Training of Trainers Training program for Operators in textile effluent treatment plants

Promotion of Sustainability in the Textile and Garment Industry in Asia - FABRIC

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

FABRIC Asia

Day 2: Presentation 2

Chemical Treatment systems

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Contents

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Units in Chemical treatment

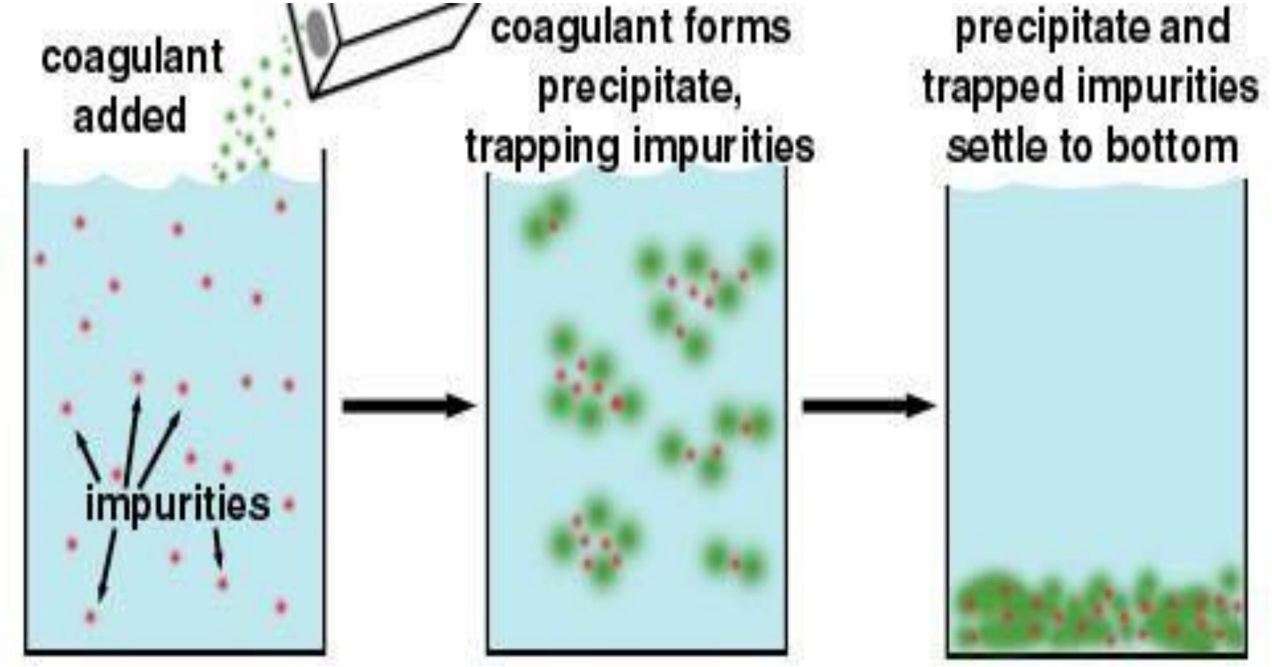
Chemical slurry preparation &	• consists of 2 or 3 small tanks with agitators. coagulant, neutralising agent and polyelectrolytes
Flash mixer	• Where the prepared chemical slurry is mixed with equalised effluent
Flocculator	• To aid settleable floc formation of solids
Solids separation unit	• Where the precipitated solids are separated throough settling, filtration or floatation

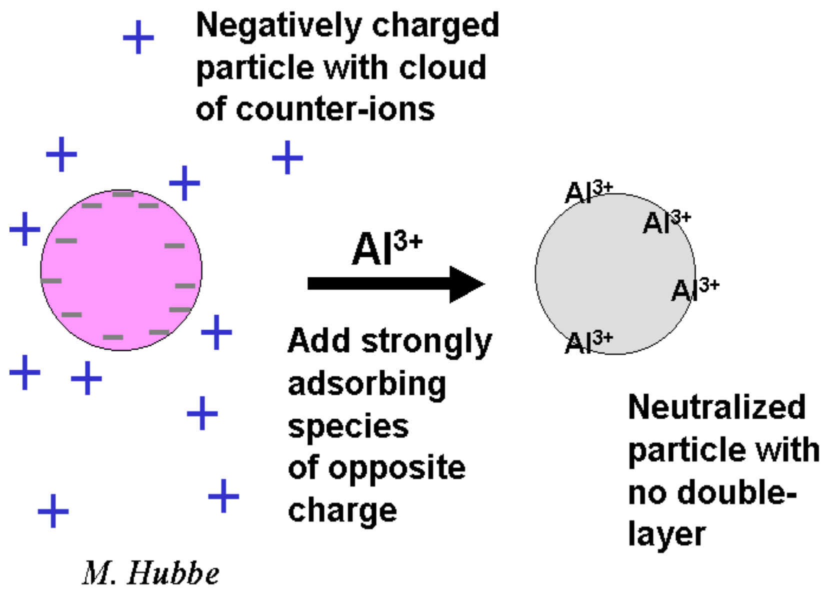
Flocculator & clarifier

QUIZ

What are the chemicals used in Textile ETP?

Coagulation





Reaction Tank / Flash Mixers

- Fitted with mixer for rapid mixing (rpm=60-150)
- HRT = 5 - 10 minutes
- Dosing system of Lime (5% solution) and $FeSO_4$ (10% solution)
- *Excess $FeSO_4$ 1 kg = 0.4 kg excess sludge and retain colour in aeration tank*

$$\text{HRT (hours)} = \frac{\text{Total Volume } (m^3)}{\text{Flow Rate of Effluent } (m^3/hr)}$$

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Color change on oxidation of ferrous ion

Ferrous sulphate`

Ferric sulphate

No overdosing of ferrous sulphate please!!

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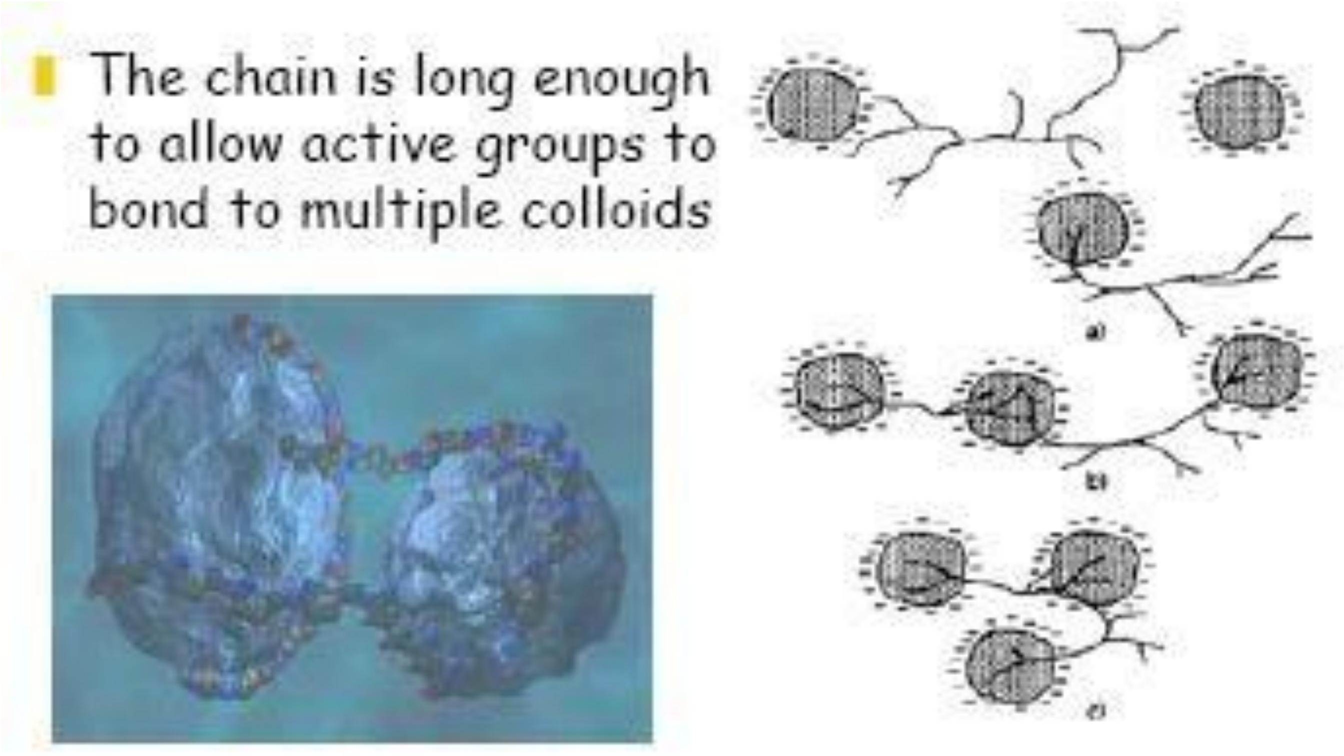
Flocculation aids



Flocculation Tank

- Fitted with mixer for rapid mixing (rpm=20)
- HRT = 20 - 30 minutes
- Dosing system of Poly Electrolyte (0.05-0.1% solution)

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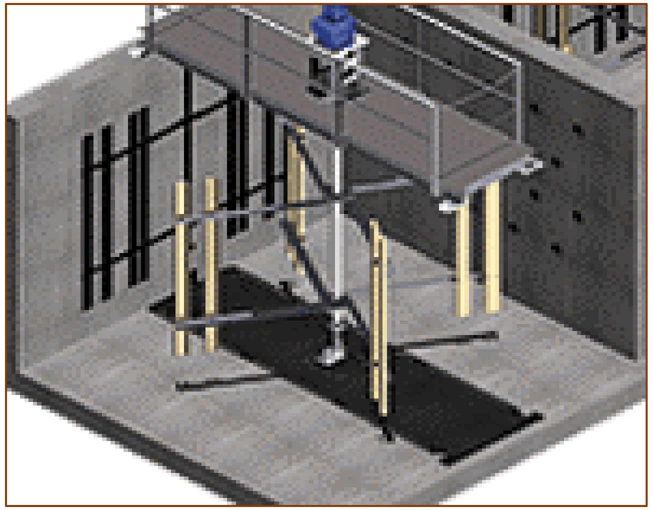
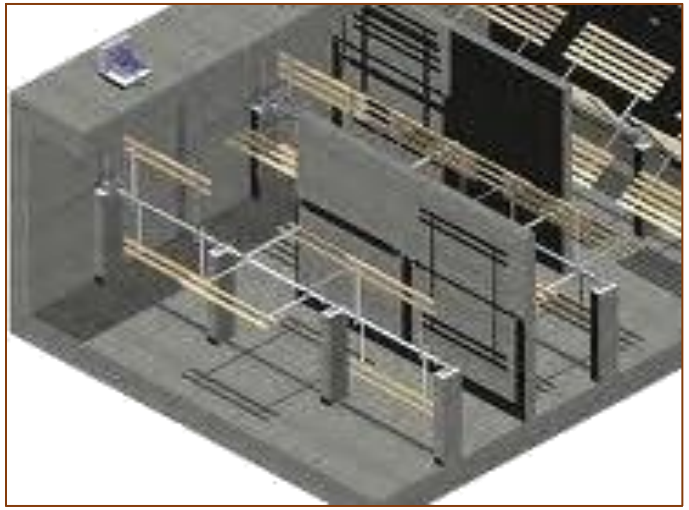
pH Correction Tank

- Fitted with mixer for rapid mixing (rpm=20)
- HRT = 5 - 10 minutes
- to bring down the pH within a range of 6.5 to 8.5
- Dosing system of lime/sulphuric acid (2.5% solution)
- *Excess lime produces excess sludge*

Vertically and horizontally rotating flocculator paddles





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Dosing Tanks

- At least two sets for each chemical with agitator
- Can hold sufficient quantities of solution for at least 8 h

- Tank Volume (m^3) = Feed Rate (m^3/h) x Time (h)

Where: Feed rate = Required flow of chemical (m^3/h)

Time = 8 h

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Ensure proper dosing

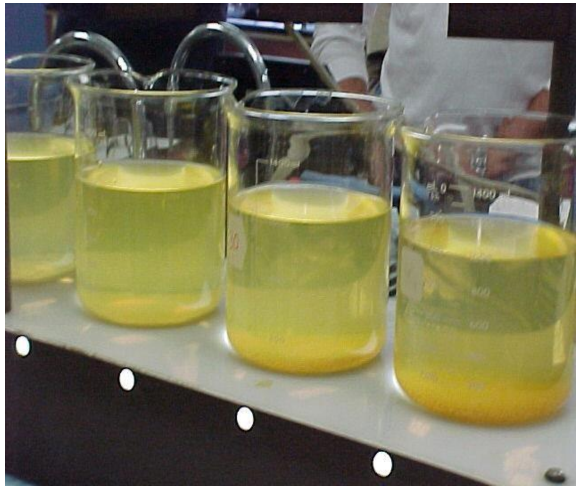
Jar Tests

Purity of the chemicals

Jar Tests

- A jar test simulates the coagulation and flocculation processes

Determination of optimum pH



- Fill the jars with raw water sample (500 or 1000 mL) – usually 6 jars
- Adjust pH of the jars while mixing using H_2SO_4 or lime (pH: 5.0; 5.5; 6.0; 6.5; 7.0; 7.5)
- Add same dose of the selected coagulant (alum or iron) to each jar (Coagulant dose: 5 or 10 mg/L)

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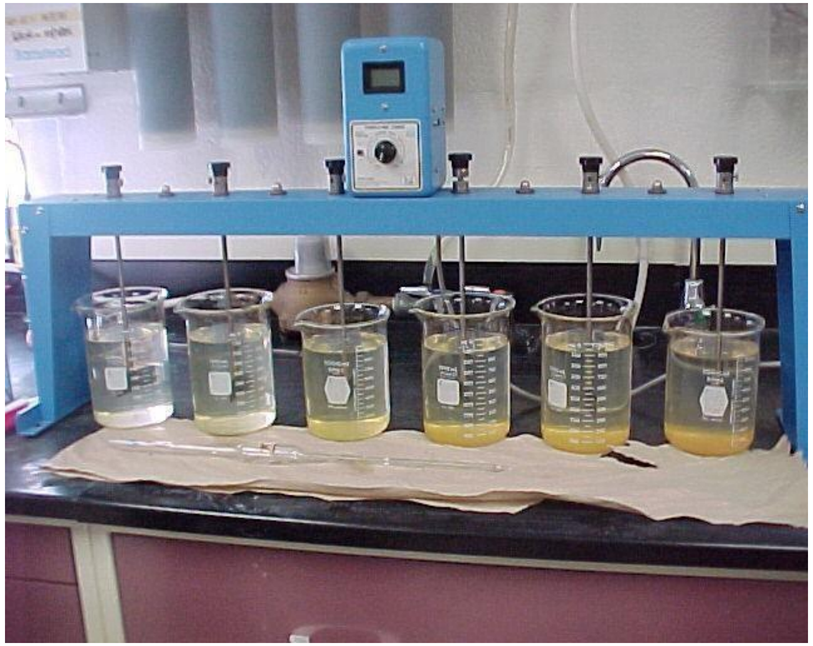
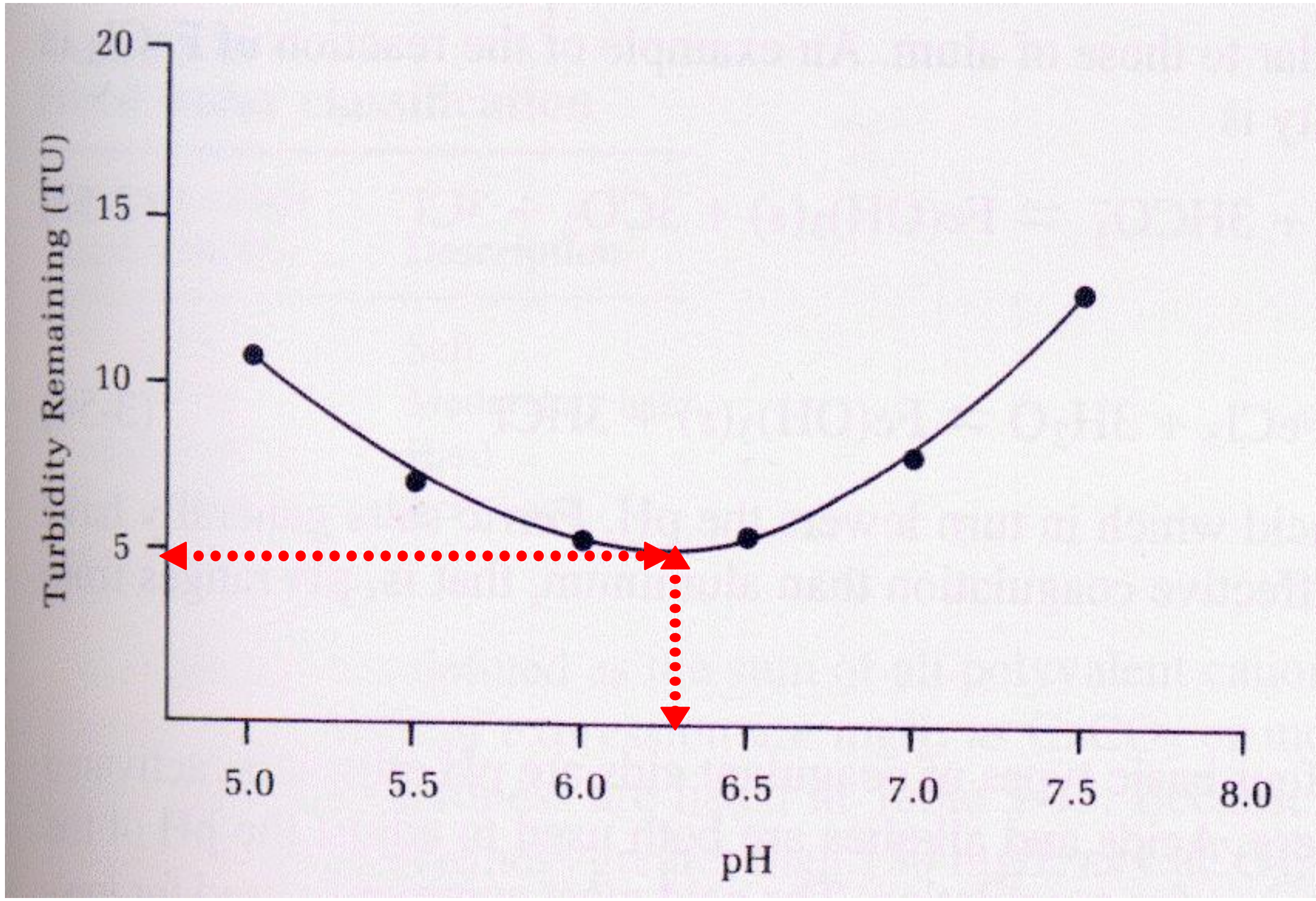
Jar Tests – optimum pH

Determination of optimum pH

- Rapid mix each jar at 100 to 150 rpm for 1 minute.
- Rapid mixing helps to disperse the coagulant throughout each container
- Reduce the stirring speed to 25 to 30 rpm and continue mixing for 15 to 20 mins
- Slower mixing speed helps promote floc formation
- Turn off the mixers and allow flocs to settle for 30 to 45 mins
- Measure the final residual turbidity in each jar
- Plot residual turbidity against pH



Jar Tests – optimum pH



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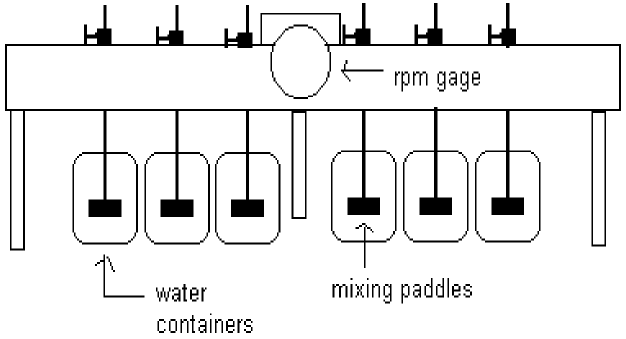
Jar Tests – Coagulant dose

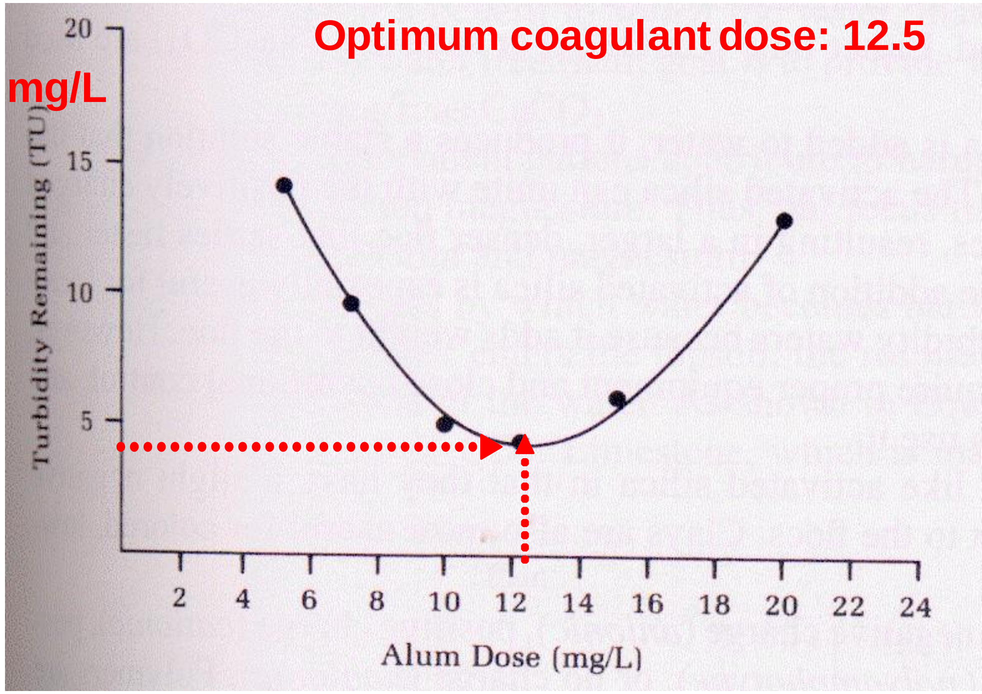
- Repeat all the previous steps
- This time adjust pH of all jars at optimum (6.3 found from first test) while mixing using or Lime/ H_2SO_4
- Add different doses of the selected coagulant (alum or iron) to each jar (Coagulant dose: 5; 7; 10; 12; 15; 20 mg/L)



- Rapid mix each jar at 100 to 150 rpm for 1 minute. The rapid mix helps to disperse the coagulant throughout each container
- Reduce the stirring speed to 25 to 30 rpm for 15 to 20 mins

Jar Tests – Coagulant dose

- Turn off the mixers and allow flocs to settle for 30 to 45 mins
- Then measure the final residual turbidity in each jar
- Plot residual turbidity against coagulant dose
- The coagulant dose with the lowest residual turbidity will be the optimum coagulant dose



Typical coagulants

Aluminum sulfate: $Al_2(SO4)_3.14\ H_2O$

Iron salt- Ferric sulfate: $FeSO_4.6H_2O$

Iron salt- Ferric sulfate: $Fe_2(SO4)_3$

Iron salt- Ferric chloride:Fe_2Cl_3

Polyaluminum chloride (PAC): $Al_2(OH)_3Cl_3$

Preliminary and Primary Treatment

Alkalinity calculation

If 200 mg/L of alum to be added to achieve complete coagulation. How much alkalinity is consumed in mg/L as $CaCO_3$?

$$\underbrace{Al_2(SO_4)_3.14\ H_2O}_{594\ mg} + \underbrace{6HCO_3^-}_{366\ mg} \Leftrightarrow 2Al(OH)_3\downarrow + 6CO_2 + 14H_2O + 3SO_4^{-2}$$

594 mg alum consumes 366 mg HCO_3^-

200 mg alum will consume (366/594) x 200 mg HCO_3^-

= 123 mg HCO_3^-

Alkalinity in mg/L as $CaCO_3$ = 123 x (50/61)

= 101 mg/L as $CaCO_3$

QUIZ

What are the types of solids separation units used in ETP?

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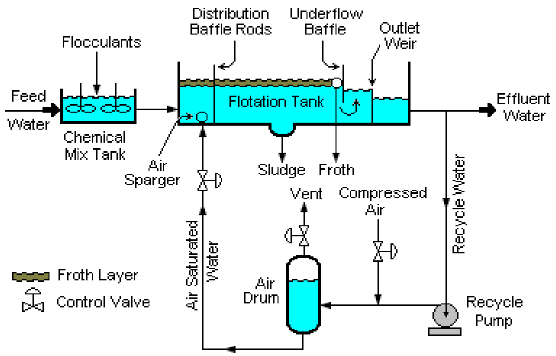
Dissolved air floatation



- In DAF sludge formation enhanced by flocculants and floatation by dissolved air.
- Air is mixed in water/effluent under pressure, then released to atmospheric pressure in flotation tank.
- Released air forms tiny bubbles adhere suspended matter causing to float to surface as foamy sludge.
- The sludge is then removed by a skimming or scooping device.
- The Krofta type DAF shown in the picture is a a traditional unit.

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Dissolved Air Floatation

- DAF works better with lighter suspended solids than one with chemical sludge (lime etc.).
- It works reasonably well in textile effluents, but process control is difficult.
- DAF units can be constructed as horizontal units - floating sludge is scooped by a travelling skimmer.
- Advantages of DAF include occupying much less space compared to sedimentation units.
- Major disadvantage is (a) relatively lower solids consistency in sludge and (b) higher O & M costs due to the requirements of higher chemical dosage.

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Dissolved Air Floatation - circular

In Krofta type circular DAF, the scum in the top is scooped using a rotating skimmer arm.

The liquid sludge is then admitted into a sludge chamber which is then taken out for dewatering.

Dissolved Air Floatation - Rectangular

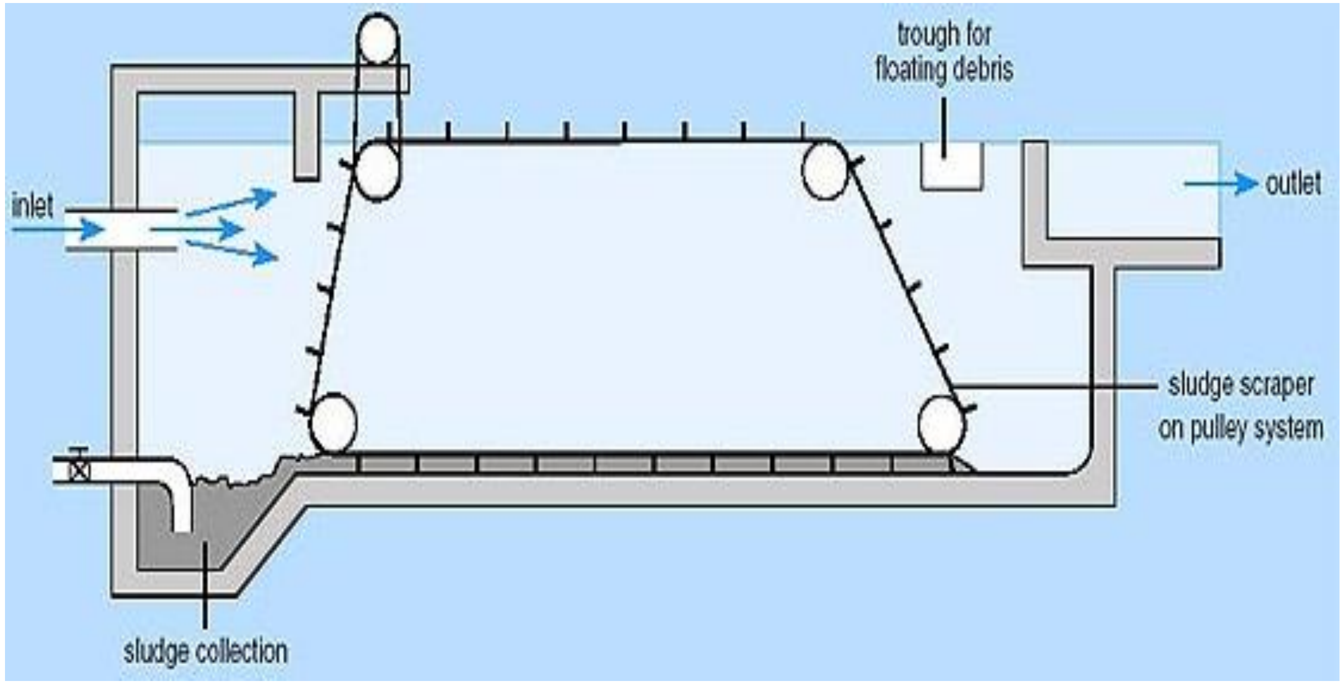
In rectangular DAF, a travelling arm scoops the sludge on the top to one side and the push it to the sludge trough.

The sludge is then taken out for dewatering.

Sedimentation

- Sedimentation removes suspended solids present. It works based on the difference in density.
- Types of sedimentation are:
  - Discrete settling, if the wastewater is relatively diluted and the particles do not interact.
  - Flocculent settling, if the particles are flocculated particles of larger mass and faster settling rate.
  - Zone settling, also called hindered settling : when particles adhere together and settle as a blanket. e.g: sludge setting in secondary clarifiers
- This sedimentation is used in both primary treatment and secondary treatment.

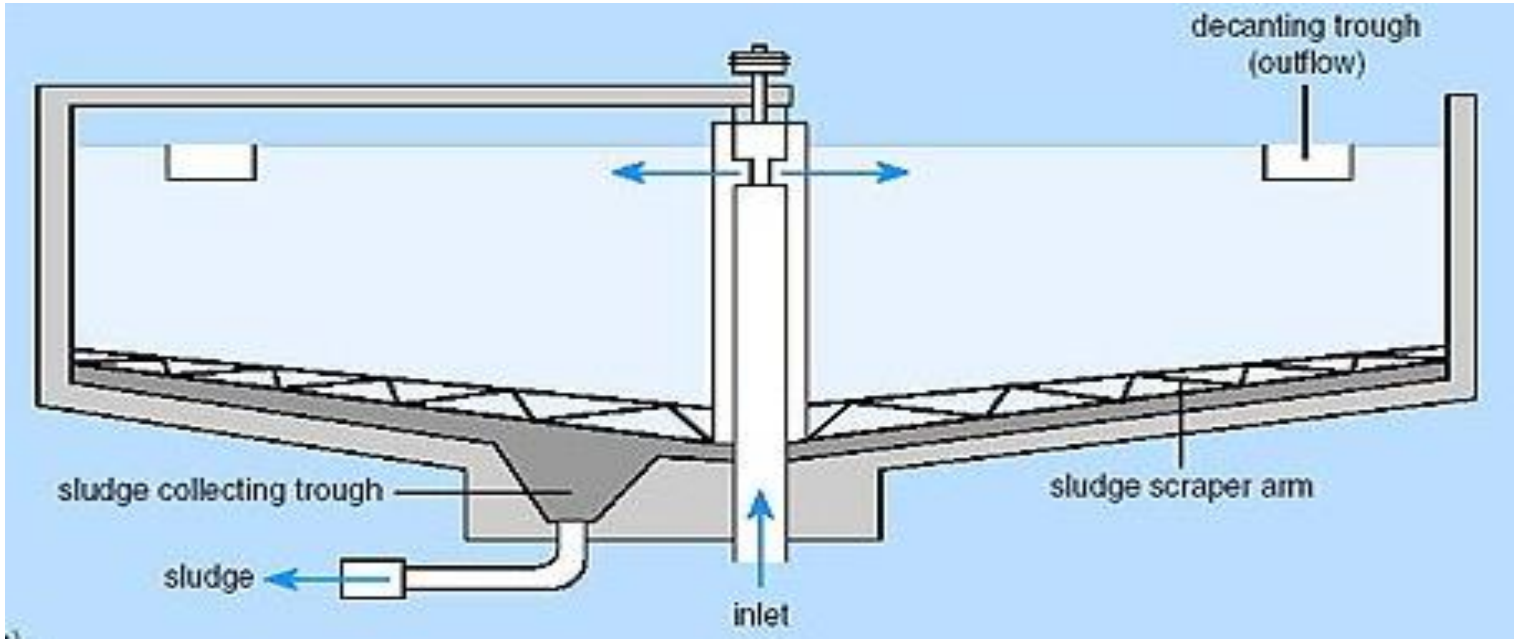
Horizontal flow settling units



Circular clarifiers

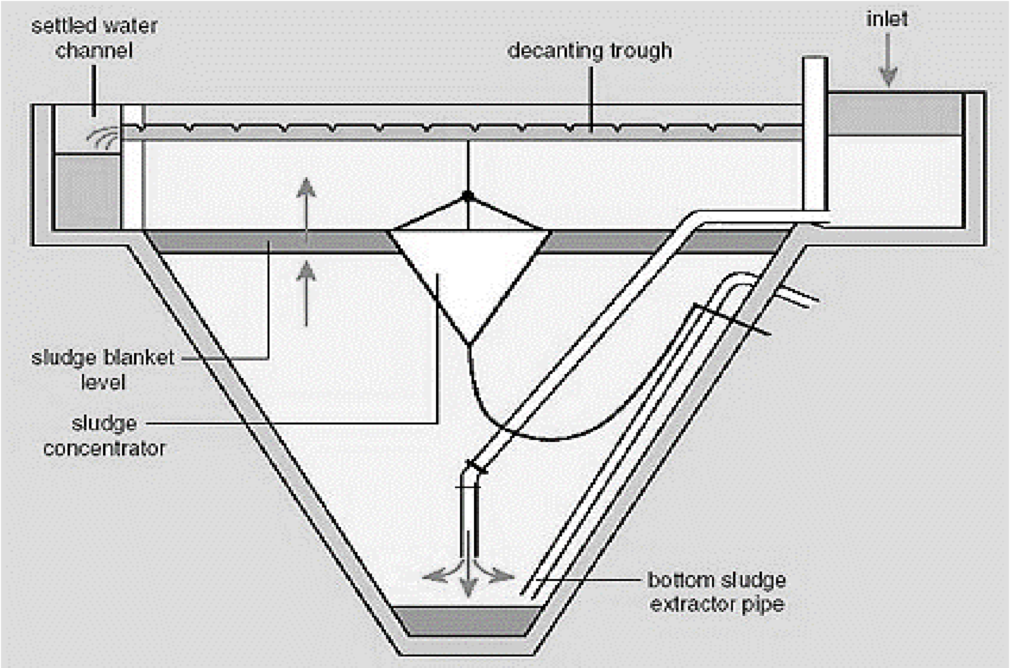
- Circular tanks more effective. Types - Centre fed and rim tanks.
- Settled solids are removed from center, bottom slope 10%.
- Sludge is swept to center by two or four arms with scrapers (Central/ Peripheral drive)
- Center-fed tanks - circular inflow well. Rim-fed tanks has baffle, effluent enters tangentially.
- Even distribution of inlet and outlet flows avoid short-circuiting - reduce separation efficiency.

Circular clarifiers



Circular clarifiers are the most common settling units elsewhere in the world, though tube settlers are more popular in Bangladesh

Hopper bottom settling tanks

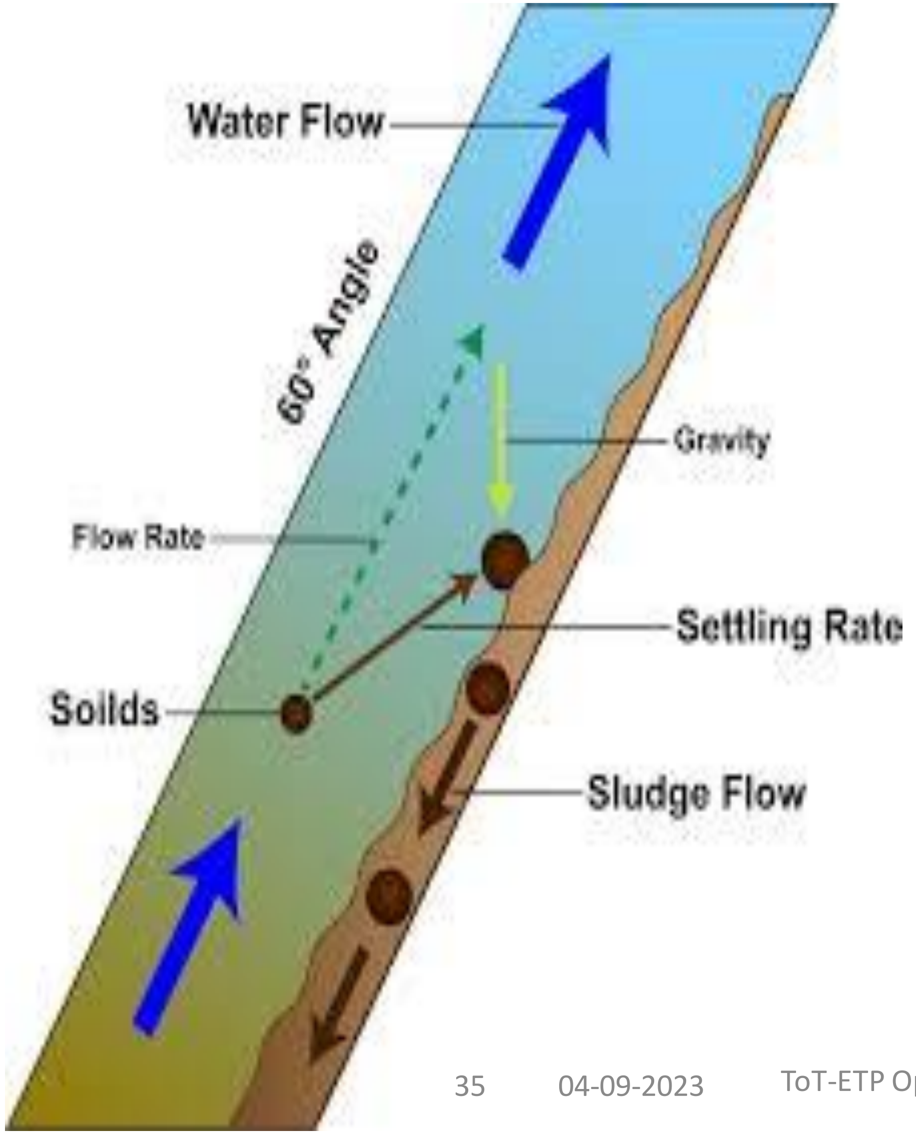


The advantage of sloped bottom sedimentation tank is that a rotating sludge scraper is not required.

Tube settler

- A tube settler is made up tubular channels that are placed adjacent to each other.
- These are placed at 60 degrees and combined to increase the effective settling area of particles.
- The settling zone depth is less than conventional clarifier.
- Individual tubes makes it easier for floc to settle fast.
- Tube settler make use of fine floc that manages to go past clarification zone to arrest fine particles

Tube settler



- Larger particles in a better shape.
- Operate on principle of settling velocity.
- Lightweight PVC tubes which are adjacently placed and joined at an angle (60 degrees)
- Tube settler is different from a plate settler

Tube settler

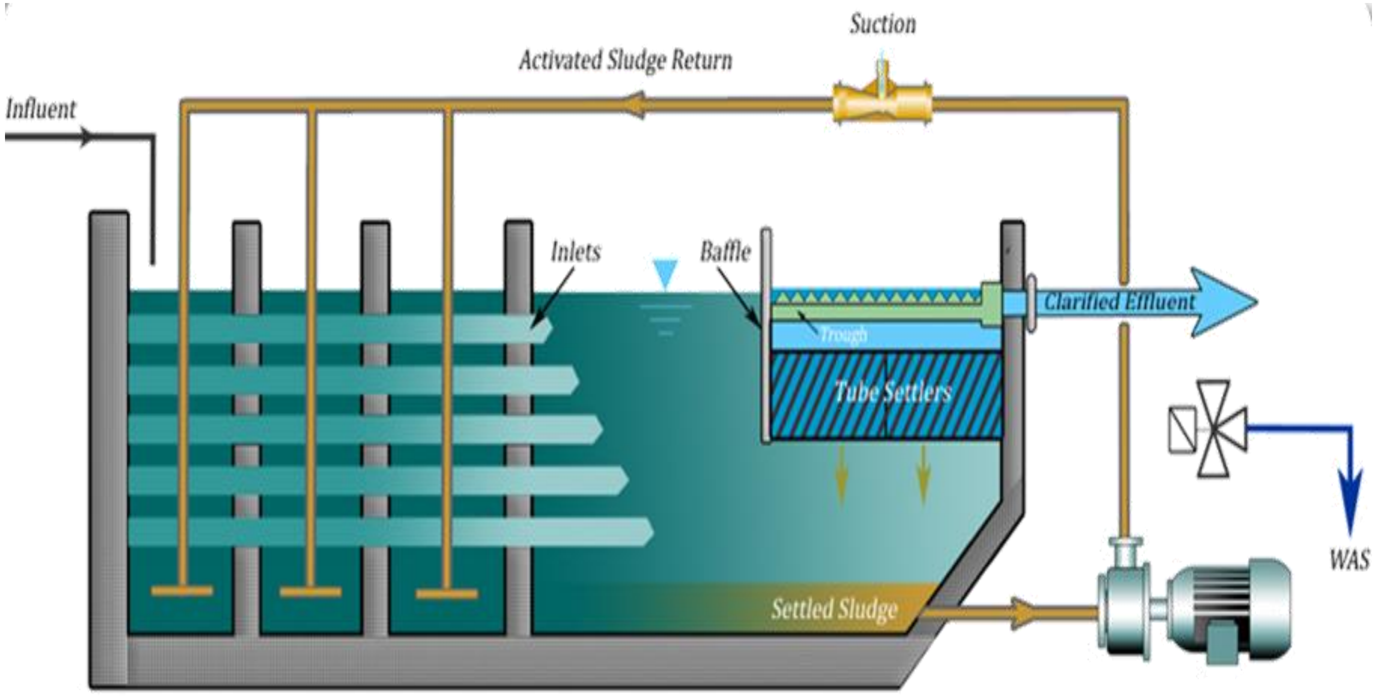
- It is smaller than conventional clarifiers
- It is made of PVC lightweight material. This makes it easily portable.
- It is quicker to install
- They can be fitted in different sizes and shapes in tanks. This is because of their lightweight and portability.

Tube Settler Advantages

- It needs more frequent sludge withdrawal.
- Unless the sludge evacuation is very efficient, it can create sludge overflows.
- If used as a pre-treatment to ZLD, the PVC can break and its chards clog the expensive membrane.

Tube Settler Disadvantages

Tube settler & media



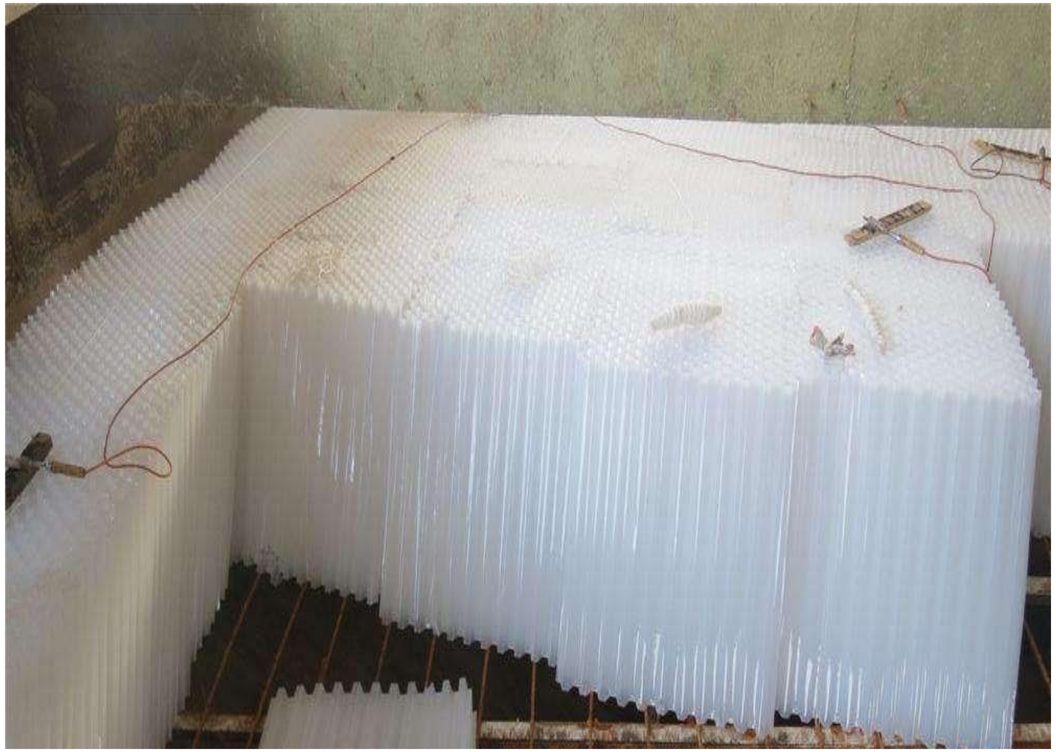


Plate settlers

Though very similar, plate settlers are usually deeper than tube settlers and the media tends to be heavier.

Its capital costs are usually higher than tube settlers.

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Importance of V Notch

V notch weir adjustment ensure uniform overflow and effective settling.

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Surface Overflow Rate (SOR)

Surface Overflow Rate (SOR) calculated falls within the guidelines:

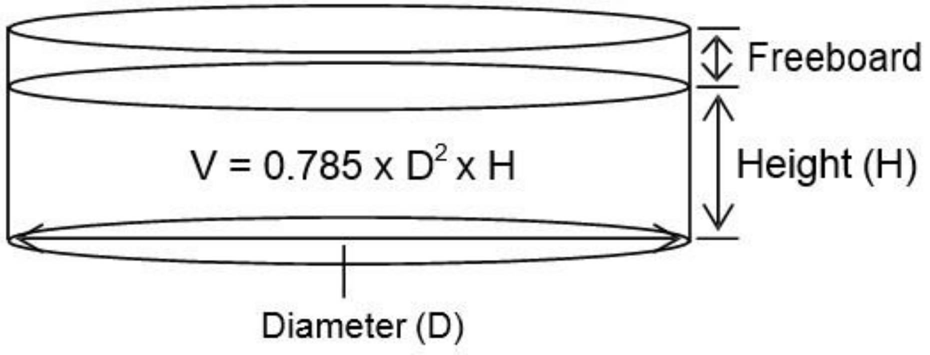
Plain clarifier: 0.9 - 1.2 $m^3/hr/m^2$(m/h)

Tube settler: 2.0 - 2.5 $m^3/hr/m^2$(m/h)

Lamella clarifier: 1.2 -1.5 $m^3/hr/m^2$(m/h)

Note: SOR (Surface Overflow Rate) is the main criteria for calculation of area (size) of clarifier, not retention time

Surface Overflow Rate (SOR)



- Surface overflow rate (SOR):

$$SOR\ (m/h) = \frac{Flow\ (m^3/\ hr)}{Surface\ Area\ of\ Clarifier\ (m^2)}$$

Where:

Flow = Proposed design flow rate

For circular clarifiers, Surface Area = 0.785x D^2

For rectangular clarifiers, Surface Area = L x W

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn and Eschborn

Friedrich-Ebert-Allee 32 + 36
53113 Bonn, Germany
T +49 228 44 60 - 0
F +49 228 44 60 - 17 66

Dag-Hammarskjöld-Weg 1 - 5
65760 Eschborn, Germany
T +49 61 96 79 - 0
F +49 61 96 79 - 11 15

E info@giz.de
I www.giz.de

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH