1. Sedimentation is a natural process by which solid particles (sp. Gravity >1), which are suspended settles under the action of gravity, when the turbulence is retarded by offering storage to the water

   Water is not allowed to rest

   Flow has very small velocity

   During this flow particles will settle at the bottom of the tank

   The flow may be either horizontal or vertical direction


**1. Horizontal Flow Tanks**

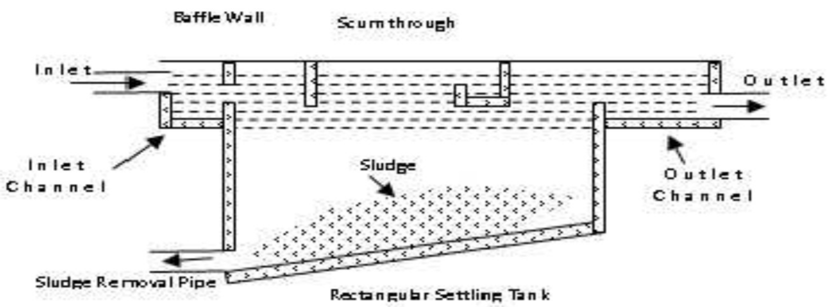
- These tanks may be **rectangular** or circular in plan
- In the design of horizontal flow tanks, the aim is to achieve, as nearly as possible, the ideal conditions of equal velocity at all points lying on each vertical line in the settling zone. (***permissible velocity 0.3m/s)***
- The direction of flow in the tank is substantially horizontal.
- They have **more length** (generally twice to width) as water need to flow more distance to settle all suspended particles.

**Rectangular Tanks with Longitudinal Flow**

Rectangular basins are commonly found in large- scale water treatment plants.

Rectangular tanks are popular as they tend to have:

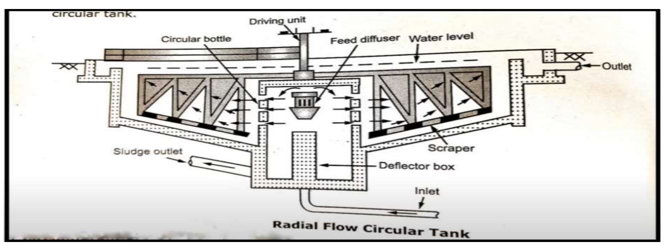
- High tolerance to shock overload
- Cost effectiveness due to lower construction cost
- Lower maintenance
- Minimal short circuiting



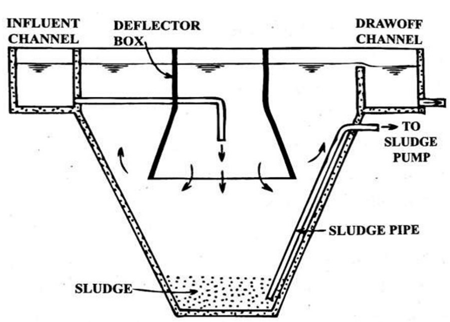

**b. Circular tanks with radial flow, with central feed**

Circular basins are often referred to as clarifiers.

These basins share some of the performance advantages of the rectangular basins, but are generally **more prone to short circuiting and particle removal problems**




2. **Vertical or up flow settling tanks**
3. These tanks generally be of circular in shape
4. Flow takes place in vertical direction
5. Hopper bottom is provided at the bottom of the tank to dispose the sludge collect from the tank.



2.

a. The maximum daily demand at a water purification plant has been estimated as 12 million litres per day. Design the dimensions of a suitable sedimentation tank (Fitted with mechanical sludge removal arrangements) for the raw supplies, assuming a detention period of 6 hours and velocity of flow as 20cm/min. **(06 Marks)**

Solution: →

Given data.

Daily demand at WTP = $Q = 12 \times 10^6$ l /day.
(Quantity of water treated in 24 hours)

Detention period $t$ = 6 hours.

Flow velocity = 20 cm/minute.

Dimensions of sedimentation tank = ? L; B; D

Quantity of water to be treated during the detention period of 6 hours

$\Rightarrow \frac{12 \times 10^6}{24} \times 6 = 3 \times 10^6$ litres { 1000 l ⟶ 1 $m^3$ }

$= 3000\ m^3$

∴ The capacity of the tank required = 3000 $m^3$

Velocity of flow to be maintained through the tank = 20 cm/minute

= 0.2 m/minute

Assuming Rectangular sedimentation tank.

The length of the tank required

= Velocity of flow × Detention period

= 0.2 × (6×60)

**L = 72 m**

Cross-sectional area of the tank required

$= \frac{\text{Capacity of the tank}}{\text{Length of the tank}}$

$= \frac{3000}{72}\ m^2$

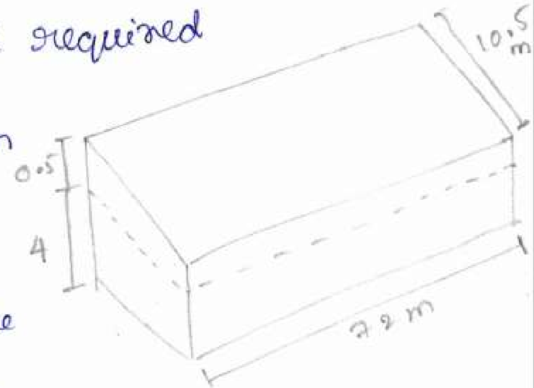
**$A = 41.7\ m^2$**

Assuming the water depth in the tank as 4 m.

∴ The width of the tank required

$= \frac{41.7}{4} \simeq 10.5m$

$\boxed{B = 10.5m}$




using free board of 0.5 m, the overall depth = 0.5 + 4.0 = 4.5 m.

∴ A Rectangular sedimentation tank with an overall size of $\boxed{72\,m \times 10.5\,m \times 4.5\,m}$ is required (can be used).

3.

Comparison between Slow Sand Filter and rapid Sand Gravity Filter:

| Sl. No. | Item | Slow Sand Filter | Rapid Sand Filter |
|---|---|---|---|
| 1 | Pre-treatment required | Water from plain sedimentation or raw water and should not coagulated water | Coagulation, flocculation and sedimentation is a must. |
| 2 | Filter media | Grain size (D10) = 0.2 to 0.4 mm, depth of sand bed = 90 to 110 cm | Grain size (D10) = 0.35 to 0.55 mm, depth of sand bed = 60 to 90 cm |
| 3 | Base material | Gravel, 30 to 75 cm depth, size of gravel is 3 to 65 mm | Gravel, 60 to 90 cm depth and 3 to 40 mm size. |

| | | | |
|---|---|---|---|
| 4 | Under drainage system | Laid in order to receive filtered water | Laid in order to receive filtered water and also to pass water for backwashing at a very high rate. |
| 5 | Size of each unit | Large, plan area – 100 to 2000 $m^2$. | Small, plan area – 10 to 80 $m^2$. |
| 6 | Rate of filtration | Small, 100 to 200 $l/hr/m^2$ of filter area | Large, 3000 to 6000 $l/hr/m^2$ of filter area |
| 7 | Economy | High initial cost of both land and materials, but low cost of operation and maintenance | Low initial cost, but higher cost of operation and maintenance. Over all, it is cheaper and economical |
| 8 | Efficiency | Very efficient in removing bacteria (98 to 99%) but less efficient in removing colour | Less efficient in removing bacteria (80 to 90 %) but very efficient in removing colour. |
| 9 | Flexibility | Not flexible for meeting variation in demand | Quite flexible for meeting reasonable variations in demand |
| 10 | Suitability and adaptability | Adopted for treating smaller village supplies or for individual industrial supplies | They are widely and almost universally adopted for treating public supplies. |
| 11 | Post treatment | Almost pure water is obtained | Disinfection is must |
| 12 | Skilled supervision | Not required | Essential |
| 13 | Loss of filter head | Approximately 10 cm | Approximately 0.3 m |
| 14 | Method of cleaning | Scrapping and removing the top 1.5 to 3 cm layer, labours required | Agitating the sand grains and backwashing with or without compressed air, it is a short and easy method |

4. **Coagulation** is a chemical technique which is directed towards the destabilization of the charged colloidal particles.

Q6) Determine the quantity of alum, required in order to treat 13 million litres of water per day at a treatment plant, where 12 ppm of alum dose is required. Also determine amount of carbon dioxide gas which will be released per litre of water treated.

**Solution:-** Quantity of water to be treated $= 13 \times 10^6$ l/d.

Alum dose required = 12 ppm i.e., 12 mg/l

$\therefore$ Amount of alum reqd. per day $= (13 \times 10^6 \times 12)$ mg

$= 156$ kg

The chemical reaction which is involved in treating water with alum is given by

$$Al_2(SO_4)_3 \cdot 18H_2O + Ca(HCO_3)_2 \longrightarrow 2Al(OH)_3 \downarrow + 3CaSO_4 + 18H_2O + 6CO_2 \uparrow$$

Now, the molecular mass of alum $(Al_2(SO_4)_3 \cdot 18H_2O)$

$= 2(26.97) + 3(32.066 + 4 \times 16) + 18(2 \times 1.008 + 16)$

$= 666.426$

$\simeq 666$

The molecular mass of carbon dioxide $(6CO_2)$

$= 6(12.01 + 2(16))$

$\simeq 264.$

$\therefore$ 666 mg of alum, if used, will release 264 mg of carbon dioxide.

$\therefore$ 12 mg of alum will release

$\Rightarrow \frac{264}{666} \times 12$

$= 4.76$ mg of $CO_2$.

6. The removal of hardness from water is known as water softening.
The advantages of softening of water are;
Reduces the soap consumption
Lowered cost in maintaining plumbing fixtures and improved taste of food preparations
For the industrial supplies, the softening is more important, because hard water causes scaling troubles in boilers and interferes in working with dyeing system.

**i) Lime-Soda Process**

in this process, lime ($Ca(OH)_2$) and soda ash ($Na_2CO_3$) are added to raw water, which react with calcium and magnesium salts, so as to form insoluble precipitates of calcium carbonate and magnesium hydroxide ($Mg(OH)_2$). These precipitates can be settled in the settling tank.
The chemical reactions which are involved are;

$$Ca(HCO_3)_2 + Ca(OH)_2 \longrightarrow \underset{\text{(Insoluble ppt)}}{2CaCO_3} + 2H_2O$$

$$Mg(HCO_3)_2 + Ca(OH)_2 \longrightarrow Ca(HCO_3)_2 + \underset{\text{(Insoluble ppt)}}{Mg(OH)_2}$$

$$MgCO_3 + Ca(OH)_2 \longrightarrow \underset{\text{(Insoluble ppt)}}{Mg(OH)_2} + \underset{\text{(Insoluble ppt)}}{CaCO_3}$$

$$\underset{\text{(Non-Carbonate hardness of Mg)}}{MgCl_2} + Ca(OH)_2 \longrightarrow Mg(OH)_2 + \underset{\text{(Non-Carbonate hardness of Ca)}}{CaCl_2}$$

$$MgSO_4 + Ca(OH)_2 \longrightarrow Mg(OH)_2 + \underset{\text{(Non-Carbonate hardness of Ca)}}{CaSO_4}$$

$$CaCl_2 + \underset{\text{(Soda ash)}}{Na_2CO_3} \longrightarrow CaCO_3 + \underset{\text{(Sodium salts)}}{2NaCl}$$

$$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 + Na_2SO_4$$

From the above reactions shows that, lime helps in removing the entire carbonate hardness of Ca and Mg and it reacts with non-carbonate hardness of Ca. then the non-carbonate hardness of Ca is finally removed by soda.
The sodium salts which are finally formed are soluble in water, but are generally not objectionable in the amounts resulting from the softening process.
Most of the calcium carbonate and magnesium hydroxide which is formed gets precipitated and can be sedimented in the settling tank.
However a little quantity of calcium carbonate and magnesium hydroxide may remain as finely divided particles, and may cause troubles by getting deposited on the filter to cause enlargement

of the sand grains called incrustation of filter media or in the pipes of the distribution system. To prevent this, water is to be recarbonated by passing carbon dioxide gas through it, as it leaves the sedimentation tank. In the recarbonation process, the insoluble carbonates combine with the carbon dioxide to again form the soluble bicarbonates, as given below:

$$CaCO_3 + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2$$

(Insoluble cal. carbonate) (Soluble Cal.bicarbonate)

$$Mg(OH)_2 + CO_2 \longrightarrow MgCO_3 + H_2O$$

$$MgCO_3 + CO_2 + H_2O \longrightarrow Mg(HCO_3)_2$$

The carbon dioxide gas to be blown in water can be produced by burning coke, gas or oil. By the recarbonation process, even though the water regains some of its hardness, yet recarbonation is advisable.