ENVIRONMENTAL ENGG.

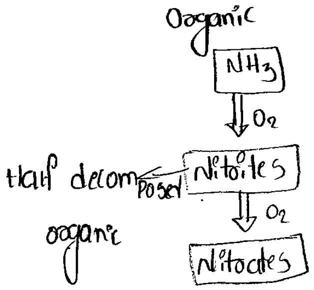
16/04/15

(20-25M)

→ Supply of Potable H_2O.

E.E
- water supply Engg (15-18M)
- waste H_2O (To reduce BOD) Engg (4-8M)
  - Domestic ↓ Residential
  - Storm ↓ RF
  - Industrial ↓ Industries
- Pollution Engg (0-2M)

H_2O	waste H_2O
① D.O :- 9.2 ppm (or) Above	① 4-5 ppm (or) above
② BOD :- (Bio chemical oxygen Demand) - Nil	② 180 mg/l (or) <180 mg/l.
③ Nitrites :- Nil	③ 0.45 ppm



The Aim of Envi. Engg is to
① Public Health → Human activities → wtr. supply Eng
② Envi. Safety.

Envt → Human → water supply Engg

→ air pollution

Human → Envt

↓

$\boxed{\text{waste } H_2O}$

Solid waste

Human utilization waste

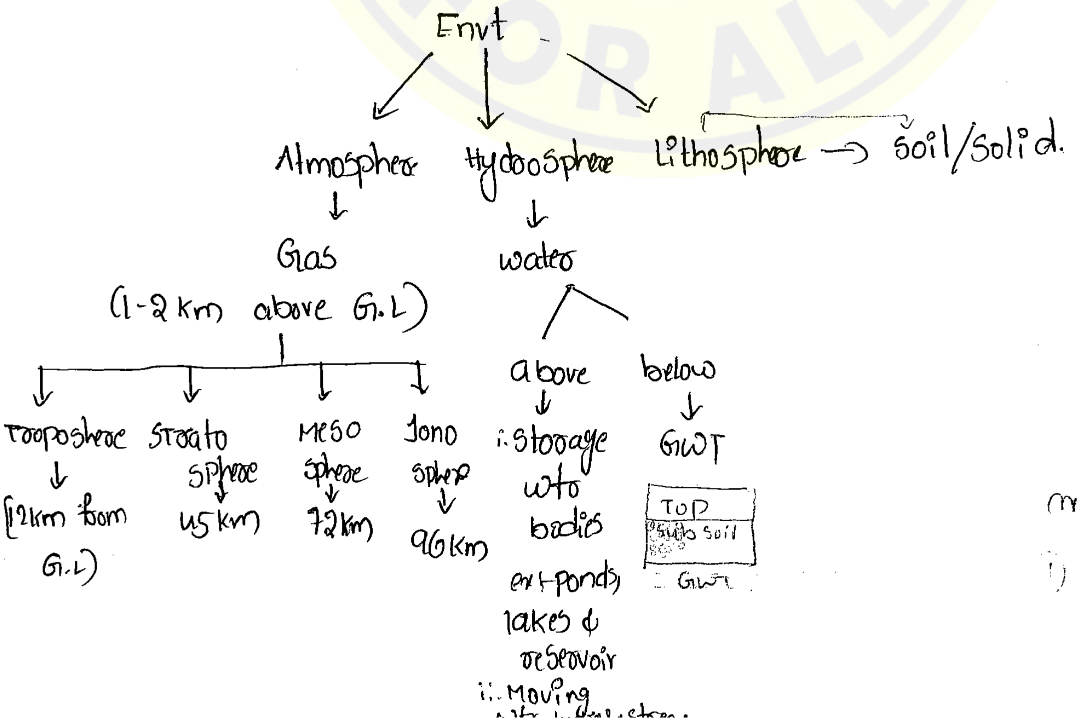
Air pollution

Before 1968 → E.E is called "Public Health Engg" (or) (water supply Engg)

"Sanitary Engg" (waste water Engg)

water supply Engg + waste wtr engg + Air pollution = E.E.

The term Environment literally means our surrounding.



WATER SUPPLY ENGG

The Branch of Environmental Engineering which deals with the study of design and construction of structures related to collection, conveyance treatment and distribution of Potable water towards public is called "water supply Engg".

2015 - 2020

① Design Period — optimum → 30 yrs
Heavy → 50 yrs.

2015 → 2020 $\xrightarrow{30\ yrs}$ 2050
↙
Design period

② Population forecasting (Estimation of future population) @ the end of Design Period)

③ Calculation of water demand (20 MLD)

④ Identification of Source. (Internal Source (or) External Source)
↓ 8MLD ↓ 12 MLD

Internal Source — with in the city (wells, river, lake).

⑤ Designing & Construction of Conveyance structure.

Canals/ channels
Pipes/ Pumps.

⑥ ~~Volume~~ of "Quality Analysis of H_2O"

Quality Analysis → Impurities present in the water.

Physical Chemical Biological

Parameter	Result	optimum [IS 10500]	
① Cl_2	1 ppm	0.2 – 0.3 ppm	→ Dechlorination.
	0 ppm		→ Super chlorination

⑦ Treatment of water

Physical Chemical

⑧ Distribution of water → By Pipe network designing is carried out usig either "equivalent pipe method" or "Hardy cross method".

Population Forecasting

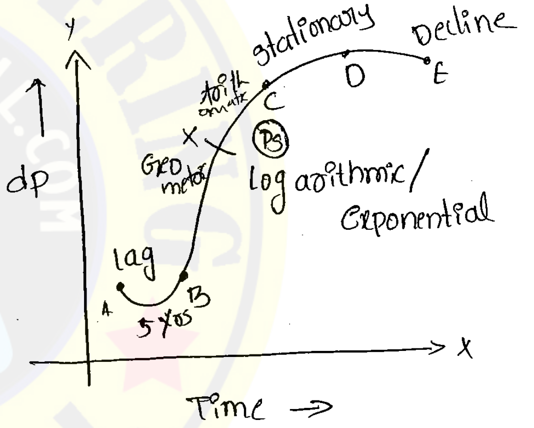
The probabilistic estimation of future population of a region @ the end of design period of the water supply project using various mathematical and graphical method is called Population forecasting method.

Fore | casting
future | estimation
↓
Based on laws of probability & "logistic curve"/ Pop Growth (curve)

Change of Population

Increase
↓
Birth, migrations, Annexation.
(Sudden ↑es of Population >5000)

Decrease
Deaths



Changes of population w.r.to Time.

Population

Small Town
↓
Old & settled City

① A-B : Lag (or) Delayed phase

Small Town → P_0

$$\frac{dP}{dt} \propto P_0$$

② B-C (logarothmic /exponential)

Town has been converting in to a City.

Developing city.

Population Growth

Geometric — Arithmatic

(yr to yr / Decade-Decade) ↓ — ↓ constant of increase

Doubling of Increase

$$\frac{dP}{dt} = \text{Constant.}$$

$$\frac{dP}{dt} \propto \text{constant}$$

$C \longrightarrow P_S \Rightarrow$ Saturated population

③ C—D

Developed City

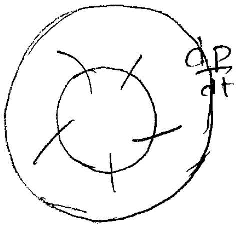
Phase — constant /Stationary state

$$\frac{dP}{dt} = P_S$$

④ D-E

Decline phase.

$$\frac{dP}{dt} \propto (P_S - P_0)$$



$\frac{dP}{dt} \propto (P_S - P_0)$

Mathematical methods

① Annual rate of Increase

Year wise → Increase → constant → Annual rate (i)
constant

$$\boxed{P_n = P_0 [1+i]^n}$$

P_n = future population (or) Design pop.

P_0 = latest known population.

i = Annual rate constant.

n = no. of years. diff b/w $(P_n - P_0)$

$$i = \left[\frac{P_n}{P_0}\right]^{1/n} - 1$$

where P_n - latest known population

P_0 - Previous known population

Yr	Population
2000	50,000
2010	60,000
2040	

n = ~~60000 - 500~~00

$$i = \left[\frac{60000}{50000}\right]^{1/10} - 1$$

$i = 0.018$

n = 2010 - 2000

= 10

$P_n = 60000\,[1+0.918]^{30}$ = ~~1,03,680~~ 102467.

② Arithematic Rate Method.

Increase of Population /Decade → constant. (x-c)

used in old & settled cities.

cities → Developing → constant rate

$$\frac{dp}{dt} = \text{constant}$$

$$\frac{P_2-P_1}{t_2-t_1} = C$$

$$P_2 - P_1 = c[t_2-t_1]$$

$$P_2 = P_1 + c[t_2-t_1].$$

1 decade = 10 yrs.

$$\boxed{P_n = P_0 + \bar{x}.n}$$

$n = \frac{3\cancel{0}}{1\cancel{0}} = 3$ yrs.

$\bar{x}$ = Arithmatic rate Constant.

Arithmatic Avg (or) mean value b/w diff. in population Per Decade.

$$\bar{x} = \frac{x_1+x_2+\dots x_n}{n}$$

Ex

Year	Pop	Diff increase
1970	8000	–
1980	15,000	7000 – x_1
1990	22,500	7500~~0~~ – x_2
2000	30,000	7500 – x_3
2030	?	

$$\bar{x} = \frac{7000+7500+7500}{3} = 7333$$

$P_{2030} = 30000 + 7333\,[3] = 51999 \simeq 52000$ $n = \frac{2030 - 2000}{10}$

*

Yr	Pop	Diff in .
1970	58,000	—
1980	68,000	10000 x_1
1990	77,500	9500~~0~~ x_2
2000	88,000	10500 x_3
2010	96.000	8000 x_4
2050	~~96.000~~	

$\bar{x} = 9500$

$P_{2050} = 96{,}000 + 9500\,[4] = 134000.$

③ Geometric Rate Method

- * Rate of increase → % of increase of pop/decade.
- * Most accepted Method for Population forecasting in India.
- * Done by Census method.
- * Used for Developing cities.

B-x

$$\boxed{P_n = P_0\left[1 + \frac{r}{100}\right]^n} \rightarrow \text{Decade wise}$$

n = no. of variables for r calc

r = Geometric rate constant. $r = [r_1, r_2, r_3, \ldots r_n]^{1/n}$

r_1, r_2, r_3 --- % of Increase Per decade

% Increase of Population $= \dfrac{\text{Present population} - \text{Pre. Popu}}{\text{Pre. Pop}} \times 100$

$\% = \dfrac{\text{diff in Pop}}{\text{Pre. Pop}} \times 100$

$$\boxed{P_n = P_0 \cdot e^{\frac{k}{100} \cdot n}}$$

k = Geometric rate constant per year.

ex ①	Year	Pop	Diff	% of Increase
	1970	8,000		$\frac{7000}{8000} \times 100 = 87.5$
	1980	15,000	7000	50%
	1990	22,500	75000	= 33.33%
	2000	30,000	7500	
	2030	?		

$$r = \left[87.5 \times 50 \times 33.33\right]^{1/3} = 52.6$$

$$P_{2030} = 3000 \left[1 + \frac{52.6}{100}\right]^3 = 106606.$$

②	Yr	Pop	diff in Pop	% Increase
	1970	25,000	+	60%
	1980	40,000	15000	
	1990	60000	20000	50%
	2000	84000	24000	40%
	2010	1,10,000	26,000	30.9%
	2030	?		

$r = \cancel{40}$ [~~15.249~~ 43.88

$$P_{2030} = 110000\left[1 + \frac{43.88}{100}\right]^3 =$$

$P_{2030} = 4,71,667.$

③ The Population of India in the year 2000 was 1 Billion and there after the population ↑ses exponentially @ a rate of 4% per year till 2020. Then the population growth rate changes to 2.5% per year & stibilizes. Estimate the Population @ the end of year 2050?

$$\begin{tikzcd}
2000 \arrow[r] \arrow[d, "4\%"] & 1 \text{ Billion} \\
2020 \arrow[d, "2.5\%"] & \\
2050 \arrow[r] & ?
\end{tikzcd}$$

$$P_{2020} = 1 \text{ Billion} \cdot e^{\frac{4}{100} \times 20}$$

$$P_{2020} = 2.2 \text{ Billions.}$$

$$P_{2050} = 2.2 \times e^{\frac{2.5}{100} \times 30} = 4.65 \simeq 4.7 \text{ Billions}$$

④ Incremental Increase Method.

Increment per decade

diff. in increment per decade → Increment of Popu.
Population

Diff. in increase of pop → Increment.

Incremental rate constant → $\bar{y}$.

$x_2 - x_1 \rightarrow y_1$

$x_3 - x_2 \rightarrow y_2$

$$\bar{y} = \frac{y_1 + y_2}{2}$$

$$\boxed{P_n = P_0 + n.\bar{x} + n\left[\frac{n+1}{2}\right]\bar{y}}$$

↓ Arthamatic ↓ Incremental populatio

Ex

Year	population	Diff. in Population	incremental value	$\bar{y}$
1970	8000			
1980	15000	7000	500	250.
1990	22,500	7500	0	
2000	30,000	7500		
2030				

$\bar{x} = 7333.$

$P_n =$ ~~13400 *~~ $3\left[\frac{3+1}{2}\right] \times 250 + 30000 + 7333 \times 3.$

✓ $P_n =$ ~~149000~~ 53499

* The population of a city in the year 2010 was 1,50,000 & there after pop ↑ses arithmatically @a rate of 5000 /decade & incrementally @ a rate of 500 per decade. Estimate the pop for 2050.

2010 → 15000 , $\bar{y} = 500$, $\bar{x} = 5000$

$$P_{2050} = 15000 + 4 \cdot [5000] + 4\left[\frac{4+1}{2}\right] \times 500$$

$$P_{2050} = 1,45,000$$

⑥ Decremental rate Method.

% of Increase → Diff. b/w Percentages.

$r_1 - r_2 = D_1$, $r_2 - r_3 = D_2$

Decremental rate constant $\bar{D} = \frac{D_1 + D_2 + D_3 + \cdots D_n}{n}$

$$\boxed{P_n = P_0\left[1 + \frac{r_0 - \bar{D}}{100}\right]\left[1 + \frac{r_0 - 2\bar{D}}{100}\right] \cdots \left[1 + \frac{r_0 - n\bar{D}}{100}\right]}$$

r_0 = latest known % of Increase

eg:

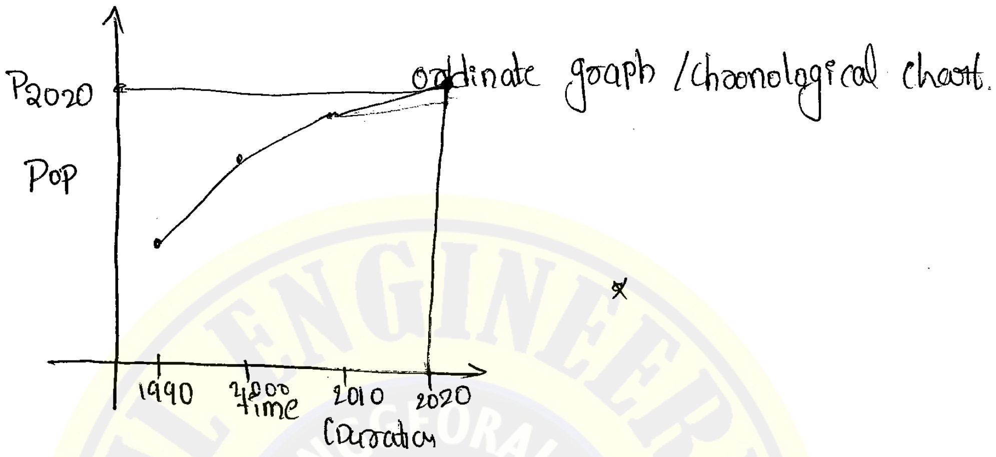
Year	Population	diff in pop	% of Increase	$\bar{D}$
1970	8000			
1980	15000	7000	87.5 %	87.5-50 =37.5%
1990	22,500	7500	50 %	16.7%
2000	30,000	7500	33.33%	
2030				

$\bar{D} = \frac{37.5 + 16.7}{2} = 27.1\%$ $r_0 = 33.33\%$

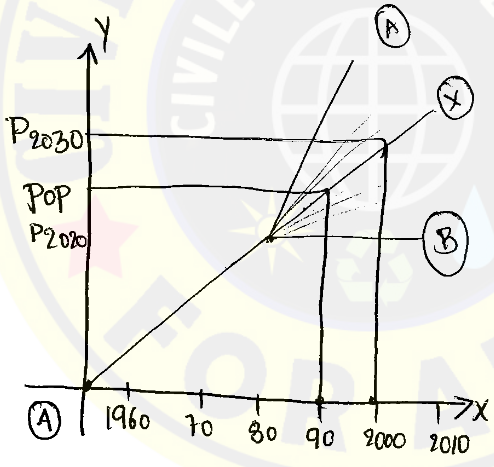
$$P_n = 30000\left[1 + \frac{33.33\% - 27.1\%}{100}\right]\left[1 + \frac{33.33\% - (2 \times 27.1\%)}{100}\right]\left[1 + \frac{3333 - 3 \times 27}{100}\right]$$

Graphical Method

① Simple Graphical method.



②



Ⓑ 1970 80 90 2000 2010

Ⓧ 1990 2000 10 20 30

1990 - 40,000
2000 - 60,000
2010 - 75,000

Ⓐ	Ⓑ
1960	1970
1970	1980
1980	1990
↓	↓
2010	2010

WATER DEMAND/DRAFT

The amount of water to be supplied every day towards the city till the end of Design Period which include all the water need of entire city and is calculated using Design population & Percapita demand is called water Demand.

$$\boxed{\text{Design Demand} = \text{Design Population} \times \text{Per capita Demand}}$$

PCD : The volume of water consumed by one individu to fulfill day to day needs of 24 hour period is called PCD.

PCD → 1 person → Activities → 1 Day
↓
lpcd → liters /capita/day
↓
Person

IS 1172-1993 – Code book for wtr supply & sanitary Engg.

135 lpcd → LIG - low income group

200 lpcd → HIG - High income group
↓
[lawns & gardnes]

$$\boxed{PCD = \frac{\text{Annual vol. of the wtr supplied}}{\text{Population} \times 365}}$$

2015 This PCD includes all type of demands. like Domestic, Industrial, public. .. etc.

WD depends up on three factors:

① population

② PCD

③ Design Period.

① WD $\propto$ Pop

Population	PCD
< 50,000	135 lPCD
50,000 - 1,00000	180 lpcd
100000 - 200000	220 lPcd
2lakhs - 5 lakhs	270 lpcd
> 5 lakhs	350 lpcd

Types of WD

Primary Demands

Secondary Demands.

Primary Demands → Domestic water Demand. → IS 1172

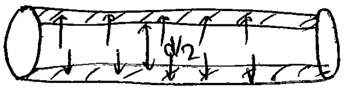
		LIG	HIG	
①	Domestic water Demand	135 lpcd 5 lt for Drinking	200 lpcd	50-60% of Total W.D
②	Industrial water Demand	70 lpcd	70 lpcd	20-25% of Total W.D
③	Public Demand	10 lpcd	10 lpcd	5% of Total W.D
④	losses & thefts	55 lpcd	55 lpcd	15-20% of Total W.D

Min Indu WD petrol/sugar → 1 lt/unit production

Max " " paper/leather → 400 lt/unit production.

Water Demand	LIG lpcd	HIG lpcd	% of Total W.D
Domestic	135	200	50-60%
Industrial	70	70	20-25%
Public	10	10	5%
losses & thefts	55	55	15-20%
	270 lpcd	330 lpcd	

Normal Design Period of water supply pipe — 15-20 years



Dia - reduces but Q is same bcoz velocity speed ↑es.

thefts ⟹ unauthorised H_2O supply connections.

Secondary water Demand

① Institutional water Demand

Min. institutional water Demand - theatres - 18 lpcd.

offices, Hotels - 45 lpcd.

Schools / colleges
- day - 70 lpcd
- Residential
  - <100 - 135 lpcd
  - >100 - 200 lpcd.

Max. Institutional water Demand

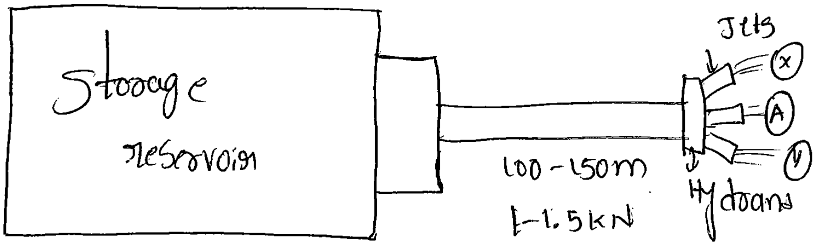
Hospitals - 400 lt /bed

② Fire Demand : The volume of water consumed to Extinguish the fire when a fire break occurs for a constant period of time is called fire Demand

Negligible : below < 1% of Total WD. ~~for~~

City < 5000000 (50 lakh) = 1-4 lpcd

City > 50 lakh <1 lpcd.



each Jet — 1100 lt/min

It travels a height of 5 Storied building - 10-15 mtrs.

$$\boxed{FD = \frac{\text{No. of hours}}{\text{of firing}} \times \frac{\text{No. of places}}{\text{of firing}} \times Q \times \frac{\text{No. of}}{\text{Jets}}}$$

$$\boxed{FD = \overset{\text{Bombay}}{3} \times \overset{\text{Delhi}}{6} \times 1100 \times 60 \times 3}$$

$$\boxed{\text{Max. water for FD} = 35,64000\,\text{lt}}$$

Population = 50,00,000

$$F\,D[\text{lpcd}] = \frac{\text{vol. of water}}{\text{Population}} = \frac{35,64,000}{50,00,000} = 0.7128\,\text{lpcd}$$

$$\boxed{FD\ \text{lpcd} = 0.7128\,\text{lpcd} < 1\ \text{lpcd}}$$

Fire Demand based on type of construction

① Rational formula $= 37 \times 10^{-3} \times c \times A^{0.5}$

c = coefficient of fire.

c = 1.5 for wooden building,
c = 1 for ordinary building
c = 0.8 for combustible building
c = 0.6 fire Resistant building.

A = Area of construction expressed in sq. mtrs.

Finally F.D in m^3.

Fluctuations in WD / Types of Design Demand:

① Avg WD → $Q_{Avg} = Pop \times pcD$

*② Max. Daily Demand → $Q_{max.daily} = 1.8 \times Q_{Avg}$.

③ Max. hourly Demand/day → $Q_{max.hourly} = 1.5 \times Q_{max.daily}$ (or)

$2.7 \times Q_{avg}$.

④ Max. hourly Demand/hour = $\frac{2.7}{24} \times Q_{avg} = 0.1125\ Q_{avg}$

⑤ Max. weekly Demand = $Q_{max.weekly} = 1.45 \times Q_{avg}$.

⑥ Max. Monthly Demand = $Q_{max.Monthly} = 1.3 \times Q_{avg}$.

⑦ Max. Seasonal Demand = $Q_{max.Seasonal} = 1.4 \times Q_{avg}$.

⑧ CID → Coincidental Draft = Q_{max} daily + Fire Demand.

Most of the Components of water supply projects are Designed for Max. Daily Demand $Q_{max\text{-}daily}$.

The capacity of storage reservoir of a water supply Project is always more than max. daily demand (or) Coincident draft. (or) Max. hourly demand per day whichever is higher.

Q. A water treatment plant has to supply water for population of 1 lakh with a per capita w/o Demand of 200 lpcd. Estimate various types of Discharges required for Designing of water supply project.

① Avg. w/o Demand Q_{avg} = 1 lakh × 200 lpcd = 20×10^6 lpcd

② Q_{max}. daily = 36×10^6 lpcd = 36 lpcd = 36 MLD

③ Q_{max}. hour = 54 MLD

④ Max. hourly Demand / hour = $0.1125 \times 20 \times 10^6$ = 2.25 MLh

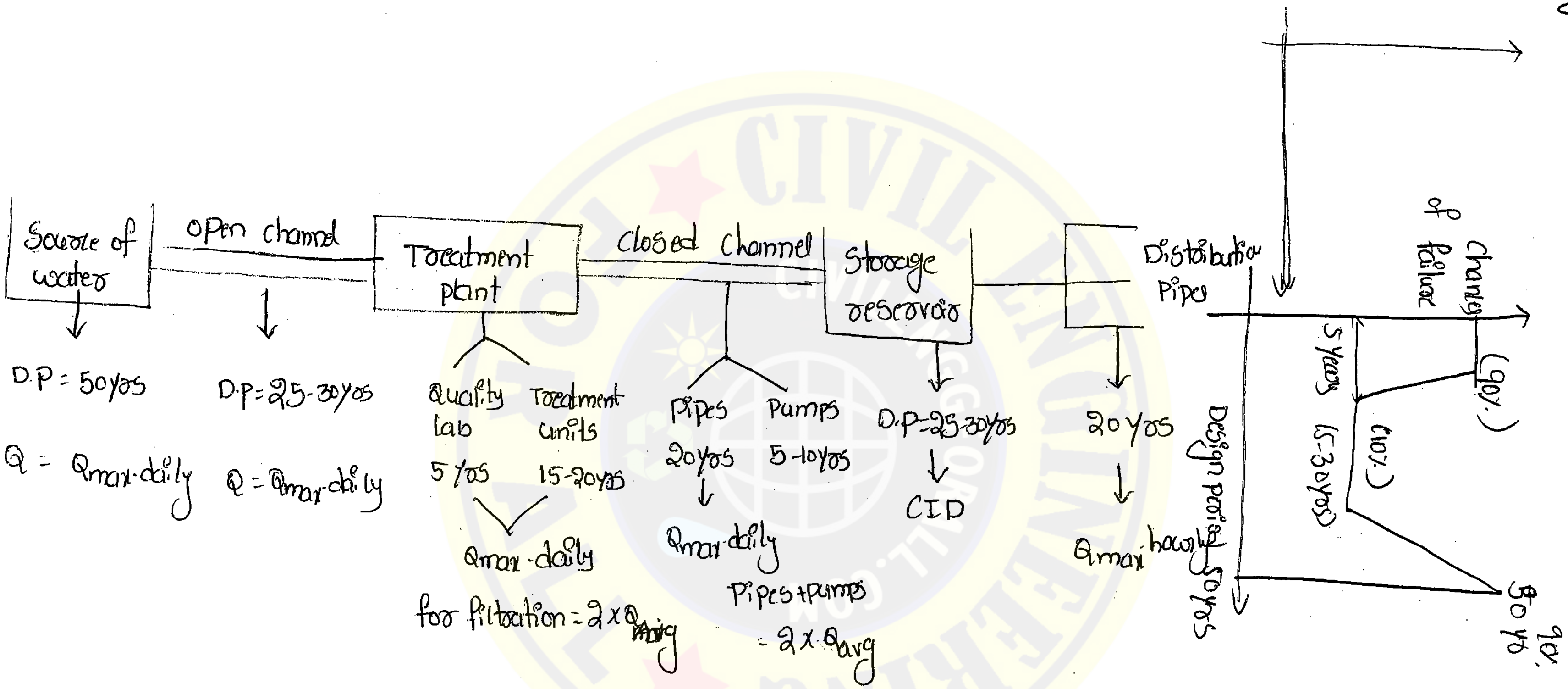
⑤ Max. weekly demand = 1.45×20 = 29 MLD

⑥ Q_{max}. Monthly = 26 MLD

⑦ Q_{max}. Seasonal = 28 MLD

Coincidental demand is unable to calculate bcoz no fire demand.

Design Period



Sources of H_2O

21/04/15

- Sources of H_2O
  - → lakes
  - → Ponds
  - → Rivers
  - → Reservoirs
  - → oceans
- Sub surface/under ground sources
  - → springs (Natural sub surfa
  - → Infiltration galleries
  - → infiltration wells
  - → wells

} artific sub surfa

<u>Surface</u> <u>Sources</u> are above G.L

lakes → large surface source (Natural always)

Mumbai (2010) → Reason:-

↓

1 crore 20 Lakhs

↓

2 lakhs

Dis. adv :- lakes carrying algae & weeds (Microscopic plants)

↓observe

$CO_2 \longrightarrow O_2$

↓

water tem < 20°   DO ↑es → ↑es microbial growth.

microbial growth → Harmless / Harmful

<u>Disinfection</u> : method of treatment.

Ponds :- Small storage (natural or artifical) water bodies
↓
50,000 Population

River water :-

. Primary Source of water supply Project.

0.69 → fresh H_2O , utilizable
↓
0.48% → River H_2O.

0.21% → other sources of water like lake, Ponds, wells, infiltration wells - - etc.

Dis. adv :- large polluted water body.

Among all Sources - River H_2O → highest pollution.

Pollution → ① Human activities → organic & In organic
ⓘⓘ Industries. → Toxic H_2O

Human activities releases → organic & in organic

→ Design ~~of~~ channels, canals for artificial supply of water.

Reservoirs :- Any kind of storage wtr body.

Reservoirs
- Natural
  - ↓ Rivers
- Artificial
  - ↓ Man made
    - ↓ Hussain sagar → Primary reservoir
      - | distribute
      - Service reservoir

Oceans : 97.8 %

- Saline water -
- Unutilizable
- Removal of salt → Desalination
  - ↓ (costly) → 1 lt - (500 - 2000/-)

Sub Surface / Ground water Sources

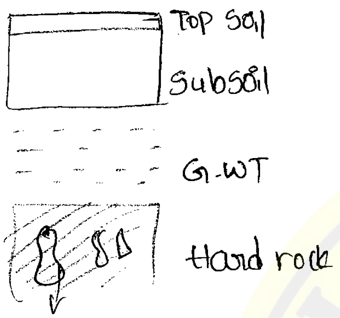
Earth formed : 3.3 million age (approx..)

Zones of Earth
- Zone of rock fracture
  - → Top soil
  - → Sub soil
    - Soil + Air + H_2O
    - Soil + H_2O → vadose/Intermediate.
    - Saturation zone
  - → Ground water table
- Zone of Rock flowage.

Rocks → Converted along to soil along with associated water

is zone of rock fracture / Breakage.

Igneous ⇒ sedimentary ⇒ Metamorphic ⇒ soil



water stored internally in rock mass

→ Zone of Rock flowage
↓
Deep water bodies = 1.6%

unavailable H_2O.

Zone of rock fracture

Sub soil

① Soil + H_2O + Air → 33.33% (equal proposition)

② Soil + H_2O → 50% + 50% vadose/Intermediate

③ Soil → 75% H_2O + 25% soil

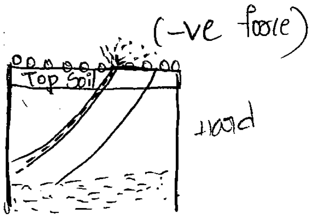
$$\boxed{\text{Sub soil + GWT} \rightarrow \text{Sub surface (or) under ground sources}}$$

Springs

The Natural out flow of water which appears on the Surface as a stream of flow naturally from sub Surface (or) Ground water table.

Natural sub Surface flow.

Ex:- water falls.



these are formed due to → weathering, blasting ... (cracks

Springs are classified into

① Surface

② Gravity

③ Artesian

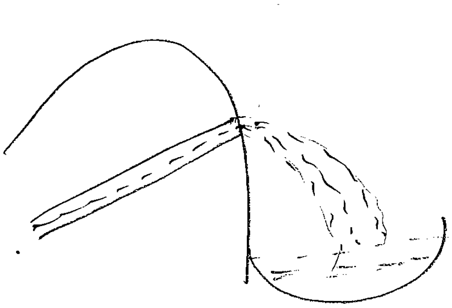
Surface Spring

If it travels Horizontally & performs Surface runoff

Gravity spring

volume of water comming from cracks, water flow against gravity. under when it comes out water flows due to the gravity.

Ex:- Papavinashanam

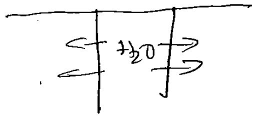


Artesian Springs:
↓
Artesian aquifer.

<u>Geological</u> <u>classification</u> <u>of</u> <u>Soil</u>

Yield → depends on Porous

Transmission → ability of water flow in sub soil horizontally.



① Aquifer → Porous + Permeability

② Aquiclude → Min porous + Min per

③ Aquitard → Porous

④ Aquifuge →

Aquifer : Humus, Loam ~~Civil~~ soil,
Black cotton soil

Aquitard : clay.

Aquiclude : Sandy clay

Aquifuge : Granite - soils of Rayalaseema.

** Aquifer : primary source of sub surface water project through sub surface lake.

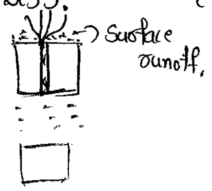
Aquifer

Unconfined
↓
No Hard mass,
only soil particles.
Aquifer which was not interrupted by rock mass

Confined.
↓
Interrupted by rock mass.

→ zone of aquifer in which the water molecules are sandwiched b/w two rock strata.

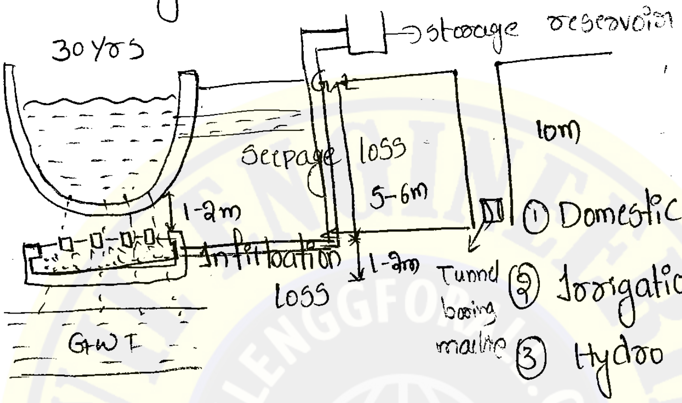
confined also called <u>artesian aquifer</u>.



Types of springs available in India → Gravity springs.

Infiltration Galleries

The horizontal rectangular tunnel constructed one - two meters deep below the river bed to entrap loss of water through infiltration from the river bed.



Prakasham barrage
Artificial Reservoir

① Domestic
② Irrigation
③ Hydro electric power → pay money vol

After completing Design period, erosion occur → water travels in vertical direction.

Infiltration Gallery Dimensions = L = 10-100m
W = 1-2m
D = 1-2m

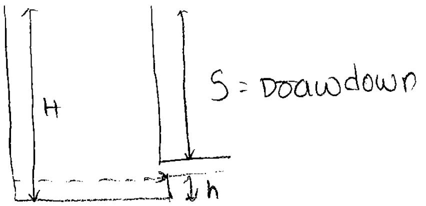
$$\boxed{Q = KL\frac{H^2-h^2}{2R}}$$

K= Coefficient of Permeability.
Distance travelled by water/minute
" " " " /day.

If k = m/min Q = m^3/min
If k = m/day Q = m^3/day

L = length of Inf. gallery
H = Max. H_2O depth
h = min. H_2O depth

$Q = m^3/min$ - m^3/day

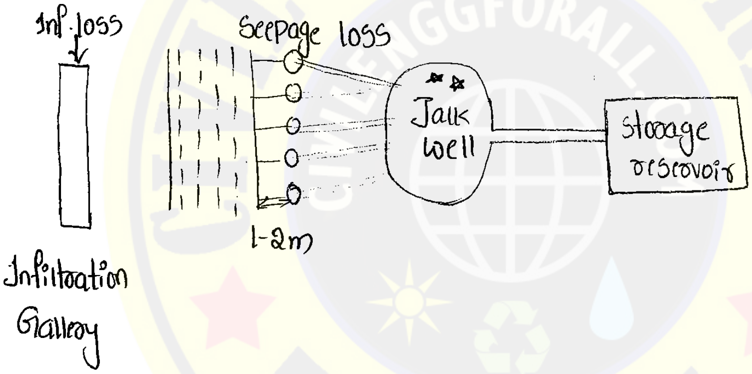


$\boxed{h = H - S}$

R = Radius of Influence.

* Infiltration wells:

Shallow circular concrete wells which are closed at top open at bottom constructed in series to entrapt seepage losses from the river bed. are called Infiltration wells



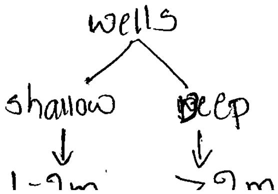
Wells

They are extracting the water from G.W.T & aquifer

Sources of water for the wells G.W.T & surrounding aquifer.

Recurruption test ⟶ aquifer

electrical resistivity ⟶ depth of GWT.



The Differentiating factor that classifies the wells into shallow and deep wells is

a) Depth
b) Discharge
c) velocity of flow
d) both a & b

Conduits for H_2O supply < Pipes
Pumps

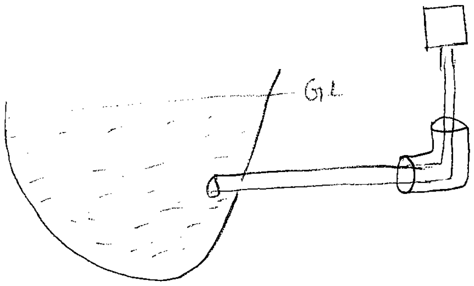
Intake structures

- Lake/Pond intakes
- River Intake < wet
dry
Portable
- Reservoir intake

The structures which are capable of extracting the volume of water and at the same time discharge towards the treatment plant (or) storage reservoir using various components like Pumps, Pipes, Joints, valves are called Intake structures.

Source ⟶ Treatment plant

① Storage
② Conveyance
③ Discharge.



Lake/Pond Intake → Bell mouth Joint

River Intake — Spy got Joint

Reservoir Intakes

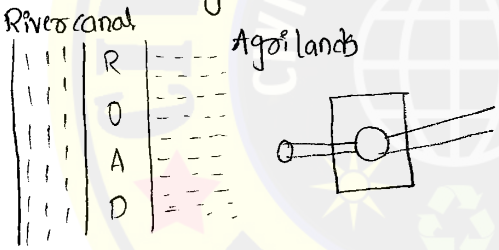
- Below G.L
  - ↓ Bell mouth
- surface
  - ↓ Spygot.

River Intake

Dry → Conveyance & Discharge.

wet → Storage conveyance & Discharge.

Portable → Temporary Structure → Flooding.



Max. Flood Level

↓

Max. Storage level.

Design of Conduits

Pipe lines — length → Distance b/w Source & Discharge Point.

Pipe lines — Diameter → Q

$$Q = A.V$$

$$Q = \frac{\pi}{4}(d)^2 . V$$

Q — Inf. Gallery → $Q = K.L \frac{H^2 - h^2}{2R}$ (Q = Discharge from Inf. gallery)

Q — Population x pcd x Factor → River / lake / Reservoirs

If value of water is not given then factor is taken as 1.8.

Rate of Supply / max. ~~too~~ H_2O Demands.

Discharge litres per day = m3/sec $\qquad Q = \frac{Q\ (\text{lt/day})}{10^3 \times 24 \times 60 \times 60}$

Hazen William Equation

$$V = 0.85\, C_H (R)^{0.64} S^{0.53}$$

C_H = Hazen William coefficient.

R = Hydraulic mean radius = $\frac{\text{wetted area}}{\text{wetted perimeter}} = \frac{d}{4}$

S = Min. Gradient / Base flow = $\frac{h_f}{L}$

$$\boxed{Q = \frac{\pi}{4} d^2 \cdot 0.85\, C_H \left(\frac{d}{4}\right)^{0.64} \left(\frac{h_f}{L}\right)^{0.53}}$$ → when velocity is not given.

① $h_f = \frac{FLV^2}{2gd}$

② $h_f = \frac{fLQ^2}{12.1 d^5}$

F = frictional factor

© $h_f = \frac{4fLV^2}{2gd}$. $\quad f$ = coef. friction

Capacity of Pumps

Capacity of Pump = $\rho Q g h$ watts

(hp) $= \frac{\rho Q g h}{746}$

Q = l/day

= 24 MLD

= 1 MLH

8 hrs pumping

⇓

Q = 3 MLH → m3/sec

Capacity of Pump $= \frac{Qgh}{0.746}$ hp

$$= \frac{Qgh}{0.746\,\eta_p \eta_m}$$

η_p = effeciency of Pump ⇒85%

η_m = efficiency of motor ⇒ 75%

$\eta_p = 0.85$, $\eta_m = 0.75$

Quality Analysis of water

Types of water

① Pure water : The water which carry 2 parts of Hydrog and 1 part of oxygen other than that no chemical element are present in it is called pure water.

H_2O

2H   1Oxy

② wholeSome H_2O

The water which is physically not pure, not clear in appearance but harmless for human consumption is called wholesome water.

③ Impurities

* Physical → Treatable → Harmless - objectionable

Dangerous ** Chemical < Treatable / unTreatable - BOD, Nitrites

* Biological → Treatable → ↓ Harmfull → Disinfection

Harmless

Physically impure but it is harmless & objectionable.

③ Palatable water : (G W T)

The water which carries the minerals required for human health naturally & sweet in taste with best quality & very clear in appearance.

It is taken from GWT. Best quality water.

④ potable water

The water which is a combination of wholesome water and palatable water and is fit for human consumption as it is prepared according to drinking water standards of IS 10500 is called Potable water.

Polatable water + wholesome water

⑤ Polluted water

The water which contains large concentration of organic and inorganic impurities which are entered in to water due to human activities (or) due to Industrial waste water is called Polluted water.

org & in org

when entered in to wate — O_2 ↓ Half org decom (Nitrites) — Dangerous

in org ↓ Harmless

Industrial waste water
↓ BOD: 180 mg/L
D: 4-5 ppm
untreated water
⇓
Dangerous.

⑥ Contaminated water

The water which carries infectius micro organisms that are able to cause harmfull diseases through water to the humans is called contaminated water.

waste water released from Hospitals.

Diseases
- Air borne
- Food borne
- water borne

T.B Hospitals → Most dangerous.

⑦ Mineral water: The water which contains added minerals Calcium, magnesium, Iron that are required for human health is called mineral water.

UV & RO

→ Purified water (or) treated water available by ultra violet (or) Reverse osmosis treatment.

E-coli digestive System.

⑧ Distilled water

The chemically purified water which contains added chemicals to prevent future contamination is called distilled water.

Distilled H_2O

⇓

Distillation

⇓

chemicals

⇓ future contamination

Impurities in H_2O 23/04/15.

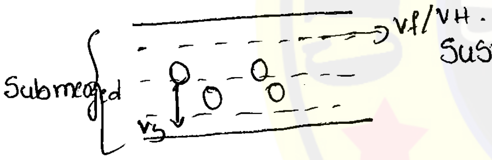
Based on size
↓
① Suspended Solids (10^{-1}mm-10^{-3}ϕ)
visible
② colloidal solids (10^{-4}-10^{-6}mm)
microscopically visible
③ Dissolved Solids (10^{-7}mm-10^{-9})
Invisible

Based on chemical nature
① organic
② In organic

Based on State of matter
① Physical
② chemical
③ Biological

Suspended Solids :-

Normally the



Suspended particles.

Canals are Designed by Lacy's method → silting → Q↓
↓ Scouring → Q↑
Open channel - Turbulent flow
↓
Eddies

No .

① Turbulent flow — Eddies disturb Particles

② velocity of flow of water (v_f) > velocity of suspended particles (v_s)

$v_f > v_s$

$v_f/v_H > v_s$

The Suspended Solids are Physical impurities → harmless but objectionable/(colour

Ex:- Sand, Silt, clay. | Algae, Fungi, Bacteria.(Biological impurities.

↓ Physical impurities.

Air & food borne ↓ Colour.

* Fungi is said to be Natural Scavengers of Environment.

↓ Dead & decaying matter on their food.

↓ which can decompose dead body.

Fungi

Dead & Decaying matter ↓ Algae Fungi

Food ↓ Inorganic.

Bacterial < Harmfull, Harmless

* Suspended Particles causes — Turbidity in water, colour, odour.

* Treatment : Sedimentation

Colloidal Particles:

* Size : ϕ 10^{-3} mm - 10^{-6} mm.

* microscopically visible.

* (-vely) charged Particles → highly active.

Properties

① adsorption :

the surface phenomena of attracting any kind of Particle on to its surface by physical forces.

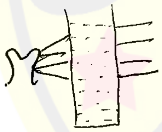
Forces of Attraction

Chemical ↓ Oppositely Charged Particles. (+ve, -ve)

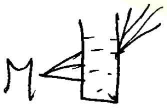
~~Bio~~Physical ↓ b/w any particle (without ~~f~~any charge) (+ve, +ve, -ve, -ve, +ve, -ve).

① Adsorption : physical force of attraction
↓
vander wall forces

② Tyndal effect : The phenomena of Scattering of light radiation when it is passed through water.

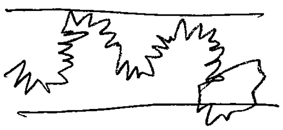


If any colloidal Particles present, they not allow the light radiation Parally, they deflect various angles.



③ Brownian effect:

The movement of colloided particals in water in a zigzag manner restricted to a circular motion.



* Collids

Lyophilic ↓ H2o loving

Bonds with water

Lyophobic ↓ H2o hating

ex:- oil, grease.

Effects:

* The collids water 'acidity' to the water.

* Taste

* Scales formation

Treatment : coagulation

③ Dissolved Solids

* ϕ 10^{-7} mm - 10^{-9} mm

* Invisible and exists in ionic form in water causes the most of the harmfull properties to the water are called Dissolved solids.

ex:- NaCl → Na^+ Cl^- (Ionic bond)

because of ionization of water. $H^+ \to OH^-$

↓ Hydrogen bond

↓ Intra molecular $\overset{H_2}{\text{bond}}$

$(cw)^{(-)}$ — $(H^{(+)}$ — $OH^{(-)})$ → $Na^{(+)}$

↓ Intra (with in)   ↓ In b/w Inter mol.

* Types

① Dissolved salts

Na^+	CO_3^{-2}
K^+	HCO_3^-
Ca^+	Cl^-
Mg^+	PO_4^-
Fe^+	SO_4^{-2}

Known Dissolved salts = 25

Total Dis. salts > 250

Effects

1. Alkalinity
2. acidity
3. Hardness
4. Corrosion
5. Scales formation.

② Dissolved gases

CO_2, NH_3, H_2S, CH_4 → odour

③ Metal ions

Arsenic, lead, mercury, Cadmium.

↓

Dagerous → cause → cancer.

④ Bacterial

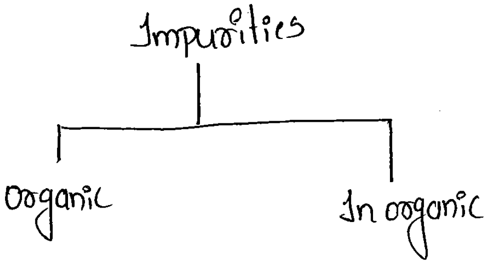
↓ cause

Turbidity in water.

Treatment : Filtration

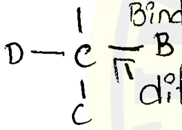
Disinfection.

* Based on chemical nature



Organic

* ϕ - large
* Complex
* Harmful
* Carbon - primary element.
* Tetra valancy → +4



$D-\overset{\overset{A}{|}}{\underset{\underset{C}{|}}{C}}-B$

Binds with 4 different Groups

* "Chyral carbon (or) "Asymmetric"
* Half decomposed, ∴ harmfull

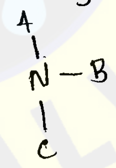
ex:- Good neutrious materials Carbohydrates, Fatts, Proteins, amino acids.

In organic

* Small
* Other than carbon - primary element
* Simpler
* Harmless

NH_3 (Ammonia) → does not Contain Carbon but it is organic.

NH_3



$\overset{\overset{A}{|}}{\underset{\underset{C}{|}}{N}}-B$

Asymmetric

because - Nitrogen is organi

Molecular N

$\overset{\overset{A}{|}}{\underset{\underset{A}{|}}{N}}-A$

In organic

* Physical Quality Analysis

The quality Analysis which gives the information about the physical appearance of water and is tested even by human senses. which is harmless but objectionable.

Desirable limit → Best Quality

Allowable limit → Avg Quality.

Temperature

① thermometer → Measurement.

② Disarable → 4°C

③ Allowabe → 10 - 15°c

④ Temperature > 20° (not allowable)

↓ Sewage

bcoz

Temperature ∝ Bacterial concentration

$O_2 \xrightarrow[\text{24 chemical reactions}]{} CO_2$ → Energy produced

Bacterial respiration

Energy → 2 ATP

$\boxed{1 \text{ ATP} = 5432 \text{ cal}}$

human → 32 ATP

1 min = 72 times respiration in Bacterial.

colour

① colourless

② Algae → green colour

③ Fungi → Brown colour

③ Iron → red

④ Manganeese → Brown

Mesurement → platinum scale
Burgess sale

$\boxed{\text{1 ml of chloroplatinum ions dissolved in 1 lt of Distilled water.}}$

1 TCU (True colour unit)/1 ppm
↓
mg/l.

Instrument : Tintometer.

⑤ $\boxed{\text{Desirable : "0" TCU}}$

⑥ allowable : 3 - 5 TCU

* Extra energy is ~~sele~~ converted to heat energy → ↑es the temp.

③ odour & Taste

* odourless & Tasteless

* Instrument : osmoscope.

* odour due to presence of Dissolved gases.

  e.g:- Hydrogen sulphate (H_2S) → Rotten egg Smell

  NH_3 → Pungent

  CO_2 → Foul

* odour detected by → Dilution experiment.

① volum. of odour containing water.

"A" ml + vol of Dist.water "B" ml = odour less

② volume of diluted water (A+B) i.e odour less water

③ Threshold odour number (TON)

$$TON = \frac{A+B}{A}$$

* Allowable limit = 5 - 7 TON

* Desirable limit = "0" TON

* Permissible ~~odour~~ = P.O = upto 5 TON

Taste :

① Flavin threshold number FTN:

$$FTN = \frac{A+B}{A}$$

A+B = volum of (tasteless) dilu water

A = volume of taste contain water

B = volume of Distilled water

② Allowable ~~upto~~ FTN.

④ Specific conductivity

* Measures the ability of water to transmit the electricity through it which is based on the concentration of "dissolved salts" Present in water.

* Portable Ionic H_2O tester.

* Dissolved salts → Ionic.

* Ionic H_2O tester - carries electrod

  ↓

  +ve electrode - (-ve ions attract)

  -ve electrode

  ↓

  attract the ions.

* Based on number of attracted ions → How much electricity pass.

* Electric resistance → ohms
  ↓ → $\frac{\text{volts}}{\text{Amp}}$

* conductivity → mho = $\frac{\text{Amp}}{\text{volts}}$.

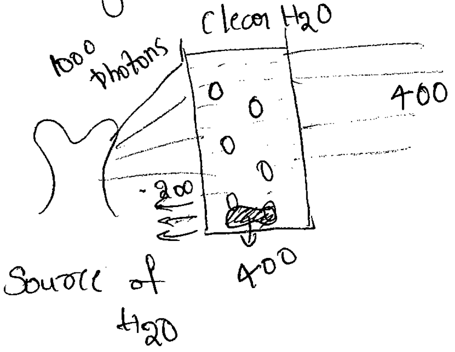
* Specific conductivity = micro mhos/cm.

* Conc. of Dissolved salts (mg/l) = 0.65 × Sp ~~contentration~~ conductivity

$$\boxed{\text{D.S mg/l} = 0.65 \times \text{Sp}_{\text{conductivity}}}$$

Turbidity / opaquness / Darkness

* The measure of resistance of water for the passage of light through it due to the presence of either suspended or dissolved solids that absorb light radiation.



* Light radiation

① Incident light → I_i → Source

② Reflected Light → I_R → sent back by H_2O.

③ Absorbed Light → I_A → Absorbed by impurit

④ Transmitted Light → I_T → Emitted from water body.

Transmitted light
- Transmission
- Scattering

* The measurement of Turbidity is based on the principle of "Beer lambert's law".

- Beer's law → $I_a \propto$ conc. of absorbing material.
- Bouger Lambert's law → $I_a \propto$ thickness of absorbing material. ↓ Independent of I_i.

$I_a \propto b.c$

$I_a = abc$

a = Molar absorption Coefficient

b = thickness

c = concentration

Units

JTU , NTU

JTU - Jackson turbidity units.

NTU - Nephlometric turbidity units.

JTU → 1 mg Silica + 1 lt of Dist. H_2O

NTU → 1 mg Formazin + 1 . lt of H_2O.

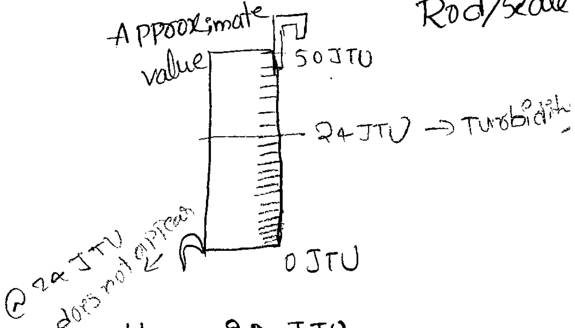
1 NTU = 1 JTU = 1 ppm.

Allowable Turbidity = up to 20ppm.

Measurement of Turbidity:

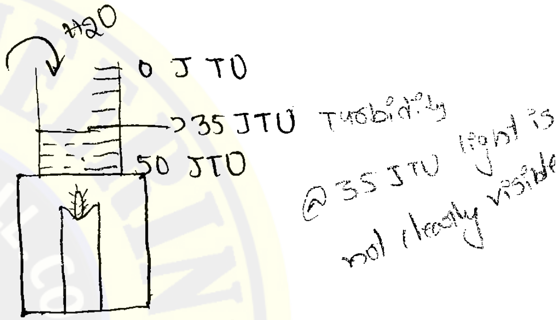
- Based on light absorption phenomenon
  - Jackson's Turbidity rod/scale
  - Jackson's Turbidity meter
  - Baylis Turbidity
  - Hellich's 〃
- Based on light scattering Phenomenon
  - Turbidity meter
  - Nephlometer (latest)
  - Present Instrument

Jackson Units of Turbidity ~~scale~~ Rod/Scale



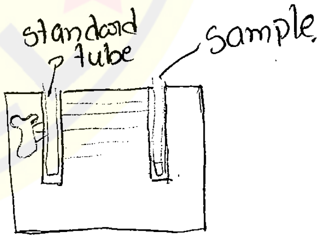
More than 20 JTU

Jackson Turbidometer



up to 2JTU

Baylis Turbidity

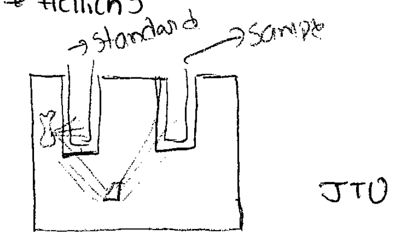


* Sample tube carries ~~no~~ Turbidity.

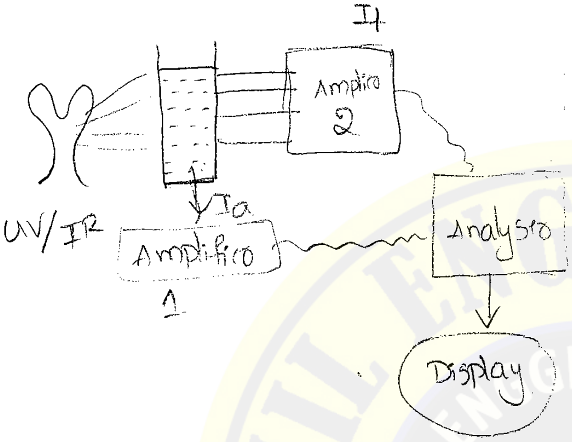
* standard tube - known turbid value

*

* Hellich's



Nephlemeter/Turbimeter



wave length = 500-800mm → visible

1000mm (or) above → uv.

UV/IR → H_g lamp

Xenon lamp

IR – emitted by carbide arc lamp

$\frac{I_a}{I_t}$ = Turbidity.

light scatter – Nephlometer

Parallel – Turbidometer.

Sampler holder

Sampler holder in the Nephlometer is cuvette. It is a rectangular tube carrying 4 faces { 2-Smooth, 2-rough

2 Smooth → Incoming.

2 rough → outgoing.

The differentiating factor b/w nephlometer & Turbidometer is the Path of light.

If the path of light is //al to the direction of source light ← Turbidometer.

Light travels ⊥ar to the Path of light the instrument is called Nephlometer. This is Possible due to the presence of rectangular sample holder & usage of a sample tube named as cuvette, containg ~~to~~ 2 smooth surfaces for incoming light radiation & 2-rough surface for outgoing light radiation. The rough surfaces emit light radiation which reflected at various angles.

* Chemical quality analysis

The quality analysis of water which determines the sanitary quality and provide information about harmful ingradients in water is called chemical quality Analysis.

Sanitary quality :-

↓

Cleanliness

↓

Harmfull

H_2o Sewage

Chemical quality Analysis

Gravimetry

↓

weight/volume

mg/l

Titrimetry

↓

colour reaction

colour Agent

H_2o + Chromophore/ indicator

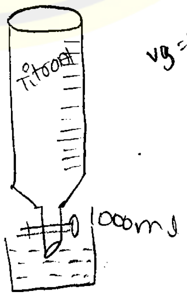
v_s = volume of sample

⇓

Coloured solution + Titrant

⇓

Change of colour / colourless.



Chlorine

Starch + H_2O ⇒ Blue → chlorin Present.

Titrant = Sodium thisulphate

volume of Titrant consumed = V_T

① Conc. of $\overset{Cl_2}{\boxed{x}}$ in mg/l = V_T [ml]

② Conc. of x in mg/l = $V_T \times$ factor

DO → $V_T \times 0.355$.

③ Conc. of x (mg/l) $= \dfrac{V_T \times N_T \times Eq.wt\ of\ \textcircled{x} \times 10^3}{V_S}$

Acidity / Alkalinity, Hardness

V_T = volume of water consumed

N_T = Normality of Titrant.

Eq. wt of x = $\dfrac{\text{mol. wt}}{\text{Valancy}}$

Mol. wt = Sum of atomic weights of molecule.

Atomic weight = No. of protons + No. of neutrons.

Valency ⇒ No. of unpaired electrons.

V_S ⇒ volume of Sample (H_2O)

mg/lt

① x [Moles/lt] → x [mg/l]

$$\underset{mg/l}{x} = x_{mol/lt} \times \text{Mol. wt of } x \times 1000$$

② x [eq/lt] → x [mg/l]

$$\underset{(mg/l)}{x} = \text{Eq. wt of } x \times 1000 \times x_{(eq/wt)}$$

③ $$\underset{\text{as } CaCO_3}{x\,(mg/lt)} = \underset{(mg/lt)}{x} \times \frac{\text{eq. wt of } CaCO_3}{\text{eq. wt of } x}$$

$\overset{+2}{Ca}\overset{-2}{CO_3}$ → eq. wt of $CaCO_3$

$40 + 12 + [3 \times 16]$

$= 100.$

valancy $= \frac{100}{2} = 50$

$$= \frac{x}{mg/lt} \times \frac{50}{\text{eq. wt. of } x}$$

Chemical Quality Analysis

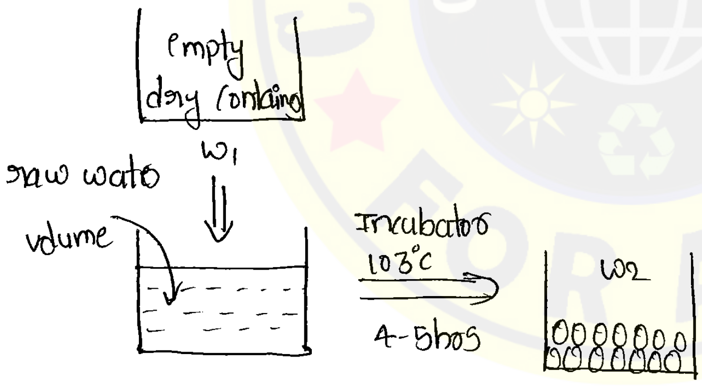
4/5/15

Solids : Solids are estimated through 'gravimetry'.

- Solids [TS]
  - Suspended [SS]
  - Dissolved [TDS]
    - Volatile (or) organic [VS]
    - Non-volatile (or) Inorganic [NVS]

* Allowable limit of solids is up to 500 mg/lt.

Total Solids [TS]



$$TS = \frac{w_2 - w_1}{V} \text{ mg/lt}$$ V = volume of Raw water

w_2 = wt of container + solids

w_1 = wt of container

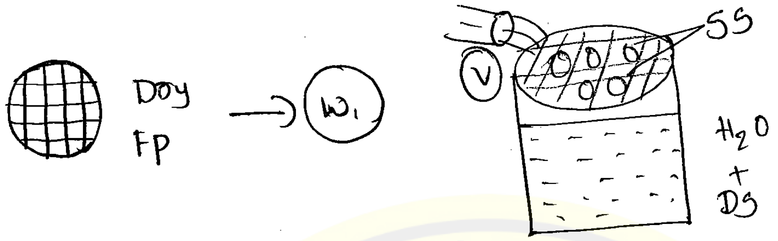
→ TS should be expressed only in mg/lt.

Suspended Solids :- SS is estimated by filtration test

For filtration test whaltmann filter paper No-44,

Dia of pores → 1 μ

→ The size of suspended solids is 10^{-1} mm to 10^{-3} mm.



FP + SS → oven → 1 hr 103°C ⇒ Dry FP + SS ⇒ W_2

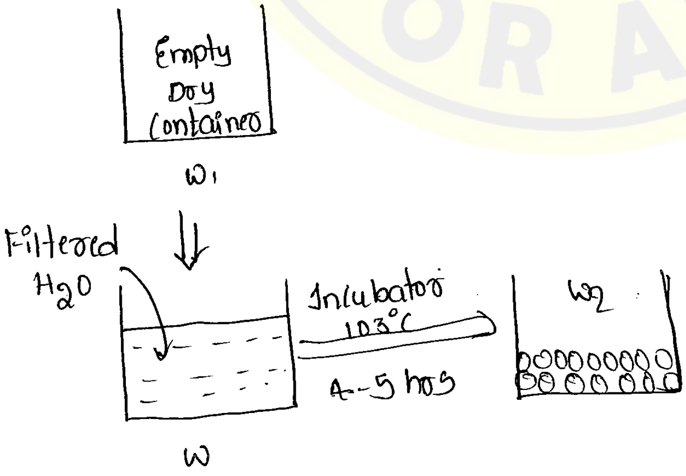
$$SS = \frac{W_2 - W_1}{V}$$,

W_2 → FP + SS

W_1 → wt of Dry FP

V → volume of water passed through FP.

Total Dissolved Solids



$$T_S = \frac{W_2 - W_1}{V} \text{ mg/lt}$$ V = volume of Raw water

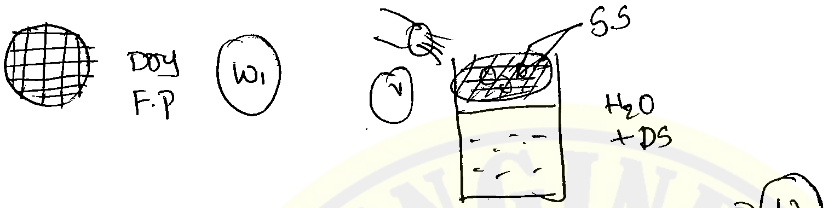
W_2 = wt of container + solids

w_1 = wt of container

→ TS should be expressed only in mg/lt.

Suspended solids: SS is estimated by filtration test. For filtration test Whatman Filter paper No-44, Dia of Pores → 1μ

→ The size of Suspended Solids is 10^{1} mm to 10^{3} mm



FP+SS → oven → 1 hr 103°C ⇒ Dry FP + SS ⇒ W_2

$$S_S = \frac{W_2 - W_1}{V}$$

W_1 = wt of Dry FP

W_2 = FP + SS

V = volume of water passed through FP

Total Dissolved Solids

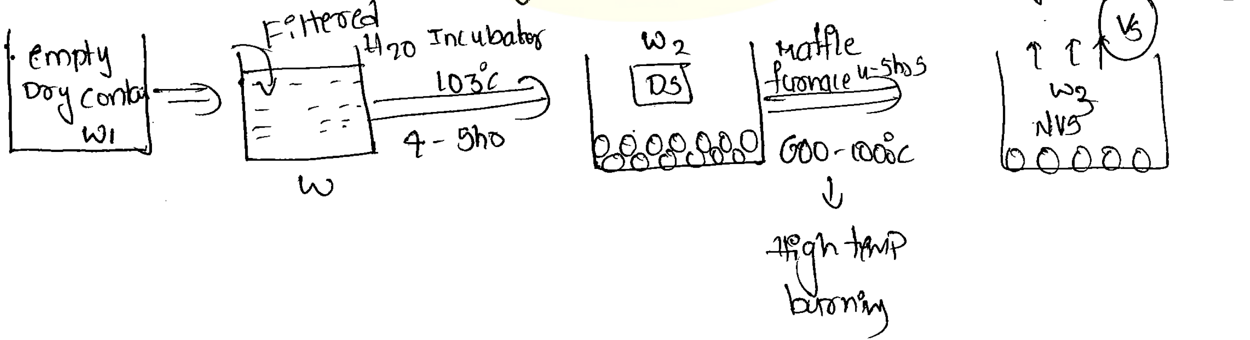
when DS exposed to high temp. i.e 600 – 1000°C, V_S converted in volatile gases and get evaporated and contained remained with NVS. $\boxed{D.S = V_S + NVS}$

W_2 = container + VS + NVS

W_3 = contain + NVS

gives wt of VS

$TDS = \frac{W_2 - W_1}{V}$, $VS = \frac{W_2 - W_3}{V}$, $NVS = \frac{W_3 - W_1}{V}$



when DS exposed to high temp i.e 600 – 1000°c, Vs converted in volatile gases & get evaporated & contained remained with NVS

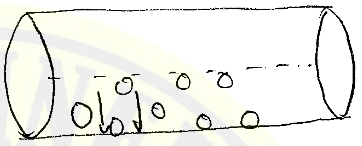
Q:- A Synthetic water Sample is Prepared by dissolving 100mg NaCl, 125 mg

Solids Present in Seewage are of 3 types suspended, dissolved and Settleble.

20 % — Suspended Solids

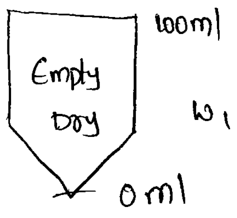
60 % — Dissolved Solids

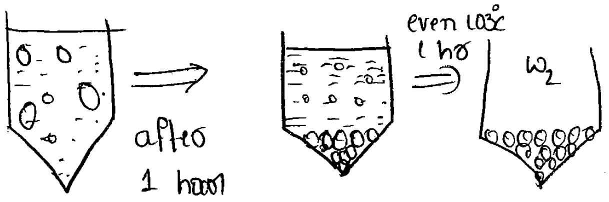
30 % — Settlable solids



The harmless solids of more than 1mm ∅ (> 1mm∅) which have been settled while the seewage is travelling from residential building towards seewage treatment plant and are settled in the bottom of Sanitary pipe due to the self cleansing velocity of seewage flow is called settlable solids.

Settleable Solids are ~~sett~~ estimated by imhoff cone test.





$$\text{Settleable Solids} = \frac{W_2 - W_1}{V}$$

where W_1 = wt of empty imhoff cone

W_2 = " " " " " + settleable

* The Negative logarithm of hydrogen ion concentration is called pH.

* Negative logorothim of hydroxyl ion concentration is called pOH.

$$\boxed{\begin{aligned} pH &= -\log_{10}[H^+] \\ pOH &= -\log_{10}[OH^-] \end{aligned}}$$

[ ] → Concentration

pH = 1 - 14

1 - 6.5 → Acidic ←
- 1 - 4.5 → strong acid
- 5 - 6.5 → weak acid

6.5 - 7.5 → Neutral

7.5 - 14 → Alkaline ←
- 7.5 - 10 → weak base
- >10 → strong base

$$H_2O \underset{\text{Ionization}}{\overset{\text{hydrolysis}}{\rightleftharpoons}} H^+ + OH^-$$

Rate Constant "k" = $\frac{[\text{Products}]}{[\text{Reactions}]}$

$$K = \frac{[H^+][OH^-]}{[H_2O]}$$

$$\boxed{K = 10^{-14} \text{ mol/lt}}$$

$[H_2O]$ = unity = 1.

$[H^+][OH^-] = 10^{-14}$

$\log[[H^+][OH^-]] = \log 10^{-14}$

$\log H^+ + \log OH^- = \log 10^{-14} = -14$

Apply "-'ve sign on both sides

$-\log H^+ - \log OH^- = 14$

$\boxed{P_H + P_{OH} = 14} \Rightarrow \boxed{p^H + p^{OH} = 14}$

Sum of Concentrations of H^+ and OH^- ions of a strong acidies = 10^{-14} mol/ltr.

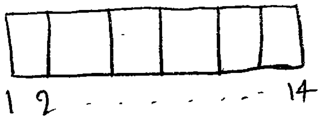
$$\boxed{[H^+][OH^-] = 10^{-14}}$$

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

The pH is an index value it does not carry any units and the pH is not going to change by it self either the change in H^+ or the change in OH^- is only responsible for change in pH value.

Measurement of pH :—
pH Paper
pH meter
Titrimetric analysis

① p^H Paper



each box having each colour.

② For accurate value : p^H meter → / electrometeric bulb → Sensitive.

The electrode associate with pH meter is Colomel electrode.

③ Titrimetric analysis : [Based on colour reaction] :

oldest method.

Most accurate method.

Indicator :-	methyl orange,	phenopthalin
Acid :-	Pink	Yellow
Base :-	~~Base~~ yellow	Pink

Acid is present	Titrant	Normality ⇒	Pink ↓ colourless	Yellow ↓ Pink
	NaOH =	0.02 N		
Base	H_2SO_4	0.01 N	Yellow ↓ Pink	Pink ↓ Yellow

vol. of Titrant Consumed $= \frac{V_T \times N_T \times 500 \times 10^3}{V_S}$

[Acidity / Alkalinity (mg/l)]

V_T = volume of Titrant , N_T = Normality of Titrant.

V_S = volume of Sample

Acidity : The obtain value of acidity in mg/l = $[H^+]$ mg/lto

Acidity → mg/l → $[H^+]$

Alkalinity → mg/L → $[OH^-]$

$$\boxed{[\overset{x}{mol/lt}] = \frac{Con\ x\,(mg/l)}{Mol.wt\,[x] \times 10^3}}$$

* Acidity → mineral acids
  CO_2, Sulphar

Alk
↓
CO_3^{-2}
HCO_3^-
OH^-

* The pH of a water Sample is found to be 9.25 estimate hydroxyd ion conc.

$pH + pOH = 14$

$pOH = 14 - 9.25$

$pOH = 4.75$

$-\log [OH^-] = 4.75$

$[OH^-] = 10^{-4.75}$ moles/lto

$= 1.77 \times 10^{-5}$ mol /lto

$[x\ mol/lt] = 1.77 \times 10^{-5} \times 17 \times 1000$ 20.3009 mol/lt

* 20 ml of 0.02 N. NaOH solution is consumed while estimating acidy of 50 ml of water sample. estimate acidity in mg/l

consumed acidity (mg/l) = $\frac{V_T \times N_T \times 50 \times 10^3}{V_S}$ eq. wt of $CaCO_3$ = 50.

~~c~~acidity = $\frac{20 \times 0.02 \times 50 \times 10^3}{50}$ = 400 mg/l

Acidity :-

Acidity (H^+)
- carbonate
- mineral acidity

Acidity caused due to carbonate acidity (CO_2) PH = 4.2 - 8.3

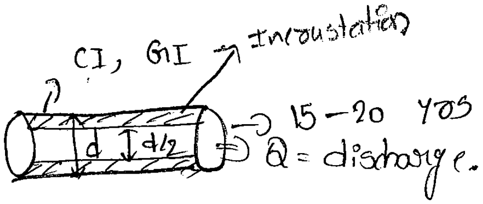
Acidity " " " mineral acidity [HCl, H_2SO_4, ets] = 1 - 4.2

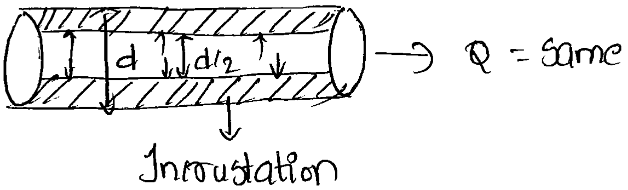
Carbonate	Mineral
CO_2	HCl, H_2SO_4
PH = 4.2 - 8.3	pH = 1 - 4.2

Effects caused due to Acidity in water

① Sediment deposit

② Incrustation





Treatment : Neutralisation → "Excess lime [$CaCO_3$]."

$CaCO_3$ → Acidic H_2O → Ca^{+2} CO_3^{-2} → (Alkaline pH) – 4
↓
7.5

H = 7.5

Alkaline H_2O — 10
↓
7.5

CaO CO_2
↓
Acidity

Not allowable in water.

$$\boxed{\text{In water allowable acidity} = 0}$$

*Alkalinity :-

$$\boxed{\text{In water allowable alkalinity} = 250 \text{ mg/lit}}$$

Alkalinity

Hydroxy	carboxy	bi carboxy
OH^-	CO_3^{2}	HCO_3^-
↓	↓	↓
Strong base	moderate base	weak base
10–14	8.2 – 10	4.3 – 8.2

① $CO_2 + OH^- \longrightarrow HCO_3^-$

② $CO_3^- + H^+ \longrightarrow HCO_3^-$

Total Alkalinity : $[CO_3^{-2}]_{mg/l} \times \frac{eq.\ wt\ of\ CaCO_3}{eq.\ wt\ of\ CO_3^{-2}} + [HCO_3^{-2}]_{mg/l} \times \frac{eq.\ wt}{eq.\ wt\ H}$

$$\boxed{T.A_{mg/lt\ as\ CaCO_3} = [CO_3^{-2}]_{mg/l} \times \frac{50}{30} + [HCO_3^{-2}] \times \frac{50}{61}}$$

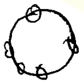
$$\boxed{T.A_{mg/lt/\ OH^-\ /CaCO_3} = [OH^-]_{mg/l} \times \frac{50}{17}}$$

Effects

① Scales formation → Industrial Boilers

② Hardness

③ Corrossion of pipes

④ Tuberculosis  Excessive growth of crystals internally & externally.

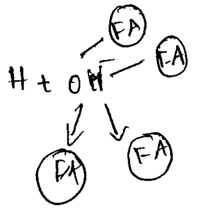
* Hardness

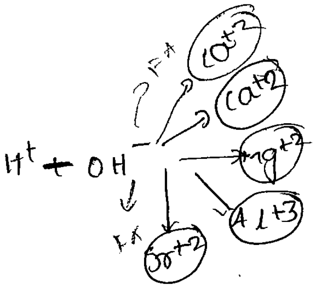
The inability of water for the formation of lather (or) foam when mixed with soap solution due to the presence of divalent (or) Trivalent cations in water is called Hardness.

H_2O + Soap Solution = lather.

↓

[un saturated fatty acids]





H_2O + Soap Solution ≠ lather

-ve charged particles | +ve

CO_3^{-2}

HCO_3^{-2}

Chlorides

Phosphates

→ H^+ ⇒ alkalinity

→ enter in to H_2O in the form of Dissolved salts.

Ca^{+2} + OH^- = hardness

mg^{+2}

Al^{+3}

Sr^{+2}

Measurement of Hardness

versanate method → Quantitative analysis

Soap Test → Qualitative analysis.

H_2O + EBT ⇒ wine red colour

↓

(Erichroom Black T)

⇓

Titrant [EDTA] — Ethylene diamene tetraacidic acid

⇓

blue.

$\boxed{\text{EDTA consumed volume} = \text{Hardness in [mg/l]}}$

Allowable Hardness in drinking water = 75 – 150 ppm

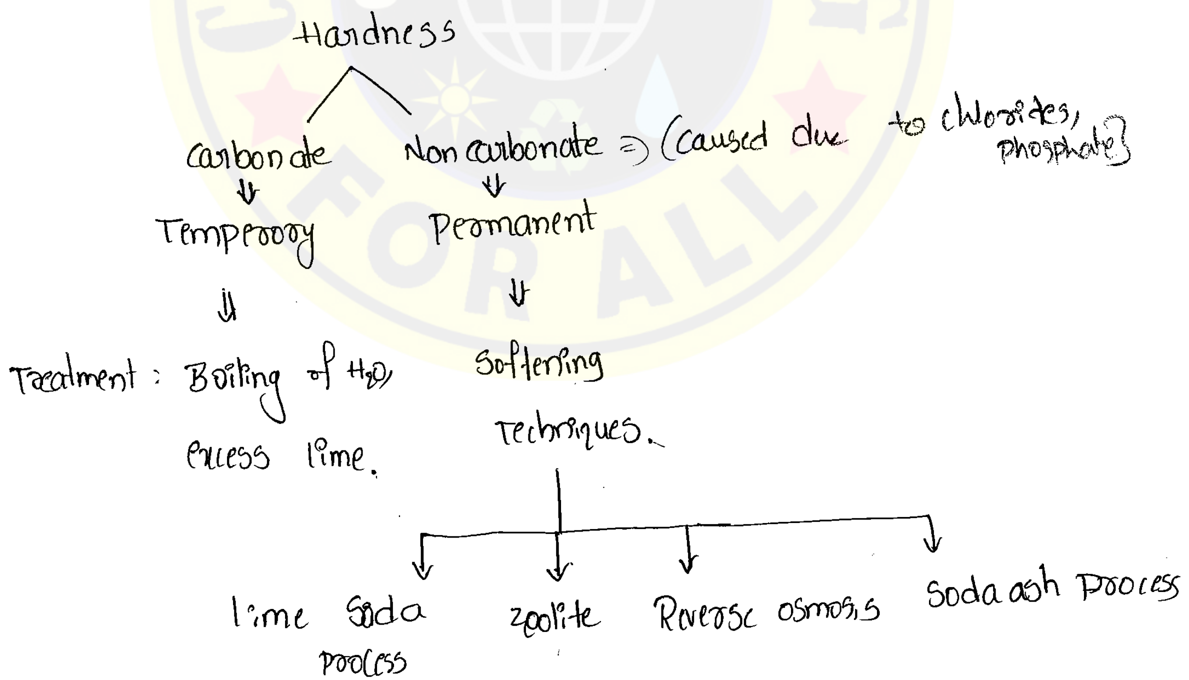
Industrial water = < 70 ppm.

$$\text{Total Hardness} = \underset{(mg/lt)}{Ca^{+2}} \times \frac{eq.wt\ CaCO_3}{eq.\ wt\ Ca^{+2}} + \underset{(mg/l)}{Mg^{+2}} \times \frac{Eq\ wt\ of\ CaC}{eq\ wt\ +\ Mg^{+}}$$

$$\boxed{T.H = \underset{(mg/lt)}{Ca^{+2}} \times \frac{50}{20} + \underset{(mg/l)}{Mg^{+2}} \times \frac{50}{12}}$$

If Al^{+3} concentration is given, then

$$\underset{\substack{mg/l \\ CaCO_3}}{T.H} = \underset{mg/lt}{Ca^{+2}} \times \frac{50}{30} + \underset{(mg/l)}{Mg^{+2}} \times \frac{50}{12} + Al^{+3} \times \frac{50}{9} + Sr^{+2}\ \frac{50}{48.2}$$



① Lime Soda Process :— $CaO + CO_2 \xrightarrow[\text{tank}]{\text{softening}} CaCO_3 \rightarrow$ crystals → sludge

Dis. advantage :— ① very difficult to Separate sludge (very smooth p

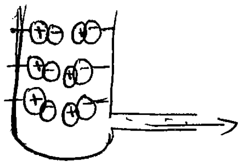
② zero hardness in not achieved.

Imp

② Zeolite Process

[Zeolite process is also called as "zero hardness or 100% removal of Hardness" or IonExchange process"]

Zeolite Resin



Mostly used softening technique for removal of Hard ness is zeolite process.

③ Riverse osmosis

Semi permeable membrane

zero Hardness but ~~EBt~~ EBT also removed. so it is not used.

④ Soda Ash process

cao + Fly ash + CO_2 → sludge formation, 75% Hardness removed.

Hardness TH= CH + NCH

CH & NCH

Relation b/w TH & TA

Total Hardness , Total alkalinity

Relation	CH	NCH
TH > TA	TA	TH - TA
TH ≤ TA	TH	zero

effects

① Corrossion of pipe lines

② Scale form

③ Bitter Taste

④ Increased laundry expenses.

5/05/2015

Eg:- A water sample analysis reveals the information about concentration of various chemical ions as fallows

Ca^{+2} - 40 mg/l , mg^{+2} -60 mg/L, Na^{+} = 24 mg/l, OH^{-} -16 mg/l

HCO_3^{-} =122 mg/l , SO_4 - 100 mg/l, PH = 7.50

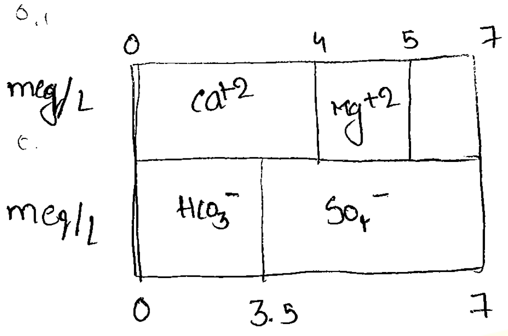
Estimate Carbonate and Non carbonate hardnes

$$T.H = Ca^{+2}\frac{50}{20} + Mg^{+2}\frac{50}{12} = 40\times\frac{50}{20} + (60)\times\frac{50}{12} = 350 mg$$

$$T.A = CO_3^{+2}\frac{50}{30} + HCO_3^{-2}\frac{50}{61} = 0 + 122\times\frac{50}{61} = 100 mg$$

T.H > T.A = CH = TA , CH = 100mg/l . NCH = 350-100 = 250

* The information regarding ionic composition of a river water Sample is given in the fig below. Estimate carbonate hardness and Non carbonate hardness.



m eq/L = milli equivalent / Lit

$Ca^{+2} = 4$ m eq/lt, $Mg^{+2} = 1$ meq/ltr, $HCO_3^- = 3.5$ m eq/l.

m eq/L $\times 10^{-3}$

↓

eq/L

↓

$x[mg/l] = x[eq/L] \times eq.wt\ \cancel{of}\ x \times 10^3$ (or) $x[mg/l] = x[eq/wt] \times 50$

$T.H = Ca^{+2} \times \frac{\cancel{mg}50}{20} + Mg^{+2} \times \frac{50}{12}$

$T.A = CO_3^{-2} \times \frac{50}{30} + HCO_3^{-2} \times \frac{50}{61}$

Ca^{+2} = 4 m eq/lt = 4×50 = 200 mg/l

Mg^{+2} = 1 m eq/lt = 1×50 = 50 mg/l

HCO_3^{-2} = 3.5 m eq/lt = 3.5 × 50 = 175 mg/l

$$T.H = 200 \times \frac{50}{20} + 50 \times \frac{50}{12} =$$

$$T.A = 175 \times \frac{50}{61} =$$

$$T.H = [4+1] \times 50 = 250 \ mg/l$$

$$T.A = 3.5 \times 50 = 175 \ mg/l.$$

T.H > T.A

CH = 250 mg/l

NCH = ~~225~~ 75 mg/l.

* The concentration calcium chloride in water is found to be 2×10^{-3} mol/lt. Estimate its concentration in mg/l - equivalent to calcium carbonate.

$$CaCl_2 = 2 \times 10^{-3} \ moles/lt$$

$$\downarrow$$

mg/lt

$$\downarrow$$

mg/lt as $CaCO_3$

mol. wt $CaCl_2$

$40 + 2(35.5)$

$= 111$

eq. wt $= \frac{111}{2} = 55.5$

$$x[mg/l] = x[moles/lt] \times mol\ wt\ of\ x \times 10^3$$

$$= 2 \times 10^{\cancel{-3}} \times \cancel{10^3} \times 111 = 222 \ mg/lt$$

$$x[mg/lt]_{eq\ CaCO_3} = \frac{x[mg/lt] \times 50}{eq.\ wt\ of\ x} = \frac{222 \times 50}{55.5} = 200 \ mg/lt \ as \ CaCO_3$$

* In A wtr treatment plant carries an influent water of PH =6 and after treatment discharges influent water of PH =8. Determine the mean PH of water carrying through treatment plant?

Influent $PH = 6 = \overset{H^+}{10^{-6}}$

Effluent $PH = 8 = 10^{-8}$

Mean $[H^+] = \frac{10^{-6} + 10^{-8}}{2} = 5.05 \times 10^{-7}$ moles/lt

Mean $PH = \log_{10} [5.05 \times 10^{-7}] = 6.29$

* Solution A of volume 300 ml, with PH of 7 diluted into Solution B of volume 700 ml with PH 5. estimate PH of diluted solution.

$V_A = 300$ ml,

$V_B = 700$ ml

	volume	PH
Sol. A	300	7
Sol. B	700	5

Diluted $[H^+] = \frac{\text{vol. A} \times [H^+]_A + \text{vol.B} \times [H^+]_B}{\text{Total volume}}$

Diluted $[H^+] = \frac{300 \times 10^{-7} + 700 \times 10^{-5}}{300 + 700} = \frac{1000 \times 10^{-7}}{1000}$

Diluted $[H^+] = 7.03 \times 10^{-6}$ mol/lt.

$PH = -\log_{10}[7.03 \times 10^{-6}] = 5.15$

* The Concentration of Ca^{+2} ions is measured as 12 meq/lt and mg^{+2} 18 × meq/lt. Estimate Total hardness.

$T.H = [12+18] \times 50 = 1500$ mg/lt as $CaCO_3$.

+ For the formation of calcium carbonate it was found that 60 gm of calcium is required. Estimate how much quantity of CO_3^{-2} is required to form ~~CaCO~~ $CaCO_3$.

$Ca^{+2} + CO_3^{-2} \longrightarrow CaCO_3$

60gm + ?

(mol. wt of Ca) 40 parts ⟶ 60 parts ⇒ $\frac{60 \times 60}{40} = 90$ gm of carbonate is required.

N₂ compounds

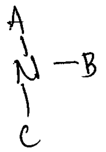
a) Ammonia N_2 :

Fresh pollution in water.

Allowable Conc. of Ammonia N_2 = up to 0.15 ppm

zero stage of decomposition

b) albuminoid or organic Nitrogen : 1st stage of decomposition.



take 8 hrs to start conver

Ammonia N_2 — Albuminoid

Allowable = 0.3ppm

Imp

$$\boxed{\text{Ammonia } N_2 + \text{organic} . N_2 \longrightarrow \text{KJELDAHL } N_2.}$$

$\downarrow$ 60% $\downarrow$ 40%

c) Nitrites

Nitrogen composed which half decomposition N_2.

2nd stage decomposition.

Not allowable in water.

Conc. zero

d) Nitrates

Fully decomposed N_2.

Allowable limit up to 45 ppm.

"BLUE BABY DISEASE" [METHAEMOGLOBINEMIA]

(fuel) energy O_2 + Haemoglobin (carrier)

$\Downarrow$

oxy-haemoglobin

$N_2 + Hb \rightarrow Met\ Hb$

(12 hrs)

Air light $<$ N_2 / $Hb + O_2 \rightarrow$ oxy-haemoglobin

with in 12 hours if it is observb if not observed

with in 72 hours baby death.

* FLUORIDES

* Estimated by colorimetry
↓
Zirconium spades solution.

* Allowable = 1.5 ppm

* Effects = ① Fluorosis.
② Yellow Stains on teeth.
③ Dental cavities [children]

* Excess — Deflouridization
Nalgonda technique

* chlorination → coagulation → sedimentation.
↓ Bleaching Powder
↓ Alum

Imp
* Sulphates

⇒ up to 250 mg/l

⇒ >250 mg/l → "Diarrhoea"
"Digestive problems".

Estimation → Titrymetry

H_2O → potassium chromate
↓
$\boxed{\text{Yellow}} \xrightarrow[\text{(Titrant)}]{\text{Silver nitrate}}$ Brick red.

Conc. of Sulphates = vol. of Silver nitrates only.

* chlorine

Allowable = 0.2 - 0.3 ppm → Future contamination

→ chlorine is enter in to water due to excess chlorination

addition of more Bleaching powder → Disinfection.
↓
(45-55% chlorine present)

Cl_2 → mg/lt

vol. of H_2O → Cl_2
↓
(B.P) + Residual B.P (IS 10500)
⇓
30 min
⇓
Estimation of Cl_2

Excess Cl_2 :-

① Permanent hardness

② Bitter taste

③ Throat infection

④ ↑es laundry expenses.

less Cl_2 :-

① Harmfull microbes

② H_2O Borne Diseases

③ Half decomposed organic matter.

Estimation of Cl_2 : Titration

H_2O + Starch + KI (potassium iodide)

⇓

Starch iodide sol.

Blue colour complex

⇓ Titrant sodium thiosulphate

Colourless.

Conc. of Cl_2 = 0.65 x vol. of Sodium thiosulphate

BIOLOGICAL QUALITY ANALYSIS

- * Give information about microbial concentration present in water
- * H_2O Borne Disease.
- * Microbes

Bacterial

Algae
Fungi → harmless in water — bcoz
- Food Borne Ex cholera
- air Borne

Virus

Protozoa

H_2O Borne Disease

① Cholera → caused by ~~virus~~ vibrio cholera

② Typhoid → Salmonella typhi or)

" Para typhi

③ Diphteria → corynebacterium diphtheriae

④ Dysentry → schizella dysentrya

Virus ⑤ Polio → polio myelitis

⑥ Jaundice → Hepatitis

⑦ Amoebiasis → Entamoeba histolytica → Protozoa

Quality Analysis < Plate count method → nutrient agar media.

Membrane filter technique → M-endo media.

⇓

To identify the presence of harmful microbes.

Pathogenic indicator organism.

⇓

Coliform Bactera

B-coli E-coli

Bacillus coli Eschrichia coli

Coliform bacteria present — harmfull microbes present.

Quantity Analysis — ① MPN count

② E-coli Index.

MPN count — ① Presumptive test

② Confirmative test

③ Dilution expt.

based on

$$\boxed{\text{MPN count} = \text{MPN Index value} \times \text{Dilution factor}}$$

$$\boxed{\text{Allowable MPN in water} = 1 \text{ per } 100\text{ ml}}$$

E-coli Index — 1 per 100 ml

More than 1 per 100 ml

⇓

Treatment

Filtration → To reduce MPN

Disinfection → Kill harmfull microbes

TREATMENT OF H_2O

- * Excess conc. → Removal   Sources
- * Deficit conc. → Addition

⇓

Potable H_2O

IS 10500

Treatment of H_2O

- Unit operations
  - ⇓ Physical
    - ⇓
    - ① Sedimentation
    - ② Filtration
    - ③ Boiling of water
    - ④ UV → Reverse osmosis
- Unit process
  - Chemical
    - ⇓ coagulation
    - Chlorination
    - ozonization
    - softening techniques
    - Aeration
  - × Biological → micro organisms

Physical forces

① Gravitational forces

② capillarity forces

③ Hydrostatic forces

Sources of H_2O :- Surface water Treatment

Largely polluted

- Organic
- Inorganic

River, Canal, Pond, Lake

Screening :-

⇒ piece of old cloth

Floating matter ⇒ [Papers, rag, vegetable matter, carry bags]

↓ Type I settling

Sedimentation :- Suspended solids

↓

Coagulation :- Colloids

↓

Filtration :- Dissolved solids, Reduce bacterial load.

↓

Disinfection :- To kill harmfull microbes.

⇓

Distribution

Sedimentation (plane sedimentation/primary sedimentation)

↓ Type II settling

Coagulation

↓

coagulation

↓

flocculation

↓

Sedimentation (Secondary sedimentation)

↓

filtration

* Ground H_2O Treatment :-

* DO ↓ (less)

* Carrying Permanent Hardness (↑)

Screening

⇓

AERATION → To increase DO

⇓

Softening methods → To reduce hardness

Filtration → Dissolved solids, Reduce bacterial loads

↓

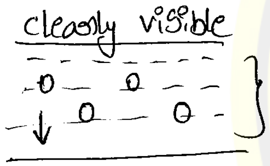
Disinfection → To kill harmfull microbes

↓

Distribution system

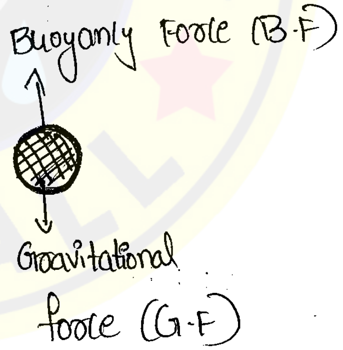
Sedimentation

The physical unit operation for the removal of suspended solids in which the particles are allowed to settle down in the sedimentation tank by virtue of their self weight & density is called Sedimentation.



Submerged condition → Sed. tank.

(not flowing & not settled)



① Turbulance → laminar flow

② $V_f > V_s$ → $V_s > V_f$.

Settling → G.F > B.F

Floating → G.F < B.F

Suspended → G.F = B.F

Type I Settling :-
⇓
Discrete Particle (Properties Do not change)

* The Particle whose dimensions are not altered while Settling are rasing in a fluid and it travels with the original dimensions is called Discrete particle and type of settling is called Type I settling.

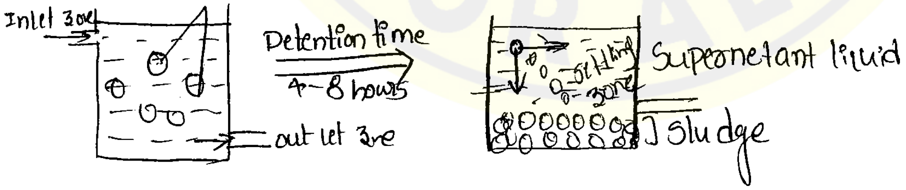
Sedimentation

① Batch Sedimentation

② Continuous Sedimentation

Batch

Continuous S.S



Clarifiers → ① Inlet zone

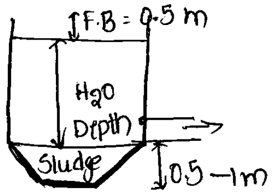
② Settling zone

③ Sludge zone

④ Outlet zone.

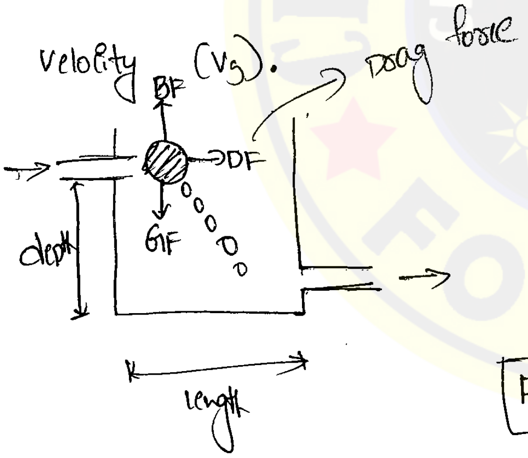
Shapes

Rectangular   circular   Hooper bottom



Settling velocity (V_s)

The velocity with which the suspended particle settles down in the bottom of sedimentation tank before the volume of water reach the outlet is called settling velocity (V_s).



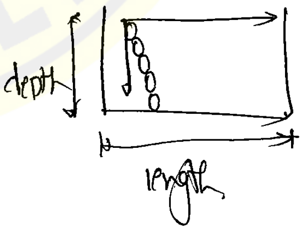
$$G.F > B.F$$

$$F_{Net} = GF - B.F$$

$$\Downarrow$$

Drag Force

$$\boxed{F_{Net} = DF}$$



$\boxed{V_s : \text{Settling velocity depends on diameter of particle}}$

Ⓘ Based Diameter of Particles

① Dia of particles $\leq 0.1mm$

$$\boxed{v_s = \frac{g d^2}{18 \mu}\left[\rho_p - \rho_w\right]}$$

where, $g \rightarrow$ gravity $\rightarrow 9.81$

$d \Rightarrow$ Dia of Susp. Particles in m

ρ_p = Density of Particle

ρ_w = Density of water

μ = Dynamic viscosity N-sec/m2

② Strokes law is valid.

(2) Dia $\leq 0.1mm$

$$v_s = \frac{g d^2}{18 \nu}\left[S_p - 1\right]$$

ν = Kinematic Viscosity = m²/sec

S = Specific gravity of particle.

d = Dia in m.

$$\boxed{S = \frac{\rho_p}{\rho_w}}$$

$\rho_w = 1000$ kg/m3

③ Dia $\leq 0.1mm$

viscosity values are not provided.

⇓

Temperature Dependent.

$$\boxed{v_s = 418\, d^2 [S-1] \left[\frac{3T^\circ + 70}{100}\right]}$$

Dia in mm.

II. Dia of particle 0.1>d<1 mm

[0.1 mm - 1mm]

$$V_s = 418d\,[S-1]\left[\frac{3T+70}{100}\right]$$

III. Diameter of particle ≥ 1mm

$$\boxed{V_s = 1.8\sqrt{gd\,[S-1]}}$$

d = dia in mm

In Grit chambers ⇒ Sewage Treatment ⇒ this formula used.

V_s
↓
Dia = 1mm
100% settled.

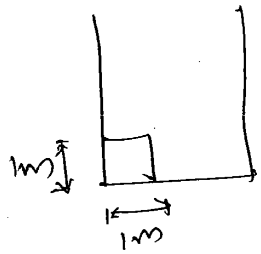
Design concepts

① over flow rate / over flow velocity / Hydraulic Loading Rate [V_o]

The volume of water loaded in to the Sedimentation tank per unit surface area of the tank per unit time duration is called as over flow rate.

unit area }
unit time } vol. of water loaded.

volume of wtr / time / Surface area
hr m²



$V_o = Q/SA$

* Rectangular $v_0 = \frac{Q}{LB}$

Circular /Hopper bottom $v_0 = \frac{Q}{\frac{\pi}{4}(d)^2}$

units : $m^3/hr/m^2$

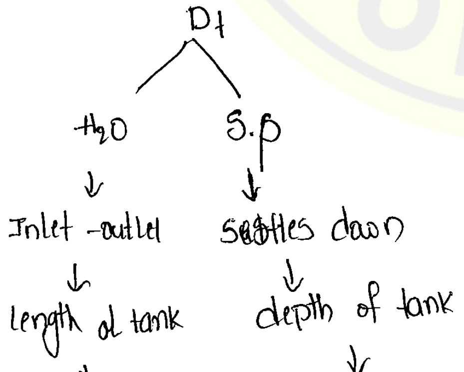
$lt/hr/m^2$

* plain Sedimentation $v_0 = 500-1000\ lt/hr/m^2$

② Detention Time (D_T) or hydraulic retention time [Dt]

The time taken by the water molecules to travel from inlet to outlet of sedimentation tank. i.e to travel the entire length of sedimentation tank. (or)

The time taken by the suspended particles to settle down in the bottom of sedimentation tank by travelling the entire depth of tank.



$D_t = \frac{\text{length}}{V_H}$ $\quad$ $D_t = \frac{\text{depth}\,[H]}{V_s}$

$$\boxed{D_T = \frac{L}{V_H}} \qquad \boxed{D_T = \frac{H}{V_s}}$$

$\boxed{100\% \text{ Settling of particles } D_{t\,water} > D_{t\,SS}}$

$\boxed{D_{t\,H_2O} = D_{t\,S.S}}$ → Suspended Particles

$$\frac{L}{V_H} = \frac{H}{V_S}$$

$$\boxed{V_S = \frac{H}{L} \cdot V_H}$$

* $D_t = \frac{\text{volume}}{\text{Discharge}}$

$$D_t = \frac{V}{Q}$$

* Plain Sedimentation (D_T) = 4-8 hours.

* Secondary Sedimentation (D_T) = 2-4 hours

③ <u>velocity of flow of H_2O / Horizontal flow water velocity</u>.

The Speed with which the volume of water will travel from inlet to outlet of Sedimentation tank with in the given Detention period is called horizontal flow velocity (V_H).

$$V_H = \frac{\text{Distance traveled by } H_2O}{\text{Detention Time}}$$

$$V_H = \frac{\text{Length}}{D_T}, \quad \boxed{V_H = \frac{L}{D_t}}$$

$$D_t = \frac{V}{Q},$$

$$V_H = \frac{L}{D_t}$$

$$V_H = \frac{L}{V/Q}$$

$$V_H = \frac{Q\cancel{L}}{\cancel{L}BH}$$

$$\boxed{V_H = \frac{Q}{BH}}$$

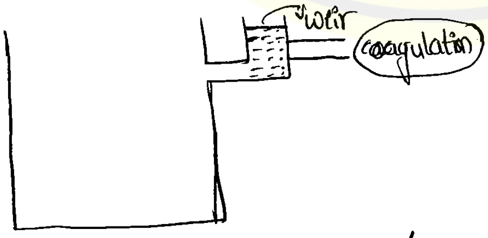
④ Efficiency of Sedimentation

$$\eta = \frac{V_S}{V_O} \times 100 \qquad V_S = V_O$$

$$\boxed{\eta = 100} \qquad Dt_{H_2O} > Dt_{SS}$$

⑤ Weir loading Rate:

The volume of water loaded in to the weight per unit time duration per unit length of weir after completion of Settling of Suspended particles is called weir loading Rate.



vol. of water loaded in unit time duration / length.

$$\boxed{WLR = Q_w / L_w} \qquad \boxed{WLR = Q_w / \pi D}$$

Rectangular   Circular

General Design Consideration

① L = 4B, L = 5B

② Depth : 3-5m

③ FB : 0.5m

④ Sludge depth & Sludge concentration & Suspended Concentration.

⑤ Volume $= D^2\,[0.011D + 0.785\,h] \rightarrow$ Circular / Hopper Bottom.

$D = \phi$ of tank

$H = H_2O$ depth

Problems

① Two Particles of ϕ 0.4mm, 0.9 mm released in to water at the same time assuming the density of particles is same. Determine V_s ratios b/w Particle A to B.

$V_s =$

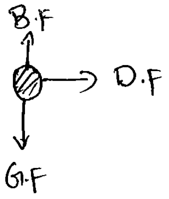
$\phi_A = 0.4mm$, $\phi_B = 0.9mm$

$V_s = \cancel{418}\, d\, [S-1] \left[\frac{3T \cancel{+70}}{\cancel{100}}\right]$

$\frac{V_{SA}}{V_{SB}} = \frac{0.4}{0.4} = 4 : 9$

② A Spherical Particle is released into water located in a settling tank of depth 'H' the particle experiences g.F / Buoyancy & water & also viscous due to the friction b/w water & particle. Give the formulas for two-Dimensio less co-efficient or factors required to Determine V_s.)

Ans:-



① Reynold's number $= \frac{\rho v d}{\mu}$

② Drag coefficient $C_d = \frac{24}{Re}$
↓
Laminar flow

① $\boxed{R_e = \frac{\rho . v . d}{\mu}}$ ② $\boxed{C_d = \frac{24}{Re}}$

Transient flow → 0.4

Turbulent flow → $\frac{24}{Re} + \frac{3}{\sqrt{Re}} + 0.31$

COAGULATION

* Coagulation for < Fine suspended particles.
Colloidal Impurities.

* Defination:- chemical unit process for the removal of fine Suspended solids and colloidal impurities due to the chemical reaction b/w impurities & trivalent aquametallic cations which forms flock followed by Type II Settling is called coagulation.

Trivalent aquametallic cation ⇒ ALUM

+3 ↓ soluble in H_2O ↓ metal ↓ + Al^{+3}

① coagulation ← Impurity + coagulant (+3)

⇓

② Flocculation ← Floc ⇒ Type II Settling → Sedimentation ③

Clari flocculator Tank

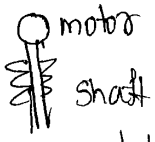
① Rapid Mixing Tank: Coagulation → DT = 2-4 hrs.

1st chamber in clari flocculator.

Alum ⇒ 16-18 mg/L

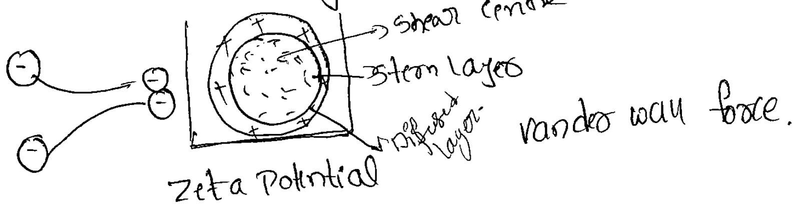
① Alkalinity - act as catalyst

② mixing devices



2-3 min Alum soluble.

Impurity + Coagulant



$Al_2 [SO_4]_3 \cdot 18 H_2O$

$Al_2 [SO_4]_3 \cdot 18 H_2O$ + water = Ionization.

$\swarrow$

$2 AL^{+3} + 3SO_4^{-}$

Design conditions :-

① velocity gradient

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

$G \rightarrow$ 700 - 1000 per sec

P = power applied on shaft

$= \tau \times \omega$

$$\omega = \frac{2\pi N}{60}$$

N = no. of revolutions per minute.

= 4000 - 5000 rpm

μ = dynamic viscosity of water $N\text{-sec}/m^2$

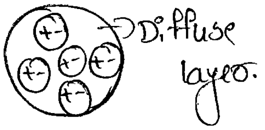
② L = 1.5B

③ D_t = 2-3 mins.

④ Depth = 1-1.5 m

② Gentle Mixing unit :-

Flocculation chambers.



$G \Rightarrow$ 70-100 per sec.

Gt = 800-1000 per min.

white mass
↓
Floc

① L = 2.5 B or 3D

② Depth → 2.5-3m

③ D_t = 20-30 mnts

③ Settling Tank : Secondary sedimentation / Type Ⓘ

① L = 4B or 5B ② Depth = 4-5 m

③ D_t = 2-4 hours ④ V_0 = 1500-2000 lt/hr/m2

velocity gradient $\boxed{G}$ = 0

* Chemical Reaction of coagulation:

$$\overset{ALM}{Al_2[SO_4]_3 \cdot 18H_2O} + \begin{matrix} 3CaCO_3/ \\ 3CaHCO_3/ \\ 3Ca[OH]_2 \end{matrix} \Longrightarrow 2Al[OH]_3 + 3CaSO_4 + 6CO_2 + 18H_2O$$

Alum + Alkalinity + Impurities in H_2O ⇒ Floc + Hardness + CO_2 + H_2O

1 Alum $\longrightarrow$ mol. wt = 666

$\downarrow$

3 Alkaline $[CaCO_3]$ = 3×100 = 300

$\downarrow$

$6CO_2 \rightarrow 6\times44 = 264$

$$\boxed{① * \text{Quantity of Alum [kg/day]} = \underset{\text{Dosage [mg/lt]}}{\text{Alum}} \times 10^{-6} \times \underset{\text{[lt/day]}}{\text{volume of } H_2O}}$$

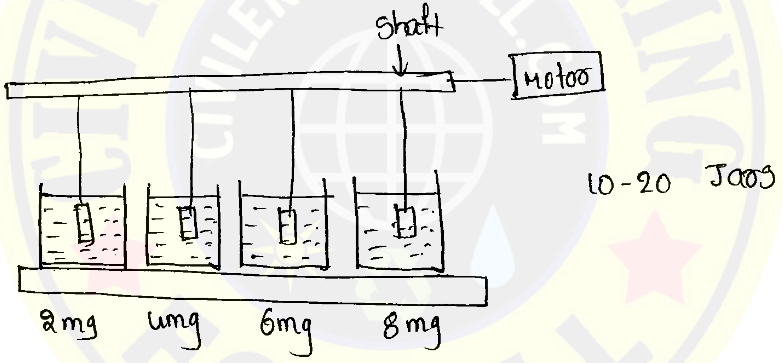
ALUM DOSAGE

Imp

Jar test :

$\boxed{\text{Optimum Dose of coagulant is obtained by Jar test.}}$

Paddle & Shaft



Aliquots of coagulant

2-3 → Rapid mixing

4-20 minute → Gentle mixing

② Quantity of CO_2 Released ; Alum 666 ⟶ CO_2 6×44

[kg/day]

1 kg Alum ⟶ $\frac{6\times44}{666}$ = 0.39 kg ~~[illegible]~~ CO_2 from 1 kg Alum

$$\boxed{\text{Quantity of } CO_2 \text{ released} = \underset{\text{Alum [kg/day]}}{\text{Qty of}} \times 0.39}$$

③ Qty of $CaCO_3$ required [kg/day]

666 → 300
Alum $CaCO_3$

$$1\ kg \rightarrow \frac{300}{666} = 0.45$$

$$\boxed{\text{Qty of } CaCO_3 \text{ required} = 0.45 \times \text{Qty of Alum [kg/day]}}$$

④ Qty of CaO required [kg/day] = 0.56 x Qty of $CaCO_3$

$$\underset{①}{CaO} + CO_2 \rightarrow \underset{①}{CaCO_3}$$

CaO → $CaCO_3$
① ①
56 100
0.56 ← 1 g.

$$\boxed{\text{Qty CaO} = 0.56 \times \text{Qty of } CaCO_3}$$

Quick lime
⇓
70-85% CaO

⑤ Quantity of quick lime required = $\dfrac{\text{Qty of CaO} \times 100}{\text{\% CaO in quick lime}}$

other coagulants

① $FeSO_4$

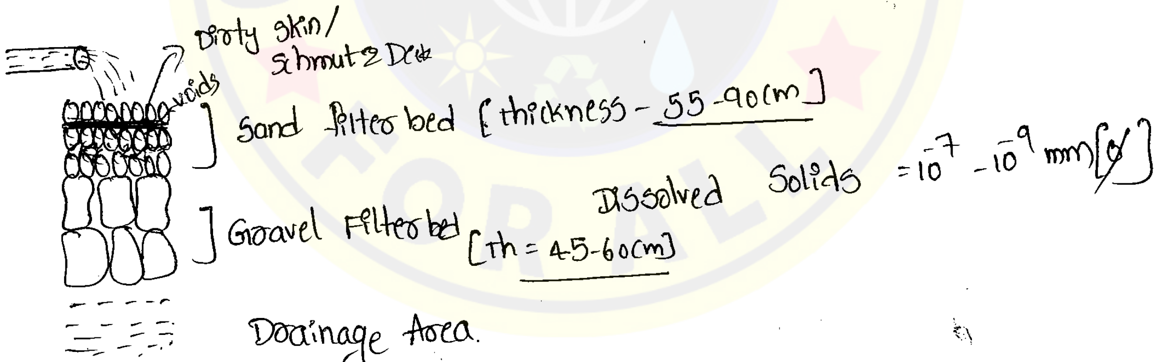
② $FeCl_2$

③ chlorinated copperas

FILTRATION

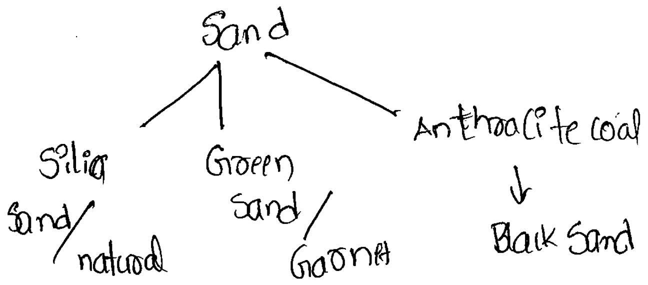
* The physical unit operation in which the volume of water is passed through granular filter beds of sand and gravel which entrap the dissolved solids and bacterial cells to reduce MPN is called filtration.

* Filtration is done to reduce Dissolved solids.
to reduce Bacterial load.



the ~~vertically do~~

Infiltration



Process of Filtration

① Mechanical straining

Sand rough → Mech force Impurities

smooth

① Frictional Force = Mechanical force.

② hydrostatic Force

② Coagulation

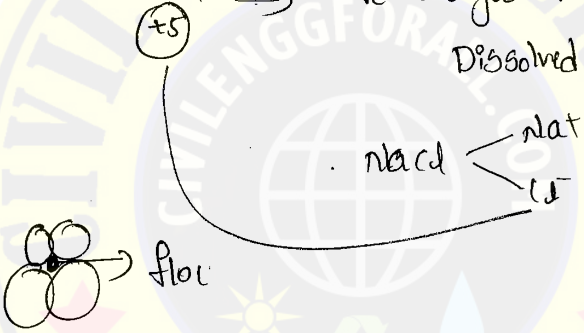
Flocculation

Sedimentation

+ve charged

Silica → -ve charged particles &

Dissolved Solids



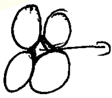
NaCl < Na+ Cl- Ionic form

③ Biological metabolism

after

Befo

(Pore completely filled with flocs) Mechanic Scraping



Microbes

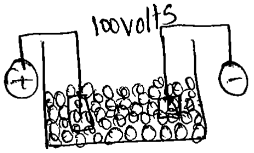
↓ take food

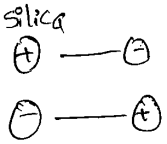
Impurities

↓

releases in the form of ~~gases~~ gases.

④ Electro osmosis





Imp order of filtration

① Electro osmosis

② Mechanical straining

③ Coagulation

④ Biological metabolism.

6/05/15

Design of Filters

① calculation of Discharge :-

vol. of water supplied → Day

Q_{max} = population x PCD x1.8

② Rate of filtration :-

The volume of water loaded into the filtration unit per unit surface area of filter bed in a unit time duration is called rate of filtration.

$$\frac{\text{vol. of wtr loaded}}{\text{unit -1}}$$

volume of H_2O /unit time/Area

lt/hr/m²

① Slow sand Filters
② Rapid gravity filters
③ Pressure filters

Based on [R o F] = Rate of filtration.

$$RoF \propto \frac{1}{\eta}$$

	Slow sand filters	Rapid gravity	Pressure
RoF :	500 – 1000 lt/hr/m²	3000-6000 lt/hr/m²	15000 lt/hr/m²
η :	99%	90%	80%
Thickness : of FB	Sand F.B > Gravel F.B 65-90cm 45-60cm	Sand F.B = Gravel FB 45-60cm	variable

Rapid Sand filter

RoF = 3000 lt/hr/m²

η = 95%

Thickness Filter bd (F.b) → SSF

The standard rate of filtration according to IS water treatment units 3000 lt/hr/m²

	SSF ~~RSF~~	R
Cleaning of Filters	3-6 months mech scrapp	back washing for each round of filtration.

③ Total Surface area for filtration.

$$T.S.A = \frac{Q}{R.O.F} \times 24$$

$$T.S.A = \frac{Q}{R.O.F \times 24} \quad \frac{l/day/}{lt/l\,\cancel{hr}\,l\,m^2}$$

④ No. of filter units

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

Q = Discharge, units Q = MLD

⑤ Individual Surface area of each FB :

$$ISA = \frac{TSA}{No.\ of\ filters}$$

⑥ Design Dimensions :-

a) SSF $L = 2.5B$

$S.A = L \times B$

$= 2.5B \times B$

$B = \sqrt{\frac{A}{2.5}}$

b) RGF,

$L = 1.5B$

$B = \sqrt{\frac{A}{1.5}}$

c) RSF

$L = 2B$

$B = \sqrt{\frac{A}{2}}$

Net vol. of water Released by Filtration from each FB

a) vol. of water → Filtered.

b) vol. of water loss during Initial Period.

c) vol. of water used for BW.

Net vol. of water = Total vol. of H_2O filtered − vol. of H_2O lost during Initial Period − vol. of H_2O for Backwashing

$$\boxed{\text{Net vol. of water} = \overset{①}{\left[ROF \times DOF \times SA_{FB}\right]} \overset{②}{\left[-ROF \times DOL \times SA_{FB}\right]} - \overset{③}{\left[ROB \times DOB \times SA_{FB}\right]}}$$

ROF = Rate of filtration

DOF = Duration of filtration

SA_{FB} : Specific area of Filter bed.

DOL : Duration of loss of water

ROB = Rate of Backwashing

DOB = Duration of " "

$lt / \cancel{hr} / \cancel{m^2} \times \cancel{hr} \times \cancel{m^2}$

$$\boxed{\text{Net volume of water} = \begin{bmatrix} ROF \times DOF \\ \times SAFB \end{bmatrix} - \begin{bmatrix} ROF \times DOL \\ \times SAFB \end{bmatrix} - \begin{bmatrix} ROB \times DOB \\ \times SFAB \end{bmatrix}}$$

eg:

* Design 5 slow sand filters for a water treatment unit which has to supply water for a population of 2 lakhs with a rate of wto supply 4 250 lpcd and assume ROF as 3000 lt/hr/m². Consider out of 5 filters 1 filter is used for back washing.

① Qavg = Population × PCD

= 2 lakhs × 250 lpcd

$$\boxed{250 \text{ lpcd} = PCD \times 1.8}$$

Qmax = Q avg × [illegible]

= ~~900 MLD~~ 500×10^5

= 50×10^6 l/day

$$\boxed{Q_{max} = 50 \text{ MLD}}$$

② ROF = 3000 lt/hr/m²

3000 × 24 lt/day/m²

③ T.S.A = $\dfrac{50 \times 10^6}{3000 \times 24}$ = 694.4 m²

③ No. of filters = 5-1 = 4

④ Individual Surface area = $\frac{694.4}{4} = 173.6 m^2$

⑤ Dimensions :

$$B = \sqrt{\frac{A}{2.5}}$$

$B = 8.33$

$L = 2.5B$

$L = 20.83$

Q:- A water treatment plant has to design a filtration unit with a design loading rate of 2500 $l/hr/m^2$. Design flow rate of 0.5 m^3/sec. Estimate surface area required.

Design flow rate = Q.

$$S.A = \frac{Q}{ROF}$$

design loading rate = 2500

$$= \frac{0.5\ \cancel{m^3} \times 1000\ \cancel{l} \times hr \cdot m^2 \times 60 \times 60\ \cancel{sec}}{\cancel{sec} \times 2500\ \cancel{l}}$$

$S.A = 720 m^2.$

DISINFECTION

[Killing of microbes] ↳ Harmfull

DISINFECTION

- Physical methods ↓
  - ① Boiling of H_2O
  - ② UV Treatment
- Chemical methods ↓
  - ① Chlorination [cheap]
  - ② Ozonization
  - ③ Excess lime treatment [cheap but causes alkaline]

100% Removal of Bacteria → "Sterilization"

  - ④ I/Br pills
  - ⑤ Potasium Permanganate process
  - ⑥ Silver electrode process,

DIS ↓ Removal

Infection ↓ Pathogenic Bacteria

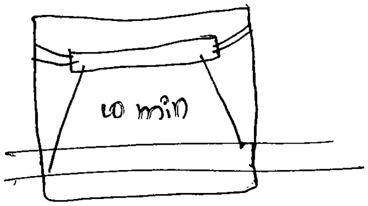
Allowing Harmless microbes

① Boiling of water

Heated above 100°C — 20-30 min

Individual Disinfection – Boiling of water – Most Suitable Method.

② UV Treatment

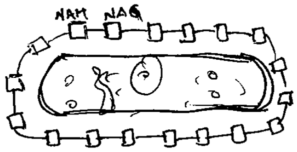


10cm → H_2O thickness

Contact period → UV & Bacteria

1000 nm (or) above.

UV Treatment - cell wall Lysis → Break



Cell wall (chemical layer)

↓

NAG = NAM

↓

β-1,4 Glycosidic bond

NAG = N-Acetyl Glucosamine

NAM = N-Acetyl Muramic Acid

* Used For :-

① Treated H_2O

② Gated Communities

Chlorination → Cl_2 - Disinfect chemical agent

Chlorination - universally accepted Disinfection Process.

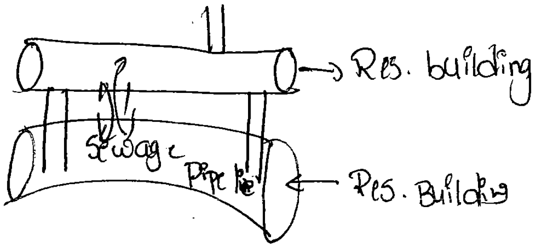
① Economical → cost → (BP) → 45-55% Cl_2

② Efficiency of Kill → 99.9% it is capable of killing. microbes/micro organism

③ Future Contamination

Microbes (100%) | organic (100%)

Yes



chloine, ozone → future contamination
$\downarrow$
cost

$$\underset{Cl \quad Cl^-}{Cl_2} + \underset{H^+ \quad OH^-}{H_2O} \longrightarrow \underset{\text{hypochlorous acid}}{HOCl} + H^+ + Cl^-$$

$$HOCl \longrightarrow \underset{\text{hypochlorite ion}}{OCl^-} + H^+$$

* Cl^- available in TWO forms

pH → 5

① $HOCl$, OCl^- } Freely available Cl_2.

$\boxed{\text{Min. } pH_{wto} \geq 5 \text{ maintain to proform chlorination process}}$

Material

pH = $\boxed{5-7.5}$ → 100% $HOCl$

7.5-8.5 → 50% $HOCl$, 50% OCl^-

$\boxed{8.4-14}$ → 100% OCl^-

$HOCl$, OCl^- } freely available Cl_2

$HOCl$
$\downarrow$
180 times
$\downarrow$
OCl^-

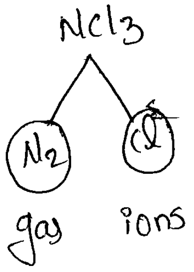
② Combined Cl_2 state

NH_3 (Ammonia)

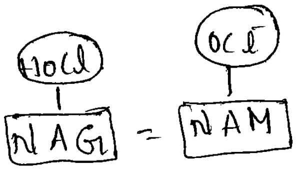
$NH_3 + Cl_2 \rightarrow NH_2Cl$

$NH_2Cl + Cl_2 \rightarrow NHCl_2$

$NHCl_2 + Cl_2 \rightarrow NCl_3$



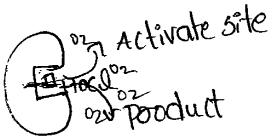
① Cell wall :



$O_2 \longrightarrow CO_2$

24 Reactions

② Enzymatic machinery Blockage.



Green, Stump → Proove above 2 Reasons are valid.

Types of Chlorination

① Pre Chlorination:

The process of chlorination which is carried out before all the methods of water treatment, when the MPN load is found to be very high. is called pre chlorination

$\boxed{MPN > 100/100ml}$

Chlorination → Sedimentation → Coagulation → Filtration → Distribution.
Distribution

② Post Chlorination

The process of chlorination which has been done as the last method of water treatment just before the disposal of water towards Distributary

System is called post chlorination.

~~Sedimentation~~ → coagulation → ~~Filtration~~ → Disinfection
Chlorination

MPN = 1-100/100ml

Sed → coag → Filt → chl → Distribution

③ Double chlorination : The process of water treatment which ~~involves~~ involves pre & post chlorinating method.

Chl → sed → coag – Filt – chl – Distributory

④ Multi chlorination : the process of chlorination which has been done more than 2 times during the water treatment plant.

Fluoride – Nalgonda Technique.

MPN > 1000/100ml

⑤ Super chlorination:-

The process of chlorination which involves addition of excess chlorine concentration of more than 25 ppm which is happend particularly during emergencies. is called Super chlorination.

Dosage of chlorine = 14-16 mg/L

More than 25 mg/l. [Emergency]

⑥ Dechlorination:- The process of removal of excess chlorine content from water using chemicals like activate carbon, Charcoal, Sulphur dioxide, Sodium thio sulphate, Sodium bi sulphate. etc is called Dechlorination.

Residual chlorine → more than 0.2–0.3 ppm.

⑦ Break point chlorination :- The additional chlorination process which is performed to increase the residual chlorine content that has been reached the break point is called Break point chlorination.

① Residual Cl_2 conc $= [-Cl_2$ demand$]$ + chlorine Dosage

or

$$\boxed{\text{Residual } Cl_2 \text{ concentration} = \text{chlorine Dosage} - Cl_2 \text{ demand}}$$

Cl_2 → Dissolved 30 min.

↓ Cl_2 added to H_2O − ↓ Cl_2 required for disinfection.

② Quantity of Cl_2 added [kg/day]

$= Cl_2$ Dosage (mg/l) $\times 10^{-6} \times$ vol. of H_2O (lt/day)

3) Qty of B.P [kg/day] = Quantity of Cl_2 x $\frac{100}{\% \text{ of } Cl_2 \text{ in B.P}}$

② OZONIZATION (O_3)

$3O$ ~~$+ H_2O$~~ High electric

$3O \xrightarrow[\downarrow\downarrow\downarrow]{\text{ac voltage}} 2O_3$

$O_3 \xrightarrow[\downarrow\downarrow]{\text{Ionization of } H_2O} O_2 + \ddot{O}$ → cell wall lysis

→ Residual ozone molecule

(oxy free radical or Nascent-oxygen)

* Costly.

$\boxed{\text{Ozonization – Swimming Pool water treatment}}$

③ Potassium Permanganate :

$\boxed{\text{Potassium Permanganate – well } H_2O}$

$KMnO_4$ → DO↓

→ High Hardness

O → ↑es DO content   Mn → reduce Hardness

④ Iodine / Bromine pills

100% Efficient in killing micro organism.

Emergency

Floods   wars.

Chlorine
Fluorine
Iodine
Bromin } Hallogens

⑤ Excess lime Treatment :

Alkalinity increases,

Excess lime Treatment - Industrial

⑥ Silver Electrode process / Electro Katadyn process

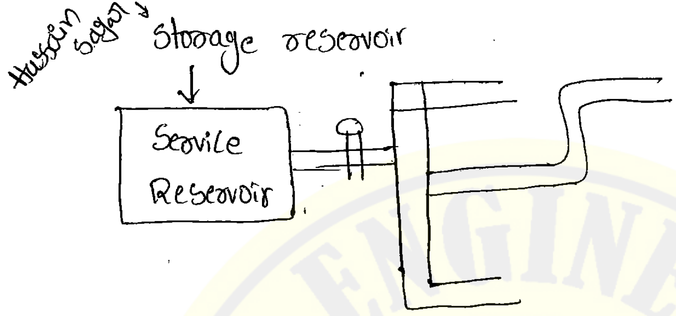
water $\xrightarrow[\text{through}]{\text{pass}}$ Electrolytic cells → Silver ions → cell wall Lysis

Silver

cell wall Lysis

DISTRIBUTION SYSTEM

* The system of conduits containing pipes & pumpes associated with valves, water meter, which are required for supply of potable water from storage reservoir towards public via service reservoirs is called as Distribute system

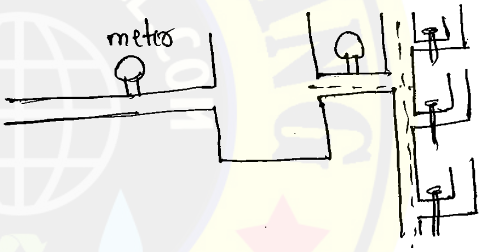


Conduits
- Pipes
- Pumps

valves

H_2O meters

Release valve.



via metering system
↓
No. of meters.

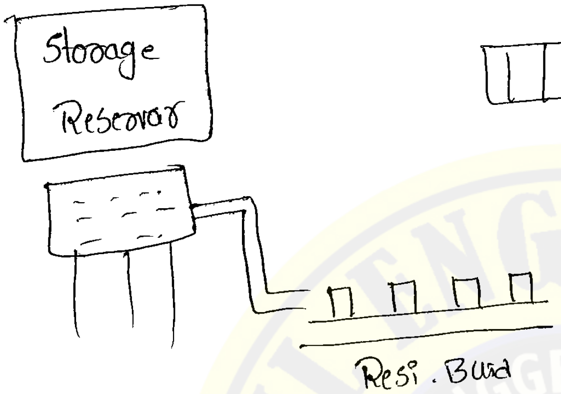
Per meter system

Per liter system

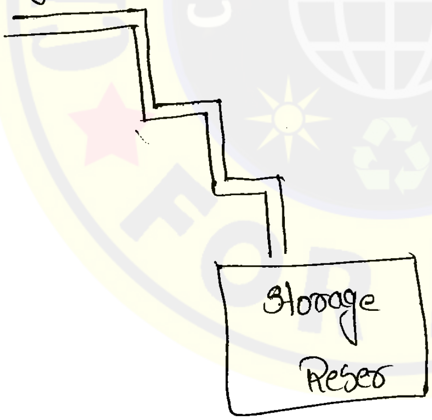
System
- Gravity System
- Pumping System
- Combined System

Gravity System
↓
H_2O flows
⇓
Gravity

Pumping System
⇓
List up H_2O
⇓
Against gravity



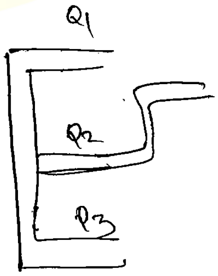
Pipe networking



Pipe networking

Hardy Cross method
⇓
$Q_i = Q_e$

equivalent pipe method
↓ Based upon
head loss



$Q_i = Q_1 + Q_2 + Q_3$

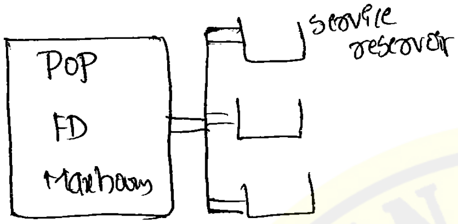
* Capacity of Reservoir = Balancing capacity + Break down Storage + Fire storage

Population

CID

Qmax hour/day

which ever is greater.

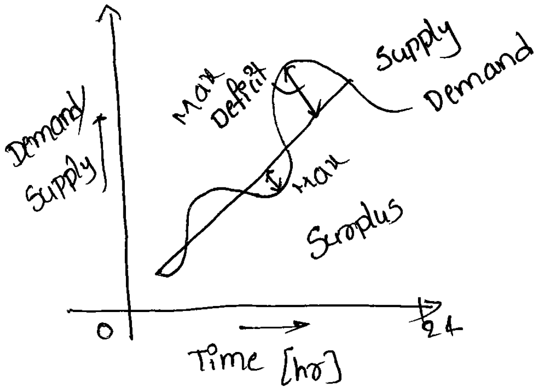


Balancing capacity [B.C]

No. of hours	Supply of H_2O	Demand of H_2O	Supply - Demand Surplus	Supply - Demand Deficit	B.C = Def$_{max}$ + Su
1	20 MLD	10	10		
2	20	16	4		
3	20	24		4	16 20 B.C = 36
4	"	40		20	
5	"	10	10		
6	"	6	14		Balancing Storage = 36
⋮	⋮	⋮	⋮		
24	20	8	16		

Balancing Storage = 36×2

$$\boxed{\text{Balancing Storage} = \text{Max. Deficit} + \text{Max. Surplus}}$$



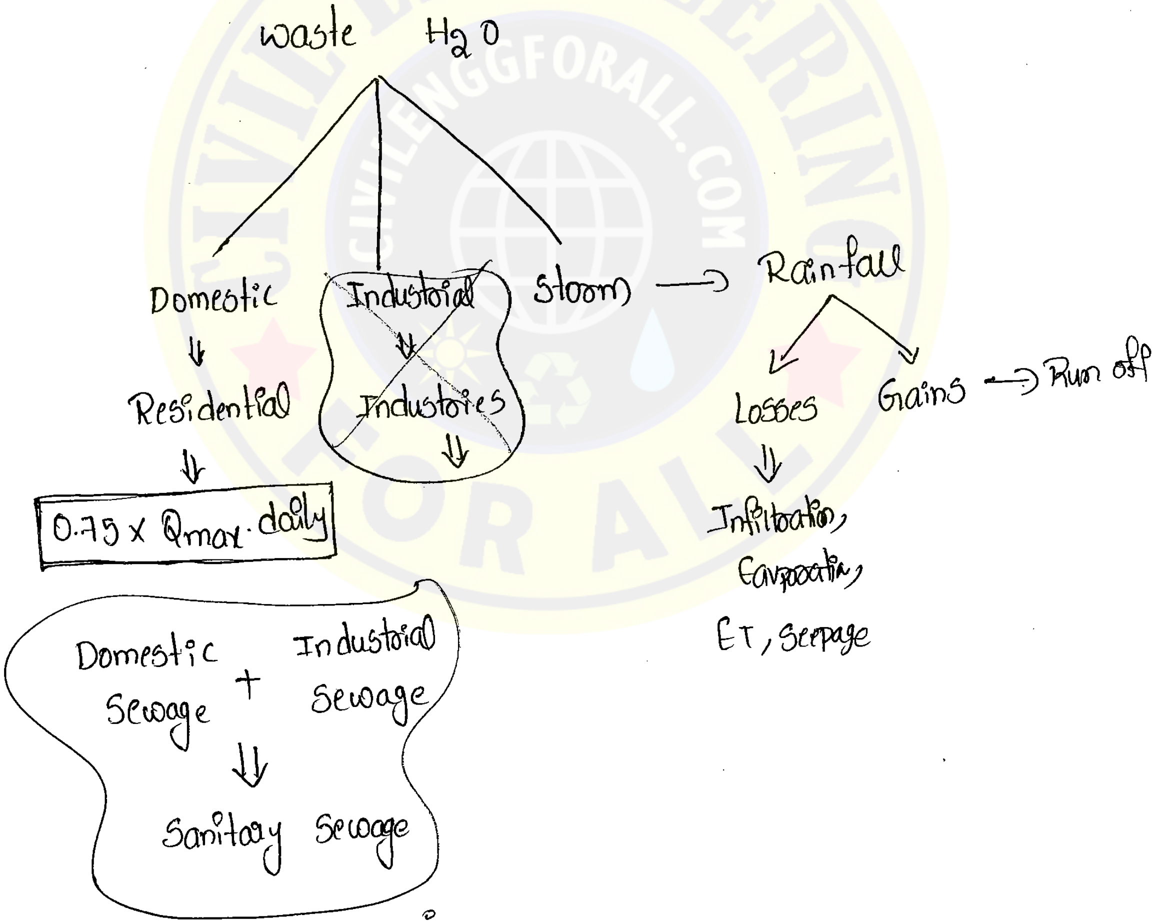
B.c = avg. of curve & table B.c.

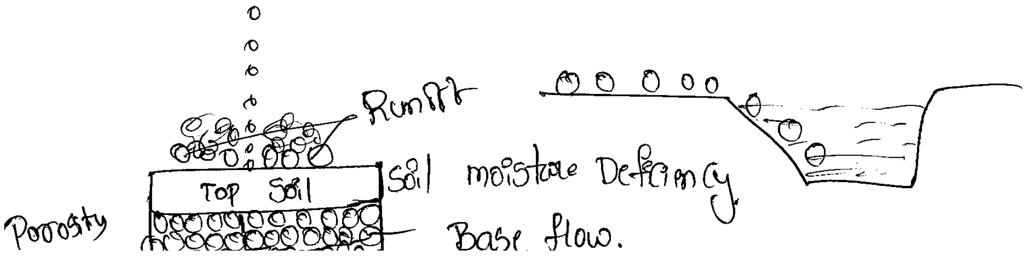
Break down Storage

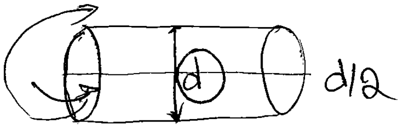
24 hr MLD , •4 hr MLD.

SANITARY ENGG

The branch of Environmental Engg. which deals with the study of design and construction of structures related to "collection, conveyance, treatment and disposal' of various kinds of wastes water released from residential buildings, rain fall & industries to ensure environmental safety & public health. is called Sanitary Engineering.







① Refuse

Any kind of waste material which was dumped into the environment either in solid or liquid or semisolid form which was rejected by humans.

② Rubbish

The inorganic dry solid waste from offices, Institutes. (Particularly stationary waste)

Rubbish → solid – Inorganic

③ Garbage

The organic dry solid waste released from residential building, houses. (dust bins)

Garagage → solid — organic

④ Sullage (Harm less)

The liquid waste released from sinks, bathrooms, Kitchens which is harmless in nature is called Sullage.

⑤ Sewage

Harmful Garbage + Harmless Sullage.

Solid + liquid

Dangerous.

99.9 % liquid waste
0.1 % Solid waste

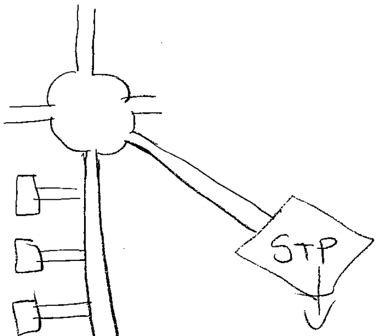
* Systems of Sanitation

Conservation system of Sanitation

⇓

Solid waste

H2O carriage System.



⑥ Dry weather flow [DWF] or [Q_{DS}] → Discharge through Domestic Sewage.

⑦ wet weather flow [WWF]

⑥ Dry weather flow

"Q sewage" from pipe line on a Non rainy day

DWF → from ~~wast~~ Domestic waste.

$\boxed{Q_{DS} = Q_{max} \times 0.75}$ or $\boxed{DWF = Q_{max} \times 0.75}$

⑦ wet weather flow

"Qsewag" on a Rainy day.

$$\boxed{WWF = Q_{DS} + Q_{SS}}$$

Q_{DS} → Discharge through Domestic Sewage

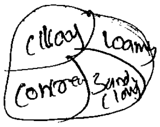
Q_{SS} → Discharge through storm Sewage

Rational Formula

$$\boxed{Q = \frac{AIR}{360}}$$

A = Area of catchment in hectare.

I = Runoff coefficient → $\frac{\text{Runoff}}{\text{Rainfall}}$



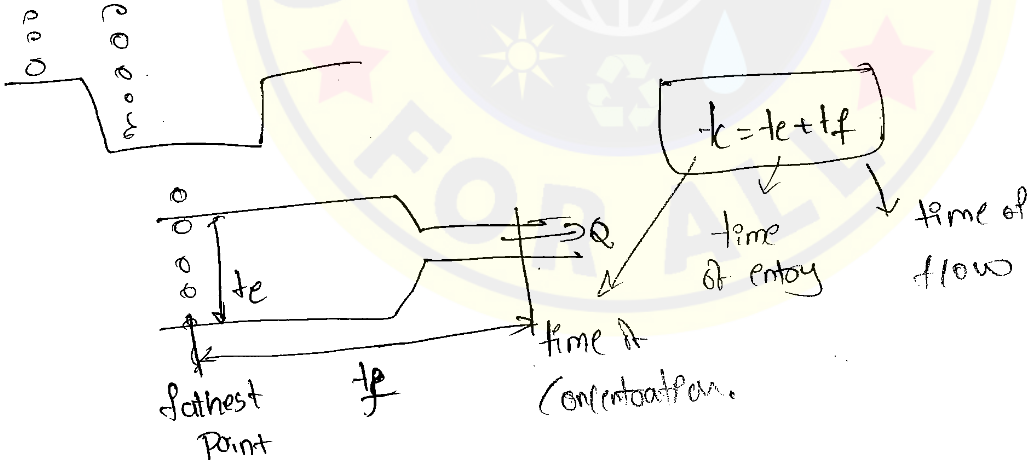
$Q = m^3/sec$.

$$I = \frac{I_1 A_1 + A_2 I_2 + \cdots I_n A_n}{A_1 + A_2 + \cdots A_n}$$

R = Intensity Rainfall = mm/hr.

$$\boxed{R = \frac{20 \cdot a}{t_c + b}}$$

t_c = Time of concentration - which is expressed in min.



$$Q = \frac{AIR}{360}$$

$$R = \frac{20 \cdot a}{t_c + b}$$

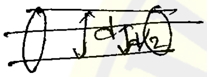
$WWF = QDS + QSS$

$$\boxed{WWF = 0.75 \times Q_{max} + \frac{AIR}{360}}$$

$$Q_{WWF} = 1.5 \times Q_{max} + \frac{AIR}{360}$$

Domestic Sewage → Q → Double
⇓
Sewer pipe

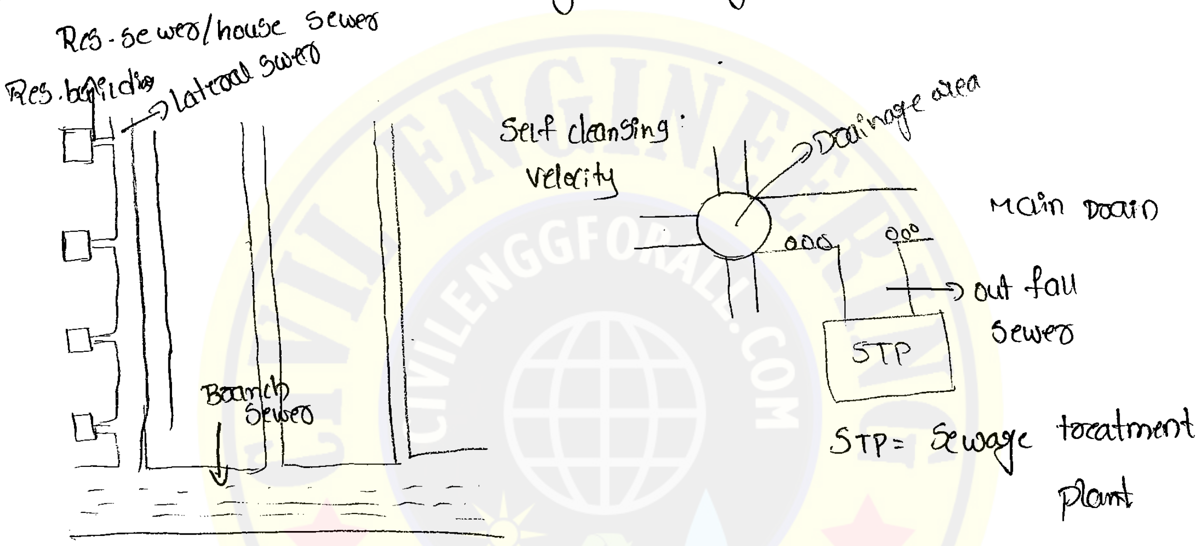
$$\boxed{Q = 2 \times 0.75 \times Q_{max}}$$



Design of Sewers

7/05/14

Sewer :- The conduit which carries domestic waste water from each & every residential building is ~~storm~~ storm waste water from various areas and transfer towards sewage treatment plant along with the separation of impurities during the flow with its self cleansing velocity is called sewer.



$$\boxed{V_{\text{Self cleansing velocity}} = \sqrt{\frac{8k}{f} gd[S-1]}}$$

where k = Sediment coefficient or sediment related factor.

f = frictional factor

Self cleansing velocity :- The velocity provided by the sewage flow by which the settleable solids are allowed to be settle down in the sanitary pipe line while sewage is travelling from drainage area towards sewage treatment plan is called self cleansing velocity.

By considering "open channel flow" sewer is designed.

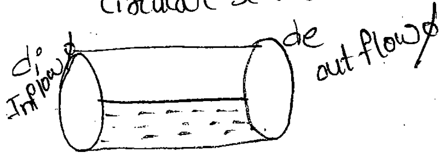
Design period of sewer - 30 yrs - 50 yrs.

Shape → Circular

→ ⊛ Elliptical / Horse shoe

(or) egg shaped sewer.

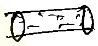
① Circular sewer



Treatment flow → storage res

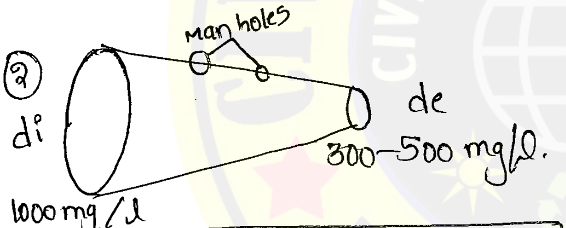
↓

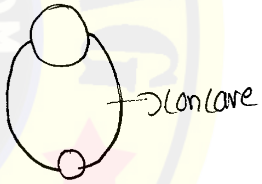
Res. building



di = de = Circular sewer

②





[Horse shaped sewer]

di > de = Elliptical sewer

↓

Runs parallaly

Best suitable method - Elliptical sewer

Conveyance

↓

vol. reduction

Impurity strength reduction

Strength of reduction $\propto$ concentration

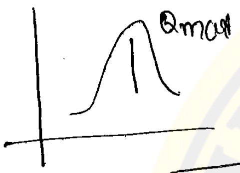
$Q = AV$

$Q = WWF$

$= \overset{\to m^3/s}{Q_{DS}} + \overset{\to m^3/s}{Q_{SS}}$

$$\boxed{Q = 1.5 \times Q_{max} + \frac{AIR}{360}}$$

Max. Day of RF.



$Q = \frac{\pi}{4} d^2 \times$ Manning's formula

$$Q = \frac{\pi}{4} d^2 \times \frac{1}{n} (R)^{2/3} (S)^{1/2}$$

n = Manning's coefficent (depending upon material & pipe construction)

R = d/4 (hydraulic mean radius)

S = Min. Gradient (or Bed slope.)

$$\boxed{Q = \frac{\pi}{4} d^2 \times \frac{1}{n} (d/4)^{2/3} (S)^{1/2}}$$

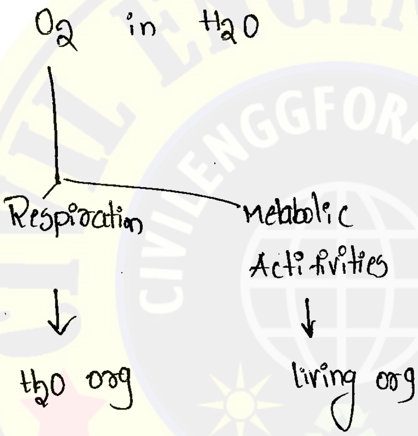
Full flow :-	Half flow :-
$Q = 1.5\ Q_{max} + Q_{SS}$	$Q = \frac{1}{2} Q_{(full\ flow)}$
$R = d/4$	$R = d/4$
$A = \pi/4\ d^2$	$A = \frac{\pi}{8} d^2$
V = constant	v = constant.

Full flow or Half flow velocity is same.

$$\boxed{\text{Min. Dia} = 15cm / 150\ mm}$$

Characteristics of Sewage

[D.O] Dissolved oxygen: The amount of oxygen present in water in a soliblised state that is required for existance of aquatic life in water and also for metabolic activities when the water is consumed by any living organism and is expressed interms of mg/lt. is called as D.O.



units:- mg/l

Saturated DO :- Sufficient DO to perform Respiration & metabolic activities in 1 lt of water.

9.2 mg/l ⟶ 20°c

14.6 mg/l ⟶ 0°c

7.4 mg/l ⟶ 30°

$$\boxed{DO \propto \frac{1}{Temp}}$$

$D.O \propto \frac{1}{Bacterial}$

Actual DO

↓

Present in H_2O

↓

Measured by "Winkler's method"

$$\boxed{O_2 \text{ deficit} = \underset{\text{Required}}{\text{Saturated D.O}} - \text{Actual D.O}}$$

WINKLER'S METHOD

① $MnSO_4 + H_2O$ [Quality Analysis]

(2ml) (100ml)

⇓

20 min

⇓ K.I + conc. H_2SO_4

2ml 2ml

brown colour precipitation

(Rxn b/w Mn & H_2SO_4)

"$Mn(OH)_2$"

DO → absent

"white" colour precipitation

⇓

"MnO_2"

"DO" → "present"

② Quantity Analysis

white precipitation + starch

↓

Indicator

⇓

"Starch Iodide" (Blue colour)

⇓ Titrant → "Sodium thiosulphate"

colourless

$$\boxed{\text{Act. D.O} = \text{vol. of Sodium thiosulphate} \times 0.65}$$

B.O.D :- Bio Chemical oxygen Demand.

- Impurities
  - organic
    - biologically active → Microbial degradation.
    - biologically in active → chlorine & Degradation & chemical
  - Inorganic

Sewage Treatment → Degradation of Impurities → Reduces BOD

O_2

↓

Cababolic Molecules

↓

Lysis or break down

The oxygen required for microbial degradation - is called B.O.D

The oxygen required for "zero" organic matter is called C.O.D

The oxygen required for 'zero' impurities - T.O.D

B.O.D :- The amount of oxygen required to decompose biologically active organic matter by microbial degradation which is measured @ a specific temp & specific time duration using D.O test is B.O.D.

C.O.D :- The amount of oxygen required for the degradation of entire organic matter either it may be biologically active or it may be biologically inactive treated by either microbial degradation or chemical degradation and is measured using Titrimetric estimation.

T.O.D :- the entire amount of oxygen required for the degradation of all the impurities present in sewage by any method of decomposition is called. T.O.D

Th.O.D :- The oxygen demand which is calculated before decomposition is carried out using molecular formulae and chemical equations for decomposition. is called theoritical oxygen demand.

T.O.C :- Total organic carbon.

The Conc. of organic matter which is expressed in terms of Conc. of carbon present in the particular molecule is called T.O.C.

Measurement of B.O.D

Specific Temperature @ 20°C

Specific Duration 5 days.

BOD_5 20°c

BOD measurement : DO test

① Dilution Experiment

Sewage "A" ml + Distilled water "B" ml → Diluted H_2O Sample → (B.O.D test)

Dilution factor ~~experiment~~ $= \frac{A+B}{A} = \frac{\text{Total vol. of Sample of Diluted}}{\text{vol. of Sewage}}$

② Diluted water → D.O test → DO initial

③ Diluted H_2O → BOD Bottles. → Incubator @ 20°c, 5 days → DO Test → Do final.

B.O.D :-

$$\boxed{BOD = [D.O_i - D.O_f] \times \text{Dilution factor}[DF]}$$

$$\boxed{Th.OD > T.O.D > C.O.D > \underset{\substack{\text{ultimate} \\ \downarrow \\ \text{"n" days}}}{B.O.D_u} > B.O.D_{5\,days}}$$

① $BOD_5 @ 20^\circ = L[1 - 10^{-K_D t}]$

L = organic matter Concentration in water.

K = Deoxygenation Constant = 0.23/day at 20°c

t = Time duration in days = 5 days.

20°c → favourable Temperature for microbes.

② $B.O.D_5(20) = L[1-e^{-kt}]$

k = B.O.D rate constant 0.1/day @ 20°c

③ $B.O.D_u = \frac{BOD_5}{1-10^{-k_d t}}$

t = Duration of organic matter degradation.

④ % of Solution is provided

5% of sewage → 5ml sewage + 95 ml $D.H_2O$

Total volume = 100 ml.

Dilution factor = $\frac{100}{5\%} = 20.$

$$\boxed{\text{Dilution factor [D.F]} = \frac{100}{\%}}$$

If DO_{sewage}, $DO_{Dist.H_2O}$, Df. is given.

$$DO_i = \frac{V_S \cdot DO_S + V_{D.H_2O} \cdot D.O_{D.H_2O}}{\text{Total volume.}}$$

eg :- ① A 2% Sewage solution was prepared and sent for D.O Test. DO_i = 7.9 mg/l and Dil_{H_2O} is placed in an incubator @ 20° 5 days after 5 days the final D.O i.e $D.O_f$ = 4.6 mg/l. Estimate ,

B.O.D = $[DO_i - DO_f] \times D.F$

D.F = $\frac{100}{2} = 50$

B.O.D = $[7.9 - 4.6] \times 50 = 165$ mg/l.

② 50 ml of Raw sewage sample is diluted in 450 ml of Dis. water to make it colourless & odour less then the diluted water sample placed in an incubator @ 20°c for 5 days. If the DO of Incubator sample is 0.86 mg/l and D.O of standard Sample is 7.8 mg/l. & D.O on diluted ~~water~~ sample of 0.35 mg/l. B.O.D = ?

$$DO_i = \frac{50 \times 0.86 + 450 \times 7.8}{450 + 50}$$

$$= 7.106 \text{ mg/l.}$$

D.F = 100.86

~~DO_f = 0.35~~

~~DO_f = 6.756.~~

~~B.O.D = 67.56~~

Sewage treatment

- Preliminary Treatment
  - ① Screening
  - ② Racks
  - ③ Grit chambers
  - ④ Detritus Tanks
  - ⑤ Skimming tanks
- Primary Treatment
  - Sediment action
  - coagulation
- *Secondary/ Biological
  - Aerobic
    - Suspended Culture system
      - ① oxydation ponds
      - ② activated Sludge
      - ③ Rotating biological ~~Compaction~~ contactors.
    - contact base System
      - ① Trickling filter
      - ② oxydation ponds
      - ③ biological towers
  - Anaerobic
    - ① sludge ~~digesti~~ digestion & drying
    - ② Septic tanks
    - ③ Imhoff tanks
- Tertiary
  - Chlorination

Preliminary Treatment :—

strength reduction & volume reduction.

after Preliminary Treatment harmfull compounds → STP

Primary Treatment :—

Sedimentation/coagulation (Sewage)
- Sludge → Mixed liquor Suspended solids [MLSS]
- supernatant liquor → contact bed culture

Sludge → MLSS → Suspended culture

Supernatant liquor → contact bed culture

Microbes (Artificial)/added
|
O_2 + Food [Impurities]
↓
Degradation

Secondary/ Biological

Aerobic
[O_2]
end products
$\boxed{CO_2 + \text{Ammonia } NH_3}$

Anaerobic
[Not oxidise O_2]
end products
$\boxed{CO_2 + CH_4 + H_2S}$

An aerobic

CO_2 + Food → O_2 + C_2H_5OH/carboxy acid
⇓
end products = $CO_2 + CH_4 + H_2S$

Aerobic
↓
organic Impurities
MSLL | liquor
↓ Suspended liquid.
Artificial microbes are added to Sewage
↓
ASP
↓
OP

↓ contact base
0000
↓
Trickling
↓
O.P

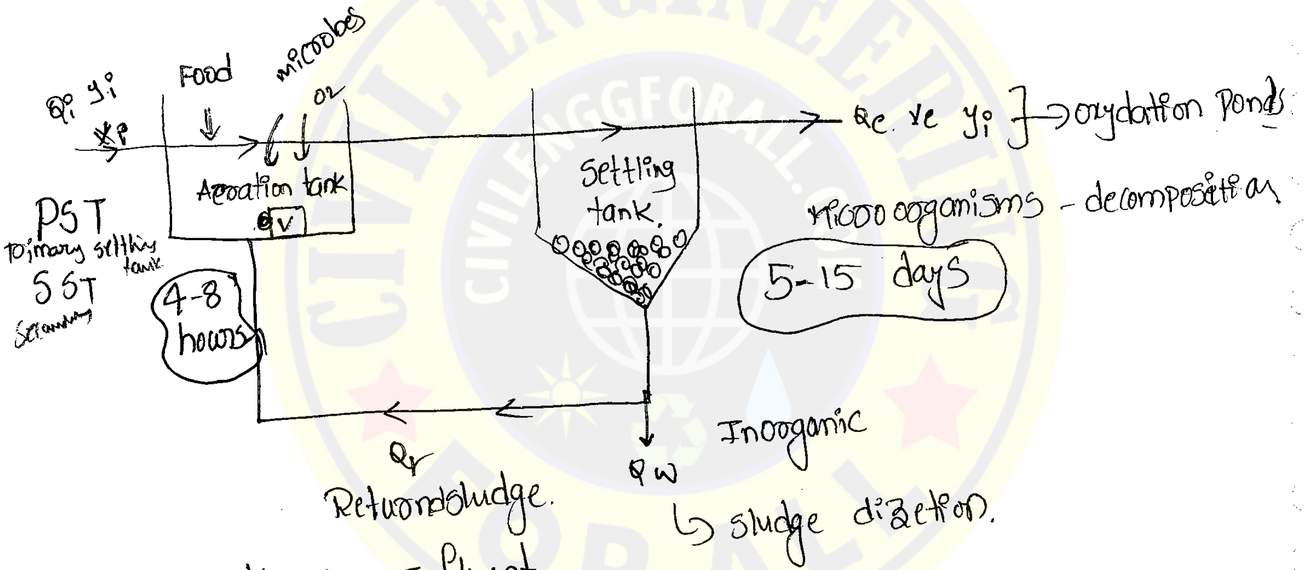
anaerobic

Anaerobic
↓
In organic Impurities
↓
Final treatment → Sludge dizetion & Drying
↓
released as gases, liquid / manure.

This process is continue till

ACTIVATED SLUDGE PROCESS (ASP) — Aeration / Decomposition ↓ settling

* The aerobic biological treatment process using suspension culture system for the treatment of settling sludge, if Primary & secondary settling tanks is carried out through aeration and decomposition of waste by highly active microbes followed by a settling in an imhoff tank is called Activated ~~Slugd~~ Sludge process.



Qi = Discharge Influent.

Amount of B.O.D

yi = Influent B.O.D (mg/l)

Xi = Influent organic matter concentration.

$$\boxed{Q_i = Q_e + Q_r + Q_w}$$

↓ oxy. pond ↓ Aeration ↓ In org. Sludge digestion

① $\eta = \frac{y_i - y_e}{y_i} \times 100$

ASP Perform 90% = η [BOD removal] ASP = 90%

② volumetric loading Rate:

Amount of BOD / time/volume

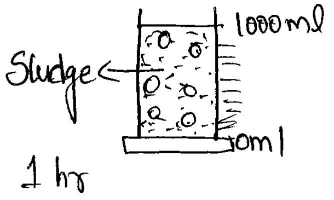
$$V_L = \frac{\text{Total BOD loaded in a given day}}{\text{volume of aeration tank}} = \frac{Q_i \cdot y_i}{V} = mg$$

Q_i = lt/day × y_i × mg/lt

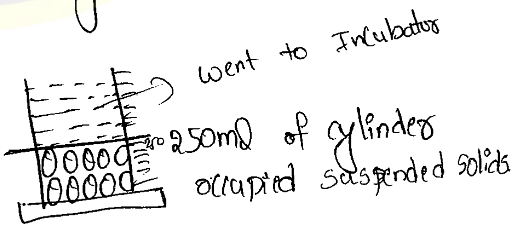
$$\boxed{V_L = mg / day / m3}$$

③ SVI → sludge volume Index

$$\text{Sludge volume Index} = \frac{\text{vol. of Sludge settled in ml}}{\text{weight of MLSS in gm.}}$$



after 1 hour



wt of dry sludge → 50gm

$$SVI = \frac{250}{50} = 5 \text{ ml/gm.}$$

④ θ_c = Mean Cell Residence time $= \dfrac{\text{Amount of solids loaded}}{\text{Amount of solids wasted/day}}$

$$\theta_c = \frac{Q_i \times x_i}{Q_e \cdot x_e + Q_w \cdot x_t}$$

$$\boxed{\theta_c = \frac{Q_i \times x_i}{Q_e \cdot x_e + Q_w \cdot x_t}}$$

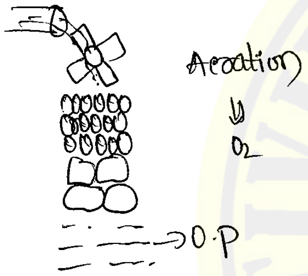
5-15 days

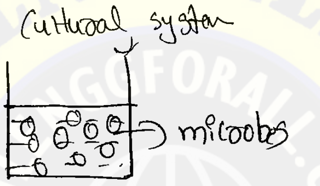
$\boxed{\text{Detention time period of ASP = 5-15 days.}}$

TRICKLING FILTERS

The aerobic biological treatment using contact bed stabilization in which the water is passed through filter beds layered with highly active micro organisms which are used to convert the dangerous sulphur and nytrogen compounds in to inorganic matter is called Trickling Filter treatment.

Superanatant liquor → filter bed → Highly active aerobic microbes → S/N_2 ⇓ Inorg





⇓ 24 hour 20°c Incubator

microbial filter

T.F

Low Rate T.F — RoF — 3000- 4000 lt/hr/m²

High Rate T.F — RoF — 6000 lt/hr/m²

Convention T.F — RoF

$$\eta = \frac{y_i - y_e}{y_i} \times 100$$

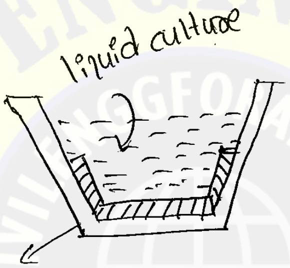
$$\eta = \frac{100}{1 + 0.011\sqrt{u}}$$

u = organic loading Rate
kg/hr/ha-m
kg/ day/ ha-m.

OXIDATION PONDS

An artificially constructed earthern basin in which aerobic biological treatment using both contact bed and suspention culture system is carried out to perform degradation of organic impurities due to symbiotic relationship b/w algae & bacteria are called oxydation ponds.

waste H2O
from
SST
ASP
TF
} send in to



clay material ~~earthern~~
is used for
bed, side slopes

earthern pond.

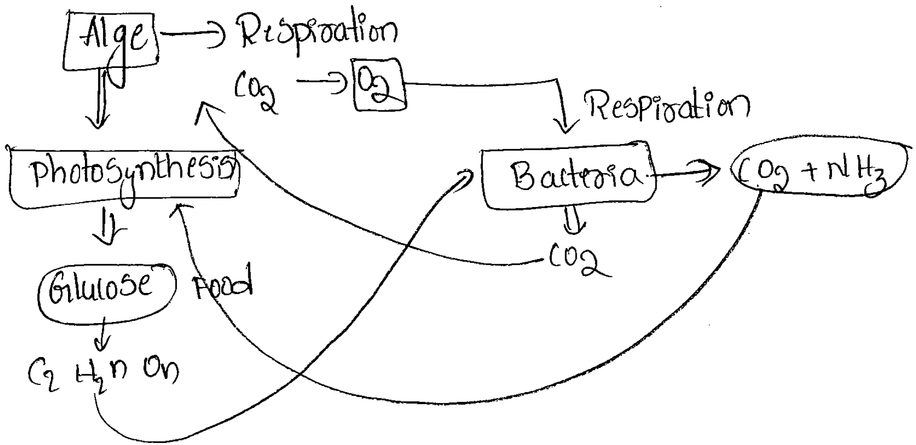
oxidation ponds
- Suspension culture
- contact bed

$\eta = 99\%$

Algae + Bacteria } Symbiotic Relationship

↓

Mutual binifit b/w any two organisms.



Dention time = 3-6 Months

Oxidation Ponds

① Aerobic oxidation ponds → O_2 present. → Aerobic degrad

② An aerobic oxidation ponds → O_2 absent → Anaerobic degrad

③ Facultative oxidation ponds →

An aerobic → phosphate / Industrial waste H_2O. ~~with metalisk~~ with metal ions

Facultative

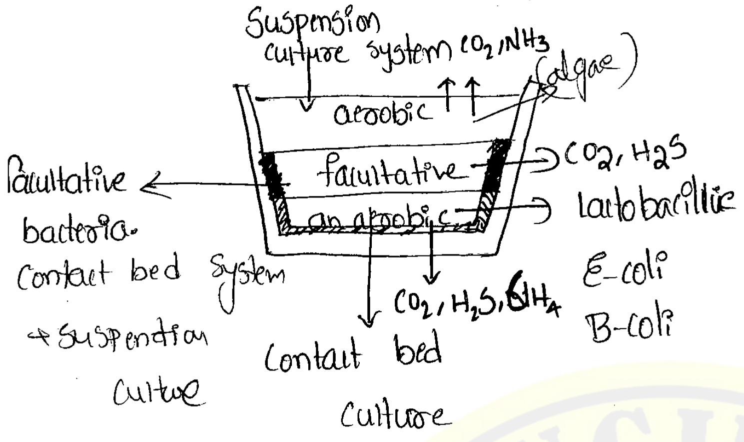
Aerobic + Anaerobic

$O_2 \to CO_2$ $CO_2 \to O_2$

The Type of oxydation Ponds which are used in India - Facultative oxydation Ponds.

Organic loading rate ⇒ Qty of org (or) BOD / unit time/ unit area organic loading rate for cold countries 60-90 kg/day/hect.

Hot countries 150-300 kg/day/hector



An aerobic → lacto bacilli

E-coli

B-coli

facultative → xanthomonas

Nitrobacter.

Algae used in oxygen ponds - chlorella

Imp

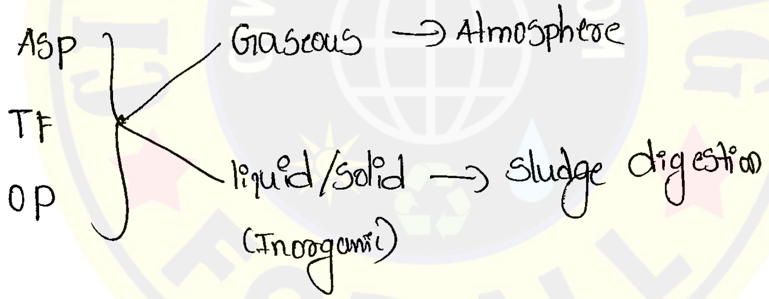
Aerobic - $CO_2 + NH_3$

Anaerobic - $CO_2 + H_2S + CH_4$

facultative - $CO_2 + H_2S$

SLUDGE DIGESTION & DRYING.

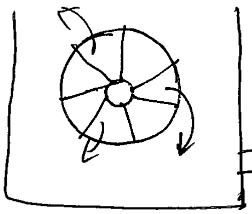
The process of anaerobic biological treatment in which the waste water and impurities from various aerobic treatments released directly and inorganic impurities have been degraded using either alcohol fermentation or acidic fermentation and convert the impurities into gases that are released in to atmosphere liquid waste water that has disposed of into water bodies (or) land treatment & Solid dried Powder sludge which is used as a manure in agricultural lands is called Sludge digestion & Drying.



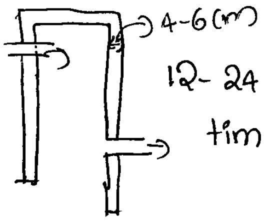
RBC → Rotating biological contactors

BT → Biological Towers

R.B.C



1 bacteria
↓ 24 hr @ 20°
10^6 bacterial (million ba



12- 24 hrs
time [Inlet-outlet]

Digestion (heating in absence of oxygen)

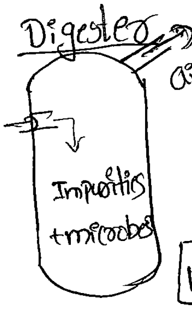
⇓

Decomposition

⇓

Temperature with bacteria

Digester



air went Gaseous does not convert in to dissolved solids (bcoz of temperature)

$\boxed{100-150^\circ c} + O_2$

* Bacteria
- Aerobic
- Anaerobic ⟶ Fermentation [O_2 + Food]
  - Ethyl alcohol ⟶ Alcohol producing bacteria. (+O_2)
  - Acids ⟶ Acidic Fermentative bacteria. (+O_2)
- Facultative

Respiration in anaerobic Process

$$O_2 \rightleftarrows CO_2$$

$\boxed{\text{End Products of Fermentation = Ethyl alcohol, acids}}$

$\boxed{\text{MPN count} \Rightarrow \text{Acid Fermentation}}$

⇓

E-coli bacteria (anaerobic ~~Pro~~ bacteria produces acid)

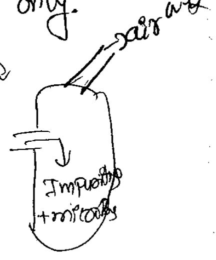
Sludge dizetion Occurs in three Process

① Alcohol Fermentation ⇒ [Highly reactive] ⇒ $C_2H_5OH + O_2$ (ethyl alcohol)

② Acid Fermentation ⇒ Butyric acid / propionic acid

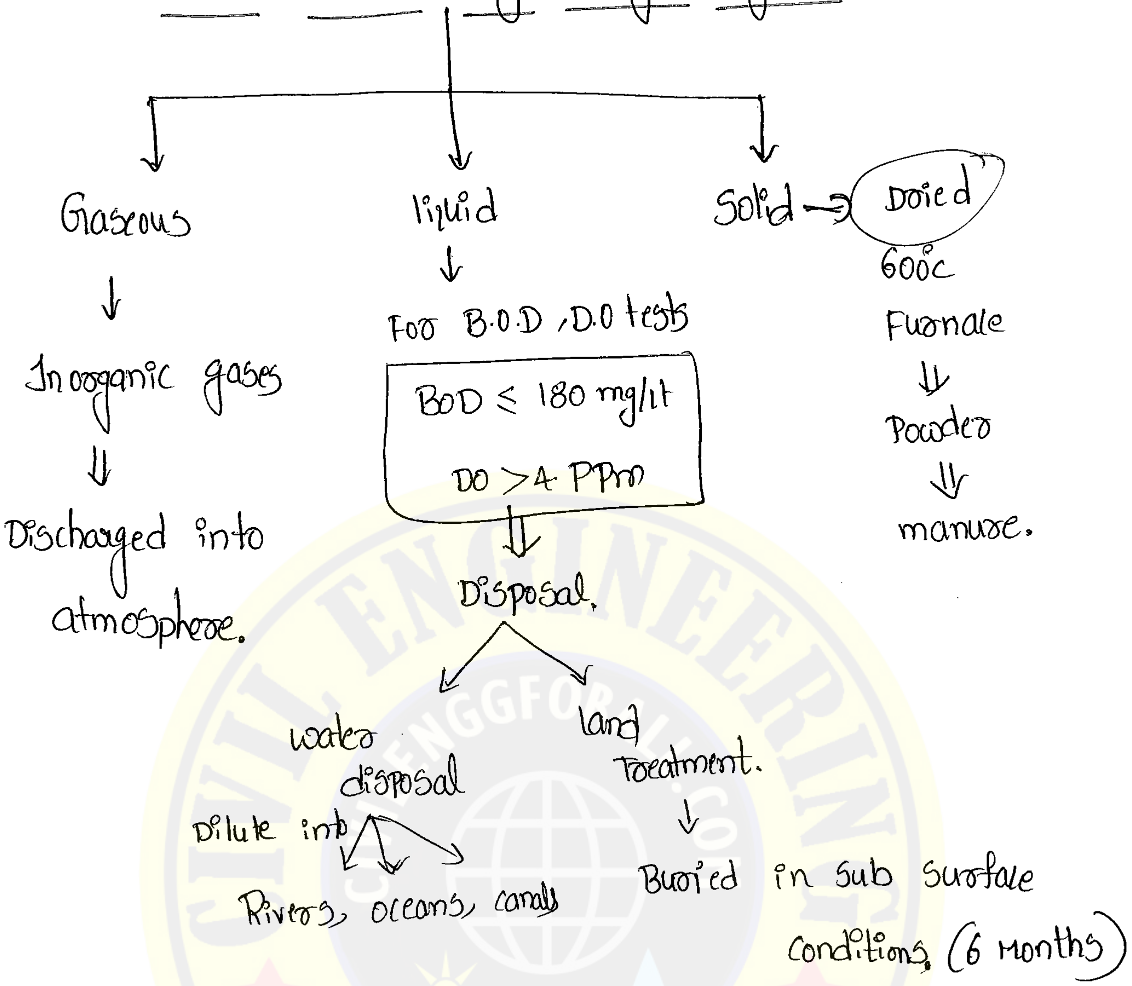
} Performed by microorganisms only.

③ Alcohol / Acid regression ⇒ Degradation of fermentative Products (+O_2) send to



100-150°c + O_2

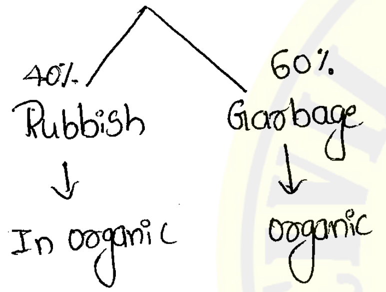
End Products By Sludge Digestion



Solid waste Management

The system that can co-ordinates b/w various activities like collection, conveyance, Degradation and disposal of various kinds of solid wastes that has been rejected by humans (or) Released by humans and dumped in to the environment is called solid waste management.

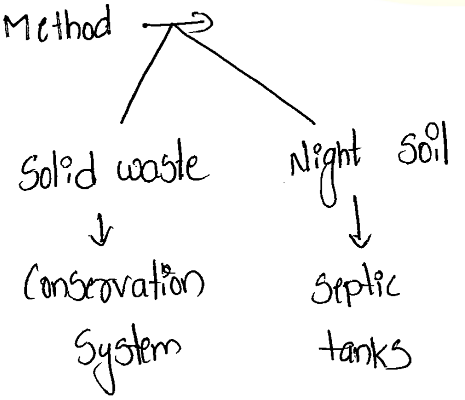
Solid waste :-



Indore method ⎤
Bangalore method ⎦ solid waste

Indore Method → solid waste + Night soil

Bangalore Method →



Solid waste

① Burning in open places.

② Incinaration.

↓

Burning in furnaces

③ Farthen Grooves.

④ Composting

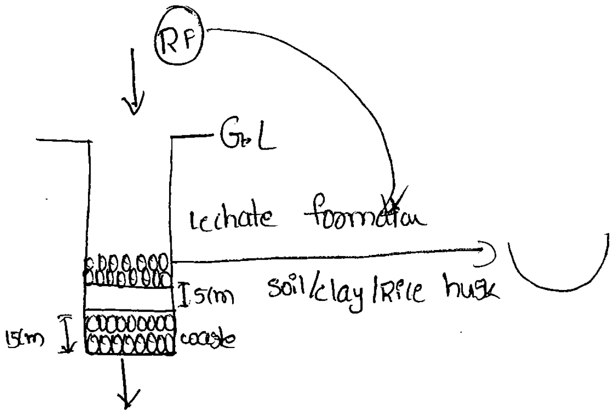
(Providing microbial culture which are capable of converting Solid waste in to Compost).

⑤ Destructive Distillation

Solid waste sent to Distillarities where 600-1000°C.

O_2 Present.

Farthen Grooves



Air pollution

* Any kind at foreign matter enter into atmosphere which is capable of disturbing the balance of atmospheric gases is called Air pollutant and their activity is called air pollution.

units :- $\mu g/m^3$. ppm $\rightarrow$ $\mu g/m^3$

mg/l — 10^3 $\mu g/l$

Ideal gas Equations

$$\boxed{Pv = nRT}$$

Pressure = 1 atm

Temperature = 273°K

Volume = depends up on atm. conditions

n = 1

R = Ideal gas constant

$$\boxed{V = \frac{nRT}{P} = 22.4\ m^3}$$ [Ideal gas conditions]

For given volume, under given condition.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

⇓

Ideal

$$\boxed{V_2 = \frac{P_1 V_1}{T_1} \times \frac{T_2}{P_2}}$$

$$\mu g/m^3 = \frac{\text{Conc. [mg/L]}}{V_2} \times \text{Mol. wt}\,[x]$$ [PPP → µg/m3]

$$\boxed{\text{For Ideal gas} = \frac{\text{Conc [mg/L]}}{22.4\ m^3} \times \text{Mol. wt}\,[x]}$$

Noise Pollution

$$\boxed{\text{Standard Noise level} = 20\ dB}$$

Imp

① **Industry**: Machine A = 50 dB
Machine B = 50 dB

Combined Noise level → 53 dB

$$\boxed{\text{According to Thumb's rule} = \text{Sound pressure level} + 3.}$$

② Machine A → 50 dB
B → 80 dB

Combined SPL → 80 dB (Max)

Population Forecasting & W.D → 1 Mark

Sources & Conveyance of water → 2M

Quality of water → 4-6 M

Sediment → 2-4

Coagulation → 2m

Disinfection → 2-4

Design of Sewers → 1 Ma

Charac Sewage → 2M

Trickling F → 1M

A SD → 1

OP → 1

11, 12, 13 → 1-2M