Filleration:-

Filteration → filteration is the process in which fine suspended particles are removed from water which could not be removed in sedimentation process.

→ Filter also removes organic matter, micro-organism and dissolved minerals from water.

→ Filteration is carried out in the unit termed as filter.

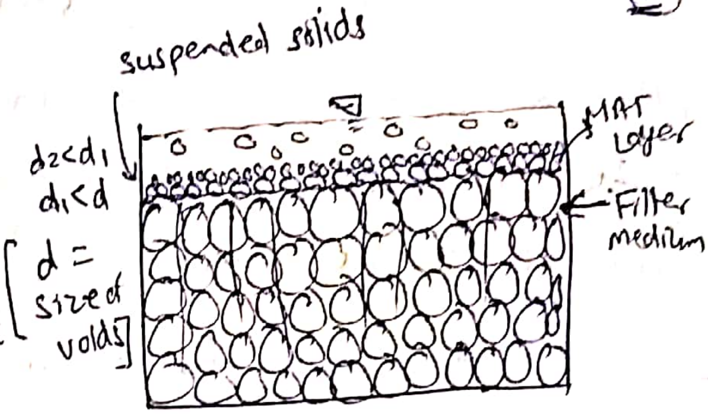
- Filter
  - Gravity
    - Slow Sand Filter
    - Rapid Sand Filter
  - Pressure filter

→ Gravity filter's are those filter in which head required by water to flow through the filter medium is provided by Height of water itself above the filter medium, where as in case of pressure filter the head is provided artificial by the external application of pressure over the filter medium.

→ When water passes through the filter medium removal of the impurities by the filter takes place. By following mechanism.

1. Mechanical straining
2. Sedimentation
3. Biological changes
4. Electrolytic Changes.

1. Mechanical straining ⇒



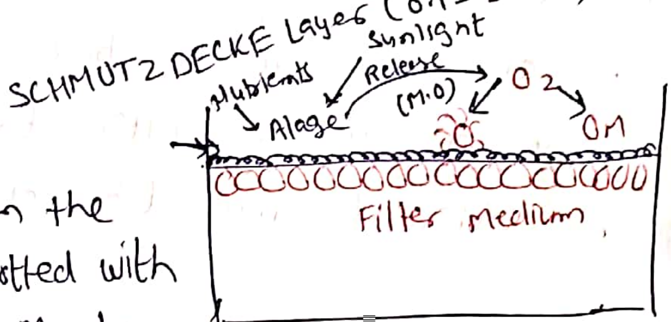
→ When water flows through the filter medium, suspended solids of size greater than size of voids of filter medium are streined out from it and are retain over the surface of medium resulting in the formation of "MAT" layer

→ ~~When water flows through~~
→ Particles of size smaller than the size of filter medium are reteined over the "MAT" layer. as the size of voids in MAT layer is smaller than the size of voids in the filter medium.

(2) Sedimentation :-

Due to the removal of turbulance from the water over the filter medium, sedimentation of suspeded solids, takes place over the medium surface. there by resulting in the removal of the solids from the filtered water.

(3) Bio-logical changes :-



(a) → For the first few days as the water passes through the filter medium the upper layers of the medium get spotted with sticky deposit of partially decomposed O.M along with the Nutrients. which provide the growth of alage which carried out photosynthesis during which O_2 is release which is utilized by M.O. to carry out the decomposition of O.M.

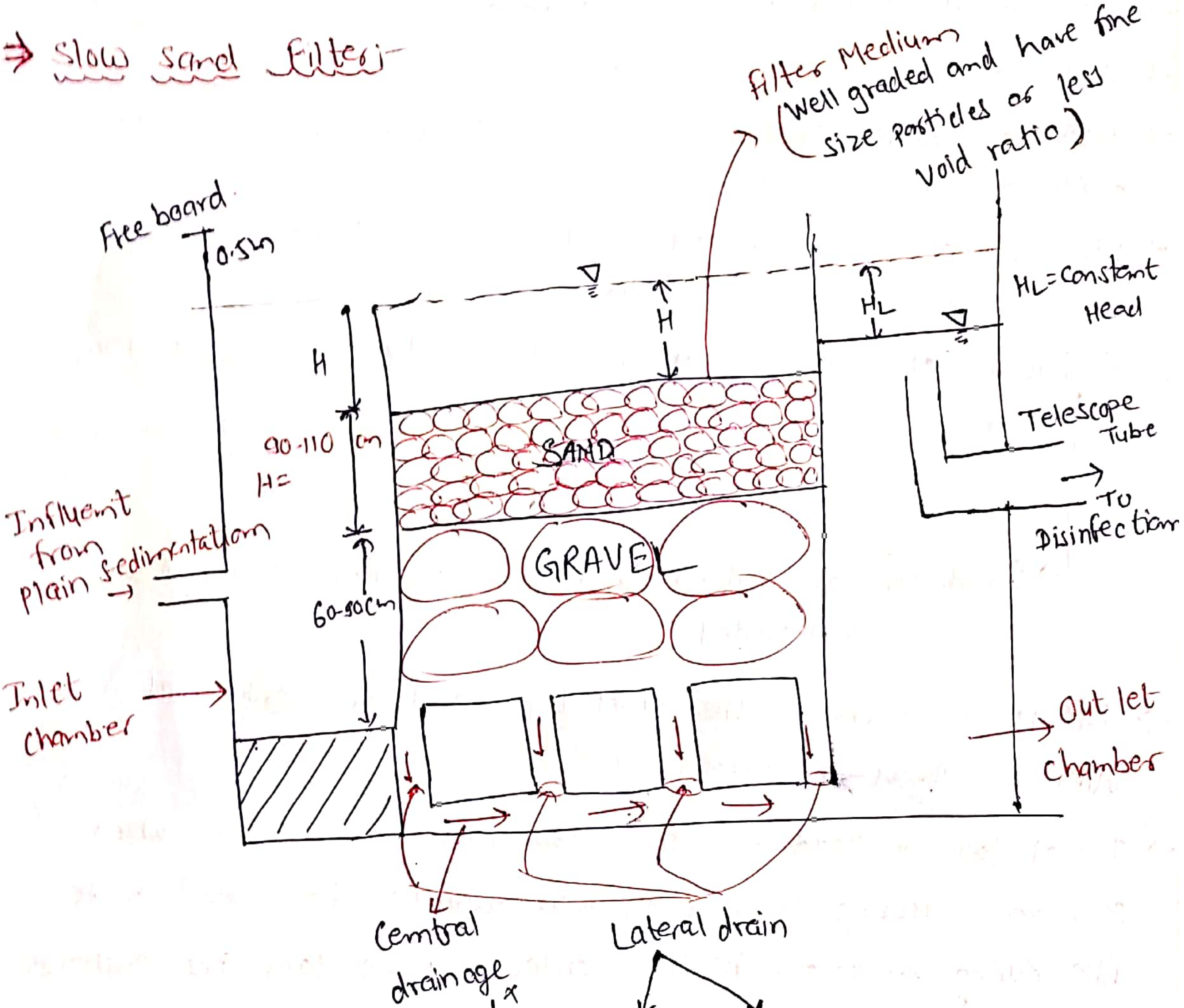
(b) A thin layer over the filter medium where the bio-logical activity takes places is refered as "SCHMUTZDECKE".

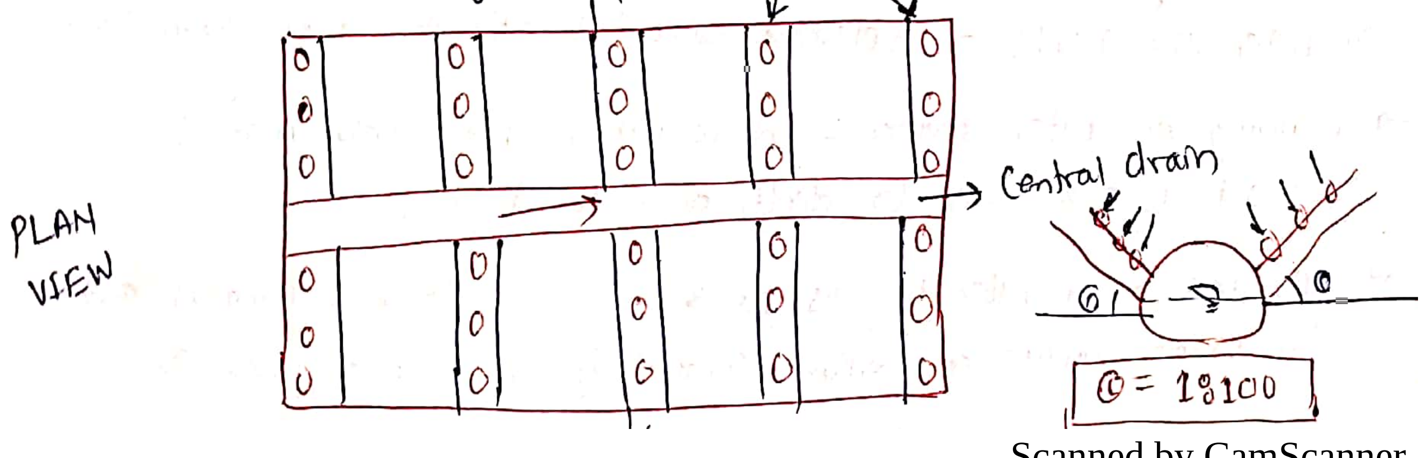
(c) Over a period of time due to removal of O.M., endogenic respiration is starts which intern reduces microbial load over the filter.

(4) Electrolytic change :-

Impurities present in water and particles of filter medium are oppositively charge, hence, because of interaction during filteration neturalization of this impurities takes places and neu neturalized impurities are further removed from the filter medium during it's cleaning process.

⇒ Slow Sand Filter :-





→ Gravel Layer in this filter is provided to support the Sand Medium.

→ Filter Medium be used is any sand, Antrasit, Activated Carbon, geotextiles etc. (Garnet).

→ Total depth of the filter varies in b/w 2.5 - 3.5 m.

→ Plan Area of each unit in the range of 100 to 2000 m^2.

→ Depth of the gravel layer in the range of 60 - 90 cm.

→ Depth of sand Medium = 90 - 100 cm.

→ Depth of water above Sand Medium is kept Same as the depth of Medium itself.

→ Effective size of Sand particles is D_{10} in the range of 0.2 - 0.3 mm (D_{10} = 0.2 - 0.3 mm)

→ Coefficient of uniformity of the filter medium is in the range of 3 - 5

$$C_u = \frac{D_{60}}{D_{10}} = 3-5$$

↳ Gradation of Soil → C_u ↑ is more than Soil will be well graded.

→ Top 15 to 30 cm of the sand layer of finer variety and other is almost of uniform size.

→ Initial loss of head of freshly clean filter = 10 - 15 cm. which goes on increasing as more and more impurities are intrupt in the filter during operation, hence in order to maintain the discharge in filter the height of telescope tube is adjusted with head Loss.

→ Cleaning of filter should be done when head loss becomes 0.7 to 0.8 times to depth of filter height.

→ for Cleaning of Filter top 1.5 to 3 cm. Sand layer is removed and remaining surface of medium Scraped by the help of racks. In

(4) After cleaning filter is again loaded with settled water but filter water is not used for next 24-36 hours. Because sufficient time is provided for growth of "Schmutzdecke".

→ Frequency of cleaning 1-3 month.

→ Rate of filteration = is 2400-4800 l/m²/day

$$S.A = QD/ROF$$

→ Provided in Rural Areas where less water demand and more availability of Area.

→ Efficiency of this filter for removal of micro-organism is 98-99%.

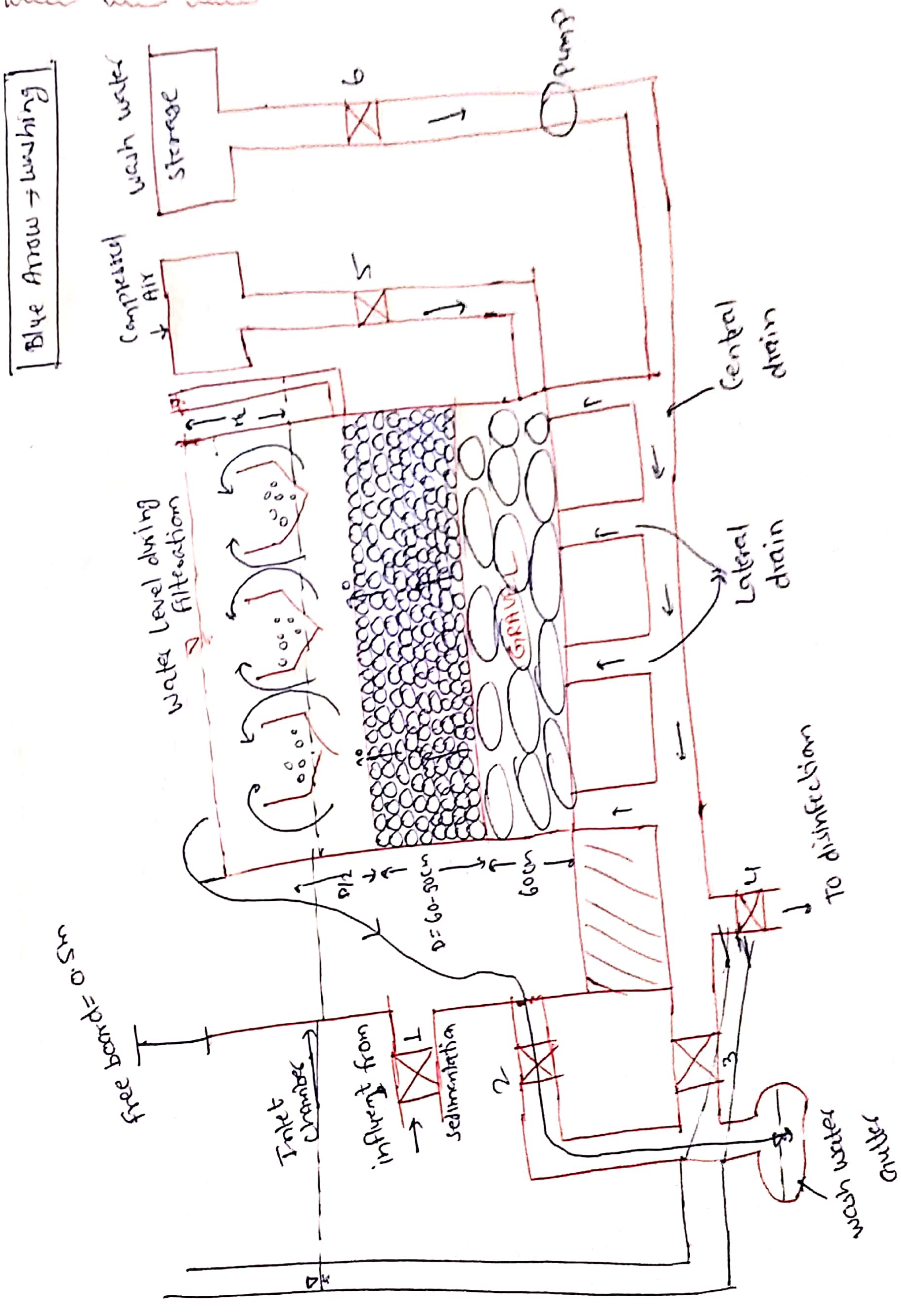
→ Not used for turbidity > 50 NTU.

→ Quality of effluent is very good.

→ No. of filters is to be provided depends upon the Area required for this filter.

Area (m²)	No. of filter
< 20	2 (1+1)
20 - 249	3 (2+1)
250 - 649	4 (3+1)
650 - 1200	5 (4+1)
> 1200	6 (5+1)

Rapid Sand Filter:-



Procedure: –

① Operation of Rapid Sand filter is same as that of slow sand filter.

② during operation valve no. ① & ④ are opened in which Settled water is flow into the filter to valve no. 1 and filtered water collected through valve no. 4.

→ Since the size of particles of medium used is bigger than size of particles used in S.S.F, impurities are able to Penetrate upto the bottom layer of filter medium. hence surface cleaning alone is not sufficent in this case. and is being accomplained by "Back washing".

→ During Back washing valve no. 1 & 4 are closed and 2, 5, 6 are opened as the result of which compressed air and wash water is forces its way upto filter medium resulting in its increasing the porosity which in tern increase the oppertunity of the intrapped impurities to get washed away along with the wash water into wash water trap, and from where it is further collected in wash water gutter to valve no ②.

→ Once Back washing is completed valve no. ② ⑤, and ⑥ are closed and filter is again loaded with settled water through valve ① But filtered water is not used and disposed in wash water Gutter through valve no. ③ as sufficent time is provided for the growth of Schmulzdecke layer and removal of left over impurities in the filter medium.

→ After sufficent time valve no. ③ is closed and filtered water is collected through valve no. 4 in between this the wash water storage is also take places.

→ Entire Back washing is completed in 15 - 30 min.

→ The Amount of water required for the back washing is 2-5% of the amount of water filtered by filter. (Q_D = Max^m daily demand)

→ frequency of Back washing is 24 to 48 hours.

→ Rate of Back washing is 15 to 90 cm/min, Normally taken to 45 cm/min.

** Always ⇒

→ Back Washing of Velocity (V_B) < settling velocity of filter medium Particles of smallest size

→ Rate of filteration = 3000 - 6000 l/m²/hour

→ Area of each unit is in the range of 10-80 m².

→ flow through the filter during filteration is laminar and is in trancition during back washing.

→ In Rapid sand filter gravel layer is properally graded as distribution of back wash water is take place through it which is critical in the operation of RSF. (To Uniform velocity is achevied to whole Area of filter media.)

→ Depth of gravel layer = 60 cm.

→ Depth of Sand Medium = 60-80 cm.

→ Effective size of Particles D_{10} = 0.35 - 0.55 mm.

→ C_u = 1.2 - 1.6

→ Min^m of 2 filter is provided to plant (1 operation & 1 stand by)

→ No of filter required = $N = 1.22\sqrt{Q}$ [∵ Q = MLD]

N = only operational filter.

→ Bacterial removal efficency of this filter is 80 - 90% which is less than the S.S.F.

⇒ Under drainage is designed according to back wash water discharge.

Design of Under drainage System :⇒

→ Lateral and Manifold system of under drain is provided in this system of filter.

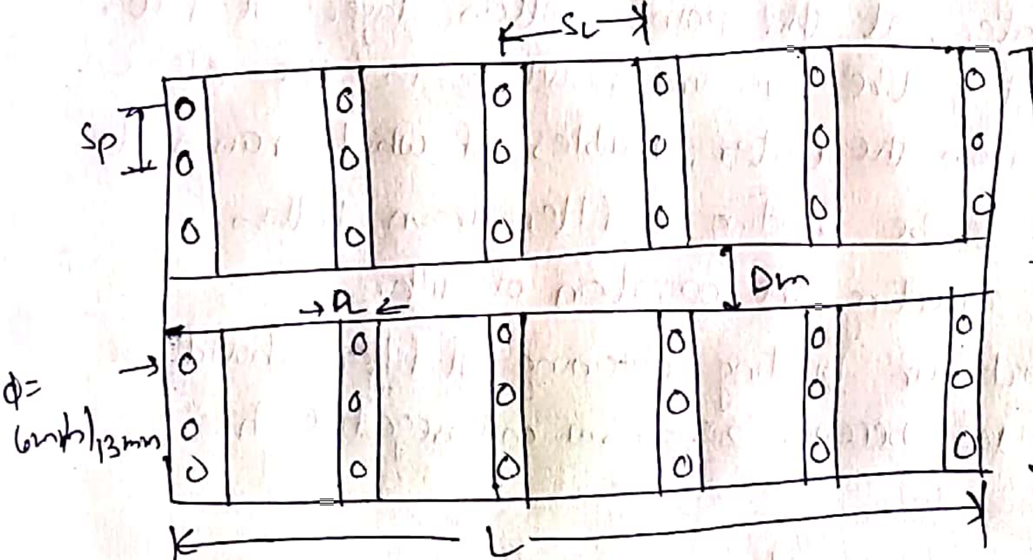
→ Size of perforation in lateral is either 6mm - 13mm. if 6mm perforation is adopted spacing b/w the perforation is kept to be 7.5 cm c/c. and if 13 mm perforation is adopted spacing between perforation is kept to be 20 cm c/c.

→ Spacing between the lateral is in the range of 15-30 cm c/c.

→ S_p Cross - Section Area of all the perforation is 0.2 % of the filter area.

→ Cross- Section Area of one lateral is 2 or 4 times the Cross - section Area of perforation in it.

(factor = 2 ⇒ 13mm perforation) } adopted.
(factor = 4 ⇒ 6mm perforation)



S_p = Spacing b/w perforation

S_L = spacing b/w Laterals

D_m = Dia of Manifold.

D_L = Dia of Lateral

φ = dia of perforation

$$N = \left(\frac{L}{S_L} + 1\right) \times 2$$

(N → No of lateral drains; L → Length; S_L → spacing)

→ Cross- section area of manifold is the twice the Cross - section area of all the lateral.

$$\text{Check} = \frac{\text{Length of Lateral}}{\text{Dia of Lateral}} < 60$$

$$\frac{\left(\frac{B - D_m}{2}\right)}{D_L} < 60$$

Actual length of Lateral $= \left(\frac{B - D_m}{2}\right) \sec\theta \simeq \left(\frac{B - D_m}{2}\right)$

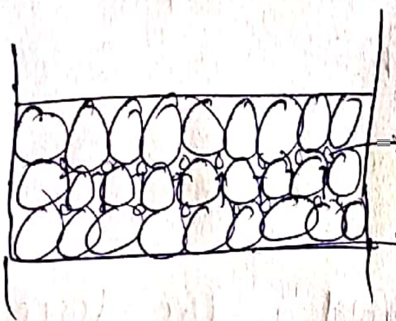
$\because$ (θ is very small so $\sec\theta \simeq 1$)

⇒ **Operational Troubles of RSF :⇒**

1. Air binding ⇒ static head of water < Resistance offered by Impurities.

→ A stege comes when the resistance offeed by the medium particles along with the intruped impurities exceeds the static head of water, at this point bottom layer of filter medium start acting like vaccum resulting in the release of dissolved gases from the water, bubbles of which raises to surface and leads to be binding of filter from bottom. there by seriously affecting the operation of filter.

→ In order to avoid air binding cleaning of filter should be done when head loss becomes 2.5 - 3.5m. and negative head becomes 1.2m.



→ Air binding can also be removed by avoiding increase in temp, removing the alge and pumping air in the filter medium.

2. Mud ball formation :-

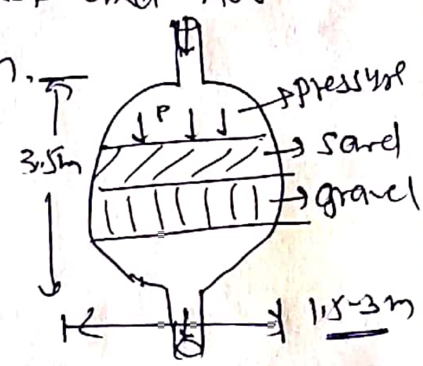
(a) Mud from the atmosphere enters into the filter medium and due to improper cleaning it sinks down to the bottom layer of filter medium where it combines with intrapped impurities and leads to formation of mud balls. size of which goes on increasing, and if it enter to gravel layer, leads to turbulance around them, resulting in the removal of filter medium particles along with back wash water. there by seriously affecting the efficiency of filter.

→ To avoid mud ball formation cleaning of filter with (NaOH) must be done
(De Flocculating agent)

3. Cracking of filter:- Due to alternate wetting and drying of medium particles, cracks are develop over the surface of medium. size of which goes on increasing as they are being subjected to constant application water pressure over them.

3) Pressure filters:- Pressure filter are same as that of rapid sand filter with the only difference that the entire treatment is being carried out in closed container.

→ Pressure filter operated similar to that of RSF and not preceded by sedimentation or coagulation.



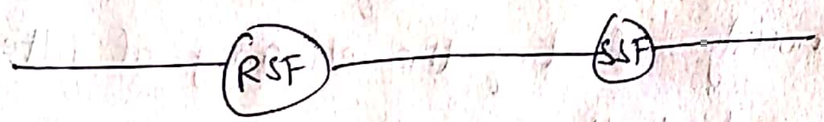
→ Dia of filter = 1.5 - 3 m.
→ Depth of " = = 3.5 m.

→ ROF = 3000 - 6000 l/m²/hr
which may be extanded up to 15000 l/m²/hr.
→ Used in Industrial water treatment or swiming pools.

Double filteration & Roughening filters:-

→ In order to increase the rate of filteration through slow sand filter with compromising with quality of effluent, R.S.F is provided before the slow sand filter.

The process is termed as double filteration and RSF is used is termed as Roughening filter.



Efficiency of RSF = η_I

Efficiency of SSF = η_{II}

Over all efficiency =

$$\eta\% = \eta_I + (1-\eta_I)\eta_{II}$$

Disinfection

→ The process of removal of disease causing micro-organism from water is referred as disinfection.

* Removal of all types of micro-organism from the water is termed as sterilization.

→ Disinfection can be done by

- Physical
  - → Boiling
  - → UV-Rays
- Chemical
  - Acid & Alkalies ($pH < 3$ & $pH > 11$)
  - Metallic Ions (Ag^+, Hg^+)
  - Oxidising Agent (O_3, Cl_2, Br_2, I_2, $KMnO_4$)

(a) Treatment with Ozone ⇒

$$O_3 \xrightarrow{H_2O} O_2 + [O] \rightarrow \text{Nascent Oxygen}$$

→ [O] ⇒ strong oxidising agent.

→ Which carries out the removal of both O.M and M.O.

→ Highly unstable → it doesn't safe gaurd against the future recontamination of water.

→ Normal dose → 2-3 mg/litre.

→ [O] → destroy the cell of micro-organism.

→ In Chandigarh O_3 is used in disinfection.

(b) Treatment with $KMnO_4$ ⇒ (Potassium Permegnate) → (Weak oxidising Agent)

→ Used for treatment of well water supply in villages.

→ Removes both Organic matter (O.M) and Micro-organism (M.O.)

→ Gives pink colour when added in water which if dis appear

→ Indicates the presence of O.M and M.O. than further $KMnO_4$ is added upto pink colour stands in water. Which indicates the removal of organic matter and M.O. from the water.

→ Used after pink colour subsidise.

→ Normal dose → (1-2) ppm at contact period of 4-6 hours.

→ Removes → 98% Bacteria and 100% cholera causing bacteria

(c) Treatment with Chlorine:-

$$Cl_2 + H_2O \xrightleftharpoons{pH>5} HOCl + HCl$$

(Hypo-chlorous acid) → Unstable

$$HOCl \underset{pH<7}{\overset{pH>8}{\rightleftharpoons}} OCl^- + H^+$$

HOCl ↓ Most distructive Disinfectent.

OCl^- ↓ Hypo-chlorite ions → stable.

→ Free available chlorine:- All the above forms of chlorine (Cl_2, HOCl, OCl^-) carries out the disinfection in the water and are being refered as freely available chlorine.

→ pH of water is maintained slightly less than 7 during chlorination.

→ $Cl_2 + NH_3 \longrightarrow$ ~~chlorin~~ chlora-amine.

⇓

Combined forms of chlorines.

⇓

25 times less effective as disinfectent than freely available Cl_2, but are more stable hence remains in water for longer duration. there by safe gaurd against future re-contamination.

$NH_3 + HOCl \xrightarrow{pH > 7.5} NH_2Cl + H_2O$

$NH_2Cl + HOCl \xrightarrow{pH\ 5-6.5} NHCl_2 + H_2O$ (Pre dominate) (Because pH < 7)

$NHCl_2 + HOCl \xrightarrow{pH < 4.4} NCl_3 + H_2O$

→ Cl_2 destroys the enzyms of micro-organism responsible for* metabolic* activity in them to carry out the disinfection.

* (Anabolism → New cells) ; ** (Catabolism – Growth of cells)

→ Different forms of Cl_2 is added into the water

- Free-chlorine → Liquid, Solid, gases
- $Ca(OCl)_2$ → Hypochlorite & Bleaching powder ($CaOCl_2$)
- Chlora Amine
- Chlorine di oxide (ClO_2)

Types of chlorination

- Break point chlorination
- Plain chlorination
- Pre chlorination
- Post chlorination
- Double chlorination
- Super chlorination
- De-Chlorination

Factors affecting the efficiency of chlorination :-

1. Turbidity → Turbidity ↑ chlorination efficiency ↓
2. Fe/Mn → Fe/Mn ↑ chlorination η% ↓
3. NH_3 → NH_3 ↑ " η% ↓
4. pH → pH ↓ " " ↑
5. Temp. → Temp ↑ efficiency ↑

Scanned by CamScanner

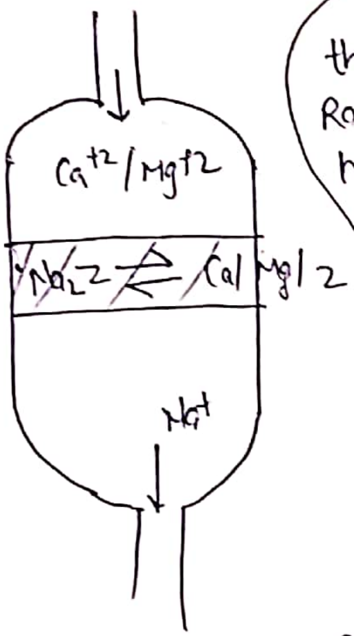
Ion - exchange :- (Removal of Hardness)

Zeolite Method

↓

Zeolite = $Na_2O \cdot Al_2O_3 \cdot xSiO_2 \cdot yH_2O$

Zeolite



$$Ca^{+2}/Mg^{+2}\begin{cases}Cl^-\\SO_4^-\\NO_3^-\\HCO_3^-\\CO_3^-\end{cases} + Na_2Z \longrightarrow Ca/Mg\,Z + Na\begin{cases}Cl\\SO_4^-\\NO_3^-\\HCO_3^-\\CO_3^-\end{cases}$$

(Ca/MgZ: Retained over the bed of zeolite)

Exausted zeolite is to be generated by passing 5-10% Brine solution, before utilizing it for further removal of Hardness.

$$Ca/MgZ + NaCl\ (5\text{-}10\%)\ (\text{Brine solution}) \longrightarrow Na_2Z + Ca/Mg\,Cl_2$$

Regeneration of Na_2Z (Na_2Z ↓ Zeolite)

Demineralisation process

Two stages

First stage

Water is passed through Cation exchange Rasin which removes the hardness from water but induces acidity in it.

↓

$$Ca/Mg\begin{cases}Cl^-\\NO_3^-\\SO_4^-\\CO_3^{-2}\\HCO_3^-\end{cases} + H_2R \longrightarrow Ca/Mg\,R + \begin{cases}HCl\\HNO_3\\H_2SO_4\\H_2CO_3\end{cases}$$

Second stage

This acidic water is then further passed through anion exchange resin which removes the acidity from water.

$$\begin{matrix}HCl\\HNO_3\\H_2SO_4\\H_2CO_3\end{matrix} + ROH \longrightarrow R\begin{cases}Cl^-\\NO_3^-\\SO_4^{-2}\\CO_3^{-2}\end{cases} + H_2O\ (\text{clean water})$$

(H_2O ↑ free from minerals)

Regeneration of cation and anion exchange resin

Acidic Sol^n ⟶ Cation exchange Rasin

Alkaline Sol^n of Na_2CO_3 ⟶ anion exchange Rasin

→ No. sludge formation in both case.

→ zero - hardness in both case.

Water demand: Amount of water required ~~by~~ for some purpose. is known as water demand

Types of water demand:-

(i) Domestic water demand (ii) Commerical and Industrial demand
(iii) Fire demand (iv) Demand for public uses (v) Compensate Losses demand

(i) **Domestic water demand:-** 50 – 60% of total water consumption.

for design purpose → considered as → 135 l/day/person.

(ii) **Commericial and Industrial demand:-**

The water requirements of commerical and public places maybe upto 45 litres/day/capita.

eg. (a) Factories with ~~toilet~~ Bathroom — 45 l/day/capita

(b) Factories with no Bathroom — 30 l/day/capita

→ Water required in the industries mainly depends on the type and size of industries which are existing in the city.

→ The quantity of water demand for industrial purposes is arround 20 - 25 % of total demand of the city.

→ Most of the big industries, universities and institutions generally have their own water supply arrangements from the private tube-wells.

(iii) **Fire demand:-** As during fire-breakdowns large quantity of water is required for throwing it over the fire to extinguish it. therefore provision is made in the water works to supply sufficient quantity of water or keep as reserve in water main's for this purpose.

(iv) Demand for public use:- Quantity of water required for public utility purposes such as for washing and sparkling of roads cleaning of sewers, watering of public parks, gardens Public fountains etc. Comes under public demand.

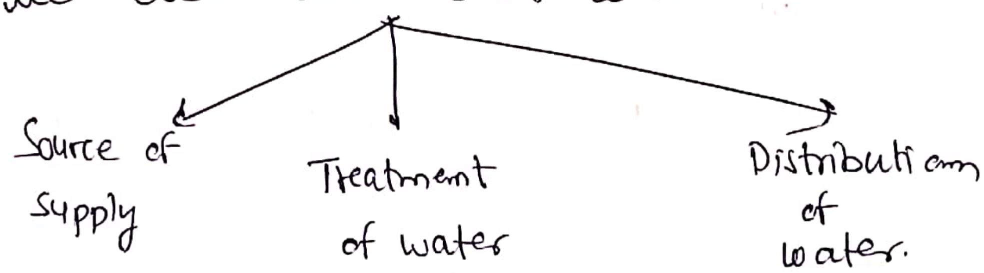
→ 5% of total water Consumption is made while designing the water works for a city.

(v) Compensate losses demand:-

Some portion of this water is wasted in the pipe line due to defective - joints, cracked and broken pipes faulty valves and fittings. etc..

→ Generally allowance of 15% of the total quantity of water is made to Compensate for losses, thefts and wastage of water.

⇒ Components of water supply system:-



→ Transmission of water:- The transport of water from storage facilities to distribution networks takes place through water transmission pipelines.

→ The water is channelled from source, such as a reservoir, to water treatment plants and then usually pumped into service reservoirs and distribution network to private homes and Companies.

Distribution System:-

It becomes necessary to distribute it to a number of houses, estates, industries and public place by means of a network of distribution system.

Distribution system consists:-

(i) Pipes of various size (ii) Valves (iii) Wameters. (iv) Pumps
(v) Distribution reservoirs (vi) Hydrants (vii) stand posts.

Following are the requirement of a good distribution system:-

(a) Convey the treated water upto the consumers with required pressured head.
(b) Sufficient quantity of treated water should reach to everyone.
(c) it should be economical and easy to maintain and operate.
(d) Safe against any future pollution.
(e) pipe lines are far ~~and~~ from sewar and not ~~lead~~ laid below sewer lines.
(f) Minimum water losses due to leakage.

Distribution System

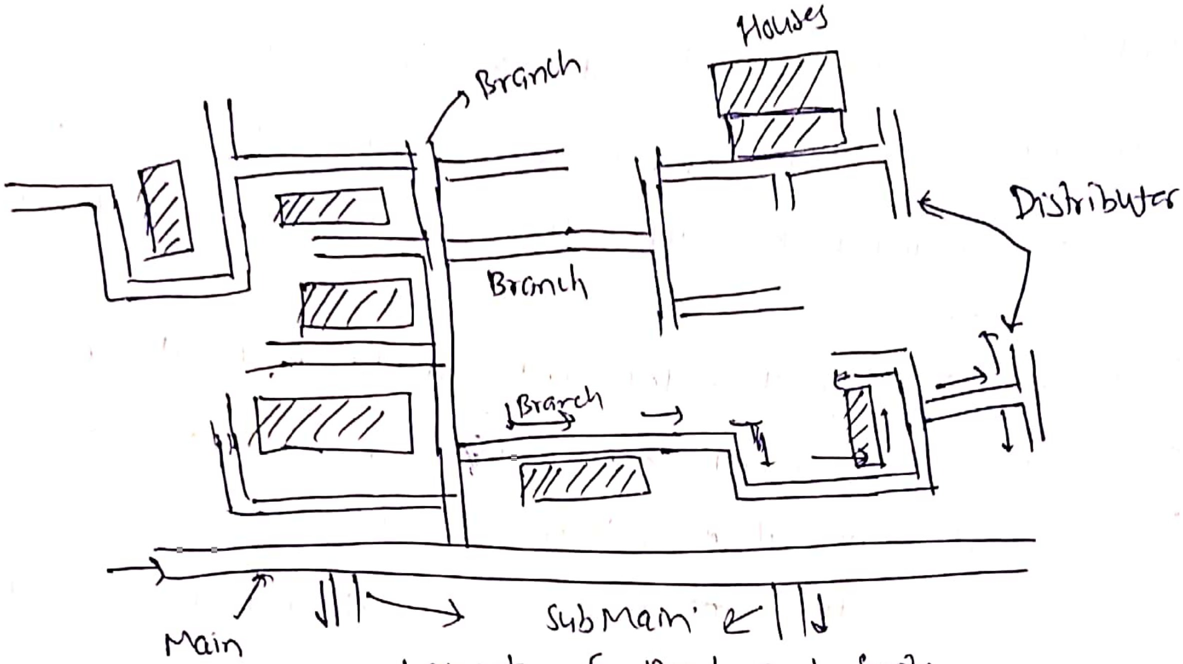
- Gravity System
- Pumping System
- Dual System

Layout of Distribution System:-

- Dead End or Tree-System
- Grid iron system
- Circular or Ring System
- Radial system.

Deaad end & Tree-System:-

In this system one main starts from service reservoir along the main road. Sub mains are connected to the main starts from service reservoir in both the directions along other roads which meet the main road.



Layout of Dead end System

Advantage:- cheap in initial cost and easy determination of pipe diameters, valves etc.

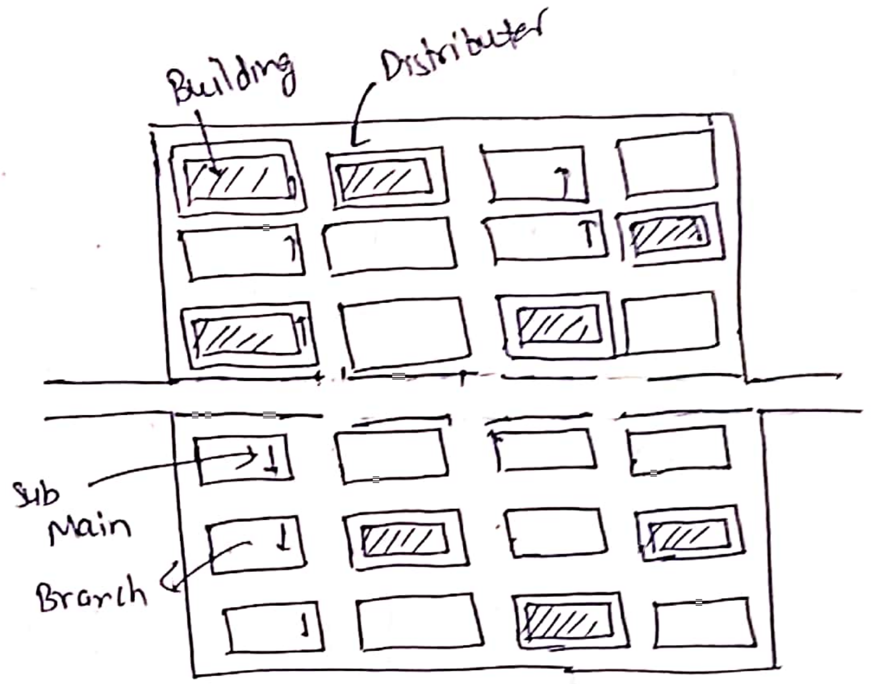
Disadvantage:- 1. formation of dead end.

2. Can't meet the fire demand.

3. Supply Can't be increased or diverted from other points

4.

(ii) Grid Iron System:- (Reticulated System)



Advantage:-

(a) Water is supplied from both the sides to every point.

(b) friction losses and sizes of pipes are reduces.

(c) Continuous flow → No stagnation.

(d) Diversion possible in case fire.

Disadvantage:-

(a) More Number of valves and longer length of pipe is required so increase overall cost.

(b) for repair of one section more number of valves are required to close.

(c) Designing is very tedious.

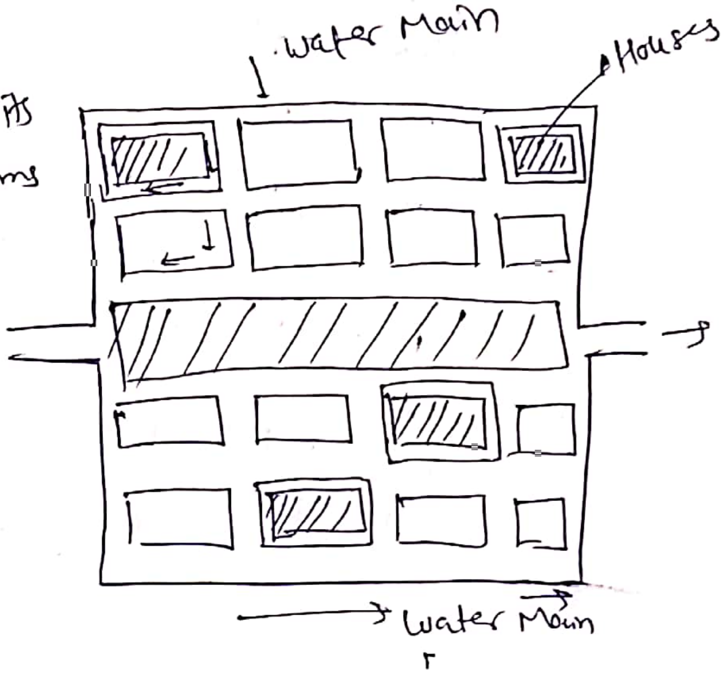
(iii) Circular or Ring System:-

→ Adopated in well planned locality of cities.
→ Locality is divided in square or circular blocks and water mains are laid around all four sides of the square or round the circle.

→ Every point receive its supply from two directions

→ Design is easier.

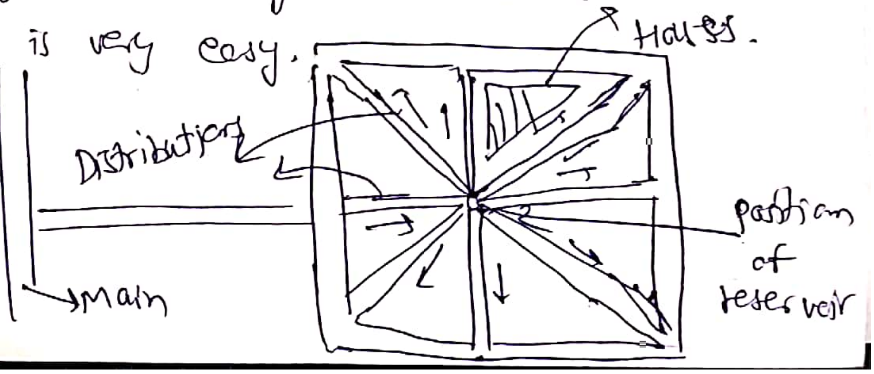
→



(iv) Radial System:-

for this system roads should be laid out radially from a centre.

→ Reverse of Ring system.
→ Water flow outward radially from one center point.
→ The entire district is divided into various zones and one reservoir is provided for each zone, which is placed in the centre of the zone.
→ Water lines are laid radially along the roads.
→ Very quick and satisfactory water-supply and also the Calculation of pipe size is very easy.



Sewage

Sewage:- The liquid waste material from people's bodies that is carried away from their homes in water in large underground pipes (sewers.)

Sewerage:- The entire science of collecting and carrying sewage by water carriage through sewers is known as "sewerage".

Sullage:- waste water from bathroom and kitchens.

Raw Sewage:- The sewage that is not treated.

Combined Sewage:- This indicates a combination of ~~Sain~~ Sanitary sewage and storm water with or without industrial waste.

Storm water:- Rain water of the locality.

Quantity of Sewage:- Quantity of sewage is mainly affected by following factors:-

(a) Rate of water supply
(b) Population
(c) Type of area served → Residential, industrial or Commercial.
(d) Ground water infiltration:

Quantity of ~~Sain~~ Sanitary Sewage:- = T

= Total quantity of water supplied + Addition due to industries + subtraction.

→ Subtractions are done due to leakage of pipe lines and water is being consumed in drinking, cooking, etc.

→ Generally subtraction is vary from 20% to 30% of total quantity of water supplied to town.

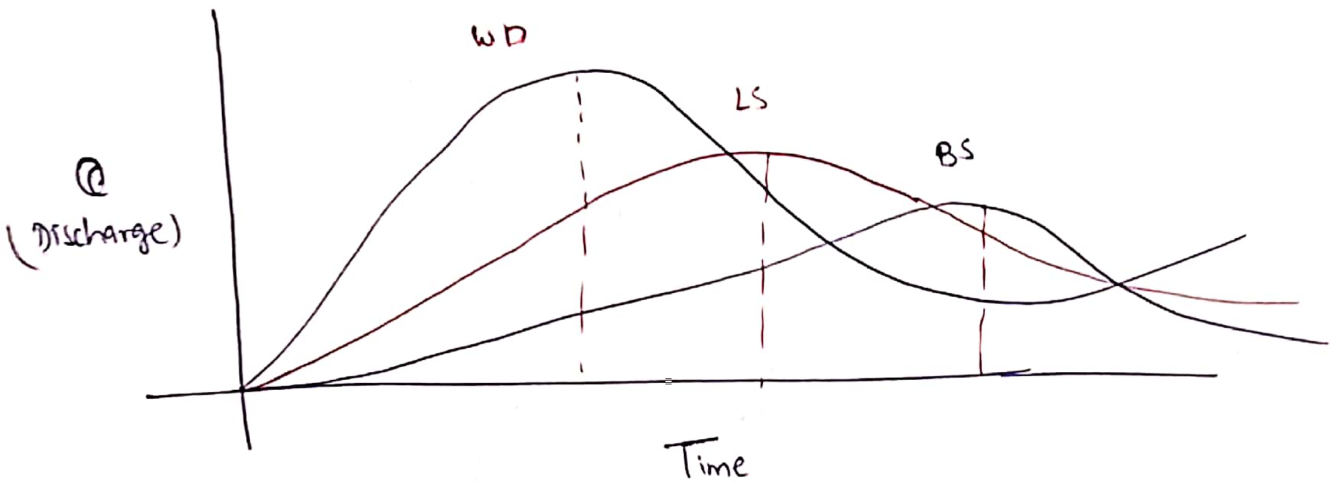
But Generally quantity of sewage for doing all calculations it is considered as 75 to 80% of total quantity of water supplied.

Variations in quantity of sewage:-

Variations in quantity may be due to some factors.

(a) Seasonal and daily variation

- Summer
- Winter
    - Industries

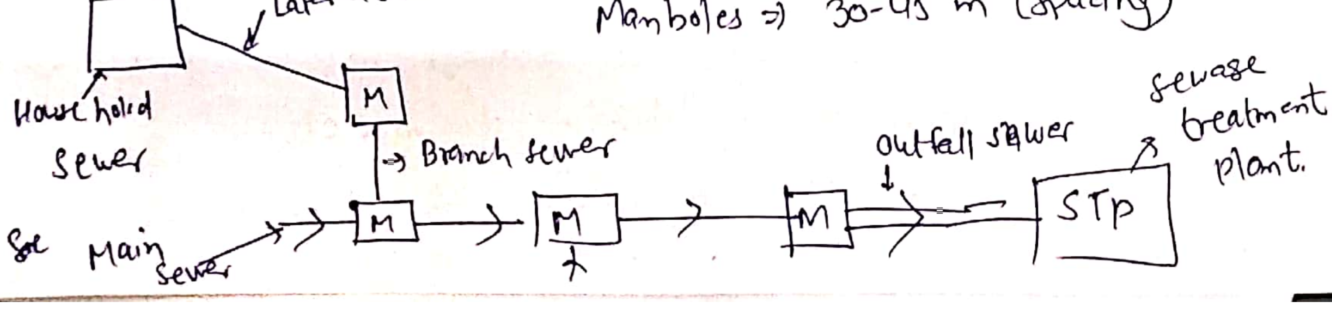


water demand > Lateral > Branch > Main > out fall sewer

Attenuation variation.

Conveyances of sewage:-

Sewage is transported by big concrete pipe structure from source to treatment plant which are known as "Sewers".



→ Manholes are provided at spacing of 30-45m or when two different sewers are meeting, slope changes, cross-section changes etc.

→ Manholes are designed for ~~inspeel~~ inspection and maintenance of sewers.

-: Shape - design parameters :-

→ Sewers are designed to carry "maxm hourly discharge" and checked at minm hourly discharge for the development of self cleansing velocity.

→ Self cleansing velocity is that which does not allow to settle of silting of the solids in the sewer.

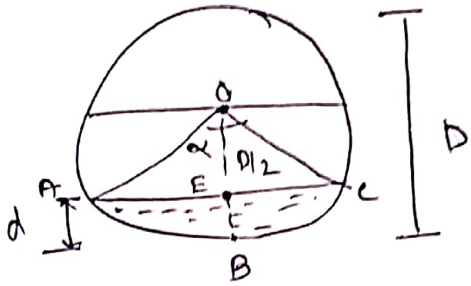
$$\text{Self cleansing velocity} = V_{sc} = \sqrt{\frac{8K}{f}(G-1)g\,d}$$

f = Friction factor

K = Constant which depends upon the type of solids present in it.

Hydraulic characteristics of sewer running full or partially full:

(a) Depth of flow:-



$= d = OB - OE$

$d = D/2 - OE$

from triangle $\triangle AOE$

$\sin\alpha/2 = \frac{AE}{OA}$, $\cos\alpha/2 = \frac{OE}{OA}$

$\Rightarrow AE = D/2 \times \sin\alpha/2$; $OE = OA\cos\alpha/2 \Rightarrow OE = D/2 \cos\alpha/2$

$d = D/2 - D/2\cos\alpha/2 \Rightarrow D/2(1-\cos\alpha/2)$

$$\boxed{\frac{d}{D} = \frac{1-\cos\alpha/2}{2}} \quad -(i)$$

(b) Area of flow:-

$a =$ Area of ABCE

$a =$ Area of OABC - Area of OAC

if $\alpha = 360^\circ$ = $A = \frac{\pi}{4} D^2$

then $\alpha = \alpha^\circ$ =

area of OABC = $\frac{\pi D^2 \alpha}{4 \times 360^\circ}$

area of OABC = $\frac{A\alpha}{360^\circ}$

Area of triangle = OAC = $\frac{1}{2} \times$ Base $\times$ height $= \frac{1}{2} \times OE \times AC$

$= \frac{1}{2} \times 2 \times AE \times OE$

$AE \times OE = \cdot D/2 \sin\alpha/2 \cdot D/2 \cos\alpha/2$

$= \frac{D^2}{8} \sin\alpha \times \frac{\pi}{\pi} \Rightarrow \frac{A \sin\alpha}{2\pi}$

$$\boxed{\frac{a}{A} = \frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}}$$

(c) Perimeter of flow:-

$p =$ length ABC

if $\alpha = 360^\circ$ = $P = \pi D$

$\alpha = \alpha^\circ$ = $p = \frac{\pi D \alpha^\circ}{360^\circ}$

$$\boxed{\frac{p}{P} = \frac{\alpha^\circ}{360^\circ}}$$

(d) Hydraulic mean depth:-

$r = a/p$

$R = A/P$

$\frac{r}{R} = \left(\alpha/360 - \frac{\sin\alpha}{2\pi}\right) \times \frac{360}{\alpha}$

$$\boxed{\frac{r}{R} = 1 - \frac{\sin\alpha \times 360^\circ}{2\pi\alpha}}$$

(e) Velocity of flow:-

$v = 1/n \, r^{2/3} s^{1/2}$

$V = \frac{1}{N} R^{2/3} S^{1/2}$

$N =$ Roughness Coefficient $\propto$ to Roughness
↓
Manning's Coefficent

$\frac{v}{V} = \left[\frac{\left(\alpha/360 - \frac{\sin\alpha}{2\pi}\right)}{\alpha/360^\circ}\right]^{2/3}$

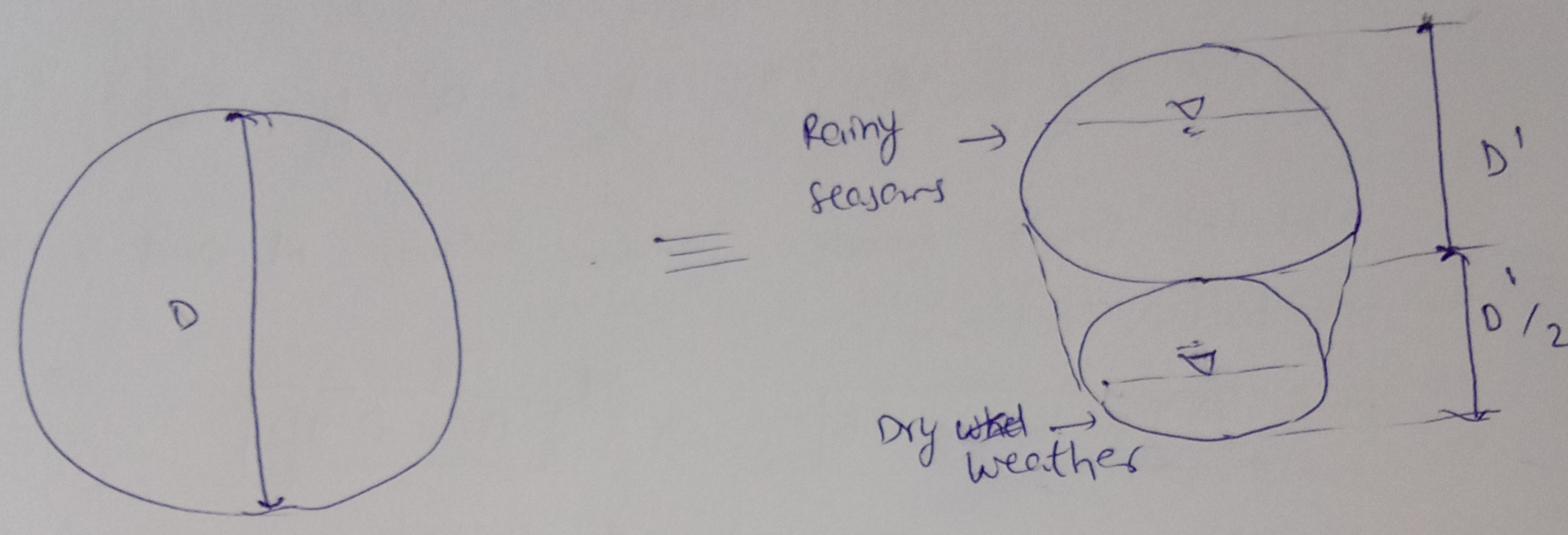
(d) Rate of flow: (e)

$q = av$

$Q = AV$

$\frac{q}{Q} = \left[\frac{\alpha^\circ}{360^\circ} - \frac{\sin\alpha}{2\pi}\right]\left[\frac{\frac{\alpha}{360^\circ} - \frac{\sin\alpha}{2\pi}}{\alpha/360^\circ}\right]^{2/3}$

(i) Egg-shaped Sewers:- (Combined Sewerage System) ⇒



Circular Section of the sewer is provided in Seperate Sewerage System. where it's advantage is obtained through out the year but in case of Combined Sewerage System in which single sewer is used to carry both Saintary sewerage and drainage discharge.

Advantage of circular section is available only during Rainy season and rest of the year depth of flow is very less than half full. hence in order to utilise the advantage of circular section through out the year in Combined sewerage System, two such circular section are placed one over each other in which upper bigger circular section is used during the rainy seasonn, and lower section is used during dry weather flow.

→ Since the section appear as an egg shape so referred as egg shaped sewer.

Note:- Two section of diff. shape is said to be hydraulically equivalent, when carry same discharge while running full on the same grade and same material.

eg

Q_o (Circular) = $Q_\square$ (Square)

$A_o V_o = A_\square V_\square$

$$\frac{\pi}{4} \times D^2 \times \left(\frac{1}{N} \times (D/4)^{2/3} S^{1/2} \right) = B^2 \times \frac{1}{N} \times (B/4)^{2/3} S^{1/2}$$

Material same, grade same means N and S are same for both section.

⇒ ** $D = 1.1B$ or ** $B = 0.9D$

⇒ For circular or egg shaped sewers:-

** $D' = 0.84D$

Quantification of storm water:-

The Rational Method:-

$$Q_{max} = \frac{1}{360} C i A$$

Q_{max} = quantity of storm water in m^3/s

C = Coefficient of Runoff.

i = intensity of Rainfall in mm/hour

A = drainage area in hectares.

$$C = \frac{\text{Runoff}}{\text{Rainfall}} < 1$$

Que:- Design a sewer so as to carry a sewage from a residential colony in a town having the following data

Area of colony = 36 Hecter

Population = 8000

Per Capita water consumpation = 170 lpcd

critical rainfall intensity = 4 cm/hr

General available ground slope = 1 in 900

assume any other data if not given and needed.

Soln:-

$Q_T = Q_{SS} + Q_{DS}$

Q_{SS} ↓ Storm sewage

Q_{DS} ↓ Domestic sewage

$Q_{SS} = \frac{1}{360} C i A = \frac{1}{360} \times 0.5 \times 40 \times 36 = 2 \, m^3/s$

[c = 0.5 assumed]

$Q_{DS} = 3 \times \left\{ 0.8 \times \frac{8000 \times 170}{86400} \right\} \times 10^{-3} = 0.037 \, m^3/s$

3 → Branch sewer

0.8 → 80% of water supply goes into sewage

Sewers are designed for "max^m hourly demand" and

Max^m hourly demand = 1.5 × Max. daily discharge

Max^m daily discharge = 2× Avg. daily discharge

So Max^m hourly discharge = 1.5 × 2 × Avg. daily discharge

Max^m hourly discharge = 3 × Avg. daily discharge

[vaild only for branch sewer.]

Type of sewer	Dia (m)	$\frac{\text{Max discharge}}{\text{Avg. discharge}}$
Lateral sewer	0.25	4
Branch sewer	0.5	3
Main sewer	1.0	2
Outfall sewer	1.25	1.5

So $Q_T = Q_{SS} + Q_{DS}$

$= 0.037 + 2 = 2.037 \; m^3/s$

So assuming sewer to be running at full depth because in Combined Sewerage System O.M. dilution will be more than by drainage water. So no problem of the gases and over flow. but in Saintary Sewerage System depth of flow should be assumed to be between 0.5D to 0.75D.

$Q = AV$

$2.037 = \pi/4 \, D^2 \times \left\{ \frac{1}{N} \times (D/4)^{2/3} (S)^{1/2} \right\}$

$N = 0.01$

So $= D = 1.28$ m.

So upper Circular Sewer $= D' = 0.84D$

$= 0.84 \times 1.28 = 1.075$ m.

$D'/2 = 1.075/2 = 0.5375$ m lower circular sewer.