# EWC 333
# Wastewater Engineering and Sanitation

## Lecture 10

**Instructor**

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# Lecture Outline

| Topics | Reference |
| --- | --- |
| • Primary treatment methods –<br>✓ Sedimentation/ settling tank<br>✓ Septic tank (covered earlier)<br>✓ Imhoff tank<br>✓ Dissolved air flotation | Water Supply and Sanitation - Feroz Ahmed and Mujibur Rahman<br>ITN -BUET |

# Purpose of Primary Treatment

- To produce high degree of clarification.

Clarification is the removal of solids from the liquid phase.

A high degree of clarification is required to reduce the load on the secondary (biological) treatment plant.

- To acquire high degree of thickening.

Thickening means the removal of liquid from the solid or sludge phase.

A high degree of thickening is desirable so that sludge handling and treatment is minimized.

# Primary Treatment Methods

Primary treatment is performed by-

(a) Sedimentation tank

(b) Septic tank

(c) Imholf tank

(d) Dissolved Air Floatation (DAF)

# Sedimentation

Sedimentation of sewage is the removal of solid settleable suspended particles present in sewage through settling by gravity.

**Types of Sedimentation:**

Depending on the addition of chemical additives –

(1) Plain sedimentation

(2) Chemical sedimentation or sedimentation with coagulation.

# Types of Sedimentation

## Plain sedimentation

- Settling occurs by natural forces, by gravitation and by natural aggregation of suspended particles

- Sedimentation is not aided by chemicals (coagulants)

- The sludge (mixture of sewage solids and water) is not retained for digestion.

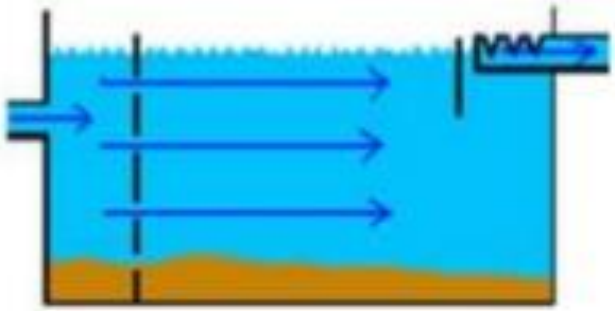
# Types of Sedimentation

## Chemical sedimentation

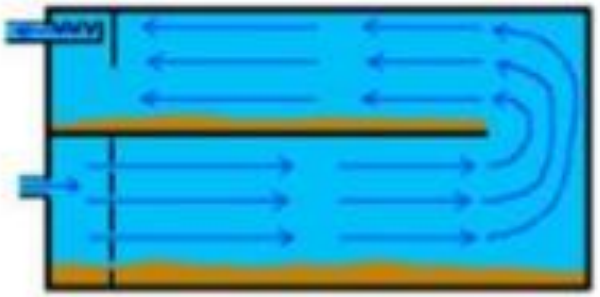
- Chemical sedimentation is accomplished by adding chemicals to sewage.

- Added chemicals form a flocculent precipitate with the waste material and thus hasten the removal of suspended solids.

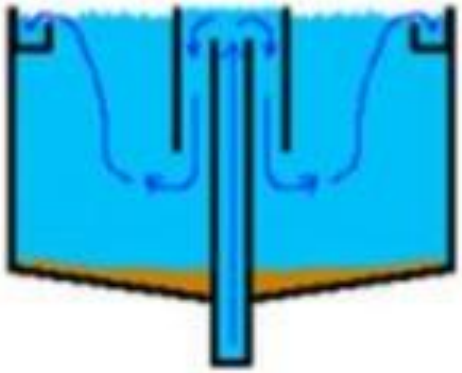
# Types of sedimentation basins



Rectangular basins

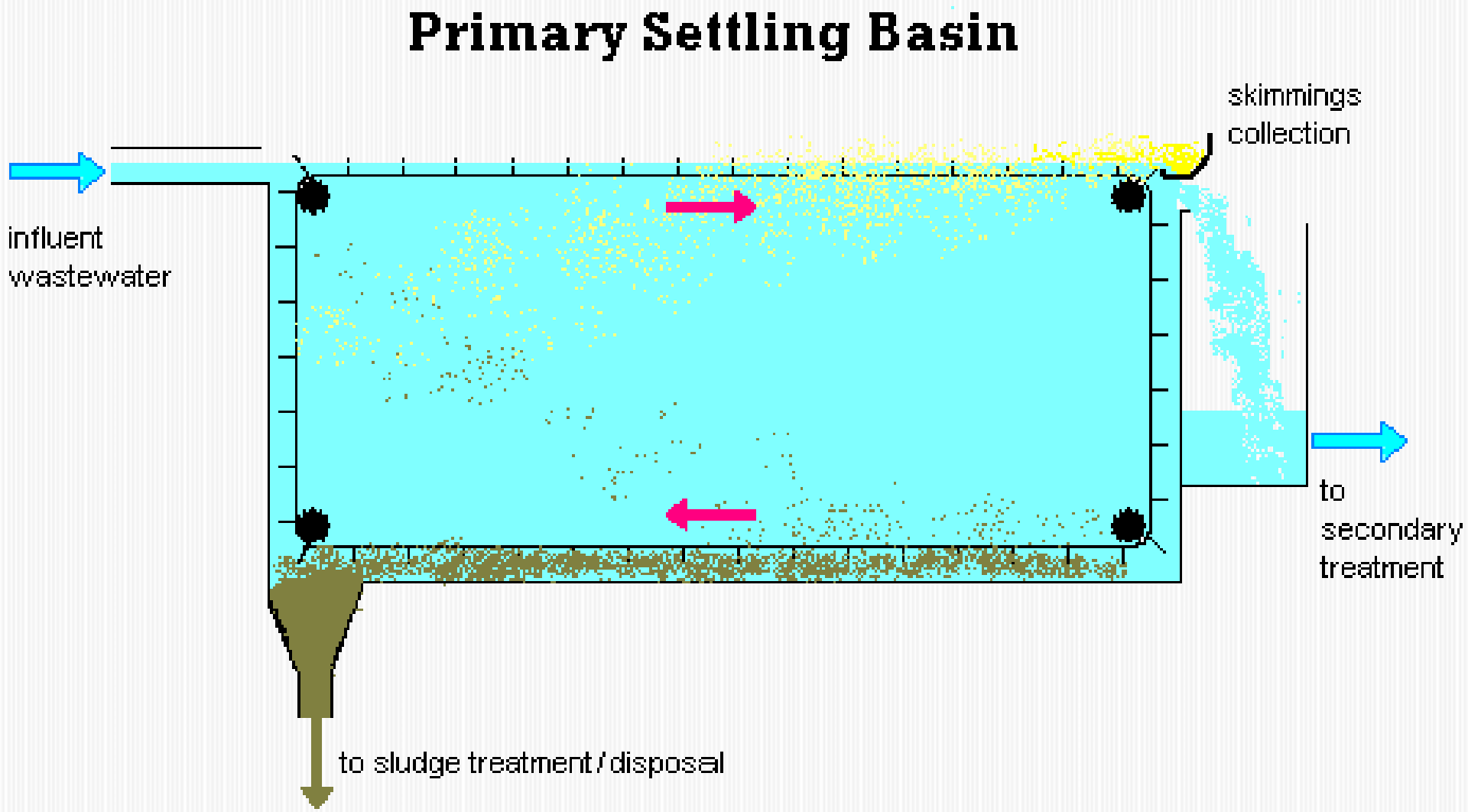


Double-deck rectangular basins

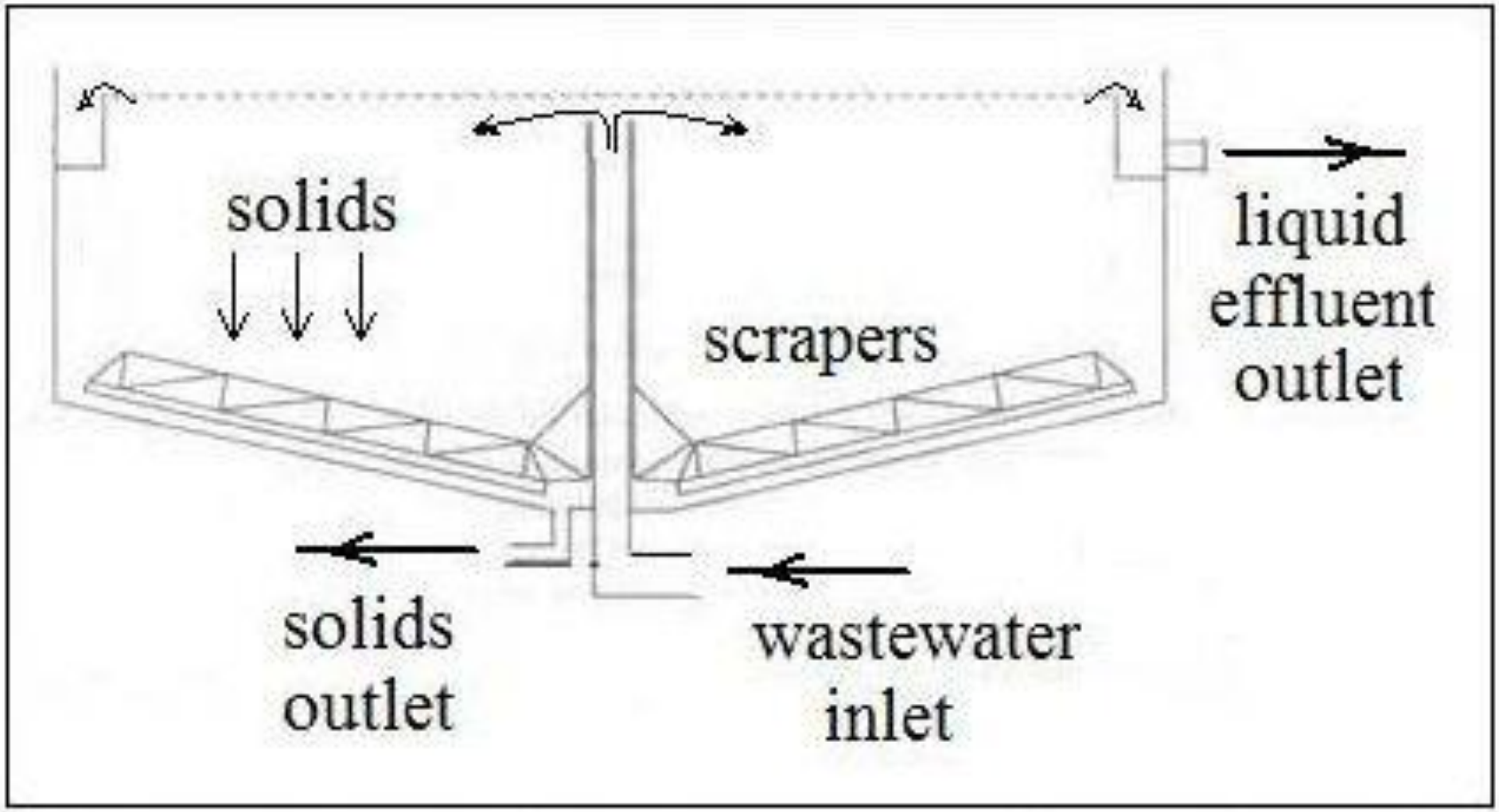


Square or circular sedimentation basins

# Rectangular Sedimentation Tank



# Circular Sedimentation Tank



# Sedimentation Tank

**Design Principle:**

The settling velocity of a particle is given by stokes law:

$$U_s = g\,(\rho_s - \rho)\,d^2/18\mu \quad \ldots\ldots(1)$$

where,

$U_s$ = settling velocity, m/s

$g$ = acceleration due to gravity, $m^2$/sec

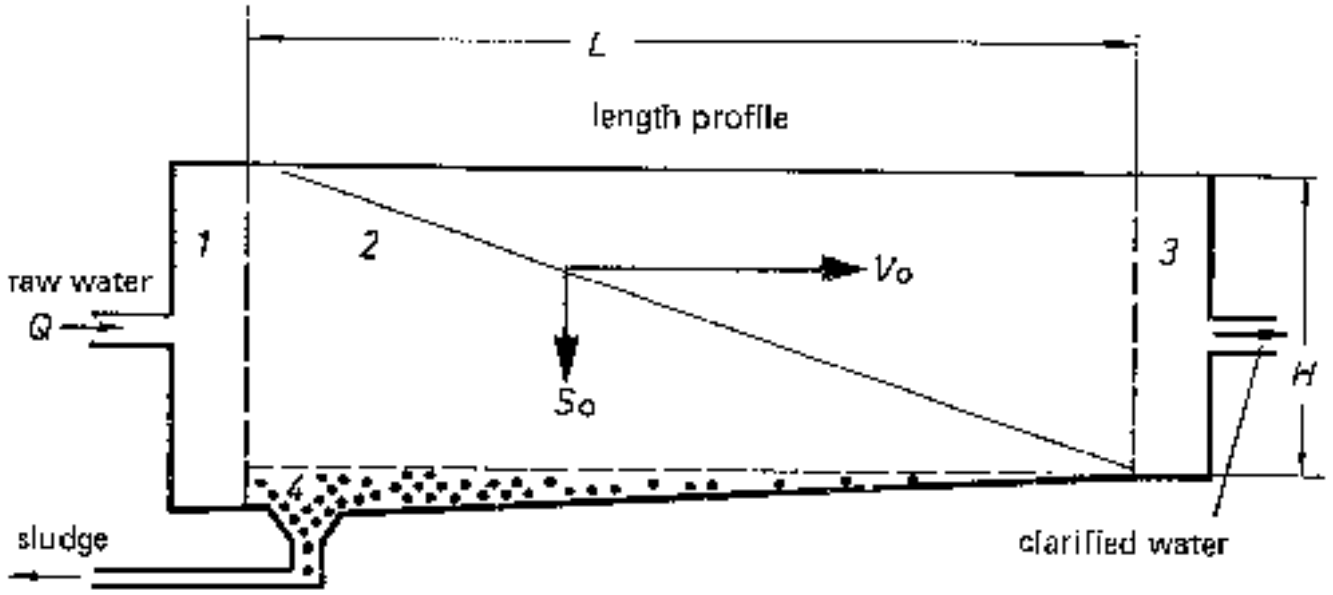
$\rho$ = density of particles, $kg/m^3$

$\rho_s$ = density of suspending fluid, $kg/m^3$

$d$ = characteristic linear dimension of the particle, m

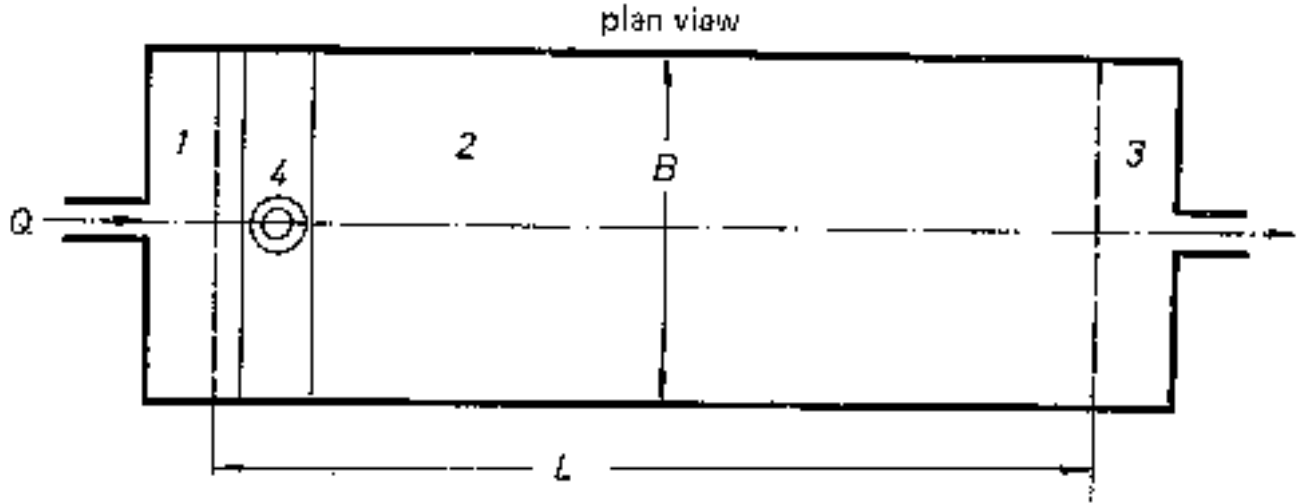
$\mu$ = molecular viscosity of suspending fluid, $Ns/m^2$

# Sedimentation Tank




L = length
B = width
H = depth

1 inlet zone
2 settling zone
3 outlet zone
4 sludge zone



# Sedimentation Tank

Equation 1 is valid only for particle's Reynolds number, $R_e < 0.2$, although little error is introduced for up to $R_e = 5$.

$R_e$ is defined as:

$$R_e = \rho U_s d / \mu \quad \ldots\ldots (2)$$

$R_e$ = Inertia force / Viscous force

A particle can be assumed to be retained in a continuous flow in sedimentation tank, if its settling velocity is high enough to permit it to settle through the full tank depth within one retention time.

Under this condition, the limiting minimum settling velocity is:

$$U_s = D / t \quad \ldots\ldots (3)$$

where,

D= tank depth, m

t= mean hydraulic retention time, sec

# Sedimentation Tank

The retention time in a continuous flow tank is given by:

$$\mathbf{t = AD/Q} \quad \ldots\ldots (4)$$

where,

A = surface area of the tank, $m^2$

AD = tank volume, $m^3$

Q = flow through tank, $m^3/s$

Therefore, $\mathbf{U_s = Q/A}$ (m/s) (from eqn 3 and 4)

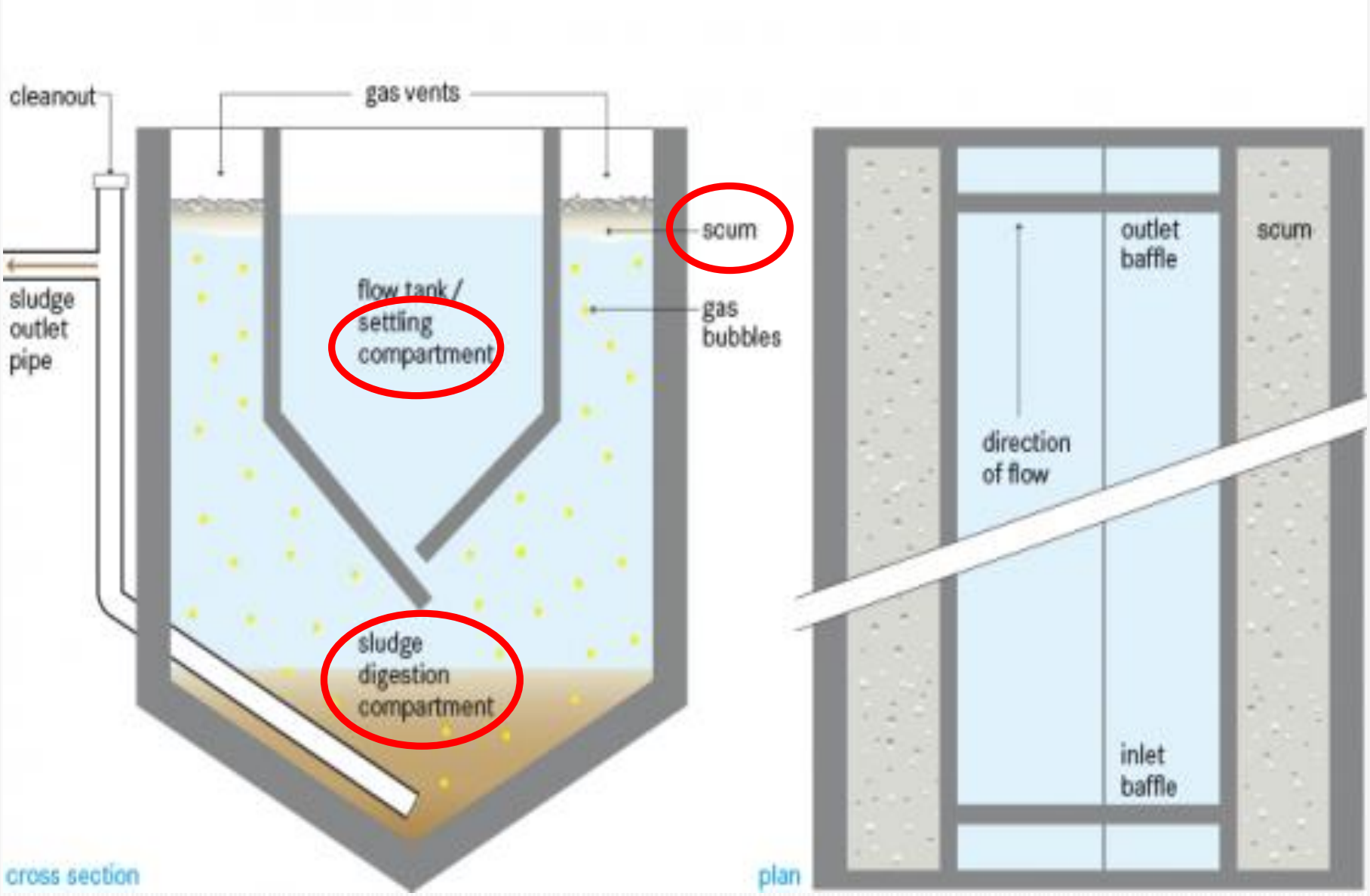
The ratio **Q/A** is the flow per unit surface area and is termed as the overflow rate.

# Imhoff Tank

- It is an improved septic tank in which the incoming sewage or influent is not allowed to get mixed up will the sludge produced, and

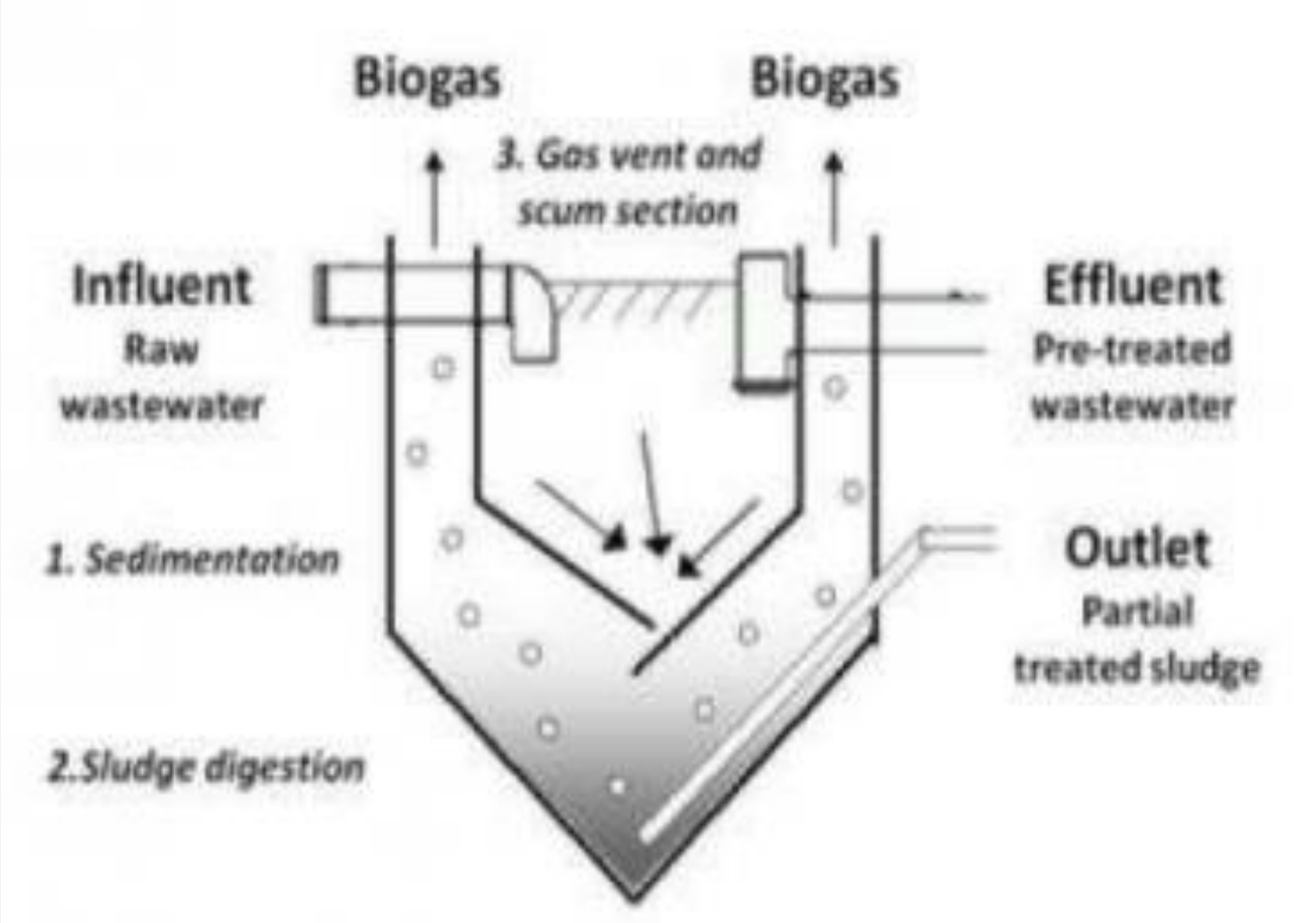
- the outgoing sewage or effluent is not allowed to carry with it large amount of the suspended matter as in the case of a septic tank.

# Imhoff Tank


cleanout
gas vents
scum
sludge outlet pipe
flow tank / settling compartment
gas bubbles
sludge digestion compartment
cross section
outlet baffle
scum
direction of flow
inlet baffle
plan

# Components of Imhoff Tank

1. Upper compartment for sedimentation
2. Lower section for sludge digestion
3. Gas vent and scum section



# Components of Imhoff Tank

## Sedimentation or Flowing Through Chamber

- The upper level of the tank is called the sedimentation or flowing trough chamber.

- This chamber is used for clarifying the water.

- Sewage flows at a very low velocity in this level.

# Components of Imhoff Tank

## Digestion Chamber

- The lower level of the tank is called the digestion chamber.

- This chamber is used for digestion of the sludge.

- Anaerobic or septic decomposition occurs in this chamber.

- The digestion chamber is made up of two or three inverted cones called **hoppers** with sides sloping (1:1) as to concentrate the sludge at the bottom of the hopper.

# Imhoff Tank

## Mechanism of Solids Removal

- The solids of the sewage settling to the bottom of the sedimentation chamber through the sloping bottom walls (slope V:H = 5:4) are made to fall in the digestion chamber through an entrance slot at the lowest point of the sedimentation chamber.

- The slot is trapped or overlapped in such a way that the gases generated in the digestion chamber cannot enter the sedimentation chamber.

# Components of Imhoff Tank

- A gas vent is provided with the digestion chamber to take care of the gases escaping to the surface.
- In order to prevent particles of sludge or scum from penetrating into the sedimentation chamber, the sludge and scum must be maintained at a distance of at least 18 inch below and above the slots respectively.
- This free clear zone is called neutral zone.

# Advantages of Imhoff Tank

- Solid-liquid separation and sludge stabilization are combined in one single unit
- Resistant against organic shock loads
- Small space requirements
- The effluent remains fresh (i.e., not septic)

# Advantages of Imhoff Tank

- Low operating costs
- Suitable for small settlements and house clusters
- Standardized designs are available
- Simple operation and maintenance

# Disadvantages of Imhoff Tank

- Very deep/high infrastructure, depth may be a problem in case of high groundwater table
- Requires expert design and construction
- Low reduction of pathogens
- Requires desludging

# Disadvantages of Imhoff Tank

- Inefficient treatment option if not regularly desludged
- Odor occurs from escaping gases
- Effluent, sludge and scum require further treatment
- Less simple than septic tank

# Application of Imhoff Tank

- Imhoff tanks are recommended for domestic or mixed wastewater flows between 50 and 20,000 population.
- Normally, Imhoff tanks are used by small communities with raw wastewater flows on the order of 950 $m^3$/day (population about 8000 people or 1300 households)
- Imhoff tanks can be used in warm and cold climates

# Application of Imhoff Tank

- As the tank is very high/deep, it can be built underground if the groundwater table is low and the location is not flood prone.
- If constructed underground, land use is very limited and Imhoff tanks can be constructed in both, rural or urban areas.
- Investment costs are low and operation and maintenance simple.

# Improvement of Sedimentation Efficiency

- Precipitation with chemicals (Lime, Alum, Ferric Chloride), though it causes additional sludge production
- Flocculation
- Tube settlers
- Lamella Plate Settlers
- Pre-equalization Basins – reduces flow variation
- Septicity Control

# Dissolved Air Flotation (DAF)

- A type of primary treatment process commonly used for industrial wastewater.
- A DAF process removes oil and grease in less space than by primary sedimentation.
- Wastewater and air are pressurized to 3 to 5 atmospheres and released in a tank open to the atmosphere.
- This releases small bubbles from the solution, which float to the top.

# Dissolved Air Flotation (DAF)

- The bubbles become enmeshed in the light solids and oils and bring them to the surface.
- A skimmer then collects solids on the water surface, and the clarified liquid continues to downstream processes.
- Other types of oil-water separating processes are also widely used in the petroleum industry.

# Advantages of DAF over Simple Aeration

- More efficient
- Lower hydraulic retention time (HRT)
- Higher solids content in sludge
- Higher quality fat recovered
- Not affected by thermal effects
- Reduced odor problems

# Disadvantages of DAF

- Higher operating and maintenance costs
- Operational problems e.g. blockage in recycle line

# Application of DAF

- DAF is used mostly for industrial sewage that contains oil, grease, and other easily floatable solids.

- Oil refineries, meat packing factories, and dairy processing plants commonly use DAF for primary treatment.

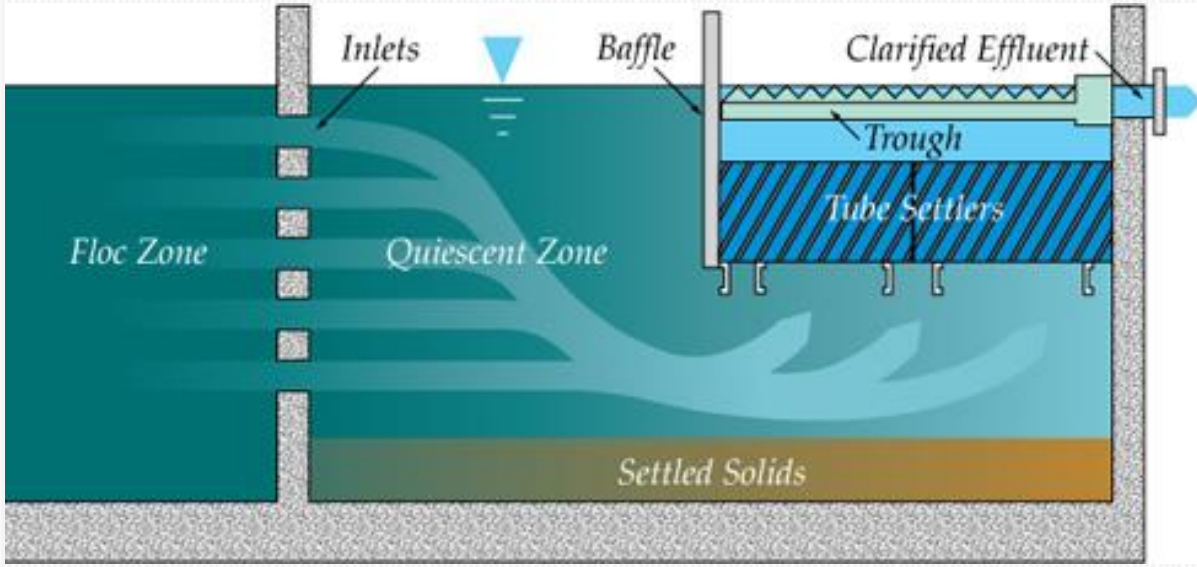
# Note

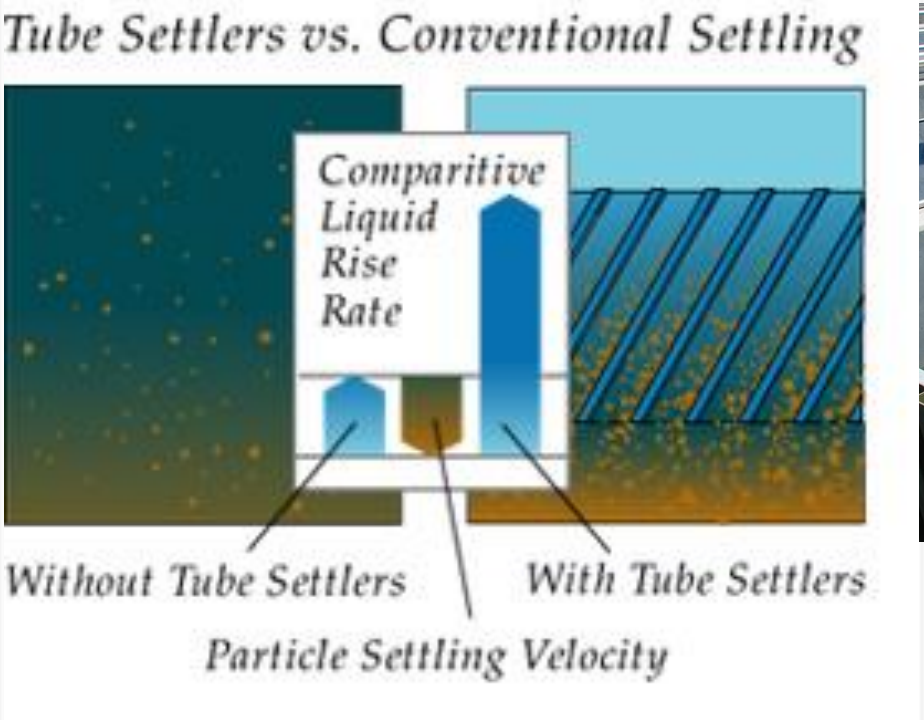
## Reynolds Number

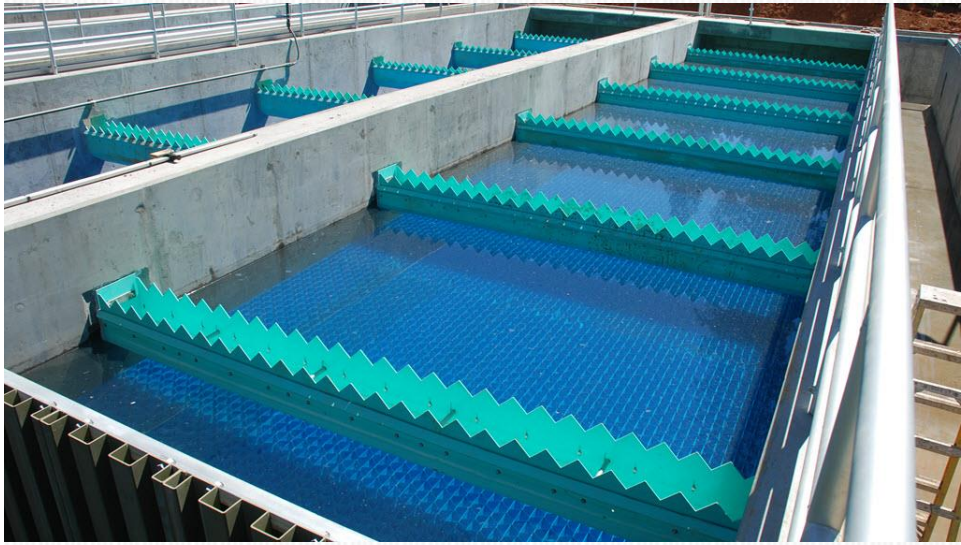
- dimensionless quantity that is used to help predict similar flow patterns in different fluid flow situations

- The Reynolds number is defined as the ratio of momentum forces to viscous forces and consequently quantifies the relative importance of these two types of forces for given flow conditions

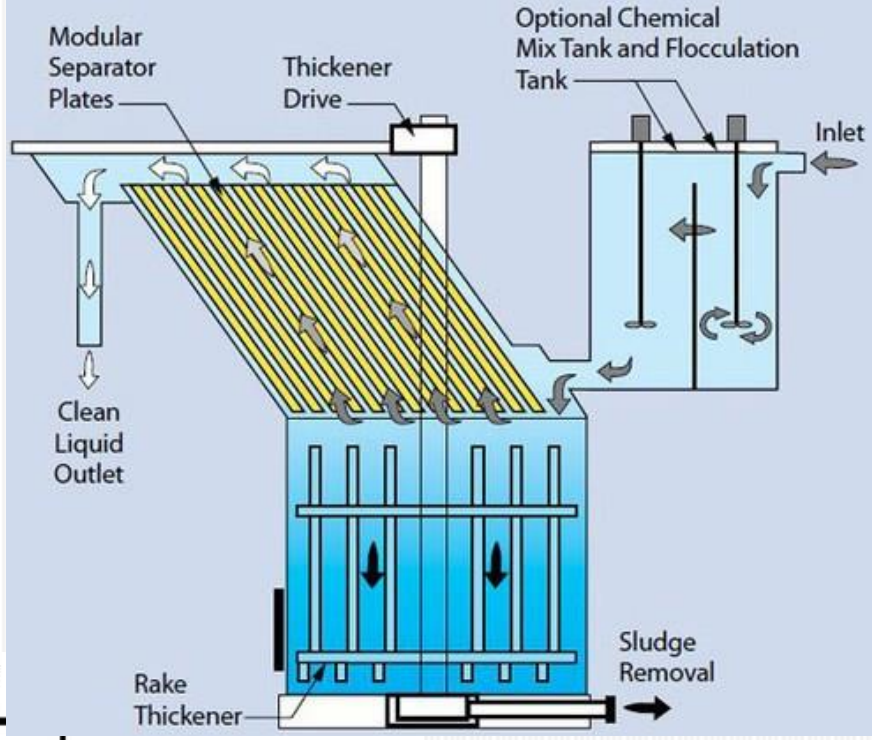
# Tube Settlers

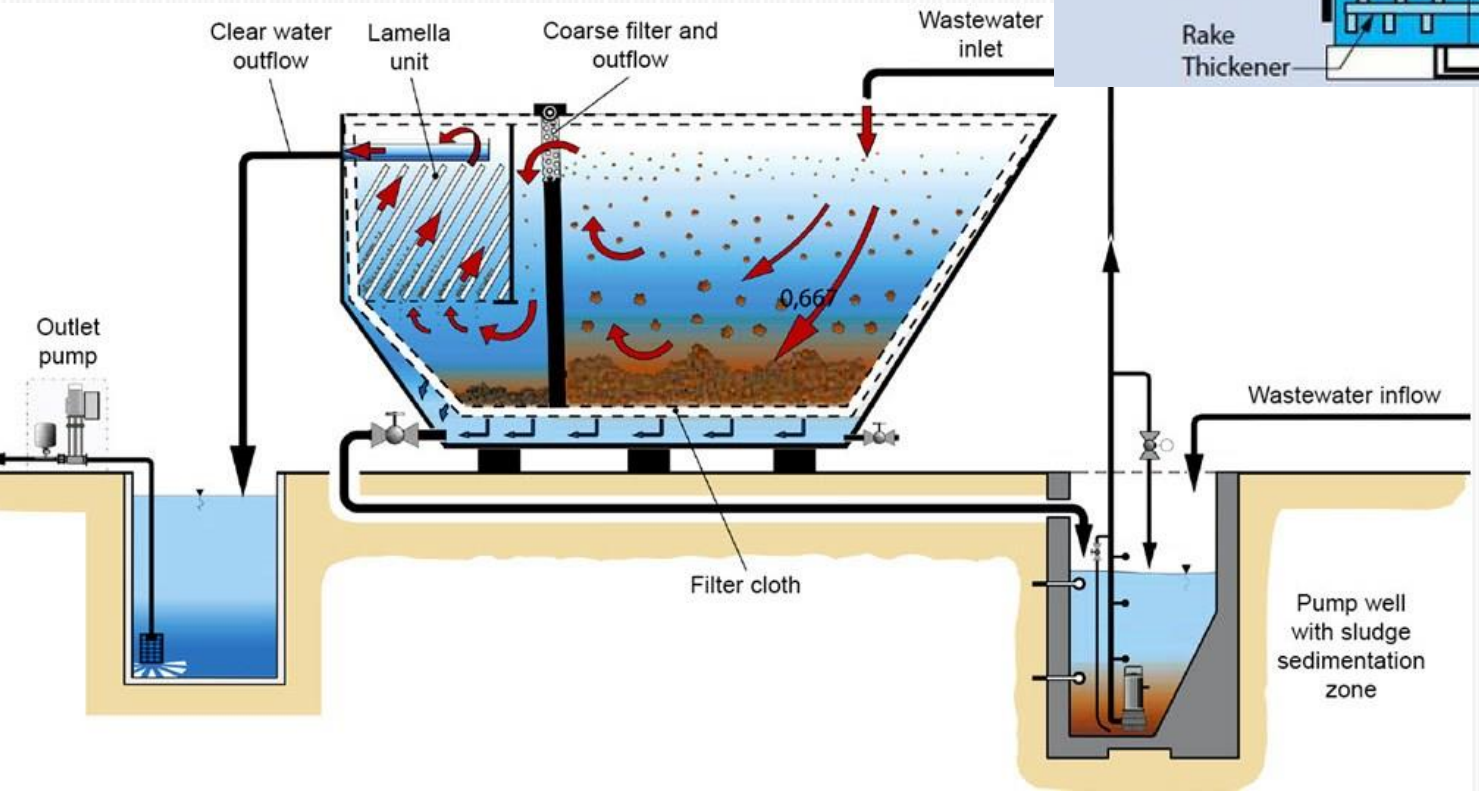


# Lamella Plate Settlers



# Pre-equalization Basin

