

كلية الهندسة
جامعة أسوان



Water Supply Engineering

Code: CONE 323

Lecture: 12
Course Instructor:
Dr. Mohamed Fekry

Purification works

Sedimentation

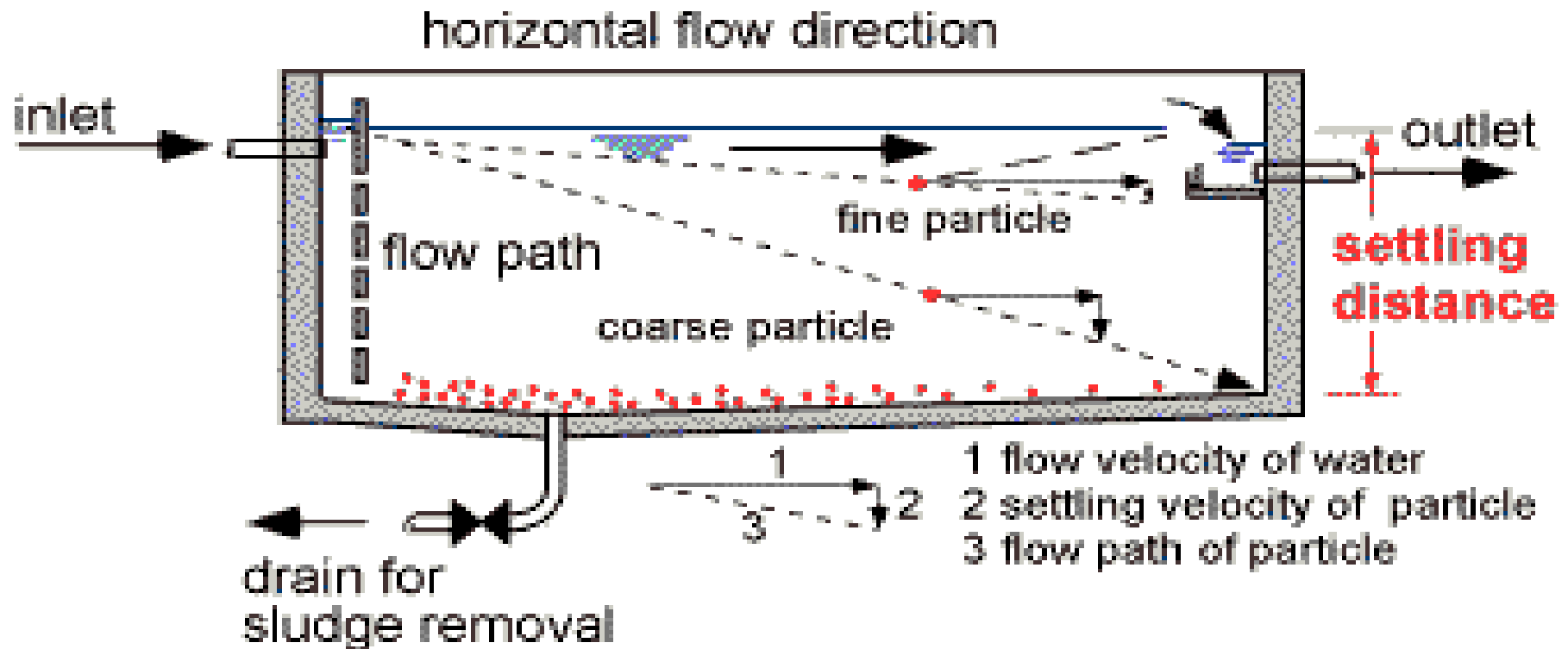
Sedimentation

Purpose:

Removal of 80% - 85% of suspended solids and colloidal matter. (In case of plane sedimentation)

Removal of 85% - 95% of suspended solids and colloidal matter. (in case of chemical sedimentation)

Sedimentation Tank



Factors effecting sedimentation:

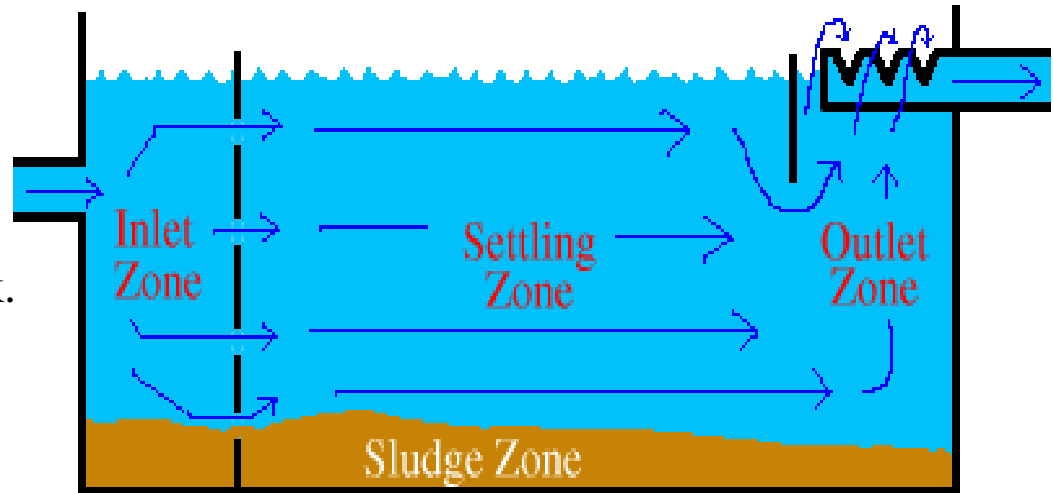
- 1- Velocity of flow $V_h \leq 0.3 \text{ m / min}$ (inversely prop.)
- 2- Viscosity (inversely prop.)
- 3- Retention time (directly prop.)
- 4- Temperature (directly prop.)
- 5- Surface loading rate
- 6- Dimension of tank (prop. with L and inversely prop. With b)
- 7- Dead zones
- 8- Characteristics of particle
- 9- Sludge with drawl

Types of sedimentation:

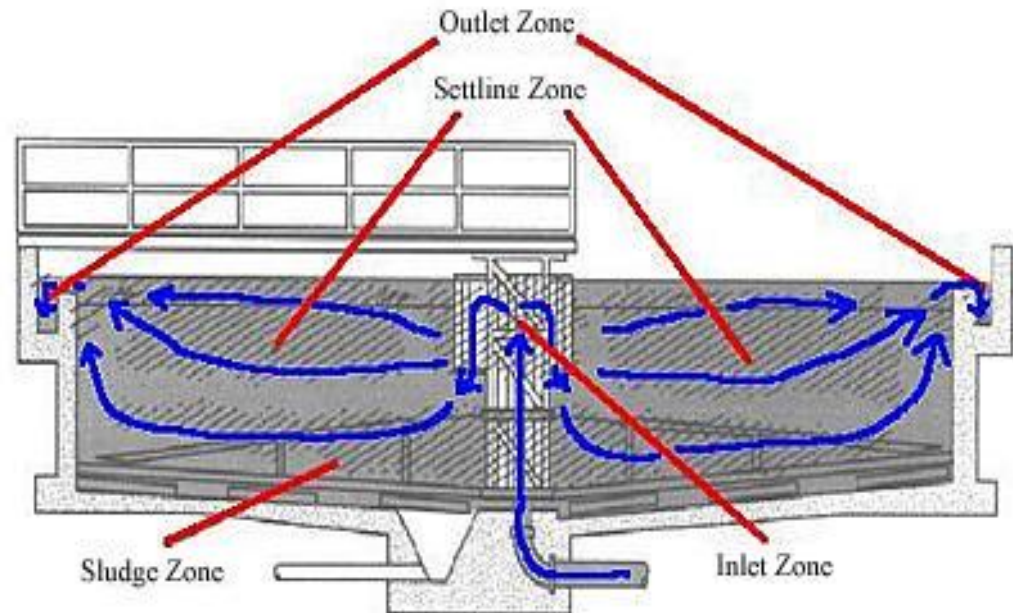
- 1- Plain sedimentation: without using any chemical substance and it is used in the slow sand filter water treatment plant.
- 2- Chemical sedimentation: using coagulant and it is used in rapid sand filter water treatment plant.

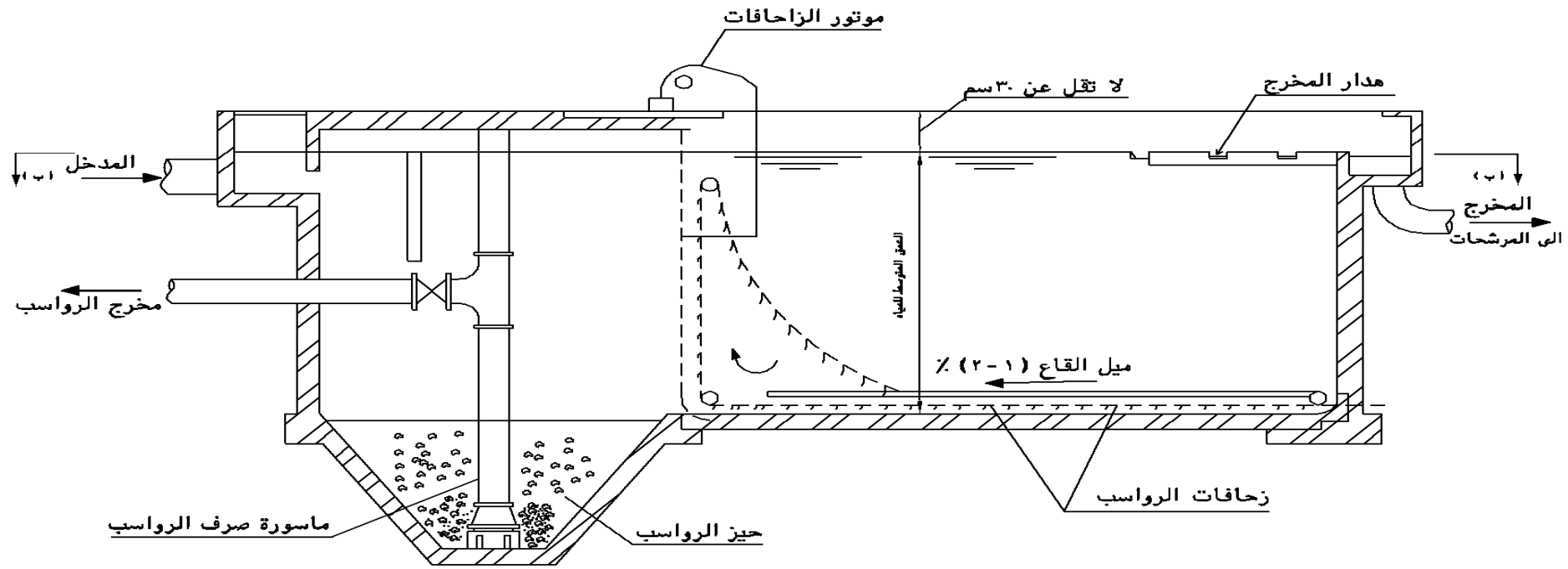
Types of sedimentation tanks:

1- Rectangular sedimentation tank.
(Horizontal flow type)

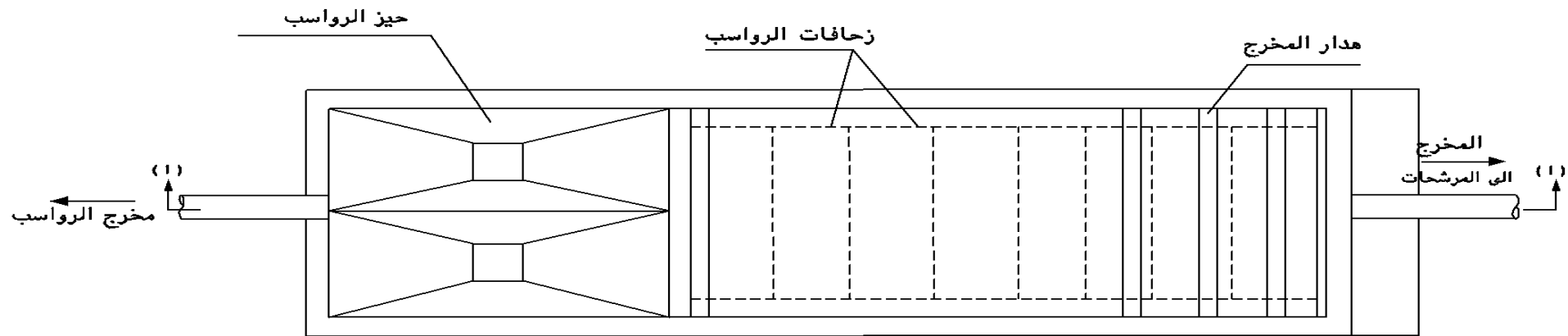


2- Circular sedimentation tank.
(Radial flow type)

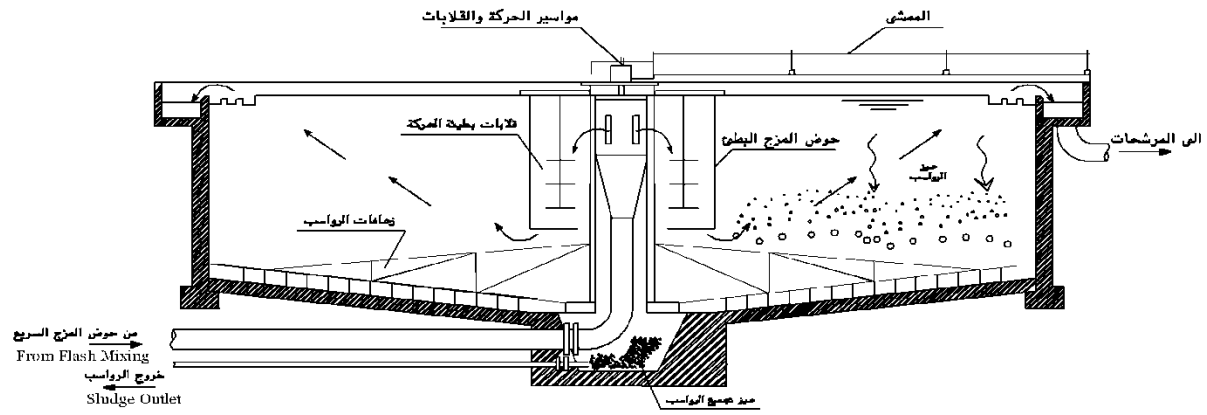




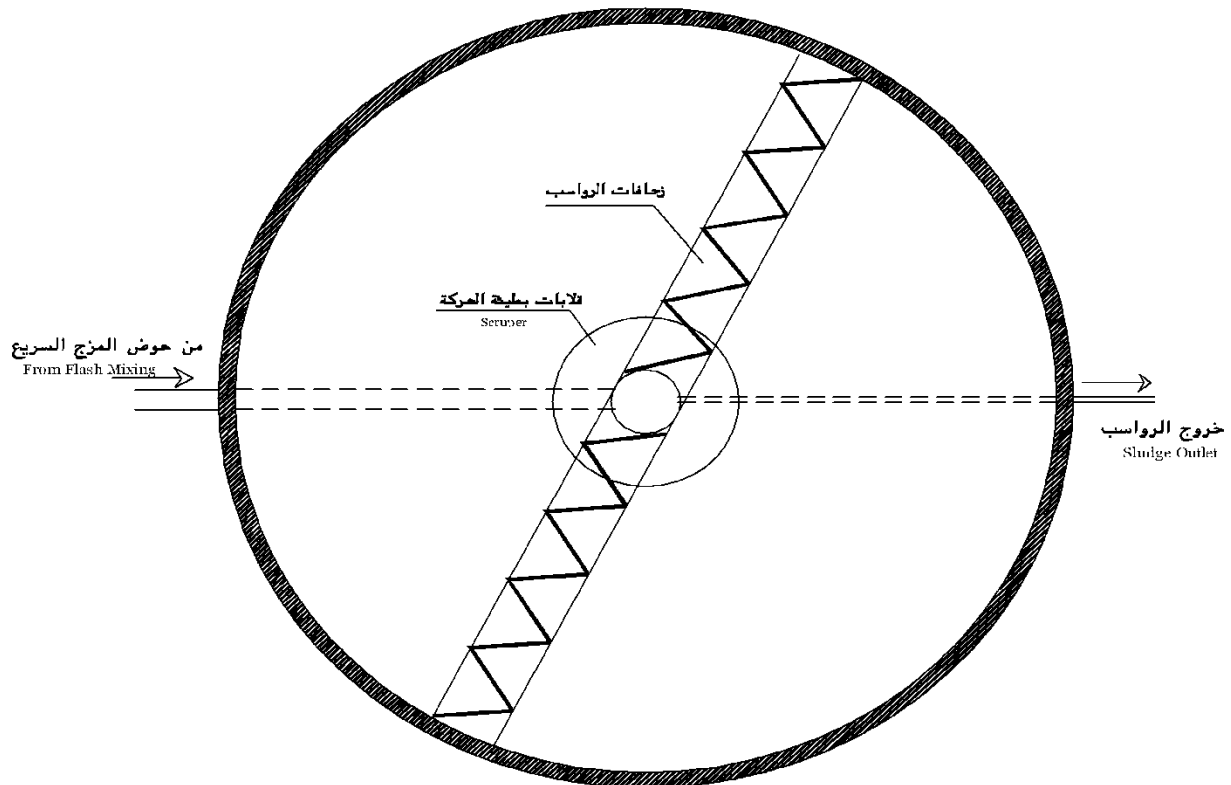
قطاع رأسي (١-١)



احواض الترسيب المستطيلة
قطاع افقى (ب - ب)



حوض ترسيب دائري بزحافات رواسب بجناحين





Design criteria:

- 1- $Q_d = Q_{\text{max monthly}} \times 1.1$
- 2- $T = 2 - 3 \text{ hrs}$
- 3- Depth = 3 - 5 m
- 4- Hydraulic weir loading = $300 \text{ m}^3/\text{m}/\text{day}$
- 5- Surface loading rate = $(20 - 45) \text{ m}^3/\text{m}^2/\text{day}$
- 6- Horizontal velocity = $Q / (n \times b \times d) \leq 0.3 \text{ m}/\text{min}$
- 7- No. of tanks ≥ 2
- 8- Rectangular tank: $L = (3 - 5) b \quad \therefore (b = L/4)$
 $L \leq 50 \text{ m}$
 $b = (2 - 4) d$
- 9- Maximum diameter of circular tank $\leq 40 \text{ m}$
- 10- Sludge pipe Φ not $< 150 \text{ mm}$



A photograph of circular sedimentation tank

Example:

For a water treatment plant of hourly out put 2400 m^3 . Determine the number and dimensions of required sedimentation tanks.

Solution:

$$V = Q_d \times T$$

$$V = 2400 \times 1.1 \times 2.5 = 6600 \text{ m}^3$$

$$S.L.R = 30 \text{ m}^3 / \text{m}^2 / \text{d}$$

$$S.L.R = \frac{Q_d}{S.A}$$

$$S.A = \frac{Q_d}{S.L.R} = \frac{2640}{\frac{30}{24}} = 2112 \text{ m}^2$$

$$d = \frac{V}{S.A} = \frac{6600}{2112} = 3.125 \text{ m} \quad (3 - 5 \text{ m})$$

$$S.A = n(L \times b)$$

$$S.A = n(L \times \frac{L}{4})$$

$$2112 = n(\frac{L^2}{4}) \quad \text{assume } n = 4$$

$$\therefore L = 45.96 \approx 46 \text{ m}$$

$$b = \frac{L}{4} = \frac{46}{4} = 11.49 \text{ m}$$

Check:

$$\begin{aligned} \text{Horizontal velocity} &= \frac{Q_d}{n \times b \times d} \\ &= \frac{2640}{4 \times 11.49 \times 3.125} = 0.3 \text{ m / min} \quad \text{safe} \end{aligned}$$

$$\begin{aligned} \text{Effluent weir loading} &= \frac{Q_d}{n \times b} \\ &= \frac{2640 \times 24}{4 \times 11.49} = 1378.59 \text{ m}^3 / \text{m} / \text{d} \end{aligned}$$

$$\text{Length of weir} = \frac{Q_d}{n \times 300} = \frac{2640 \times 24}{4 \times 300} = 52.8 \text{ m}$$

Clarifloculator tanks

Purpose:

Flocculation and sedimentation.

Removal of 85 - 96 % of the suspended and colloidal matters

Design criteria:

$T_1 = 30$ min (for flocculation), $T_2 = 2.5$ hrs (for sedimentation)

For outer chamber

$$T_o = T_1 + T_2 = 3 \text{ hrs}$$

$$d_o = (3 - 5) \text{ m}$$

$$\Phi_o \leq 40 \text{ m}$$

$$V \leq 0.3 \text{ m/min}$$

$$\text{S.L.R.} = Qd / n (S.A_o - S.A_i) \rightarrow (20 - 45) \text{ m}^3/\text{m}^2/\text{day}$$

$$\text{Hydraulic weir loading} = 300 \text{ m}^3/\text{m}/\text{day}$$

For inner chamber

$$T_i = T_1 = 30 \text{ min}$$

$$d_i = d_o - 1 \text{ m}$$

$$\Phi_i = (1/2 - 1/3) \Phi_o$$

$$V_i \geq 0.3 \text{ m/sec}$$



Clarifloculator tank

Example:

Design Clarifloculator tanks in water treatment plant of daily out put 48000 m³ and working hours 16 hrs per day.

Solution:

$$Q_d = \frac{48000 \times 1.1}{16} = 3300 m^3 / hr$$

For outer chamber

$$V_o = Q_d \times T_o \quad (T_o = 0.5 + 2.5)$$
$$= 3300 \times 3 = 9900 m^3$$

$$d_o = (3 - 5) m \quad \text{take } d_o = 4m$$

$$A_o = \frac{V}{d_o} = \frac{9900}{4} = 2475 m^2$$

$$A_o = n \frac{\pi \phi_o^2}{4}$$

$$2475 = 3 \frac{\pi \phi_o^2}{4} \rightarrow \phi_o = 32.41m$$

For inner chamber

$$V_i = Q_i \times T_i \quad (T_i = 0.5)$$

$$= 3300 \times 0.5 = 1650 \text{ m}^3$$

$$d_i = d_o - 1 \text{ m}$$

$$= 4 - 1 = 3 \text{ m}$$

$$A_i = \frac{V}{d_i} = \frac{1650}{3} = 550 \text{ m}^2$$

$$A_i = n \frac{\pi \phi_i^2}{4}$$

$$550 = 3 \frac{\pi \phi_i^2}{4} \rightarrow \phi_i = 15.28 \text{ m}$$

Check:

$$S.L.R = \frac{Q_d}{n \left(\frac{\pi \phi_o^2}{4} - \frac{\pi \phi_i^2}{4} \right)}$$

$$S.L.R = \frac{3300}{3 \left(\frac{\pi 32.41^2}{4} - \frac{\pi 15.28^2}{4} \right)} = 1.7 \text{ m}^3 / \text{m}^2 / \text{hr}$$

Purification works

Filtration

Filtration

Purpose of filtration :

Removal of remaining 4% of suspended solids.

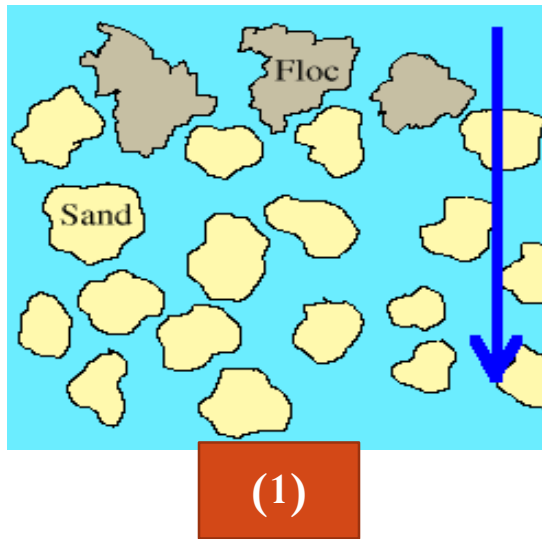
Removal of odor, color and taste.

Removal of iron and manganese.

Removal of 90 % of bacteria.

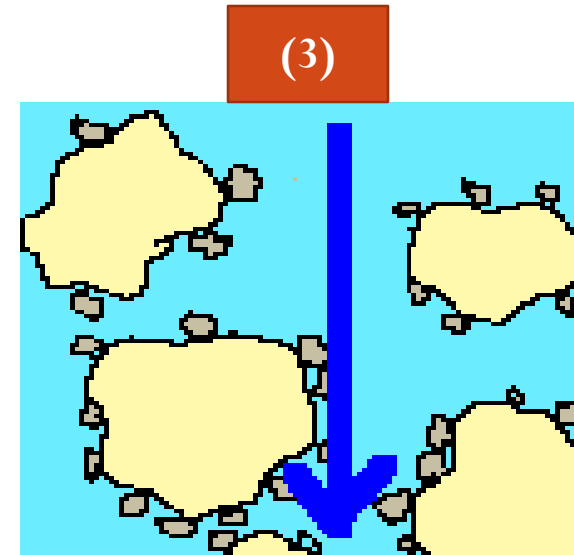
Mechanism of filtration :

1- Straining action: strain particles that has a big size on the sand surface.



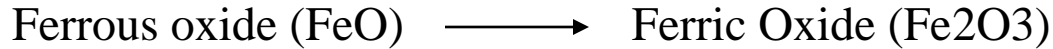
2- Sedimentation action: sediment the small particles in the gaps between the sand particles.

3- Adsorption action: the gelatinous layer around the sand particles attracts the suspended solids.



4- Biological action: the bacteria which grow in the gelatinous layer around the sand particles decompose the organic matter.

The red color due to iron removed in rapid sand filter by biological action.



5- Electrical action: particles with different electrical signs attract, so the suspended solids attract to sand surface of different electrical sign.

Factors affecting filtration :

- 1- Thickness of sand layer.
- 2- depth of water above the sand layer.
- 3- Characteristics of sand.
- 4- Preparation of water to be filtered.

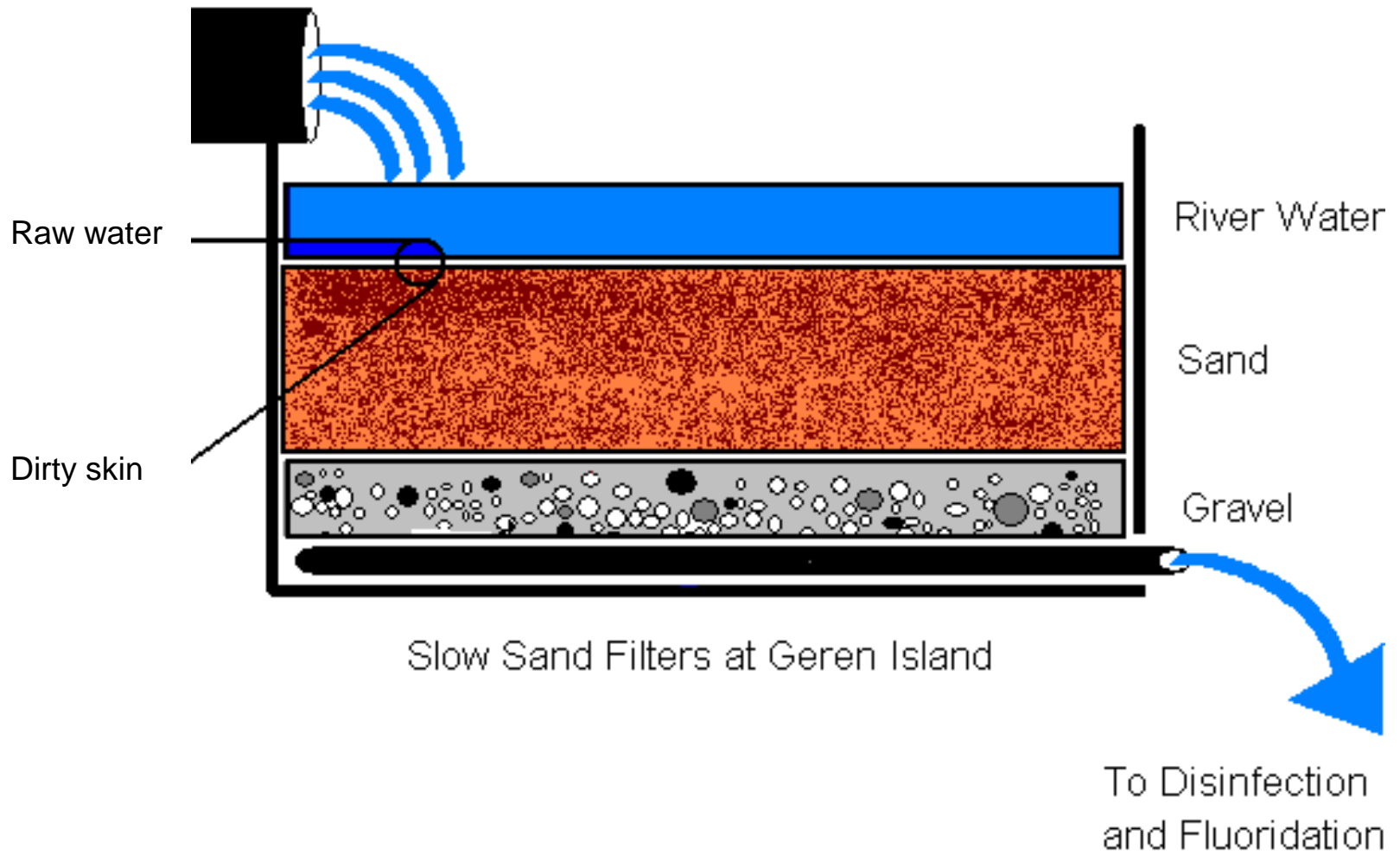
Types of filters:

- 1- Slow sand filter (gravity type)
- 2- Rapid sand filter (gravity type)

Slow sand filter

Slow sand filters used in case of plain sedimentation.

The filtration action is at the surface of the sand layer.



Slow Sand Filters at Geren Island

A schematic diagrams of slow sand filter



slow sand filter with water layer



Clean slow sand filter without water layer



Under drainage system of slow sand filter



Removal of dirty skin layer

Design criteria:

- 1- $Q_d = Q_{\text{max.monthly}}$
 $= Q_{\text{ave}} \times 1.5$
- 2- Rate of filtration = 3 - 5 $\text{m}^3/\text{m}^2/\text{day}$
- 3- Area of filtration = 1000 - 2000 m^2
- 4- Thickness of sand layer = 70 - 140 cm of diameter
0.25 - 0.35 mm
- 5- Thickness of gravel layer = 70 - 140 cm
- 6- Inlet velocity = 0.5 - 0.7 m/s
- 7- Velocity in under drainage system not > 0.6 m/s

Advantages of slow sand filter :

- 1- good quality of water with respect to the rapid sand filter outlet water
- 2- Save the quantity of water used in the filter washing
- 3- Save the energy used in washing filter
- 4- There is no problem in getting rid of the polluted water of washing
- 5- low construction fees
- 6- Easy to design and to operate

7- does not need trained labor

8- does not need any chemicals

Disadvantages of slow sand filter :

1- The outlet water discharge is too low compared to the rapid sand filter

2- Needs a large area.

Example:

It is required to design slow sand filter for a city of daily out put 60000 m³.

Solution:

$$Q_d = 60000 \text{ m}^3 / \text{d}$$

$$\text{Rate of filtration} = 3 - 5 \text{ m}^3 / \text{m}^2 / \text{d} \quad \text{take it } 5 \text{ m}^3 / \text{m}^2 / \text{d}$$

$$\text{Area of filters} = Q_d / \text{R.O.F}$$

$$\text{Area of filters} = 60000 / 5 = 12000 \text{ m}^2$$

$$\text{Area of one filter} = 1000 - 2000 \text{ m}^2$$

$$\text{NO. of filters} = 12000 / 1000 = 12 \text{ filter} + 1 \text{ reserve}$$

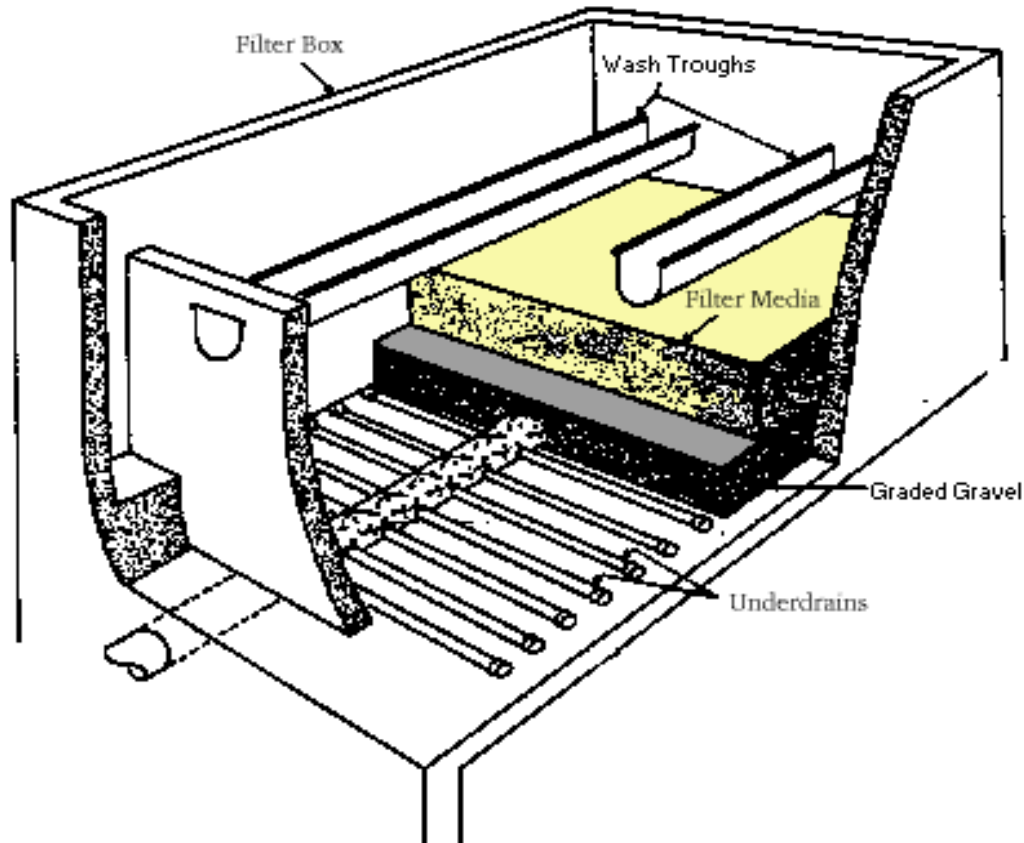
Rapid sand filter

The filtration action is through the sand layer.

Requirement of chemical coagulant is essential.

Cleaning of filter by using water under pressure in up word direction.

In rapid sand filter the thickness of sand layer decreases, the height of water above the sand layer increases and the size of sand particles increase.



A schematic diagram of rapid sand filter

Operation of rapid sand filter:

1- Start of operation stage

Open V5 and V4 to let the water go from the bottom to the upper layers of sand to get rid of air between the sand particles.

2- Maturation stage

Close V5 and V4 and open V1 and V6 for 5 – 15 minutes to create the glutinous layer around the sand particles.

3- Filtration stage

Close V6 and open V1 and V2 for 12 – 36 hours.

4- Washing stage

Close V1 and V2 and open V3 for 4 – 6 minutes, and open V5 and V4 for 6 minutes. The washing period is 8 – 10 minutes or 15 to 20 minutes in case of using air.

- At the start of washing empty the water in the sump and the under drainage system by opening V5 and V6 let the water height 10 cm above the sand surface.
- Close all the valves and open V3 for entrance of compressed air.
- V5 is opened in all washing stages.

Open V1 and V5 all other valves closed. Effluent sometimes filtered to waste for a few minutes after filter has been washed to condition the filter before it is put into service.



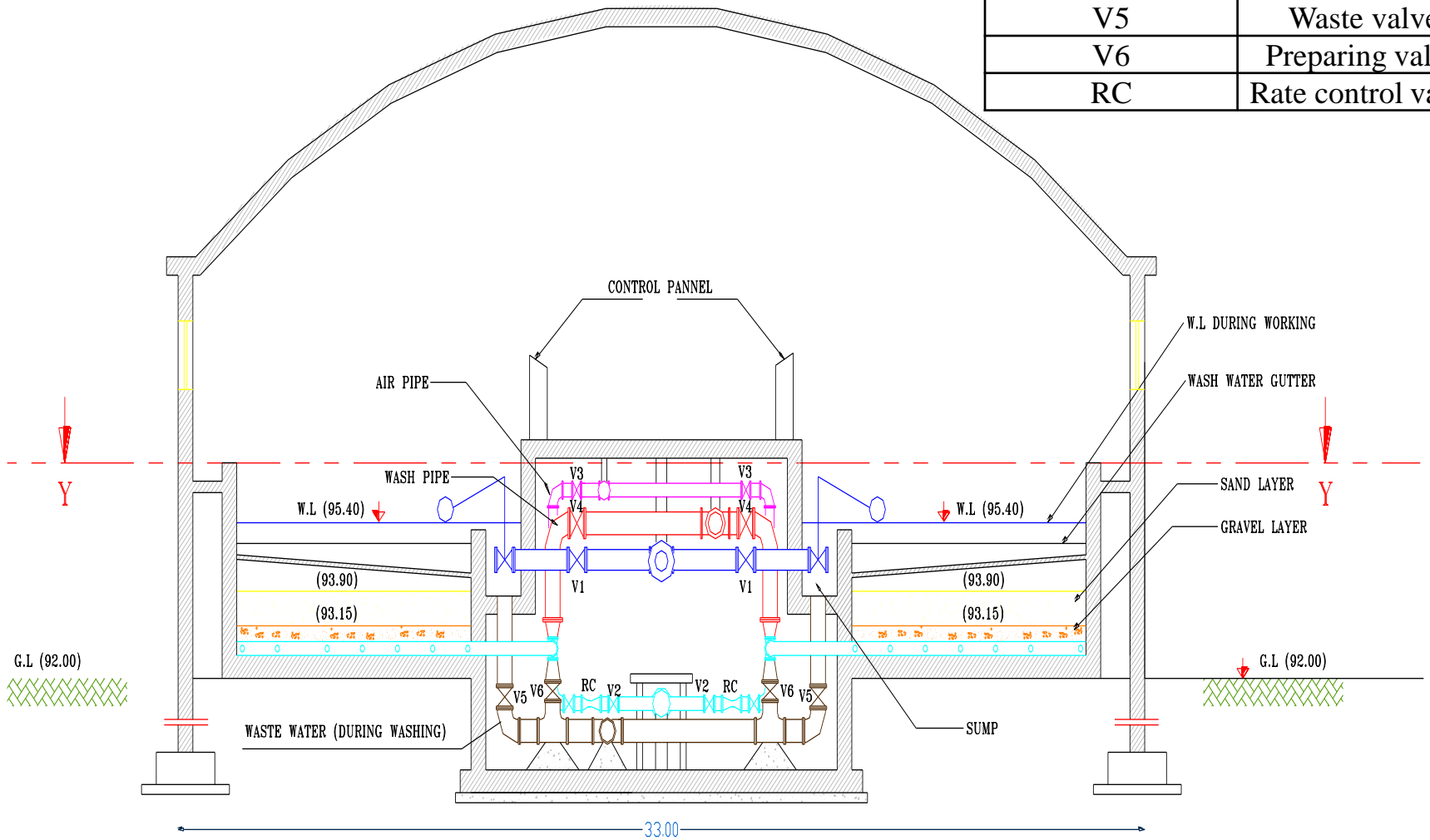
Rapid Sand Filter

Rapid Sand Filter
Back-wash and Air-wash type



Rapid sand filter

V1	Inlet valve
V2	Outlet valve
V3	Air valve
V4	Wash valve
V5	Waste valve
V6	Preparing valve
RC	Rate control valve



Design criteria:

- 1- $Q_d = Q_{\text{max.monthly}} \times 1.1$
- 2- Rate of filtration = (120 - 180) $\text{m}^3/\text{m}^2/\text{day}$
- 3- Area of filter = (40 - 60) m^2
- 4- Thickness of gravel layer = (30 - 60) cm
- 5- Thickness of sand layer = (50 - 70) cm size of sand (0.6 - 1.5) mm
- 6- Area of filters = $Q_d / \text{rate of filtration}$
If $5 < n < 30$ \diamond take 2 filters for wash
if $n \leq 5$ \diamond take 1 filter for wash
if $n \geq 30$ \diamond take 4 filters for wash
- 7- L : B = 1 : 1.25

Example:

It is required to design rapid sand filters for a city of daily out put 60000 m^3 .

Solution:

$$Q_d = 60000 \times 1.1 = 66000 \text{ m}^3 / \text{d}$$

$$\text{Rate of filtration} = 120 - 180 \text{ m}^3 / \text{m}^2 / \text{d} \quad \text{take it } 150 \text{ m}^3 / \text{m}^2 / \text{d}$$

$$\text{Area of filters} = Q_d / \text{R.O.F}$$

$$\text{Area of one filter} = 40 - 60 \text{ m}^2 \quad \text{take it } 50 \text{ m}^2$$

$$\text{Area of filters} = 66000 / 150 = 440 \text{ m}^2$$

$$\text{NO. of filters} = 440 / 50 = 8.8 \sim 8 \text{ filters} + 2 \text{ for wash}$$

$$\text{Area of filter} = 440 / 8 = 55 \text{ m}^2$$

$$\text{If } L = 8 \text{ m} \quad B = 6.88 \text{ m}$$

$$\text{R.O.W} = 5 \times \text{R.O.F}$$

$$= 5 \times 150 = 750 \text{ m}^3 / \text{m}^2 / \text{d}$$

Assume time of washing 10 minutes

$$\text{Amount of washing water} = \text{R.O.W} \times n \times A \text{ (of one filter)} \times \text{time of wash}$$

$$= 750 \times 8 \times 55 \times (10/24 \times 60)$$

$$= 2291.67 \text{ m}^3 / \text{m}^2 / \text{d}$$

Purification works

Disinfection & Underground Water Tanks

Disinfection

Purpose:

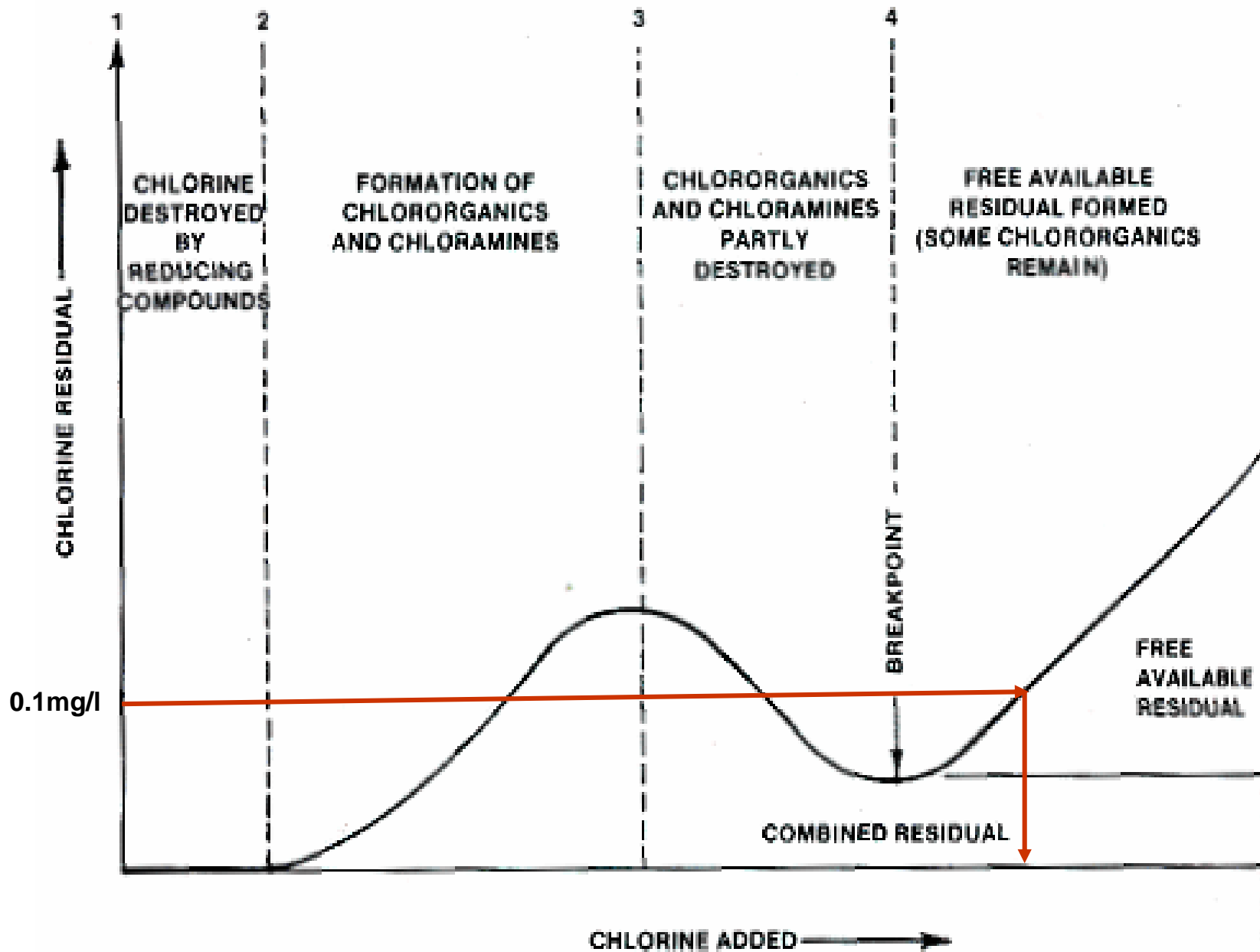
Destroy all bacteria.

Methods of disinfection:

- 1- Heat
- 2- Ultra violet
- 3- Chlorination

Factors affecting efficiency of chlorination:

- Temperature directly proportional
- Ph value inversely proportional
More efficient at pH less than 7.
- Chlorine dose
Chlorine dose 0.5 – 1 mg/l is required to give the residual from 0.1 – 0.3 mg/l.
- Adequate mixing
- Retention period (½ hr)





Injection by Chlorine

4- Ozone (O_3)

The ozone dose is 2 – 3 mg/l.

Advantages:

Ozone kills the bacteria faster than the chlorine

Disadvantages:

1- High cost

2- It disappeared after 10 minutes, so it doesn't has residual to protect the water networks thus chlorination is better than ozone.

Clear water reservoir (ground reservoir):

Purpose:

1- Cover the contact time for disinfection.

2- Cover the emergency requirement for 6 - 8 hr of Q_d .

3- Cover the difference between max consumption daily and monthly through a day.

4- Cover 80% of fire demand (120 – 240 m³/ 10,000 capita).

Design criteria:

1- $Q_d = Q_{max}$ monthly

2- Volume = bigger of (V_1, V_2, V_3) + V_4

$V_1 = Q_d \times 1/2$ hr for disinfection

$V_2 = (Q_{max}$ daily – Q_{max} monthly) x 24 hrs

$V_3 = Q_d \times 8$ hrs

$V_4 = 4/5 (120 \times pop/ 10,000)$

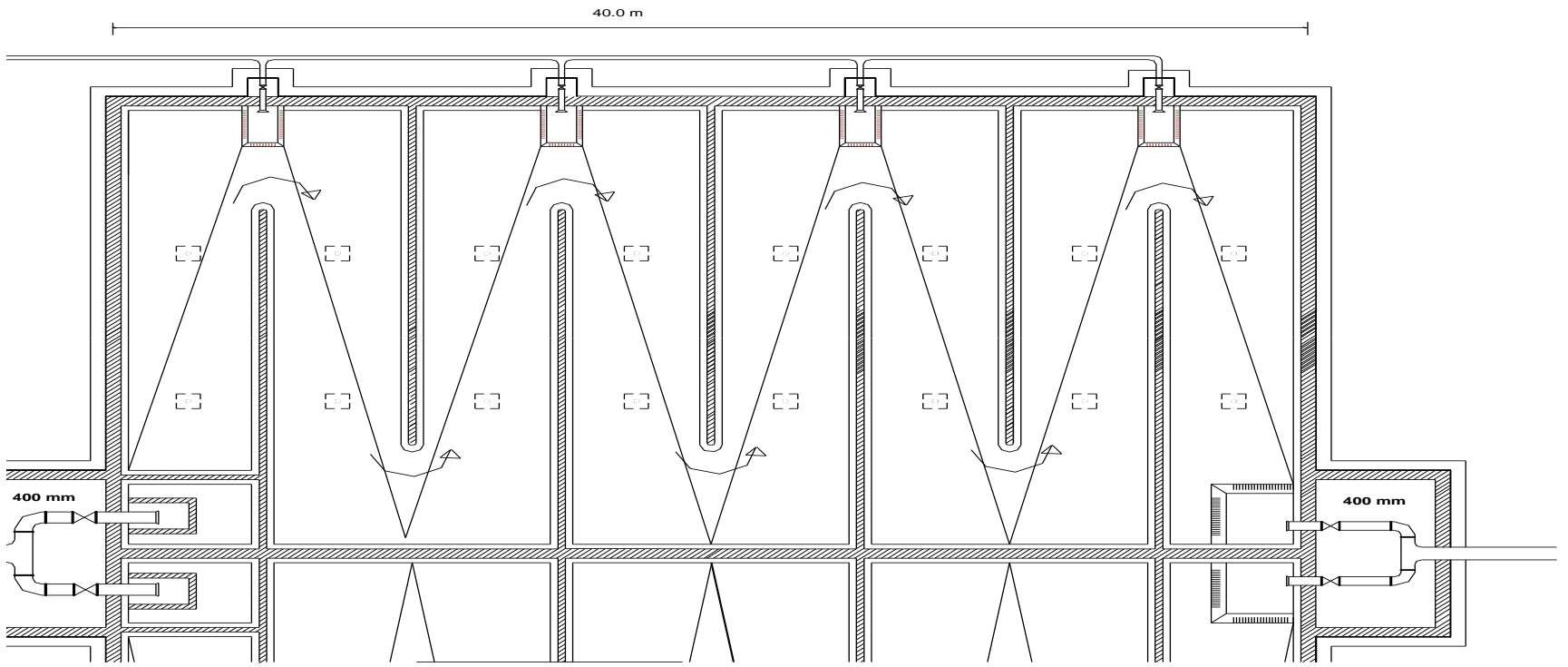
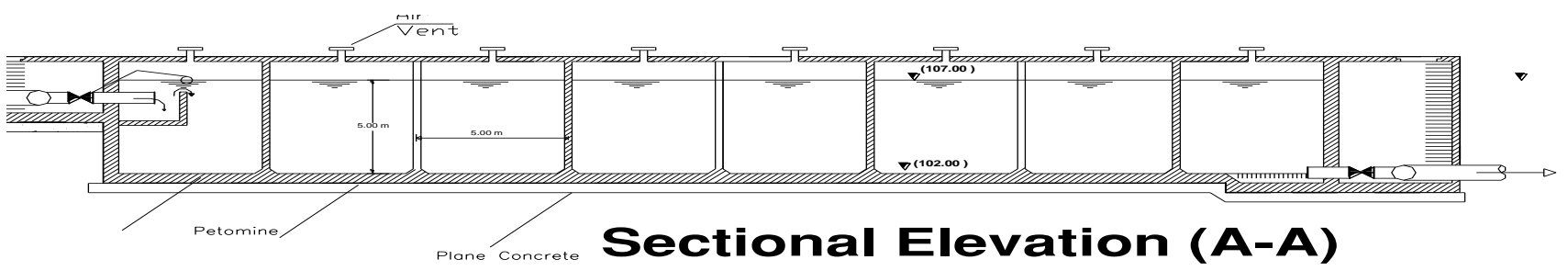
3- No. of tanks ≥ 2

4- $L \leq 50$ m and a number devisable by 5

5- $B \leq 50$ m

6- $d = 2.5 - 6.5$

Size (m ³)	D (m)
2500	2.5 - 3.5
2600 - 13500	3.5 - 5
13600 – 20000	5 - 6.5



Clear water reservoir

Example:

For a city of population 75,000 capita and water consumption 200 l/c/d. It is required to design ground reservoir. The working hours are 20 hours.

Solution:

$$Q_{ave} = \frac{\text{population} \times q_{ave}}{1000}$$

$$Q_{ave} = \frac{75000 \times 200}{1000} = 15000 \quad m^3 / d$$

$$Q_{\max \text{ monthly}} = 1.5 \times Q_{ave}$$

$$Q_{\max \text{ monthly}} = 1.5 \times 15000 = 22500 \quad m^3 / d$$

$$Q_{\max \text{ daily}} = 1.8 \times Q_{ave}$$

$$Q_{\max \text{ daily}} = 1.8 \times 15000 = 27000 \quad m^3 / d$$

Volume:

$$V1(\text{for di sin fiction}) = Q_d \times 0.5 \text{ hrs}$$

$$V1(\text{for di sin fiction}) = \frac{22500}{20} \times 0.5 = 562.5 \quad m^3$$

$$V2(\text{for emergency}) = Q_d \times 8 \text{ hrs}$$

$$V2(\text{for emergency}) = \frac{22500}{20} \times 8 = 9000 \quad m^3$$

$$V3(Q_{\max \text{ daily}} - Q_{\max \text{ monthly}}) = (27000 - 22500) \times 1 \text{ day} = 4500 \quad m^3$$

$$V4\left(\frac{4}{5} \text{ fire demand}\right) = \frac{4}{5} \times 120 \times \frac{75000}{10000} = 720 \quad m^3$$

$$V = 9000 + 720 = 9720 \quad m^3$$

$$\text{Take } d = 4m \quad , n = 2$$

$$\text{Area} = \frac{9720}{2 \times 4} = 1215 \quad m^2$$

$$L = 40 m \quad \rightarrow \quad B = 30.37 \approx 30 m$$

Filtration – Disinfection – Underground water tanks

Lec2 - إمداد مياه ا.د.حمدي سيف
Drinking water treatment2.ppt