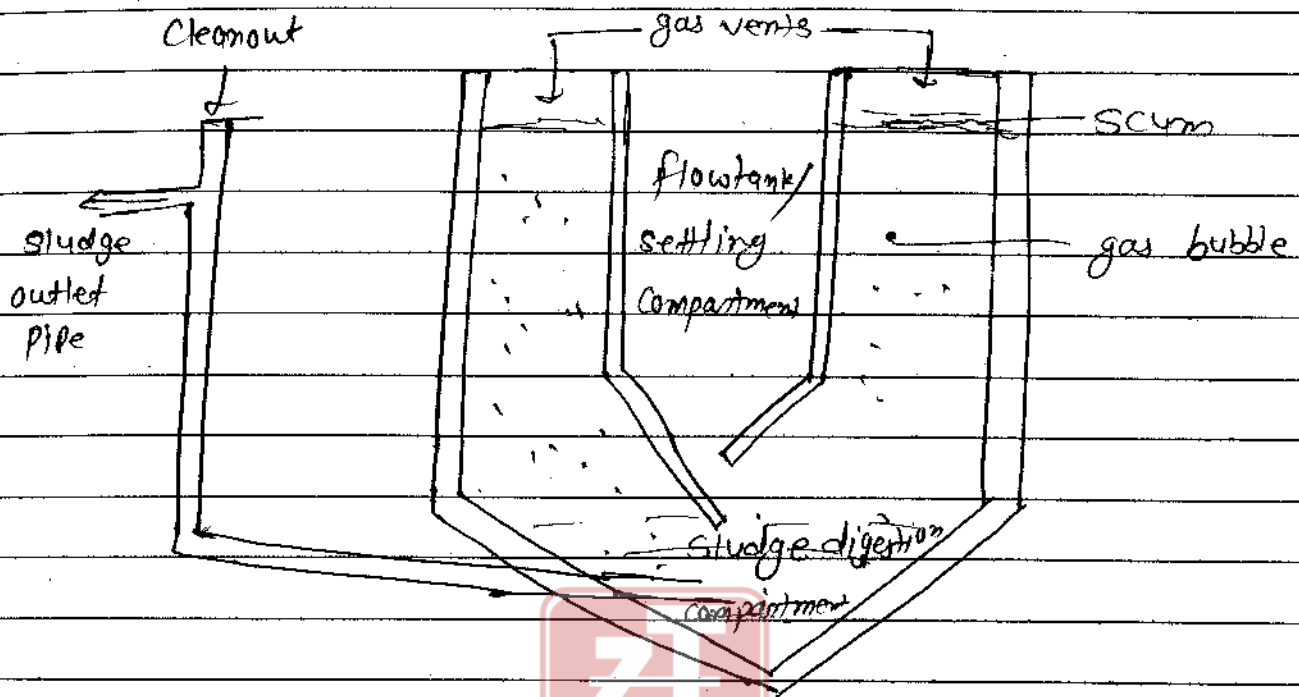
In $\boxed{Q = \frac{2004}{\sqrt{t}}}$ $\rightarrow$ lit/m²/day

• Vol^m of septic tank (V)

$$= (\text{Sewage flow Rate} \times \text{Detention time})$$

$$+ (\text{Sludge Accumulation Rate} \times \text{Cleaning period})$$

Imhoff tank:-



- Imhoff tank is an improvement over septic tank.
- It is a double story unit in which upper story is settling compartment & bottom story is sludge compartment.
- Imhoff tank is an anaerobic stabilization unit. But its upper story is aerobic unit & bottom story is anaerobic unit.
- Detention time $\rightarrow$ 2-4 hrs. (Usually 2 hr.)
- L/B ratio $\rightarrow$ 3-5
- Length $\approx$ 30m
- Total depth 9-11m

Sludge Digestion process:-

- The treatment of sludge is known as sludge digestion.
- From STP (sewage treatment plant) sludge is obtained from

PST & from SST. The sludge from PST is known as primary sludge or raw sludge. & the sludge from SST is known as Secondary sludge.

- Raw sludge contains huge quantity of undigested organic matter as compare to Secondary sludge.
- There are 2 process of sludge digestion
 1. Aerobic digestion
 2. Anaerobic digestion.

Aerobic digestion:-

The Aerobic digestion of sludge leads to the growth of bacteria.

- Hence for raw & digestion of raw sludge aerobic process is avoided to avoid mass growth of bacteria.
- Primary Sludge / Raw sludge is digested anaerobically.
- Aerobic sludge digestion process is similar to extended aeration process.

Anaerobic Sludge Digestion process:-

- Most of sludge which is obtained from STP is digested by Anaerobic process.
- Anaerobic digestion is carried out by following M.O.
 - i) Acid formers
 - ii) Methane formers

Acid formers:-

Acid formers are facultative or Anaerobic M.O.

They quickly respond to the food (a.m.) & convert a.m. into acid & alcohols.

Methane Former

There are strictly anaerobic m.o.

- They are very delicate against shock loading. Because they work in a narrow pH range of 6.5 - 7.5.
- They convert volatile acids & alcohol into gases like CH_4 , CO_2 , H_2S etc.

In anaerobic sludge digestion process following units are involved/employed.

(1) Sludge thickener:-

It removes moisture content from the sludge.

Sludge thickening process:-

- i) gravity thickening
- ii) air-flotation
- iii) centrifugation

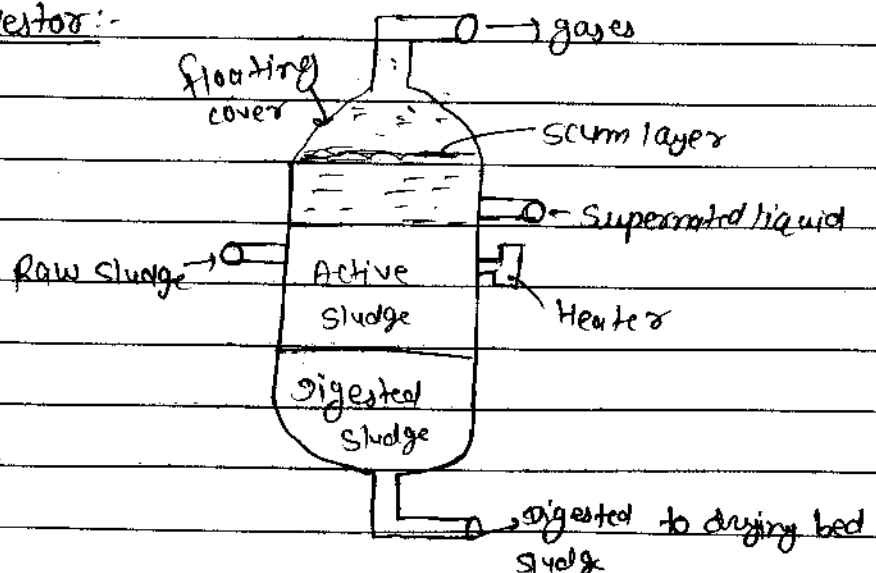
(2) Sludge Digester:-

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There are 2 types of Sludge digester.

- (i) Std. rate sludge digester
- (ii) High rate sludge digester

(i) Std. rate sludge digester:-



- In std. rate sludge digester mixing of sludge is not carried out & raw sludge is directly feed into the digester without any mixing.
- These digester are circular in plan area.
- Dia. — 3-12 M
- Slope of bottom portion — 1:1 to 1:3
- Depth of tank — 6m & greater
- Digestion time — 30 days

• As per Indian std. the vol^m of tank is given as

$$V = \left[V_1 - \frac{2}{3} (V_1 - V_2) \right] \times t + V_2 T$$

V_1 = vol^m of raw sludge added per day

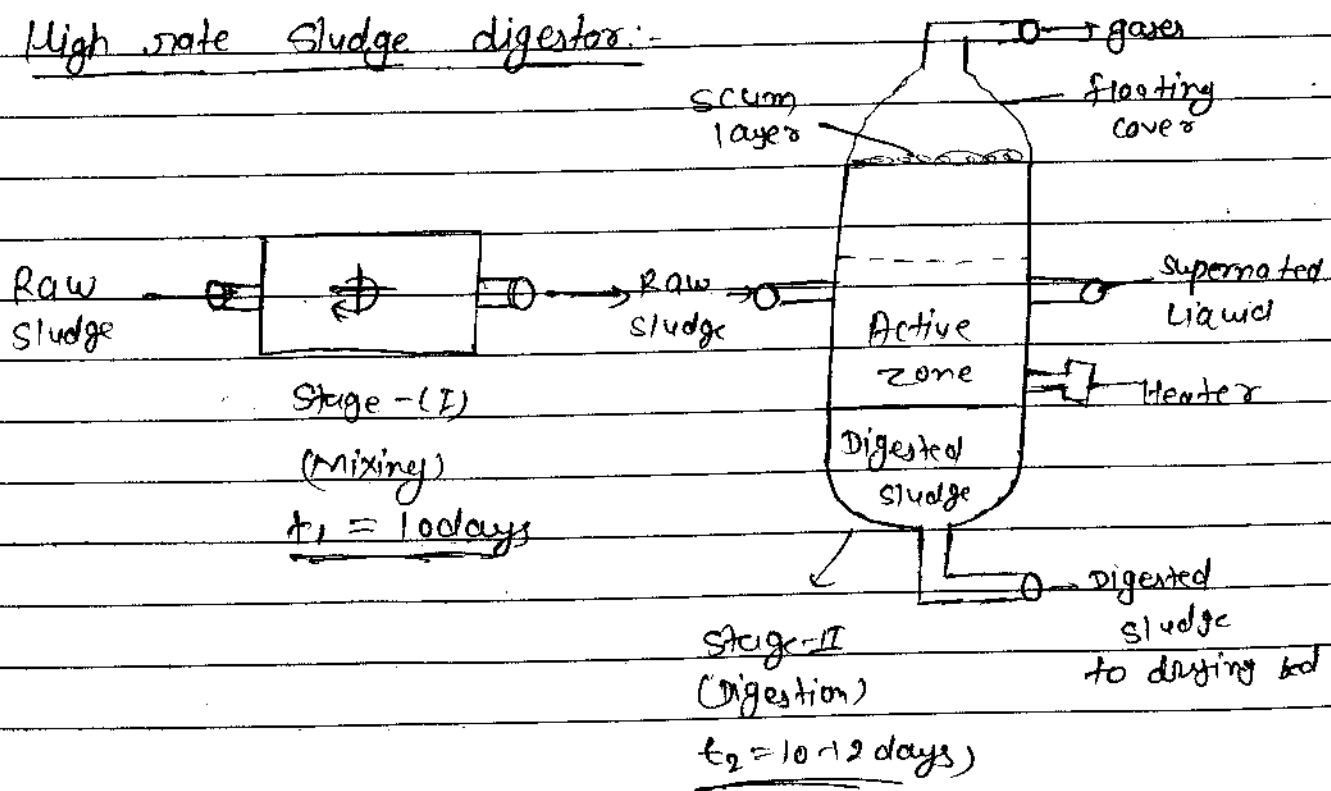
V_2 = vol^m of digested sludge withdrawn per day

t = digestion time (30 days)

T = monsoon period

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(ii) High rate Sludge digester:-



- In High rate sludge digester the mixing of sludge is carried out in a separate unit.
- During mixing of raw sludge, de-watering is not allow.
- High rate sludge digester is a Double stage process
 1. mixing stage
 2. Digestion stage

Important Points:-

- ① Vol^m of digested sludge, $V_d = \frac{1}{3}$ vol of Raw sludge (V_R)

$$V_d = \frac{V_R}{3}$$

- ② Vol^m moisture relationship

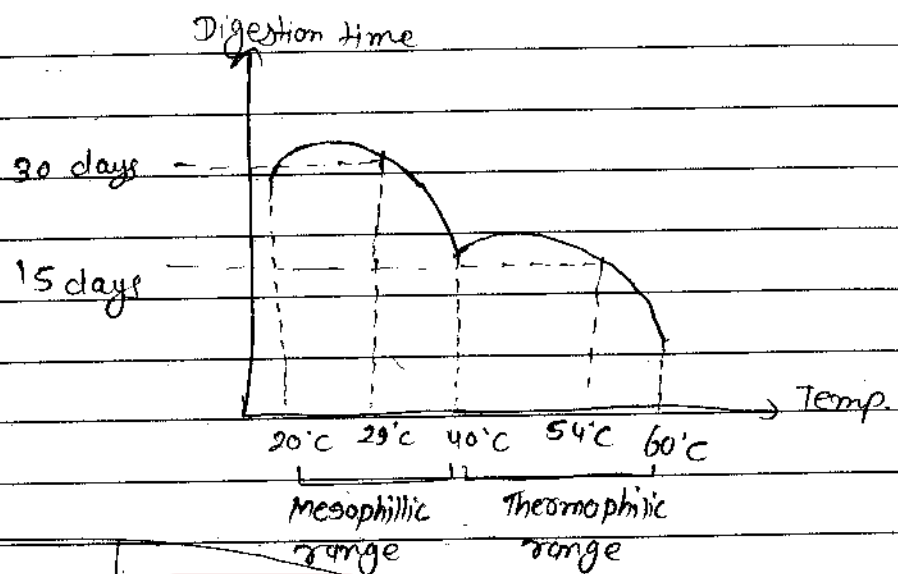
Raw sludge (A)	Digested Sludge (B)
↓	
$V_A (100 - p_A)$	$= V_B (100 - p_B)$

p_A & p_B are moisture content in raw sludge & digested sludge respectively

③

Sludge	moisture content
(i) Raw sludge (Sludge from PST)	95%.
(ii) Sludge from SST (second after trickling filter)	96-98%.
(iii) Sludge from SST after ASP	98%.

④ Effect of Temp. on sludge digestion:-



	Optimum temp.	Digestion time
Mesophilic range	29°C	30 day
Thermophilic range	54°C	15 days

⑤ Reaction involved in Anaerobic digestion

(a) Acid fermentation (acidogenesis)

↓

(b) Acid regression

↓

(c) Alkaline formation fermentation

↓

(d) Methane formation (Methogenesis)

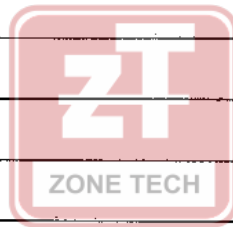
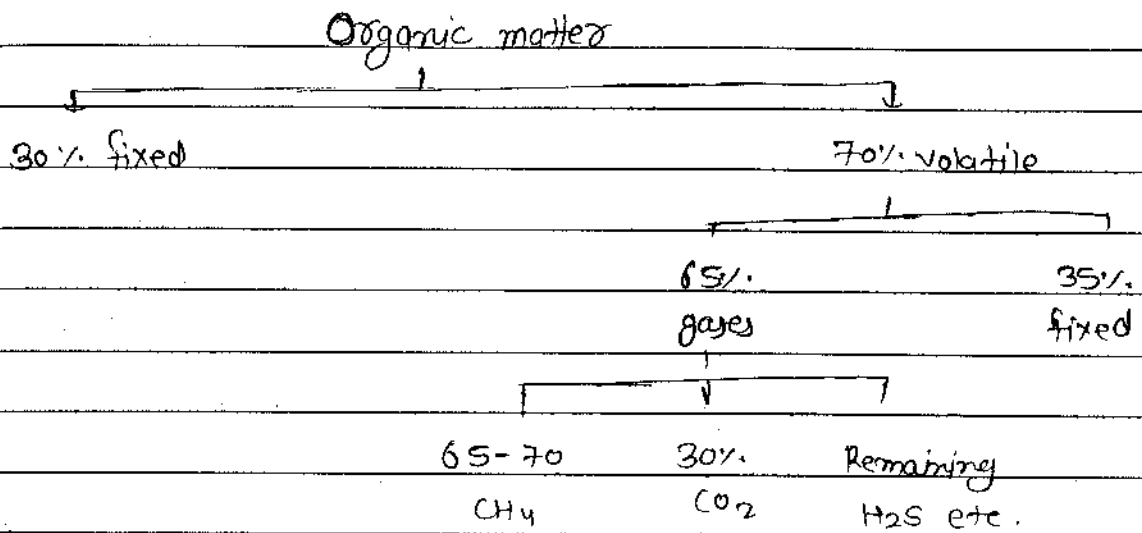
⑥ End products:-

(a) Digested solids (fixed)

(b) Supernated liquid (Containing Active m/o)

(c) Gases (CH_4 , CO_2 , H_2S , etc.)

⑦ has production:-



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- Disposal of Sewage effluent -

In water Bodies
(Dilution method)

- Disposal in
- River
- Sea
- Lake

On Land

- Sewage forming
- Effluent irrigation

① Dilution method :-

Acc. to royal commission report the following provision have laid down for disposal of sewage effluent in a water body.

	Dilution factor	Required Treatment before disposal
①	> 500	No need of treatment
②	500 - 300	primary treatment such as plain sedimentation is required & sewage effluent should not contain suspended solids more than 150ppm
③	150 - 300	Treatment such as screening, sedimentation, chemical precipitation etc. are required & sewage effluent should not contain suspended solids more than 60ppm.
④	< 150	Complete treatment is required. Suspended solids $\neq 30ppm$ BODs $\neq 20ppm$

Disposal of Sewage effluent in river:-

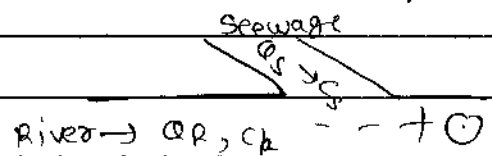
When sewage is disposed off in a river, the self purification by natural agent take place & this property of river is known as self purification property.

Following mechanism are involved in self purification of river

① Dilution & dispersion:-

It is not a method of self purification.

$$C_{mix} = \frac{Q_R \cdot C_R + Q_S \cdot C_S}{Q_R + Q_S}$$



Q_S = Sewage discharge

Q_R = River discharge

C_S = Concentration of material in Sewage

C_R = " " " " in River

C_{mix} = " " " " in Mix

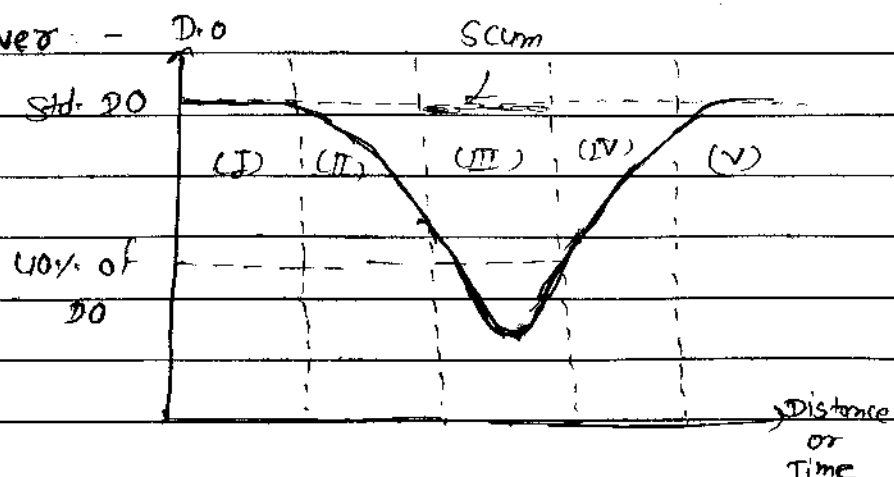
② Sedimentation:-

③ Sun light (Photosynthesis)

④ oxidation

⑤ Reduction

Zone of pollution in River -



Zone - I :- Zone of clean water

Zone II :- Zone of degradation (It is found upto a certain distance at downstream side from point of disposal)
• DO reduced to 40% of saturation
dissolved O_2
• Algae dies & fish can't survive in this zone
• water becomes dark & turbid

Zone III :- Zone of active decomposition

- Zone of heavy pollution
- water becomes more darker
- DO may fall even to zero
- Both algae & fish can't survive
- Aerobic reaction replaced by anaerobic reaction & ugly scum forms on the surface.
- At the end of this zone DO may reach upto 40%.

Zone IV :- Zone of recovery

- BOD falls down
- DO can reach upto saturation

Zone V :- Zone of clean water

- pathogens may exist in water

E.I.A

- i Environmental Impact Assessment :-

- Development & Environment can't be separated from each other. Any development process is bound to have its impact on the environment. Thus to insure the development is sustained with min. environment degradation, environmental impact Assessment is necessary.
- The E.I.A is one of the most widely used tool for identify & mitigate the adverse ecological effect of development proposals.
- In 1987 UNEP (United Nations Environment program) adopted a set of goals & principals on E.I.A.
- E.I.A compared alternatives which could be used to complete a project & identifies the best alternative with the best combination of economics & environmental cost and benefits.
- The process of Environmental Impact Assessment follows a systematic ways which is as follows.
 - i) Collection of Info Information about an area & its characteristics.
 - ii) Prediction of effect of development project on the area including the effect on people living in this area or using this area.
 - iii) Vital information that can be used to make an informed decision regarding whether the development should be permitted or not.

AIM :-

E.I.A has following aims.

- To stabilise that, before the decisions are taken by the Competent authority or to authorise activities that are likely to significantly affect the Environment.

It means the Environmental effect of those activities should be taken into account.

- To promote implementation of appropriate promotion in all countries with consistence with national laws & decision making process through which the for going goal may be realised.
- To encourage the development of procedure for information exchange, notification & consultation, b/w States.

Objectives of E.I.A. :-

- To provide a detailed description of proposed activity
- To ^{improve} provide planning of major projects by providing alternatives.
- To relate the activities of proposed action to planning regulations
- To analyse the primary (Direct) & Secondary (Indirect) environmental impacts. The impacts may be physical, ecological, social, aesthetic in nature.
- To generate alternatives to reduce negative impacts
- To provide a process for a participatory planning activity b/w interprise &, govt. & Community

Environmental Impact Statement (E.I.S.)

Environmental Impact Statement documents the information & estimate the impacts derived from various steps in the process of E.I.A.

- An E.I.S. should be comprehensive & its content must at least fulfill the requirement of the relevant EIA legislation.

- The following point should be a good E.I.S. also go further than the min. requirement if other significant impact are identified.

- Most E.I.S. are broadly organised into 4 sections

→ 1. Non-technical Summary

→ 2. A ^{discussion} ~~decision~~ of relevant method & issues

→ 3. A description of project & of all the environmental base line condition.

→ 4. A discussion of ^{likely} ~~likely~~ environmental impact

- Ideally an E.I.S. should also included the main alternative considered & proposal for monitoring

→

Important point for E.I.S. :-

- Not very technical

- All technical terms should be explained in text.

- Clearly state assumptions if any.

- Should be honest & unbiased

- Should be specific.

- It is easier & more defensible to claim that an impact insignificant

E.I.S. Preparation process :-

EIS preparation Process:-

1. → Sponsoring Entity prepares

- purpose & need of project
- public / Agency participation plan
- Alternatives Analysis
- Key Environmental issues
- Agency Consultation require

2. Draft notice of Intent

3. Head quarters / EMD reviews / AAMS signs and publishes the notice

4. Sponsoring Entity Conduct scoping (Discussion) } - Imp
Min. 45 days

5. Prepares preliminary draft EIS

6. Review of preliminary draft EIS

7. Complete draft EIS & draft NOA

8. Management review of draft EIS

9. Public review - Min - 45 days

10. Final EIS with response to [public response]

11. Pre Concurrence review

12. Final EIS & draft NOA (Notice of ^{availability} ~~Availability~~)

13. ROD (Record of Decision)

Note:-

• HQ & EMD (Environmental management division) Complete NOA

• AAMS publish NOA - 30 days

(Accredited Asset management specialist) → AAMS

Environment Management Plan [EMP] :-

- EMP is a site specific plan, developed to insure the implimentation of a project is an environmental sustainable manner where all contractors & sub-contractors including consultant, take appropriate action to properly manage the risk arising from the project.
- It described roll & responsibility of the key personal & Contractors who will be incharged of the responsibilities to manage the project site.

Features of EMP :-

- It is prepared in accordance with rules & requirements of MoEF (Ministry of Environment & forest) & CPCB SPCB.
- It ensure that the project is operated in accordance with the design.
- It confirms proper execution of the project through Supervision & monitoring
- It addresses the public complaints during construction & operation of facilities
- It ensure that the corrective majors to minimize the adverse effect of a project on environment & nearby people.

Elements of EMP :-

4 Elements

- (i) Commitment & policy
- (ii) planning
- (iii) Emplimentation
- (iv) measurement & Evolution

EIA Guidelines :-

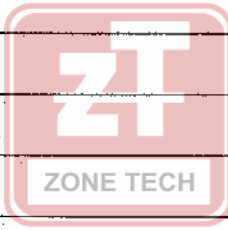
- EIA guidelines were issued in 1994 by ministry of environment of forest.
- Responsibility for implementation of the EIA guideline with MoEF is also called as IAN-
IAA (Impact Assessment Agency)

Guidelines :-

- (i) EIA clearance is required for 29 categories of industries from the central govt.

→ Sector of Industries

- Mining
- Thermal power plant
- River valley project
- Ports
- Harbours
- Airports
- Communication
- Atomic energy
- Transportation (Rail Road Highway)
- Tourism (Hotel, resort, beach)



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- (ii) Public Hearing is mandatory for environmental clearance. The public hearing will be conducted by state pollution control Board before the proposal are sent to MoEF for environmental clearance.

- Public Hearing is not required for following projects

1. Small scale industrial undertaken located in notified or designed industrial Area or Industrial Aestates
2. Areas mark for industry under the jurisdiction of industrial development authorities.
3. widening & strengthening of Highways
4. Mining project (Major minerals) with lease area upto 25 Hect.
5. Units located in export processing zone & special Economic Zone (SEZ)
6. Modernization of existing irrigation project.

(iii) The site clearance has to be obtained from MoEF. If site clearance is granted then it is valid for 5 years & for specific capacity from the time of construction, operation or mining.

(iv) From time to time specific region have been notified as ecological fragile by MoEF, under the environmental protection act (1986). These regions are —

- Durgam valley
- Dharm - taluka (MH)
- ~~Murad - janzare~~ Murad - janzara (MH)
- Specific area of Aravali range in Alwar district of Raj. & bungram dist. of Haryana.

(v) Sector specific guidelines are issued from time to time for diff. sectors.

Methodology of EIA :-

1. Adhoc method
2. Overlay method
3. Checklist method
4. Networks
5. Metrics

1. ADHOC method:-

- It is most common method
- This method indicates the broad area of likely impacts by listing compoising environment parameter likely to be affected by developemet project.
- An Adhoc method involves a team of specialist to identify the impact in the area of expertise.
- It is a rough method of assessment.

2. Overlay method:-

- It descroibed the welled developed approach in planning & land skipping anchatecure.
- This technic is based on the used of a series of overlay maps depecting the Environmental factors & land features.
- By overlaying these map area ~~passing~~ possessing a preferred combination of these variable can be identifying with the project area boundary, the impacted area & relative geographical location.
- The overlay approach is generally effective in selecting the alternative & identify the certain time of Impact.

• It can't be used to quantify the impacts or to identify the secondary & tertiary interrelationship.

3. Checklist method:-

• This is basic method of E.I.A. checklist method ranges from listing of environmental factor to highly structured approach involving importance of waiting weighting for factors. at the application of scaling techniques for the impact of each alternative on each factor.

• There are 4 category of checklist

i) Simple checklist:-

It includes a list of parameters with no guidelines.

ii) Descriptive checklist:-

It includes the identification of environmental parameters and guideline that provide how parameter data to be measure.

iii) Scaling checklist:-

It is similar to descriptive checklist with addition of information basis to subjective scaling of the parameter values.

iv) Weight scaling weighting checklist:-

It represent scaling checklist with the information provided as to subjective evaluation of each parameter w.r.t. ^{every} ~~each~~ other parameter.

4. Network method:-

This method works from a list of a project activity to establish cause condition effect relationship.

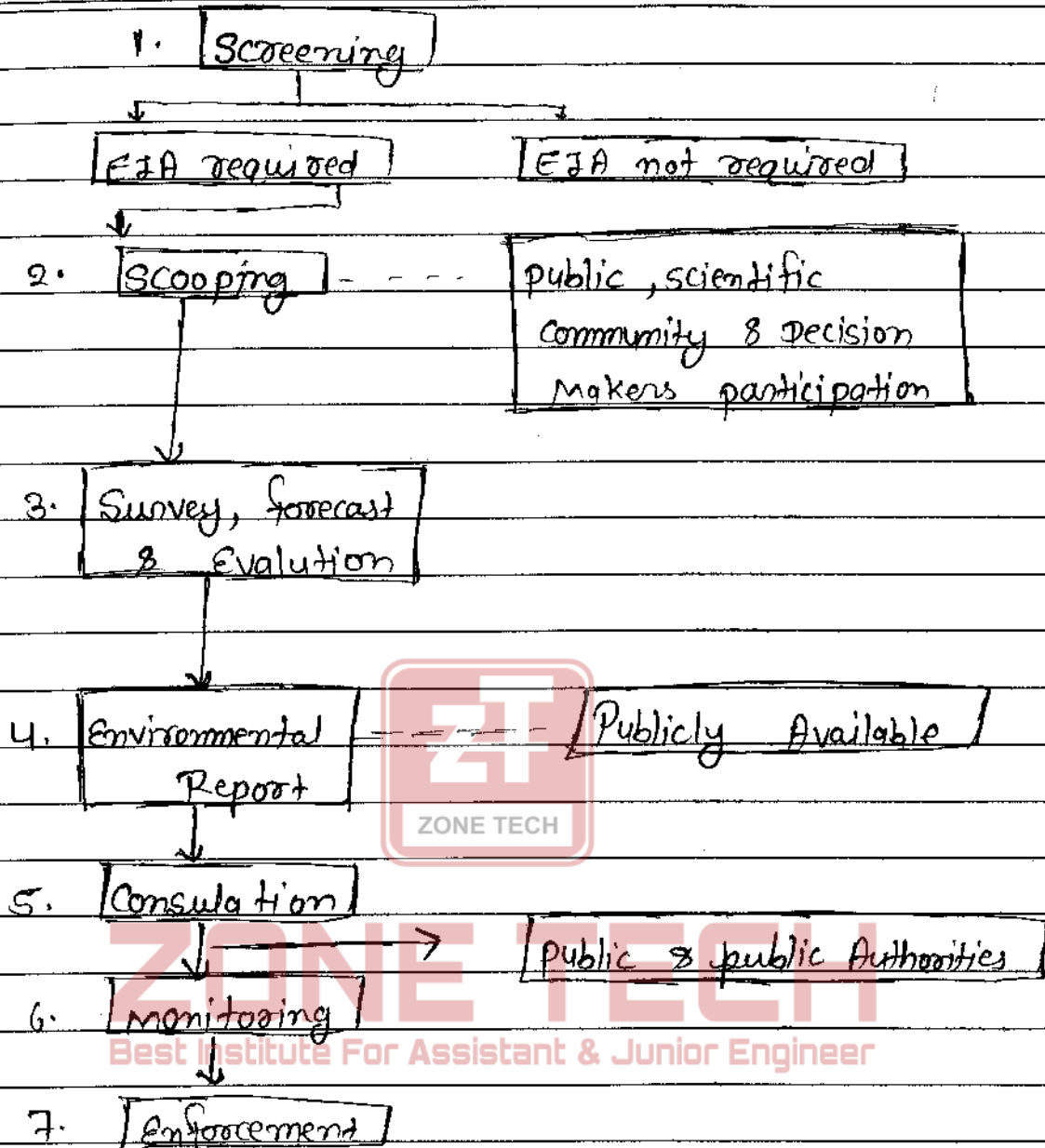
- This is the method which integrate causes & consequences by identify inter-relationship b/w causal action & impacted environmental factors.

5. Metrics method:-

- This method is basically generalized checklist where usually one dimensional of a metrics is a list of environmental, social & economical factors likely to be affected by proposed project.
- The other dimensions is a list of action associated with the development.
- These apply both construction & operational b. project

E.I.A. Process:-

- It is an interdisciplinary & multi step procedure which ensured that environmental issues are raised when a project is a first discussed & all concerns are addressed. as the project is the implemented.
- This process involves following steps:-



Content of EIA report :-

- Executive Summary
- policies & legal & administrative framework for EIA
- Description of Environment
- Description of the proposed project
- Significant Environmental effect
- Analysis of Socio economic Impact of the project
- Analysis of Alternatives
- Mitigation actions or Mitigation Management plan

- Environmental management & Training plan
- Monitoring plan

• EIA for a project was first initiated on 21st Jan. 1970 in United State of America (USA) as far as India as concerned the ministry of Environment & Forests & govt. of India for the first time issued Environmental guidelines for setting up the specific type of industry in Aug. 1985.

• On 27 Jan. 1994 the MoEF & GOI issued its first important notification & it has been spaned by a notification of Sep. 14, 2006, that was 2nd notification.

• The Industries & Activities which come within the preview of 1994 notification are given in the article 22.2, while the details of 2006 notification are given in the article 22.3.

• Environmental appraisal Committees [EAC]

- Mining project
- Industrial project
- Thermal power project
- River valley project
- Multi purpose, Irrigation
- Hydro Energy project
- Infrastructure development
- Nuclear power project

EIA notification 1994

• 27 Jan. 1994 included $27 + 5 = 32$ type of project & activities / Industries.

Category A :-

15 type of activities & Industries were necessarily require to obtain Environmental clearance irrespective of the cost of project

Category B :-

one type of project needed Environmental clearance if the project cost exceeded by $\geq \underline{\text{₹ 5 cr.}}$

Category C :-

16 type of project needed Environmental clearance when project cost exceeded $\underline{\text{₹ 50 cr.}}$

Category A list :-

- Pesticides (Technical)
- Petro chemical Complex
- Bulk drugs & former pharmaceuticals
- Asbestos & Asbestos product
- Hydro chloric acids & its derivative
- Alkali industries
- Integrated paint complex
- Mining project (major mineral with more than $\downarrow$ 5 Hect. ^{lease area})
- Tanned road in Himalayas & forest areas
- Distilleries
- Raw skin & Hides
- Dyes
- Foundries (individual)
- Electroplating
- Meta amino phenyl

Category B list:-

- All tourism project b/w (200-500m of High water tide line) or at the location with the elevation more than 1000m.

Category C list:-

- Exploration for oil, gas & there production, transportation & storage.
- Synthetic rubber
- Primary metalurgical industries (Production of Iron, steel, Aluminium, copper, zinc, Pb & farnow alloys)
- Electric and furnishes (Mini steel plant)
- viscous stap staple fibre & filament yarn
- Storage batteries integrated with manufacture of oxides of Pb (lead) & lead antimony alloy.
- Thermal power plant
- Highway project
- Pulp, paper, News-paper print
- Cement
- New-Construction project
- New Industrial unit.

EIA notification 2006:-

All project or activities have been divided into 2 category.

- Category A
- Category B

- The project or activities which are following in category A A needs Environment clearance from the Central govt.

on the recommendation of EAC.

- The preparation of EIA is necessary for all such category A projects.
- Project or Activities following in category B shall be further divided into sub-category into 2 category
 - category B₁
 - category B₂
- Projects following under category B₂, shall not required any EIA report where as the projects under category B₁ shall required EIA report.
- Category B project or activity need environmental clearance from state level environmental Assessment Authority (SEIAA) to be Consiquated by Impact central govt.

Note:- (EIA)

The Stateⁿ Authority shall grant sta environmental clearance to B B category project on the recommendation of State expert appersal Committee [SEAC]

- In Absence of duly Consiquated SEIAA or SEAC, A category B project shall be treated as category A project
- An application for obtaining Environmental clearance (E.C.) shall be made in form no. 1.

Stages in the Environmental Clearance process:-

- Screening (required only for category B project)
- Scoping
- public consultation
- Appersal

① Screening:-

In case of category B project, this stage will entail the scrutiny of an application seeking prior Environment clearance made in form No. 1 by concerned state expert appraisal committee.

- The project requiring an EIA report shall be termed category B₁ project & remaining project shall be termed category B₂ & will not require an EIA report.
- For categorization of projects into B₁ or B₂ except for item No. 8(b) [township & area develop project], the MoEF shall issue appropriate guidelines from time to time.

② Scoping:-

Scoping refers to the process by which state expert appraisal committee in the case of category A & state expert appraisal committee in case of category B, including application for ~~expansion~~ expansion & and/or modernization and/or change in product mix of existing project or activities, determine detailed & comprehensive terms of reference (TOR) addressing of all relevant environmental concerns for the preparation of EIA report in respect of project or activity for which prior Environmental Clearance is sought.

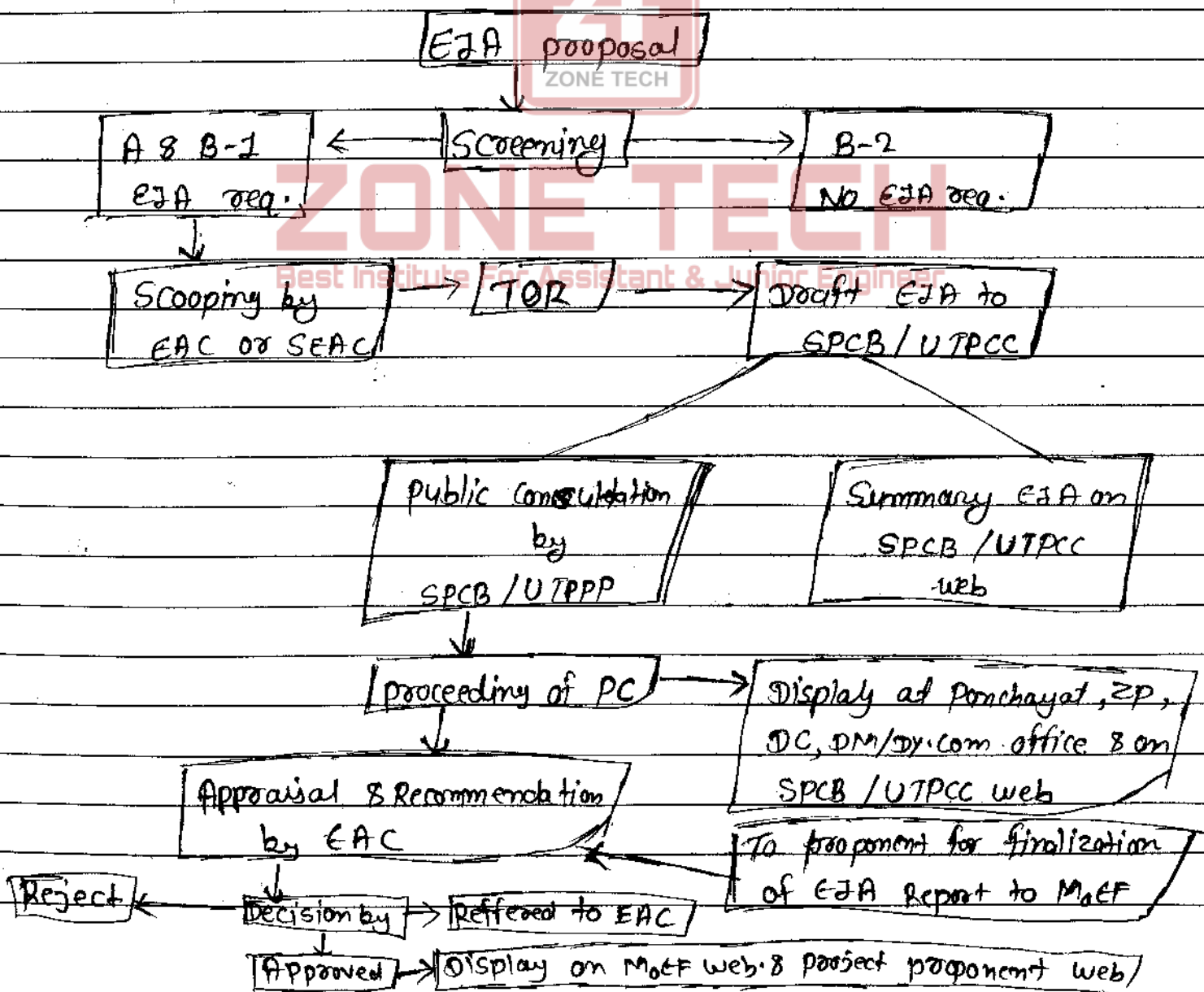
③ Can Public Consultation:-

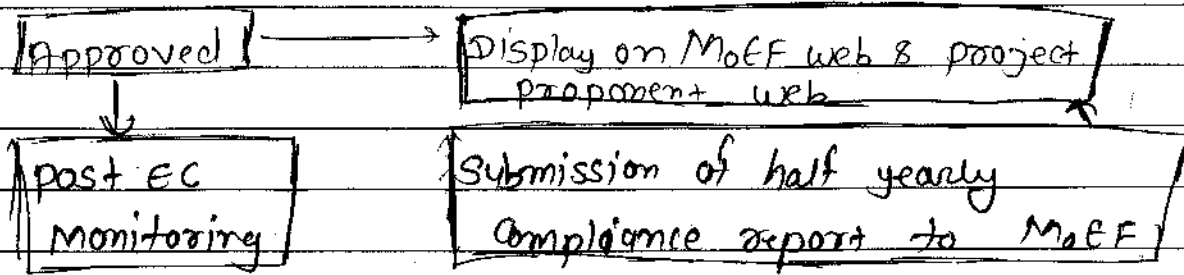
It refers to the process by which the concern of local affected persons &

Other who have stake in Environmental impact of a project or activity are ascertained with a view to taken into account all the material concerns in the project of activity designed as appropriate.

(4) Appraisal :-

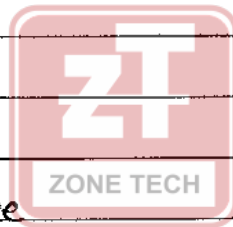
Appraisal means detailed scrutiny by EAC or SEAC of the application & other document like final EIA report, Outcome of public concern Consultation including public hearing, proceeding, Submitted by the applicant to the regulatory authority concern for grant of E.C.





Ambadment 2009:-

The project proponent will make public at their cost, the term of environment clearance obtained by the advertising into local newspapers of district or state where project is located.



Ambadment in 2006:-

Clearance

- The Environmental Clearance now be issued in an integrated manner along with building permission under building by law for all building construction covering 20000 - 150000 sqm of built up area.
- Environmental Clearance for built up area from 1.5 - 3 lakh m² will be given by state level authority. While the area above 3 lakh m² will be approved or clear by union govt.
- Area less than 20000 m² will be subjected to a self declaration.
- However the size of building 5000 - 20000 sq.m will also follow environmental norms for construction & enviro maintainance page.

The project proponent shall submit performance data & Certificate of Continued Compliance of project every 5 years to the Environmental cell with special focus on following parameters:

→ Energy use (including all energy sources)

→ Energy generated on site from on site ~~renewal~~ Energy Source

→ Water use & waste water generated, treated & reused on site

→ Waste generated & treated on site

→ Tree plantation & maintenance

→ No consent to stabilise or operate under the water act 1974 & ^{air} ~~water~~ act 1981 will be required from the SPCB for residual building built up area upto 1,50,000 Sqm

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National & International Event related to Environment :-

Development of international environmental law before UN. ^(United State)

1872 - Switzerland proposed an international regulatory Commission on protection of Bird

1909 :- The first international institution step up to address the issue of protection of national under the international Congress for 'protection of nature' in Paris

1921 :- Convention concerning the use of lead (Pb) in Paint in Geneva

1931 :- Convention for regulation in whaling

Environmental concern after UN (United State)

• The first global conference on environment convened by UN's UNESCO (United nation Educational, Scientific & Cultural organization) in 1968 at Stockholm, Known as UN conference for human Environment

→ Green Issue :- Impact of human activity on the Environment has resulted now in new social political & ecological moment which is called as 'Green issue'.

→ Green piece is a group of 40 countries headquarter located in Amsterdam

→ Green politics, eco greens or green movement related to Germany & North America developed in 1980s

1. Stokholm declaration or UN-Conference on human Environment 1972

- The first conference on human environment ^{initiated} by UNO which was held in 1972.
- 114 states had ~~addend~~ attend the conference. 5 June world environment day, 26 principle.

2. United nation Environmental Program (UNEP)

- The stokholm conference also proposed a new UN agency as (U-NEP)
- Establish in 1972 at Nairobi.
- The following global convention were signed under the sponsorship of U-NEP
 - Convention of the control of international trade in endangered ~~endangered~~ species of wild fauna & flora. [CITES] in Washington in 1973.
 - Convention of migrated species [CMS], Bonn - 1979
 - Vienna Convention for the protection of ozone layer depletion, ~~Vega~~ Vienna 1985
 - Montreal protocol on substance that deplete the ozone layer Montreal 1987
 - Basel Convention on the control of trans-Boundary movement of Hazardous waste & their disposal Basel 1989
 - Green Index published by U-NEP :- This index provides the combined data of GDP & economic growth of Environment.
 - Global 500 ^{Award} ~~Award~~ :- It is started by U-NEP in 1987.
 - It is awarded to into any organization that deals environmental related issue & political & social & legal level.

- Champion of Earth :- U-NEP establish champion of Earth in 2004 as an annual award program to recognise outstanding Environmental leaders at a policy level. 6 Award are given out each year with one additional special prize.
- This award program is a Successor to U-NEP's global 500 role of Honour
 - 6 Categories of Champions of Earth award
 1. Entrepreneur vision policy
 2. policy leadership
 3. Science & Innovation
 4. lifetime achievement award
 5. Inspirational & Action
 6. Eminent Champion
 - India receive 2 award in out of 6 categories in 2018 for Kochi International Airport (Entrepreneur vision), 2nd Narendra Modi (policy leadership)
 - Hon'ble PM Narendra Modi has received this award for his leadership of International Solar alliance (ISA) & pledge to eliminate single use of plastic in India by 2022.

Note:-

Mr. Tulsiram Tanti founder chairman & Managing director of Suzion Energy Limited was named by U-NEP as a Champion of Earth award in 2009. for his Enter-preneur vision in combatting the climate change.

The World Conservation Strategy (1980)

Launched by International Union for Conservation of nature & natural resources (IUCN) with collaboration with U-NEP, WWF, UNESCO & food & agricultural organisation.

World Charter for Nature (1983)

- The UN general assembly adopted the world charter nature after 10 year completion of Stockholm Convention.

World commission on Environment & development (WCED) OR Brundtland Commission - 1987

UN general assembly established (WCED), chaired by Norway Prime minister gro Harlem Brundtland.

- To inspect critically issues related to Environment & Development & deal with it through practical solutions.
- To come up with the ideas in which international cooperation can be promoted.

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Caring for the Earth (Strategy for Sustainable Living in 1991)

Earth Summit 1992 (or) United nation Conference on Environment & development (UNCED).

It was held on 3rd June 1992 in Rio de Janeiro. Came into effect from March 21, 1994.

- Earth Summit is the one of the most important ~~conf~~ outcome of Brundtland Commission.
- The Earth Summit resulted in following documents:
 1. Rio - declaration - (Environment protection)
 2. Agenda 21 :-

It is non-binding, voluntary implementation action plan

by United nation.

- Total 5 document, concluded in 300 pages
- Agenda 21 recommended for UN-convention on Combant degitification (UNCCD) with come into form in 1996

3. forest Poinciple:-

- 4. Convention of Biological diversity
- 5. United nation frame work for climate change (UNFCC)
- 6. United nation Convention to Combant desertification (UNCCD)

Int

Rio - declaration:-

The declaration focused on the goals mainly helped breaking the Agenda of development countries to the front seat

- Adopted by 175 countries & UNCED
- This aggreement is supported by Agenda 21

United Nation framework Convention of climate change (UNFCCC)
On 11th Dec. 1990, the United nation general assembly Stablsh interation negotiating committee (INC) for UNFCCC. This treaty produced on Earth Summit.
• Presently 197 Countries members it has. or parties

Main goal:-

Limiting the Global temp.

Time line of UNFCCC:-

1979 - WCC

1988 - Intergovernmental panel on climate change

COP - Conference of Parties

1990 - IPCC first report assessment report

1991 - INC (inter govt. nation climate change)

1992 - INC adopted UNFCCC

1994 - UNF entered into force

1995 - Cop 1 → Berlin

1997 - Kyoto protocol formally adopted in Dec. at Cop-3

• UNFCCC Countries initially divided into 3 groups

Annex 1

Annex 2

Annex 3

Annex 1 parties:-

Industrialized countries & European Communities & those countries who agreed to decrease their release of CO₂ to aim 5.2 % Below their 1990 level

Annex-2:-

Developed countries & European countries which provide monetary resources for lessening countries along with sub-category of annex-1 countries consisting of the OECD Organisation of Economic Co-operation & Development members formed in 1961.

Annex-3

Developing countries

Note:-

Acc to another classification countries are classified as annex countries (developed countries) & Non-annex countries (Developing countries)

UN Convention of Combant desertification (UNCCD):

- Accepted in 1994 in Paris
- Came into force in Dec. 1996, recommended by Rio-^{declaration}~~conference~~ agenda 21, y.e. 2006 was declared as international ~~event~~ year of desert & desertification
- This Convention have been ratified by 197 states
- The first country to withdraw this convention in 2013 is Canada. But in 2016 Canada again become a party.
- Cop-1 of UNCCD was held in 1997 in Roam.
- Cop-14. New Delhi
- The UN convention to combant desertification held from 2 sep. — 13 sept. 2019 at greater Noida (New Delhi)
[196 countries, 94 environment minister & hosted by India]

UN Commission of Sustainable development (CSD) :- 1992

1992 under the umbrella of economic & social council (ECOSOC) to followup on adoption of Rio-declaration & agenda 21

World Summit on Sustainable declaration (WSSD): (02)

Johannesburg declaration (Rio + 10)

- It occurred 10 years (2002) after the first Earth Summit in Riodejenero. Thus causally nickname as (Rio + 10)

Montreal protocol:-

Montreal protocol which came into force in 1989, which is one of the most effective international treaty to gradually phase out the emission of ODS (Ozone Depleting Substance) into the atm.

- 197 member parties have signed. Several amendments carried out.
- Kijali amendment agreement was 8th amendment.
- Successful cut down of 8% of CFC production & other ODS

Kijali agreement:-

- It was a historic agreement which was signed by 7 countries with a vision of amending the Montreal protocol in 28th meeting of Montreal protocol, held in Kijali (capital of an African country) 15th Oct. 2016.
- The countries signed the agreement are expected to cut down the manufacture & the use of Hydro-fluoro Carbon (HFC), Green house gas by approximately 80-85% from their Base line till 2045.
- This step is expected to hold the avg. rise in global temp. up to 0.5°C by 2100.

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Global environmental Facility (GEF):-

- In 1992 at the Rio-Earth summit GEF was restructured & moved out of the World Bank system to become a permanent institution
- 10 agencies are currently operated.
- 183 countries in partnership

UNESCO [United nation Educational Scientific Cultural Organization]

- UN Based agencies Founded 16th Nov. 1945 Headquarter Paris.
It declared purpose is to contribute peace & safety.

World wide Fund (WWF)

International non-govt. Organisation. Founded in 1961

- living planet report is publish in every 2 year since 1998 by WWF.
- It is based on living planet index & Environment
- 100 countries members it have.
- Earth hour movement started by WWF to reduce the carbon emission.
- It begins in Sironi (Australia) in 2007 under it every year on last Saturday of march, less important appli Electrical appliance should be shut for 8:30 pm — 9:30 pm. India participate in 2009

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Vasel Convention :-

Adopted on 22 march 1989 & Come into power in 1992.

- Main purpose :- The objective of the convention is to defined human health & Environment against unfavourable effect of dangerous waste.

Rotter dom Convention :-

Come into force 24 Feb. 2004

Objective :-

Human health & Environment is a matter of concern & if any individual or organisation tries to

harm it, can be arrested only by the responsibility of
Concern parties & govt.

IPCC (Environmental Inter-governmental panel on Climate change):

Recognised by UNEP & world meteorological organisation (WMO)
in 1988.

• 195 countries are members

• 4th ~~assess~~ assessment report (AR-4)

• projected increase in global mean temp. over the 21st
century b/w $1.1 - 6.4^{\circ}\text{C}$ in (2007).

• 5th Assessment report (AR-5)

This is most significant report by
the end of 21st Century the mean rise in global temp. could
be more than 4°C

• To keep the mean rise in temp. well below 2°C , the global
green house emission in 2050 need to be 40-70% lower
than in 2010 & level near zero or below in 2100

AR-6 (6th Assessment report): -

An agreement was made in 43 section of IPCC in
April 2016 to finalize the AR-6 Synthesis report in 2022

Global International water Assessment (GIWA): -

• Lead by U-NEP since 1999.

• 50% funding of GIWA is covered by WEF.

Stockholm Convention on persistent organic pollution:-

• It is an international treaty presented by UNEP &
Signed on May 22, 2001. Came into effect May 17,
2004.

- on 2018 it had 182 countries member.
- It aims to restrict the production of persistent organic pollutant.

Kyoto protocol:-

- It is an international agreement link UNFCCC.
- Adopted in Kyoto (Japan) in 11th Dec., 1997 ~~is~~ come into force 16 Feb. 2005

Chronology:-

- 1992 UNFCCC was adopted at Rio Earth Summit
- 1994 UNFCCC come into force.
- 1995 Cop was created & first meeting COP-2 were held in Berlin.
- The Kyoto protocol was adopted at Cop-3 in Japan. It come into Commission in 2005, put obligation to reduce Carbon Emission on developed countries by 2012.
- In the first phase of Kyoto protocol 2008-2012, 37 industrial nations & European Union were obligated to reduce green house gas emission upto 5.2% with the level of 1990.
- 2005 montreal action plan produced at cop-11
- 2005 Canada become a first country that refuse to be a part of protocol.
- 2015 the first Binding period under the protocol terminate

COP-12 ~ Nairobi Conference 2006

COP-14 ~ 2008 (Poznan Conf.)

COP-15 ~ 2009 (Copenhagen)

COP-16 ~ 2010 (Cancun)

COP-17 ~ 2011 (Durban)

COP-18 ~ 2012 (Doha Conf.)

- The modified list of green house gases includes 7 gases
 - CO_2 , CH_4 , NO_x , HFC , PFC & sulphur Hexa fluoride (SF_6), Nitrogen tri-fluoride (NF_3)
- Doha agreement establish in 2nd Commitment period 2013-2020.
- It was decided to reduce the emission of green house gases upto 18% with the level of 1990

COP-19 - Warsaw Conf. 2013

COP-20 - Lima Conf. 2014

* COP-21 - 2015 (Paris agreement) ✓

COP-22 - 2016 (Marrakech meeting)

* COP-23 - 2017 (BONN Conf.) :- ✓

It is actually an extended version of Paris agreement.

Achievement:-

- Rule book
- Talanoa Dialogue
- Gender Action Plan

Minamata Convention on Mercury :-

• Adopted in 10th Oct. 2013, at Kumamoto (Japan) Come into force 16 Aug. 2017

• Can

Cardiff biological protocol :-

In 2003, on Bio safety

Nagoya protocol :-

on access to genetic resources & the fair & equitable benefits

Ramsar Convention:-

- It is an international treaty for conservation & sustainable utilization of wet land.
- Adopted in 2 Feb, 1971 in Town Ramsar.
- Came into force 21 Dec. 1975
- presently there is a total of around 2500 Ramsar site
- (Montreal report) Catalogue of Ramsar site:-
In India 75 sites.

In Raj. - 2

- Kevladev & ~~Saetika~~ Symbhan lake.
- Chilka lake (1st Ramsar site in India Asia) was removed in 2002.
- International green leaf Day
- International tiger day, global tiger day - 29 July.
- World Environment day - 5 June
- World Forestry day - 21 March
- World Habitat day - 1st Monday of Oct. of Every year
- World Ozone day - 16th Sep.
- World water day - 22 March
- World day of forest - 31 March

National Green Tribunal (NGT):-

- It is a specialised body set up under NGT act 2010.
- For effective & expeditious disposal of case relating Environmental ~~protection~~ ^{protection} & Conservation of forest & other natural resources.
- With the establishment of NGT, the India became 3rd country in the world to set up a specialised Environment Tribunal after Australia & New Zealand.

And first developing country

- NHT is mandate to make disposal of applications or appeals finally within 6 months of filing of the same.
- The NHT have 5 place to sitting
 - New delhi — principal place
 - Bhopal
 - Pune
 - Kolkata
 - Chennai

Structure of NHT :-

Now

- Chair person → (Justice Prakash Shrivastava)
- Judicial members
- Expert member
- office term plan — 5 year
- Not eligible for reappointment —
- Chair person is appointed by Central govt. in consultation with CJI.
- There are atleast 10 & max. 20 full time judicial members & Expert member in Tribunal.
- Land Marks

→ In 2012, (POSCO) a steel maker company sign MOU with Odisha Govt. to setup steel project but NHT suspended this order & this was considered a radical step in favour of local communities & forest.

→ In 2012, Almitra H. Patel v/s Union of India Case, NHT gave judgement of complete prohibition of open burning of waste on lands, including land fills. It is regarded as the single biggest landmark case dealing with the issue of solid waste management India.

In 2013, Uttarakhand (UK) flood case, the Alaknanda Hydro power Corporation Limited was ordered to compensate to the praitisonal (अफिसन). The NHT directly relied on the principle of (polluter ~~pay~~ pays).

In 2017, The act of living festive or Yomama food playing was declared violating the environmental ~~laws~~ norms & the NHT panel imposed a penalty of ₹ 500. only

The NHT in 2017 imposed an interim ban on plastic bags less than 154µm thickness in Delhi. Because they were causing animal death, clogging the ~~river~~ ^{sewer} & harming the environment.

To self learn

- Act:- Year, chapter, Important points, amendment change
- Swachh Bharat Mission
- 6-20 sammelan (environmental topics)

Pollution Indices:-

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- Industrial Waste Water Treatment -

Dairy Dairy waste :-

Dairy Dairies are the center where raw milk is processed, either for immediate consumption or converted into dairy product such as whey, cheese, Butter, Dry milk powder, Ice cream etc.

- These manufactured product may be supplied to other industries such as bakeries, conchy manufacturers.
- Dairies handling milk are classified as receiving, bottling, condensing, dry milk powder manufacturing, Ice cream, cheese & butter making.
- The waste water generated in a dairy contains highly putrescible organic matter. So it is necessary to treat this waste water before its disposal.
- Almost all the organic matter of dairy waste are easily biodegradable.

Operation in a Dairy :-

- ① Receiving
- ② pasteurization :-

This process consist of heating of milk to 260°C for 30 min. & immediately refrigerator. It kills all the m/o. including the pathogenic m/o which may have entered in the milk through diseased animal.

- ③ Bottling
- ④ Condensing :-

Pasteurized milk is heated & evaporated under vacuum. The concentrated milk is pumped through a closely set ~~bed~~ valves that Breaks fat.

Sugar is added to the milk & the sterilized sweetened milk fill in till containers, pack & send to the customer.

⑤ Dairy milk manufacturing

⑥ Cheese making

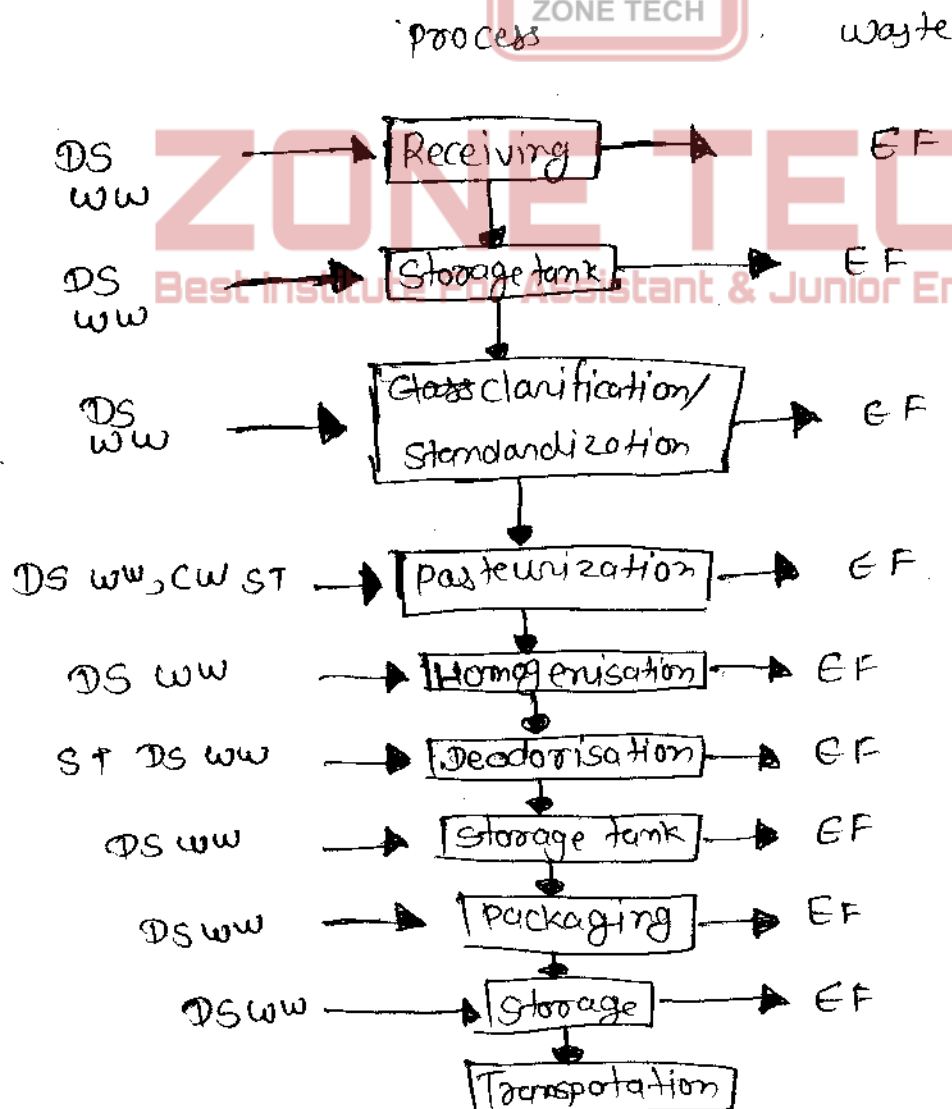
⑦ Butter making

⑧ Casein making:-

Soured & spoiled milk is treated with mineral acids to produce casein.

It is used in manufacturing of plastic paint, resins & waxes.

Milk processing flow Diagram:-



- Effluent Sources from various units of milk processing.
 - DS - Detergents & Sanitizing Agents
 - WW - Wash water
 - ST - Steam
 - CW - cooling water

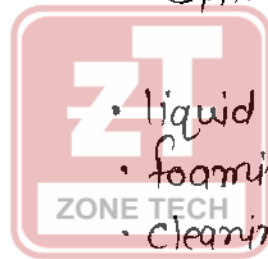
Dairy process

- Receiving & storage

Source of waste

- poor drainage of tanker.
- Spills & leakage from pipe
- foaming
- Spills from storage tank

- pasturization



- liquid losses
- foaming
- cleaning operation
- By products

- Homogenisation

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- liquid losses & leaks
- cleaning operation
- Separation

- Separation / clarification

- foaming
- Pipe leaks

- product processing stage.

- product washing
- Sludge removal from clarifiers
- Damage milk package
- over filling
- poor drainage

Cheese making

- over filling
- Using salt in cheese

Butter making

- product washing
- using salt

Milk powder manufacturing

- Start up & start down losses
- plant malfunction
- Stag losses
- cleaning
- Bagging losses

Characteristics of waste water generated from Dairy :-

- BOD $\rightarrow$ 0.8 - 2.5 kg per metric ton of milk in the untreated effluent.
- COD $\rightarrow$ 1.5 times of BOD
- Suspended Solid $\rightarrow$ 100 - 1000 mg/lit
- Total Dissolved Solid $\rightarrow$ 10 - 100 mg/lit (phosphorus)
 $\rightarrow$ 6% of BOD (In Nitrogen terms)

Composition of waste water of Typical Dairy Industry :-

Item	Value
• pH $\rightarrow$	7.2
• alkalinity $\rightarrow$	600 mg/lit as CaCO_3
• TDS $\rightarrow$	1060 mg/lit
• Suspended solid $\rightarrow$	760 mg/lit
• BOD $\rightarrow$	1240 kg/lit
• COD $\rightarrow$	84 mg/lit
• Total Nitrogen $\rightarrow$	84 "

• phosphorus	11.7 mg/lit
• oil & grease	290 "
• chloride	105 "

Treatment options :

1. Discharge & Subsequent treatment of dairy waste water at a nearby STP.
2. Removal of Semi-solids & Special waste from the site by waste disposal contractors.
3. Onsite treatment

1. Direct Discharge to a STP :-

- onsite pre-treatment process - physical screening
- pH Control
- Composition Balancing
- fats, oil & grease removal

→ pH Control :-

Alkaline degreaser generally used for saponification of lipids & the effective removal of protein substance having pH of 10-14.

- while a pH of 1.5 - 8 can be encouraged with acidic cleaners
- optimum pH - 6.5 - 8.5
- most commonly used chemical, if pH correction needs to be carried out in balancing tank
e.g. H_2SO_4 , HNO_3 , $NaOH$, CO_2 , & lime

flow & Composition Balancing :-

- The pH adjustment & flow balancing can be achieved by keeping the effluent in equalization or Balancing tank for at least 4-6 hrs. 6-12 hrs.

→ Fat, oil & grease removal :- (FOG)

The FOG treatment unit should be placed before or after balancing tank.

- If the balancing tank is placed before the fog unit, the large fat globules can be accumulated in the tank as the discharged effluent cools down & suspended fat aggregate during the retention period.
- If Balancing tank is placed after fog unit, the unit should be large enough to accommodate the max. anticipated flow from the factory.
- Flow balancing should precede fog removal.

General fog removal system include following :-

- Gravity traps
- Air flotation & Dissolved air flotation
- Enzymatic Hydrolysis of FOG →
- High COD removal efficiency as well as the effluent of better quality is reported.
- USA UASBR (upflow anaerobic sludge Blanket reactor) treating Hydrolysed dairy processing waste water & compared to the result of a UASBR treating the same waste water without prior ~~any~~ enzymatic Hydrolysis treatment, ^{are} not better

Treatment Methods :-

1. Biological treatment
2. Land treatment
3. Irrigation

1. Biological treatment :-

Aerobic biological system :- Aerobic filter, activated sludge process, sequencing Batch reactor, treatment pond, RBC (Rotating Biological Contractor)

Anaerobic biological System:-> Conventional digester, contact digester, fix bed digester, fluidized bed digester, UASB, Anaerobic lagoon or pond

2. Land treatment:-

Interest in the land application of the waste is also increasing as a direct result of the general move of regulatory authorities to restrict a waste disposal into rivers, lakes & oceans. But also because of high cost of incineration & land filling.

- Nutrient such as Nitrogen & phosphorus that are contain in waste water which make these waste attractive as organic fertilizer.

3. Irrigation:-

→ The organic impurities in dairy waste are easily biodegradable & hence can be conventionally subjected to biological treatment.

→ In view of High BOD value the raw waste, it is possible to digested to a whole waste anaerobically after reducing its oil & grease contents.

- A dairy in Mumbai has practiced anaerobic biological treatment for the past few years & the generated enough electric power from the gas produced to meet the dairy's entire power requirement.
- Satish & Gopal Krishan used anaerobic ^{contact} filter containing sand as a filter medium for treating synthesis waste of dairy.
- Harichand & Saxena used anaerobic digestion process for treating the waste water produced in manufacturing of cheese.
- Bhalenao discuss the use of aerated lagoons & oxidation ditch for treatment of dairy waste water.

- Kolanski & Nyhuis reported for performance of 4 sequencing batch reactor operating in pannel on 3 three eight hour cycle. They found BOD, Total Nitrogen & Total phosphorus removal as 99%, 90% & 97% respectively

Note:-

- Generally the treatment of dairy waste water is anaerobic in nature.

Tannery :-

- Leather manufacturing process in Tannery Industries ^{J.} To chemical used:- Sodium chloride, 10%, Sodium liquor, 4%, Lime, 5%, ammonium sulphate, & ammonium chloride, 1.2%, sodium ammonium bysulphate, 1.8%, Bate [Bat - Barium - Telluride] phenolphthelene indicator, 0.1%, of ammonium sulphate, 1%, of diluted sulfuric acid, 4%, of basic chromium sulphate, 1%, of sodium bi-carbonate, 1%, formate

2. process :

(i) Prepatory stage (beem house ^{operation} ~~operation~~)

(ii) Tanning & Crusthing

(iii) Surface Coating

(iv)

(i) Prepatory stage:-

- Prepatory stage are when hide/skin is prepared for tanning.

It may include following stages

(A) Preservation

(B) Soaking in water (washing)

(C) Liming - removal of unwanted protein

(D) unhairing

(E) fleshing

(F) Splitting

(G) deliming

(H) deliming

(J) degreasing - (oil & grease removing)

(L) fatting - removal the fat layer inside the skin

(K) Bleaching

(ii) Tanning & Crustling:-

→ The word tanning means the process by collagen fibres in a skin react with chemical agent such as Tannin, Alum or other chemical compounds. The hide/skin have the capacity to absorb tanning, acids & other chemical substance which prevent them from decaying & make them damp resistance.

→ Crustling is, when hide/skin is thin & returned & lubricating of on a colouring station.

• Crumlimitation is a sub process of crustling which include drying & softening operation.

(iii) Surface Coating:-

For some leather a surface coating is applied which may include - oiling, brushing, padding, spraying, roller coating, curtain coating, polishing, plating, imposing, ironing, combing, glazing.

Waste generation points:-

Process / Source	waste
• Stokeland	• manure
• Killing floor	blood
• Dehairing	hair & Dirt
• Insides removal	paunch manure & liquor
• Rounding	press liquor

- Carcass dressing
- By product

Flesh, mass, blood, grease, manure
grease, offal

Facts:-

- only 150kg of raw material is converted into fine leather out of 1000kg of raw material.
- There is a waste of 850 kg around.
 - 56-60% Flesh
 - 35-40% Chrome shaving, chrome split & buffing dust
 - 5-7% Skin trimming
 - 2-5% Hair
- Tanning process at least required 300kg of chemicals which are added per ton of hide.

Tannery effluent Content:-

- Solids, BOD, Nitrogen content, Sulfide, Natural Salts (Sulphate, chlorides, oil & grease, chromium compound like Cr^{6+} , Cr^{3+}).

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Treatment scheme for waste water:-

Process involved in common effluent Treatment plant:-

There are 4 stages involved in the process of CETP

- ① preliminary stage
- ② Primary stage
- ③ Secondary stage
 - (a) Aerobic process
 - (b) An-aerobic process
- ④ Tertiary stage

Preliminary stage includes →
i) grit Removal
ii) oil & grease Removal

primary stage includes →
• Equalization
• Neutralization
• Sedimentation

Secondary stage includes:-
↳ Aerobic process
↳ Activated sludge process
→ Aerated lagoons
→ Trickling filters
→ Sequential Batch Reactor (SBR)
→ Submerged Aerobic fixed film reactor
→ Membrane Bio-reactor.
:- Anaerobic process
→ Anaerobic Contact Reactor
→ up flow sludge Blanket
→ fixed Bed Reactor
→ Biological Removal of heavy metals

Tertiary stage includes:-

Sand filter
Carbon filter
Micro filter
Reverse osmosis
• Ultra filtration
• Retention Pond
• Nano filtration

Treatment of other O/M :-

Treatment of Acids & Alkalies $\rightarrow$ Neutralization
oil & grease Removal $\rightarrow$ Skimming devices

Treatment of chromium :-

following processes:-

- ① The chrome water from the leather manufacturing process is pumped into a reactor. pH must be 3.
- ② The magnesium oxide is added which may increase the pH level from 6-7. Chrome will be settled as sludge and clean water is get.

Textile industry and waste water treatment :-

pollution problem in textile industries:-

① Dissolved solids

② Color

③ Toxic metal

• The metals may come as impurity with the chemicals used during processing such as caustic soda, sodium carbonate and salts.

• The source of metal could be dye stuff like metalised Modern dyes. The metal complex dyes are mostly based on chromium.

④ other compounds

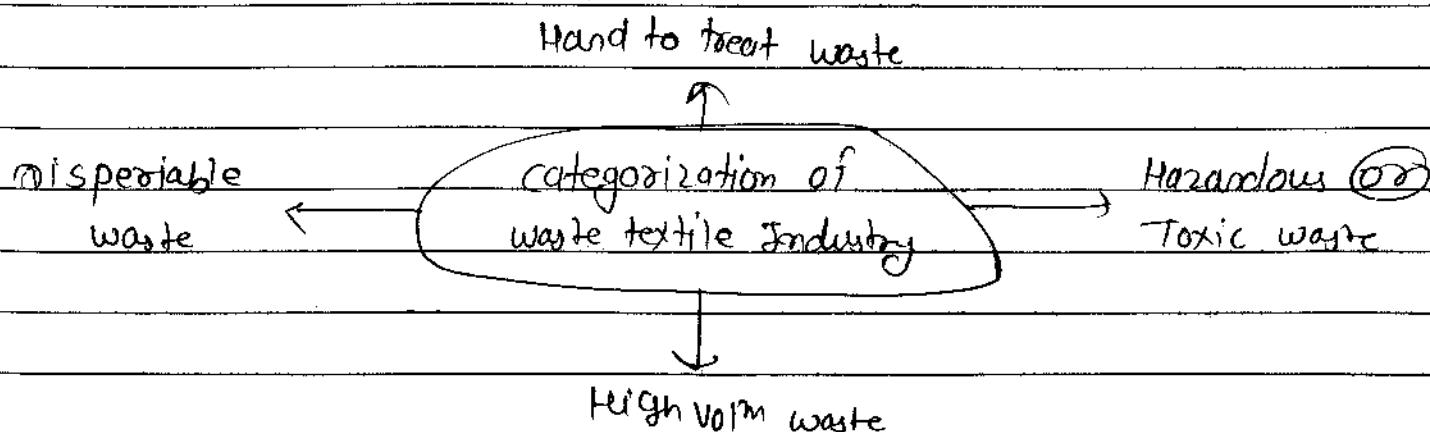
• Refractory Refractory Materials $\rightarrow$ Non-Biodegradable organics
Ex: detergents - COD $\uparrow$

• organic compounds of dye stuffs, acids, Sizing materials, enzymes, tallow etc.

Effluent production from diff. process of Textile Industries.

Process	Effluent Composition	Nature
• Sizing	Starch, waxes, Carboxymethyl cellulose, polyvinyl Alcohol (CMC) wetting agents (PVA)	High in BOD, COD
• Desizing	Starch, CMC, PVA, Fats, waxes, Redins	High in BOD, COD, SS, DS
• Bleaching	Sodium Hypochloride, Cl_2 , NaOH, H_2O_2 , acids, Surfactants, $NaSiO_3$, sodium phosphate, Short cotton, Fiber	High alkalinity High SS
• Mercerizing	NaOH, cotton wax	High pH, low BOD, High DS
• Dyeing	Dye stuff area, reducing agents, oxidizing agents, acetic acid, detergents, wetting agents	Strongly colored, High BOD, COD, DS, Low SS, heavy Metals
• Printing	Paste area, Starches, gums, oils, binders, Acids, Thickeners, crosslinkers, Reducing Agents	Highly coloured, high BOD, oily appearance, SS slightly Alkaline, low BOD

Waste generation from textile Industry:-



① Hard to treat waste:-

- Non-Biodegradable organic or inorganic Metals are the chief source which contains color, Metals, phenols, contains surfactants toxic organic matters.

② Hazardous (or) toxic waste:-

- Metals
- Chlorinated solvents
- Non-Biodegradable (or) Volatile o/m

③ High Volume waste:-

- High vol of waste water
- Wash water from preparation and continuous dying processes & alkaline wastes from preparatory processes
- Batch dye waste containing large amounts of salt, acid or alkali.

④ Dispersible waste:-

- waste stream from continuous operation (preparatory, dying, printing, finishing)
- paint paste (printing screen, square & drum cleaning)
- Lint (preparatory, dying, washing operations)
- foam from coating operations
- Solvents bottoms from solvents recovery
- Batch dump of washed processing (finishing mixes)

Classification

Classifications of waste water treatment process

- ① Primary →
- Screening
 - Sedimentation
 - Equalization
 - Neutralization → pH adjustment
 - Mechanical flocculation & chemical coagulation

- ② Secondary →
- Aerated lagoon
 - Trickling filter
 - Activated sludge process
 - oxidation ditch & pond
 - Anaerobic digestion

③ Tertiary - oxidation technique

- electrolytic precipitation & foam fractionation
- Membrane technologies
- electrochemical processes
- Ion exchange method
- photo catalytic degradation
- Adsorption (Activated Carbon etc.)
- Thermal evaporation

④ for primary treatment (MF & CC)

- 80-90% of TSS
- 40-70% of BOD
- 30-60% of COD
- 80-90% of the Bacterial Removal
- Most commonly used chemical for CC are alum, ferric chloride, ferric sulphate, ferrous sulphate and lime.

② Secondary treatment:-

- 99% of BOD Removal in Aerated lagoon
- The major disadvantages are the large space requirements & further chemical contamination
- Trickling filter: Shape → Rectangle
Depth → 1-3 m
Medium → well graded of size 40-150mm
- aerobic M/o - Zoogaea
- Activated sludge process →
- An effluent aeration for 5-24 hrs. is required
BOD removal - 90-95%
- Oxidation Ditch - hydraulic Retention time → 12-24 hrs
Sludge Removal → 20-30 days
- Anaerobic digestion → Temp 35°C
pH → 7-8 for 30 days
End products → CH_4 , CO_2 , NH_3

③ Tertiary treatment:- oxidation technique

- It forms AOX (Absorbable toxic organic halides)
- Sodium hypochlorite decolorizes dye Both efficiently.
- It is low cost technique

disadvantages:-

- Sludge formation in huge quantity which required eff. Sludge digestion process

• Ep 8FF

- Membrane filtration
 - Reverse osmosis
 - Nanofiltration
 - Ultrafiltration
 - Microfiltration

Industry Specific standards for effluent as per CPCB

1. For Dairy Industries:-

Effluents	Concentration in mg/l except pH	Quantity per product processed
pH	6.5 - 8.5	-
BOD ² (3 day at 27°C)	100	-
Suspended solids	150	-
oil & grease	10	-
waste water generation	-	3 m ³ / kl of milk

2. For Tanneries:-

Std. for Treated effluent max. permissible values
(in mg/l, except for pH)

• pH	6 to 9
• Biological oxygen Demand (BOD ₅ at 27°C)	20
• Chemical oxygen Demand (COD)	250
• Total Suspended solid (TSS)	50
• Total Dissolved solid (TDS)	2100**
• Sulphides (as S)	2.0
• Total chromium (as Cr)	2.0
• Hexavalent chromium (as Cr ⁶⁺)	0.1
• oil & grease	10

Max. specific water consumption for processing hides / skin (monthly avg. values)	
Raw to wet blue / white	20 m ³ per ton of hides / skins
post tanning process	20 m ³ per ton of hides / skins
Raw - to - finished	40 m ³ per ton

Max. waste water discharge = 85% of Max. water consumption

Factors to re-calculate finished leather into wet blue / white & Hide:

Shoe upper leather

15 ton of Raw hides/skins = 7.84 ton of wet blue
= 2.94 ton of finished leather

upholstery leather:

15 ton of Raw hides/skin = $\frac{5.08}{5.08}$ ton of wet blue
= 1.48 ton of finished leather

All Integrated textile units, units of cotton / woolen / carpets / polyester, units having printing / dyeing / Bleaching process or manufacturing & harmless units.

Treated effluents

Max. concentration values in mg/l except for

pH, colour and SAR

pH

6.5 - 8.5

Suspended solids

100

Color, P.C.U (Platinum

150

Cobalt - Units)

BOD (at 3 days at 27°C)

30

oil & grease

10

CO₂

250

Total chromium as (Cr)

2.0

Sulphide (as S)

2.0

phenolic compounds

1.0

(as C₆H₅OH)

Total dissolved solids (TDS)

2100**

Sodium Absorption Ratio

26**

Ammonical Nitrogen (as N)

50

Fermentation Industry (Distilleries, Maltaries & Breweries)

Parameter	Concentration not be exceed mg/l except for pH and SAR Color & odour)
• pH	5.5 - 9
• Color & odour	All efforts should be made to remove color & unpleasant odour as far as practicable
• Suspended solids	100
BOD (3 day at 27°C)	
• Disposal into Inland surface water or river / streams	30
• disposal on land or for irrigation	100

Organic Chemicals Manufacturing Industry:-

Parameters	Limiting Concentration in mg/l, except for pH & Bioassay test
pH	6.5 - 8.5
BOD 3 days, 27°C	100
oil & grease	10
Bioassay test +	Min. 90% Survival after 36 hrs in 100% effluent
Nitrate (as N)	10
Arsenic (as As)	0.2
Chromium (Hexavalent)	0.1
Chromium Total	1.0
Lead (as Pb)	0.1
Cyanide (as CN)	0.2
Zinc (as Zn)	5.0

Mercury (as Hg)	0.01
Copper (as Cu)	2.0
Nickel (as Ni)	2.0
phenolic (as C_6H_5OH)	5.0
Sulphide	2.0

+ Bioassay test shall be conducted as per IS : 6582-1971.

Bulk Drug & Formulation (Pharmaceutical)

Compulsory parameters:

pH	6.0 - 8.5
BOD (3 days at 27°C)	30
COD	250
TSS	100
oil & grease	10
Ammonical Nitrogen	100
Bio-Assay test	90% Survival of fish after first
Additional parameters	96 hours in 100% effluent

Benzene	0.1
Xylene	0.12
Methylene chloride	0.9
Chlorobenzene	0.2
phosphates as (P)	5
Sulphides as (S)	2
phenolic Compounds	1
Zinc	5
Copper	3
Total Chromium	2
Hexavalent Chromium (Cr^{VI})	0.1

Cyanide (as HCN)	0.1
Arsenic	0.2
Mercury	0.01
Lead	0.1
SAR	Less than 26 (applicable only for discharge on land)

AIR QUALITY INDEX (AQI) as per CPCB :-

- The Central Pollution Control Board is executing a nationwide programme of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP).
- The network consists of 804 operating stations covering 344 cities/towns in 28 states & 6 Union Territories of the Country.
- Under NAMP, following 4 air pollutants have been identified for regular monitoring at all the locations.
 - Sulphur Dioxide
 - oxides of Nitrogen, NO_2
 - Respirable Suspended particulate Matter ($\text{RSPM}/\text{PM}_{10}$)
 - fine particulate Matter ($\text{PM}_{2.5}$)
- The monitoring of Meteorological parameters such as wind speed & wind direction, relative humidity (RH) & temp. were also integrated with the monitoring.
- The monitoring of pollutants is carried out for 24 hrs. (4 hr sampling for gaseous pollutants and 8 hr sampling for particulate matter) with a frequency of twice a week, to

Research

NEERI - National Environmental Eng. Institute, Nagpur

have 104 observations in a year.

- The monitoring is being carried out with the help of CPCB; SPCB; PCC; NEERI, Nagpur

AQI :-

- AQI is a tool for effective communication of air quality status to people in terms which are easy to understand.
- It transforms complex air quality data for various pollutants into a single no. (index value), nomenclature and color.
- AQ sub-index and health breakpoints are evolved for 8 pollutants (PM_{10} , $PM_{2.5}$, NO_2 , SO_2 , CO , O_3 , NH_3 , Pb) for which short-term up to 24 hrs.
- Based on the measured ambient concentrations of a pollutant, sub-index is calculated, which is a linear function of concentration (ex. the sub index for $PM_{2.5}$ will be 51 at concentration $31 \mu g/m^3$, 100 at conc. $60 \mu g/m^3$ & 75 at conc. of $45 \mu g/m^3$).

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AQI Category	AQI
Good	0-50
Satisfactory	51-100
Moderately polluted	101-200
Poor	201-300
Very poor	301-400
Severe	401-500

How AQI Calculated:-

- The sub indices for individual pollutants at a monitoring location are calculated using its 24 hrs avg. concentration

values (8-hr in case of CO & O_3) and health breakpoint concentration range. The worst sub-index is the AQI for that location.

2. All the 8 pollutants may not be monitored at all the locations. Overall AQI is calculated only if data are available for min. 3 pollutants out of which one should necessarily be either $PM_{2.5}$ or PM_{10} . Else, data are considered insufficient for calculating AQI. Similarly a min. of 16 hr data is considered necessary for calculating subindex.
3. The sub-indices for monitored pollutants are calculated and disseminated, even if data are inadequate for determining AQI. The Individual pollutant-wise-sub-index will provide air quality status for that pollutant.
4. The web-based system is designed to provide AQI on real time basis. It is an automated system that captures data from continuous monitoring stations without human intervention, and displays AQI based on running avg. values [ex. AQI at 6am on a day will incorporate data from 6am on previous day to the current day.]

National Real time Network :-

Air

At present, the Real time Ambient ^{Air} Quality Monitoring network consists of 261 continuous, Ambient Air quality monitoring stations in 134 cities covering 23 states & Union Territories which are connected to the web-Based system.

317 - Total stations

45 - Raj.