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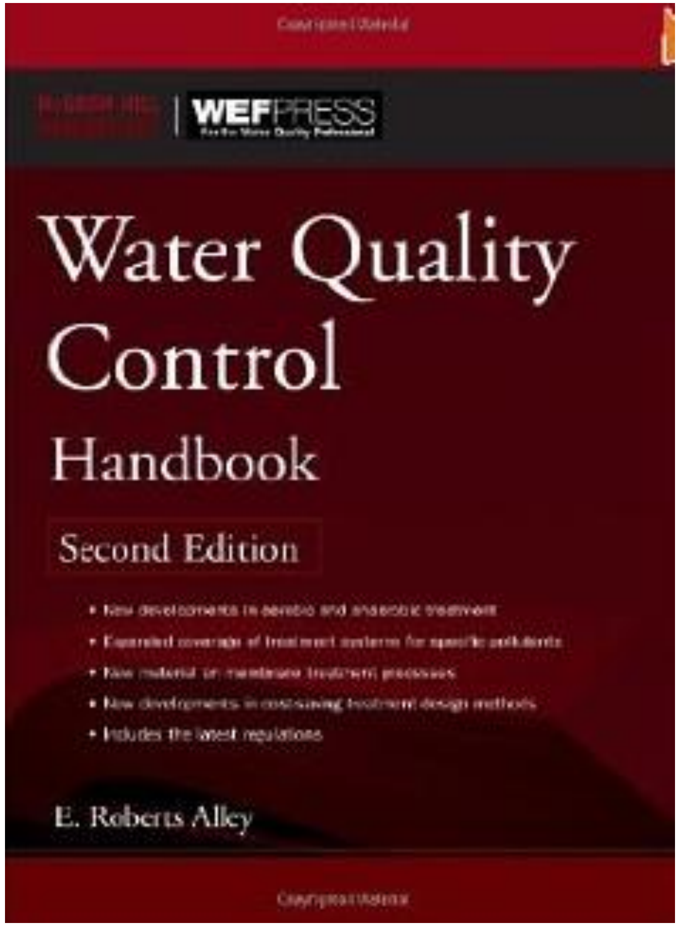
Wastewater Management I.

Bibliography



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Wastewater

Wastewater is any water that has been affected in quality by

anthropogenic influence

Sources of wastewater:

Municipal/communal wastewater – contains everywhere nearly the same contaminants

Storm water

Industrial wastewater: contamination can be much different, it depends on the industry. Industrial wastewater must be cleaned mostly on the site.

Collection of Wastewater

- **Combined system** of sewers: transports both storm water runoff and sewage in the same pipe
- **Separate system** of sewers: transports sewage alone and storm water runoff alone (or directly to surface water)

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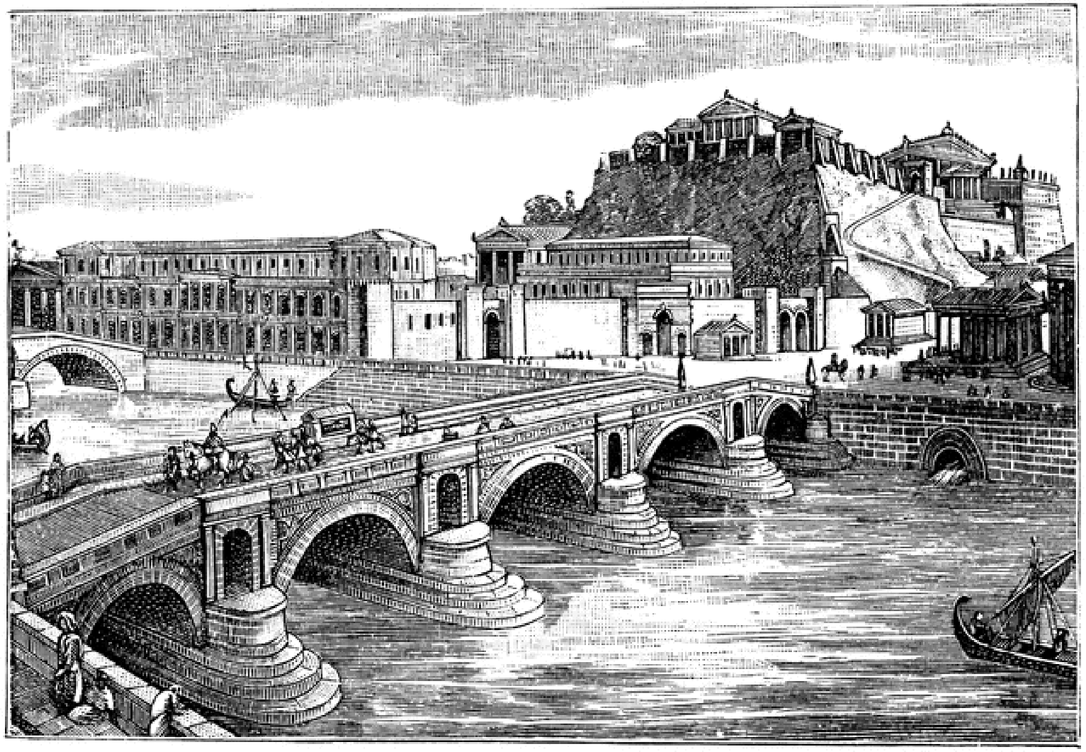
History: Cloaca Maxima one of the world's earliest sewage systems. Constructed in Ancient Rome



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Contamination in wastewater

From physical point of view:

- Solids:
  - solid of high density (e.g., stones)
  - swimming solid (e.g., wood)
  - suspended particles (grit, sand, small organic particles, drops of oil etc.)
- Soluble materials
- Emulsions
- Gases

Contamination in wastewater

From chemical point of view:

- Organic
- Inorganic

Organic

BOD = Biochemical Oxygen Demand

The BOD is a measure of the rate at which micro-organisms use dissolved oxygen in the bacterial breakdown of organic matter (food) under aerobic conditions.

Organic

BOD_5

The BOD_5 test indicates the organic strength of a wastewater. Biochemical Oxygen Demand gives the amount of oxygen consumed for biodegradation of organic compounds at 20°C over 5 days in 1 liter wastewater in laboratory conditions (dark, without oxygen). It is a measure of the biodegradable organic matter in the wastewater. $\left[\frac{\mathrm{mg}\ O_2}{\mathrm{l}};\ \frac{\mu\mathrm{g}\ O_2}{\mathrm{l}}\right]$

Organic

COD = Chemical Oxygen Demand

The basis for the COD test is that nearly all organic compounds can be fully oxidized to carbon dioxide with a strong oxidizing agent under acidic conditions

COD is a measure of the amount of oxygen consumed from a chemical oxidising agent under controlled conditions. The COD is generally greater than the BOD as the chemical oxidising agent will often oxidise more compounds than is possible under biological conditions.

Water	**BOD_5 [mgO_2/l]**	**COD [mgO_2/l]**
Clear river	1-3	
Contaminated river	30	
Municipal waste-water	200-350	600
Industrial waste-water		n*1000

Inorganic contaminants

- Nitrogen
- Phosphorus
- Toxic metals (Hg, As, Pl, Ag etc.)
- Cyanide etc.

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Wastewater Treatment Plant

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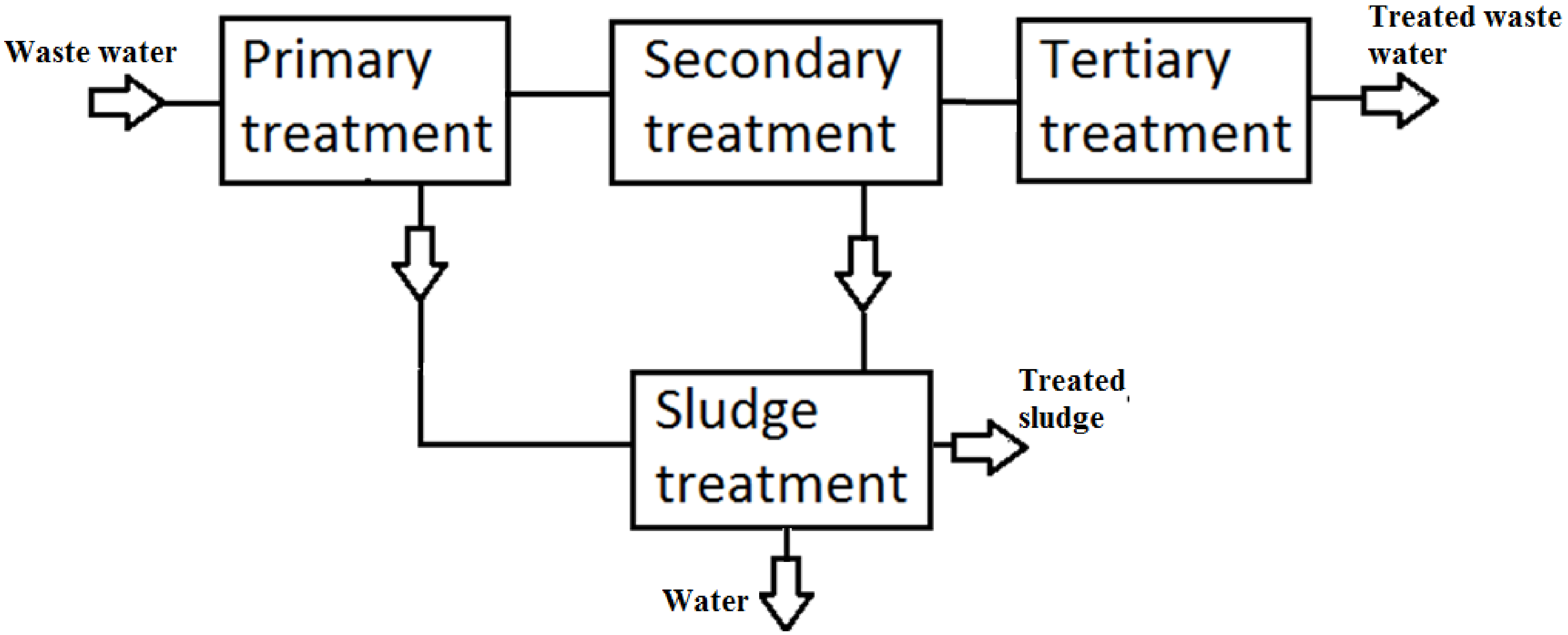
Wastewater Treatment Plant

Wastewater treatment can involve

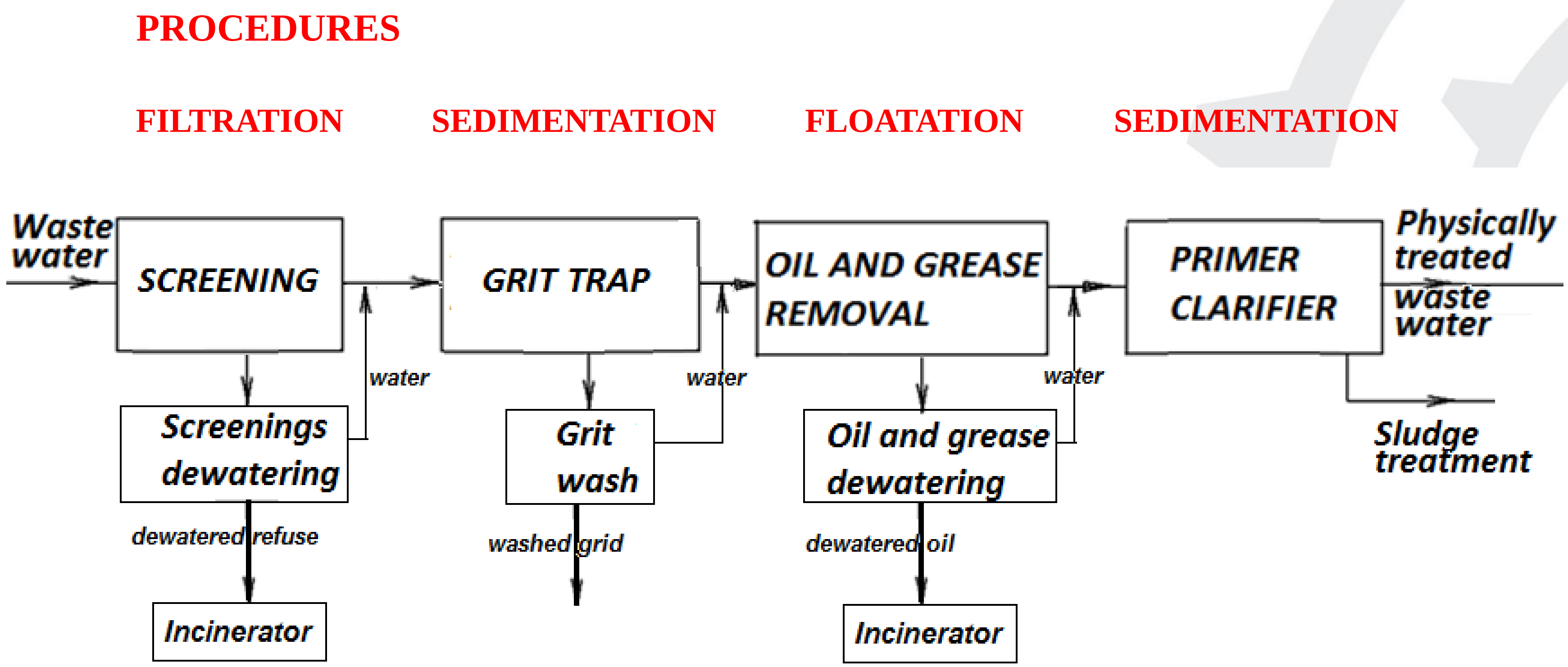
- **Physical**
- **Biological**
- **Chemical**

processes or combination of these processes depending on the required outflow standards.

Main parts of a wastewater treatment plant



Physical (primary) treatment



After dewatering water must be returned to waste water line.

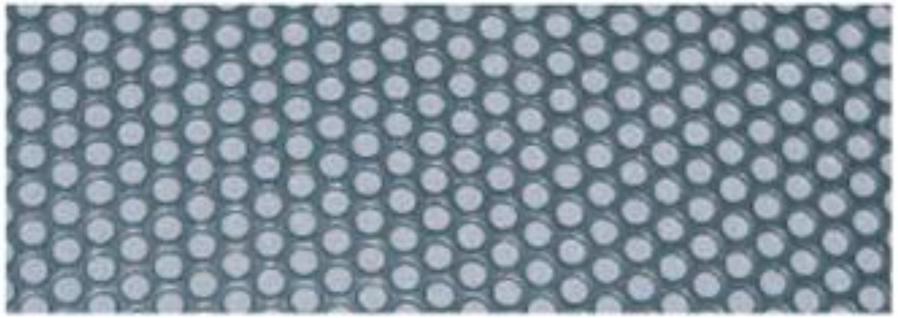
Racks and screens

Screen is a device with openings for removing bigger suspended or floating matter in sewage which would otherwise damage equipment or interfere with satisfactory operation of treatment units.

Screen surface types

Coarse screen

Fine screen



Perforated plate screen

Mesh screen

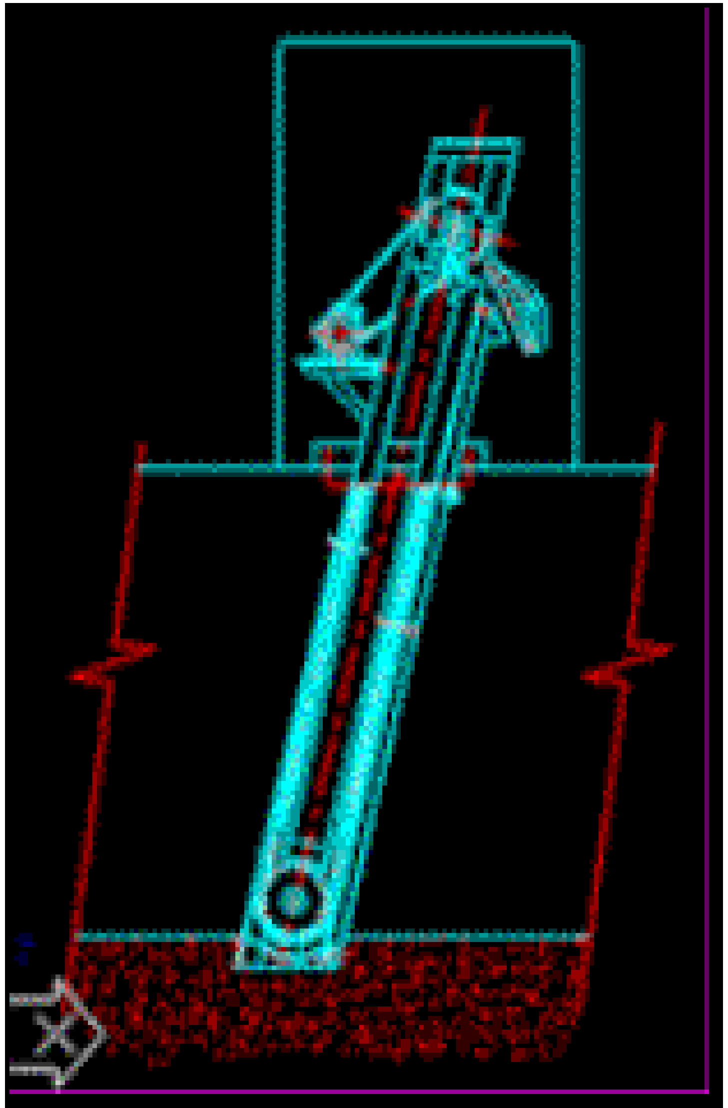
Screening

- Coarse screening, for spacing of over 40 mm
- Medium screening, for spacing of 10 to 40 mm
- Fine screening, for spacing under 10 mm

Parallel bars make easy to empty the refuse.

Bar screen

Inclined bar screen



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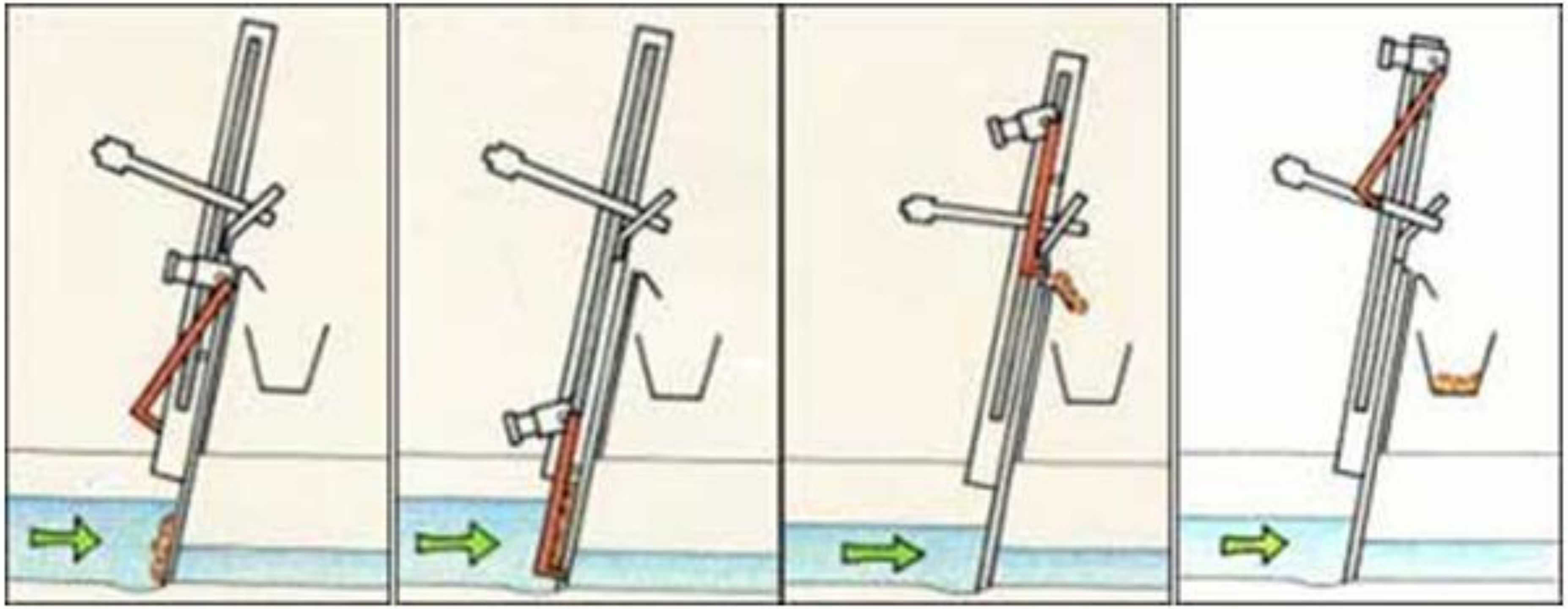
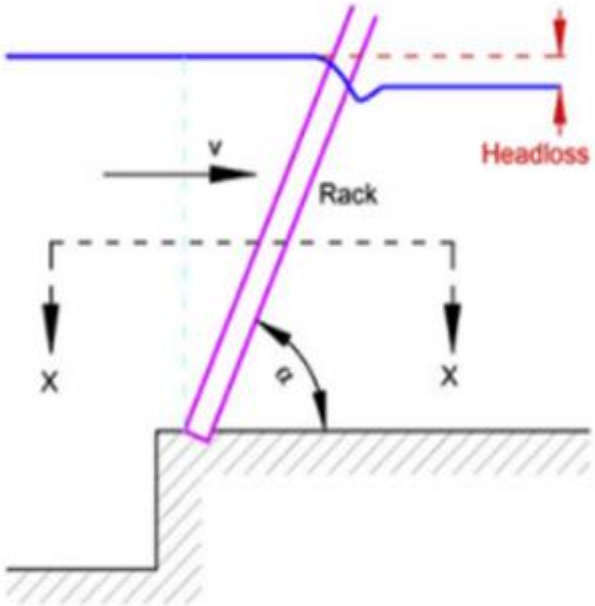
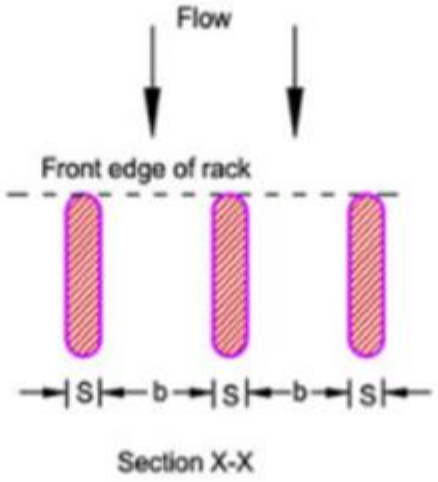
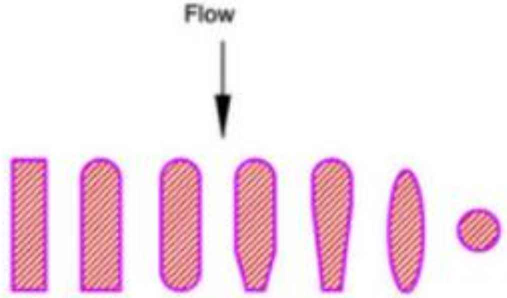
Inclined bar screen



Head loss in screens







Type	a	b	c	d	e	f	g
β	2.42	1.83	1.67	1.03	0.92	0.76	1.79

Kirschmer's formula

$$h_v = \beta \left(\frac{S}{b}\right)^{4/3} \sin\alpha \frac{v^2}{2g}$$

Δh head loss [m]
S thickness of bars [mm]
b clear spacing between bars [mm]
v velocity of approach [m/s]
α angle of bar inclination, degree
β screen loss coefficient

Inclined bar screen

Inclined bar screen

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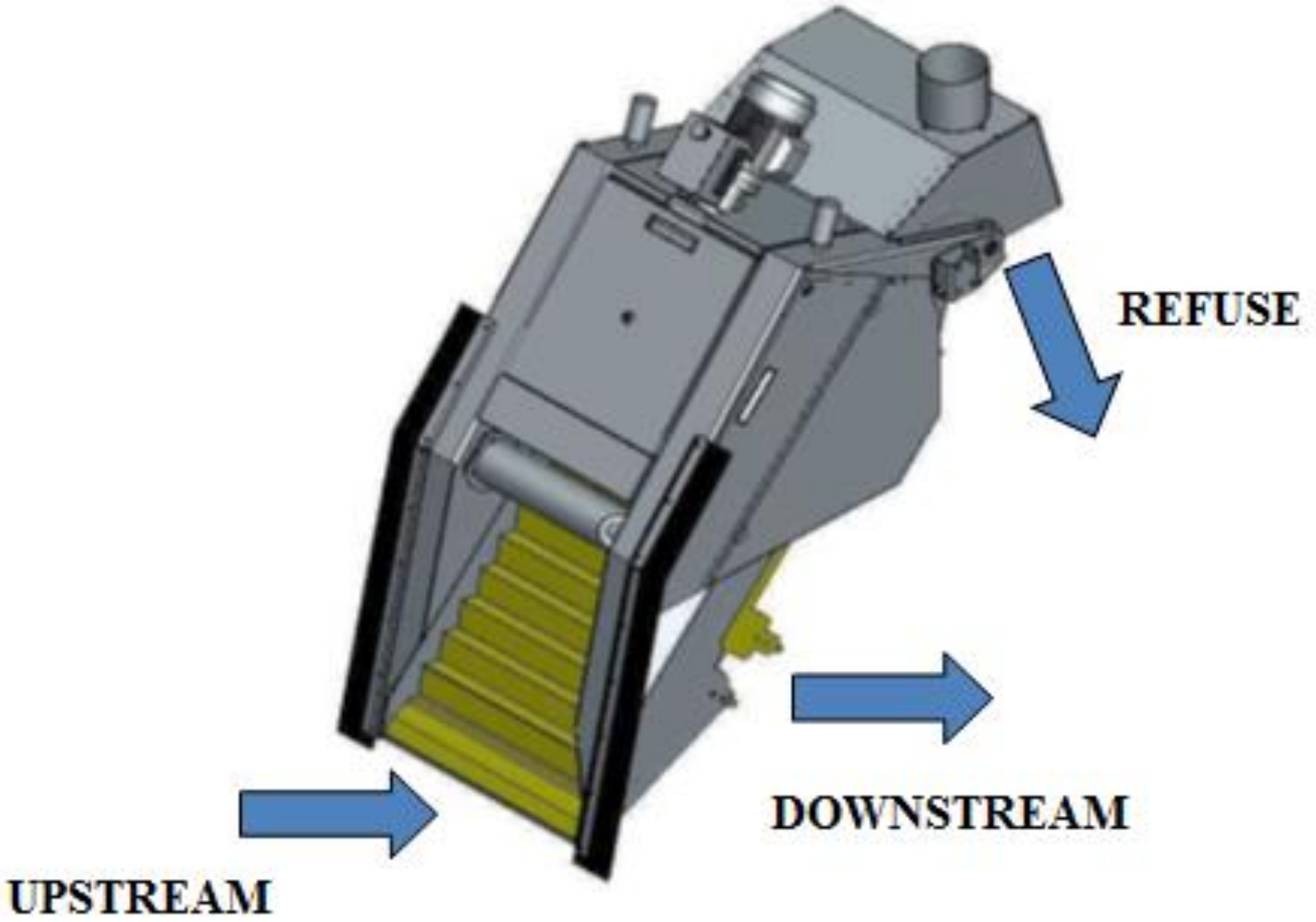
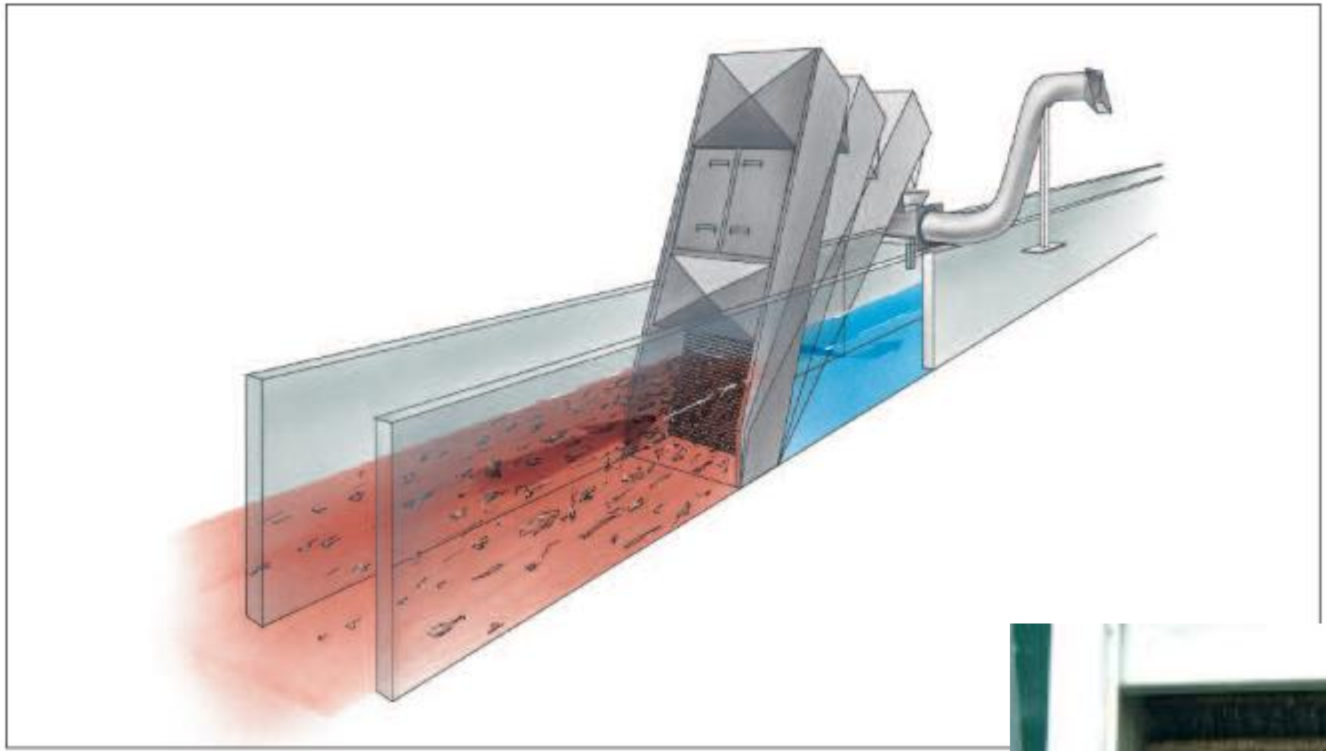
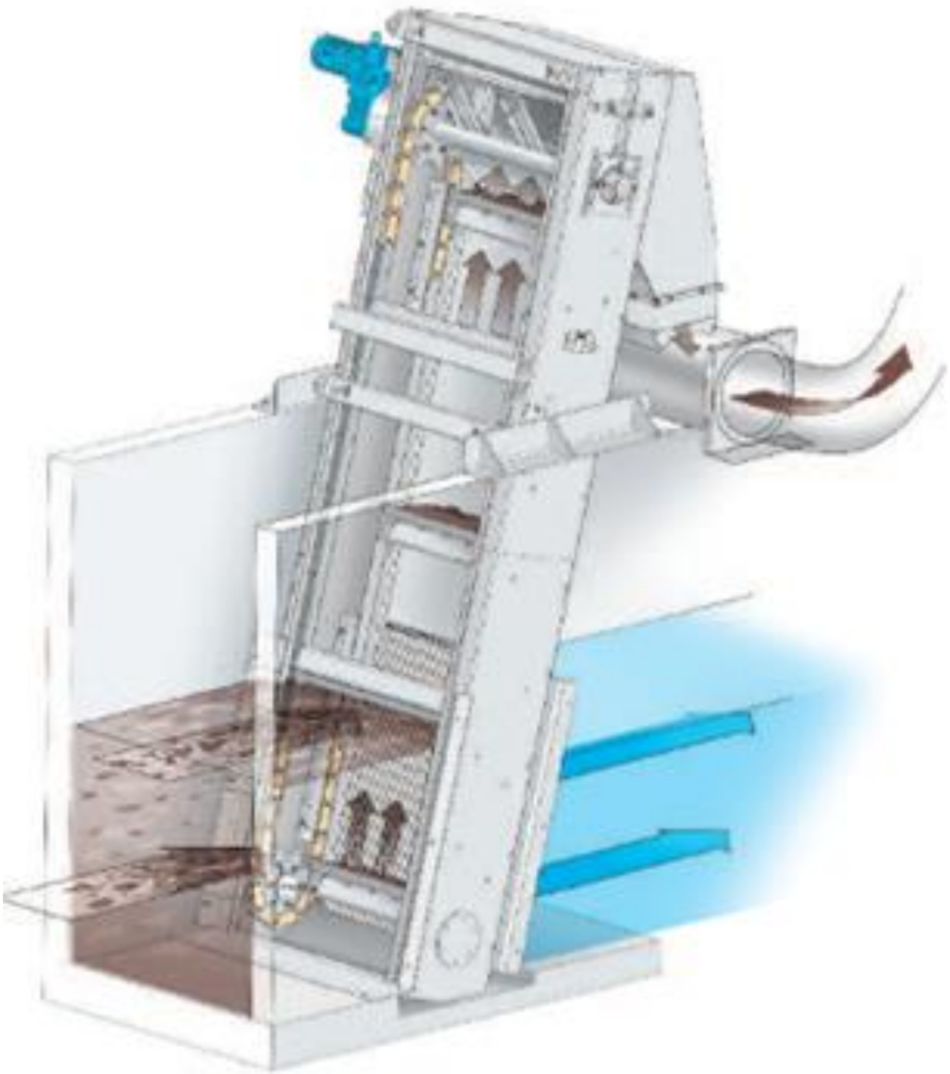
Self Cleaning Step Screen



Self Cleaning Step Screen



Self Cleaning Step Screen



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Self Cleaning Step Screen

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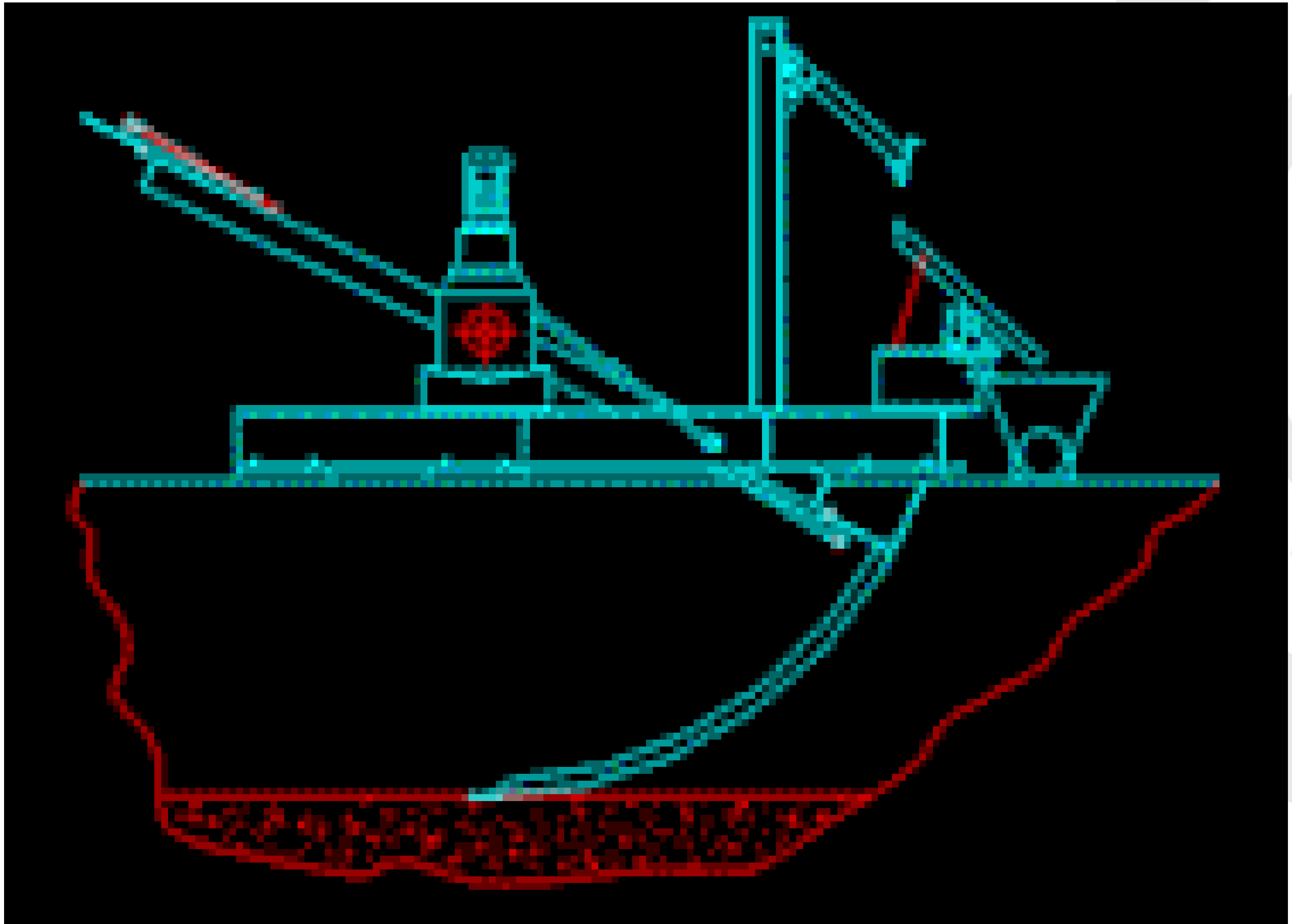
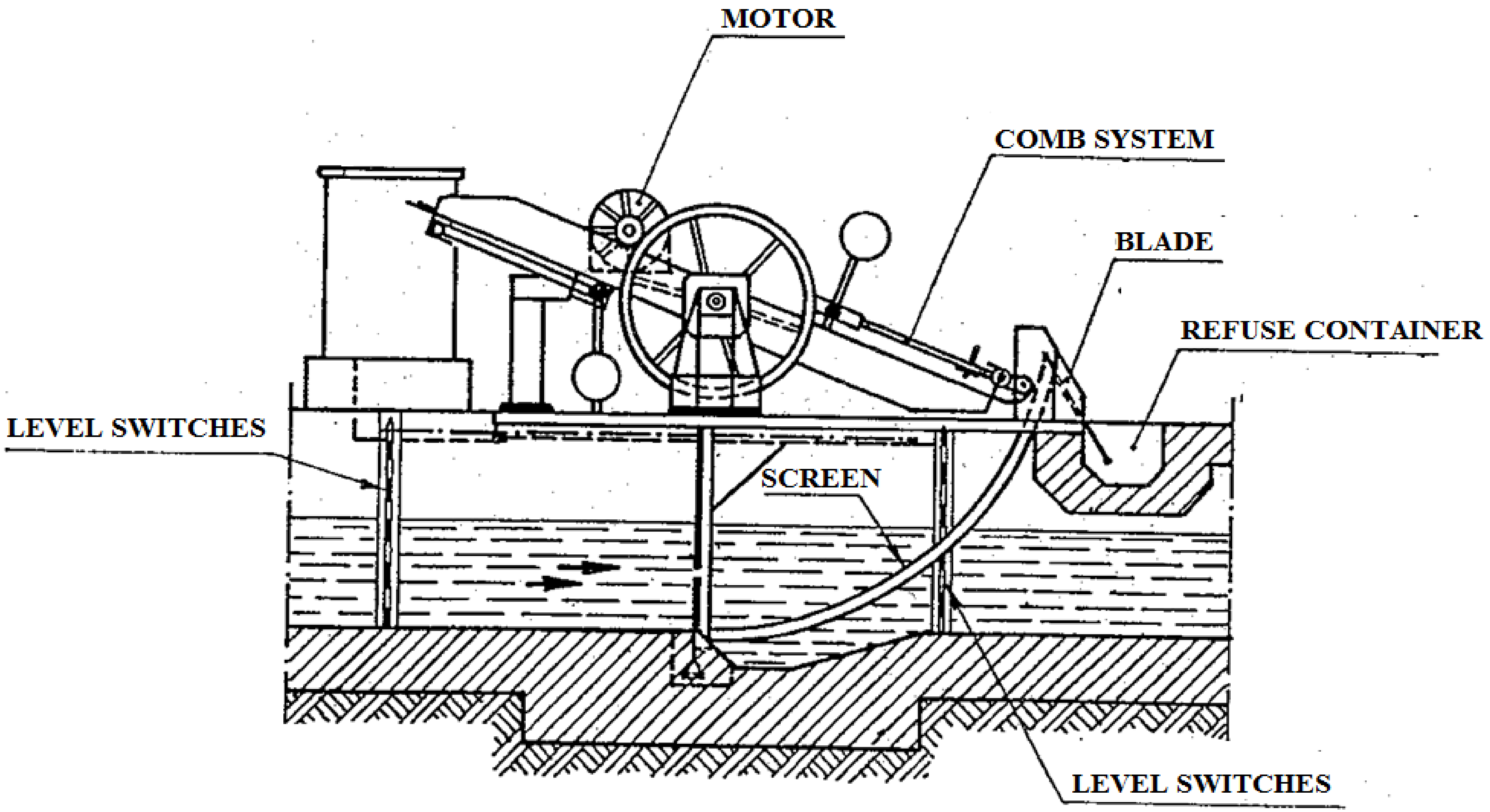
Radial Bar Screen



Radial Bar Screen



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Radial Bar Screen

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Radial Bar Screen

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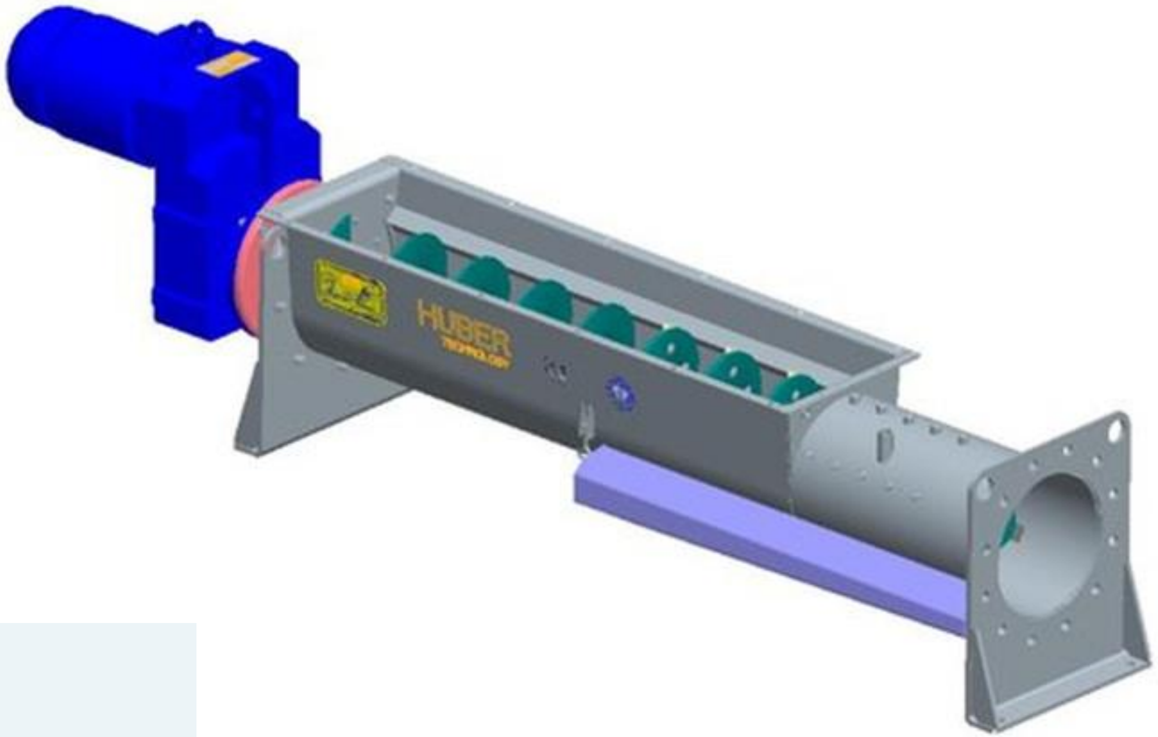
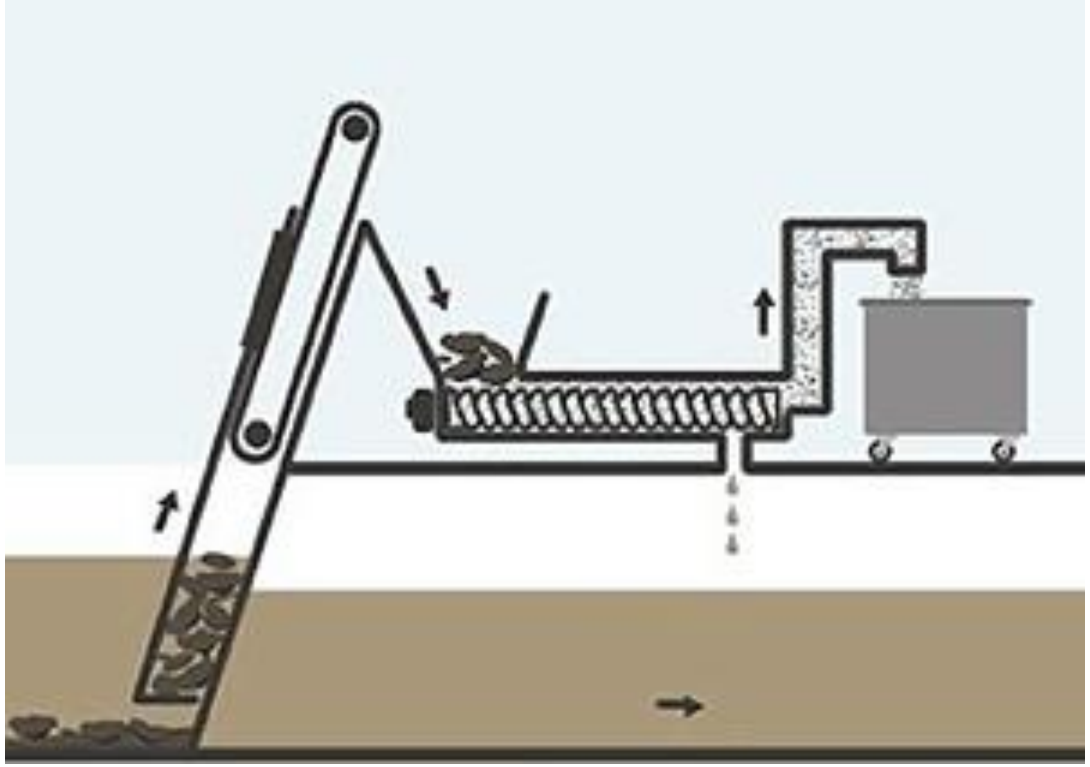
Refuse dewatering

Screw press for dewatering





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Dewatered refuse

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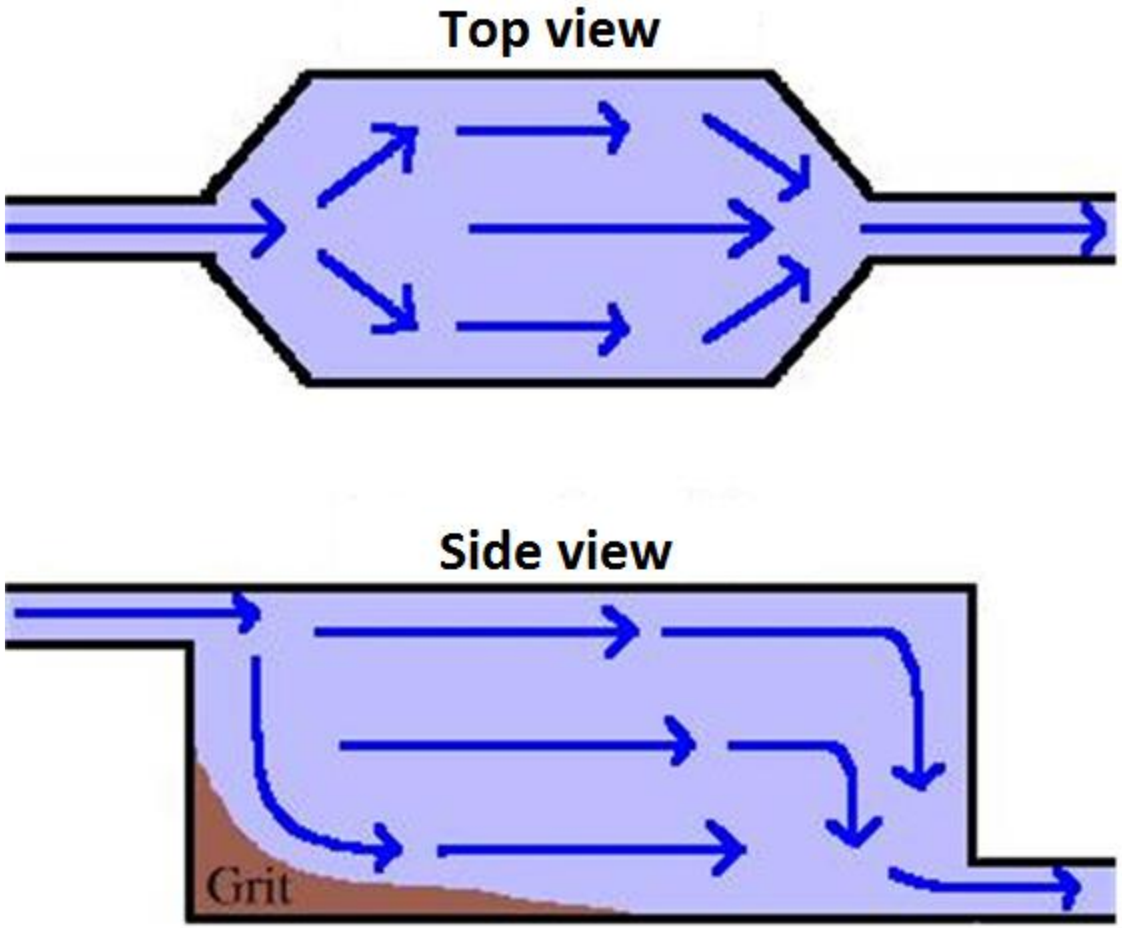
Grit traps/chambers

Grit chambers are basins to remove the inorganic particles to prevent damage to the pumps and to prevent their accumulation in sludge digesters.

Grit Trap



The larger the cross section area, the slower the waste water flow.

Grit Chamber 10.0 x 0.5m

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Grit Trap

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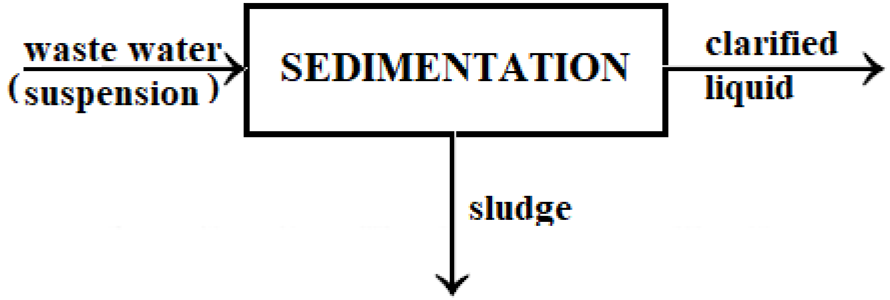
SEDIMENTATION

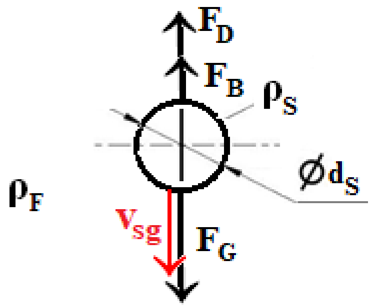


Suspension is a heterogeneous mixture of
a fluid that contains solid particles sufficiently large
for sedimentation

Settling velocity

Behavior of solid particles (balls) in fluid phase:

Settling velocity due to gravity v_{sg} is constant, if the forces are balanced.



Gravity force:

$$F_G = m_S g = \frac{d_S^3 \pi}{6} \rho_S g$$

Buoyancy force:

$$F_B = \frac{d_S^3 \pi}{6} \rho_F g$$

Drag force:

$$F_D = C \frac{\rho_f}{2} v_{sg}^2 \frac{d_S^2 \pi}{4}$$

Diameter of particle:	d_S
Solid density:	ρ_S
Liquid density:	ρ_F
Dynamic viscosity of liquid:	μ_F
Drag coefficient	C

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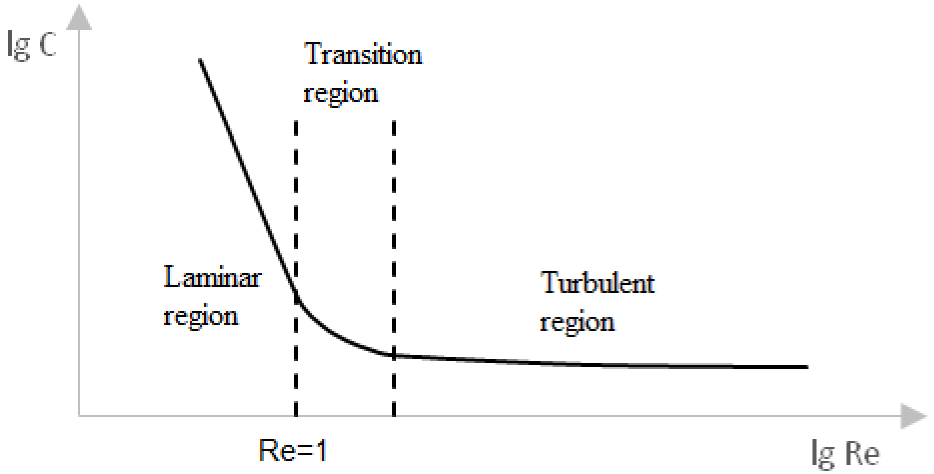
Settling velocity

Drag coefficient vs. Reynolds number



In laminar(Stokes) region:

$$C = \frac{24}{Re} \qquad Re<1$$

$$Re = \frac{v_{sg} d_S \rho_F}{\mu_F}$$

$$C = \frac{24\mu_F}{v_{sg} d_S \rho_F}$$

$$F_D = \frac{24\mu_F}{v_{sg} d_S \rho_F} \frac{\rho_f}{2} v_{üg}^2 \frac{d_S^2 \pi}{4}$$

$$F_D = 3\pi d_S v_{sg} \mu_F$$

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Settling velocity

$$F_G = F_D + F_B$$

$$\frac{d_S^3\pi}{6}\rho_S g = 3\pi d_S v_{sg}\mu_F + \frac{d_S^3\pi}{6}\rho_F g$$

Settling velocity due to gravity:

$$v_{sg} = \frac{d_S^2(\rho_S - \rho_F)g}{18\mu_F}$$

a) $v_{sg} \sim d_S^2$

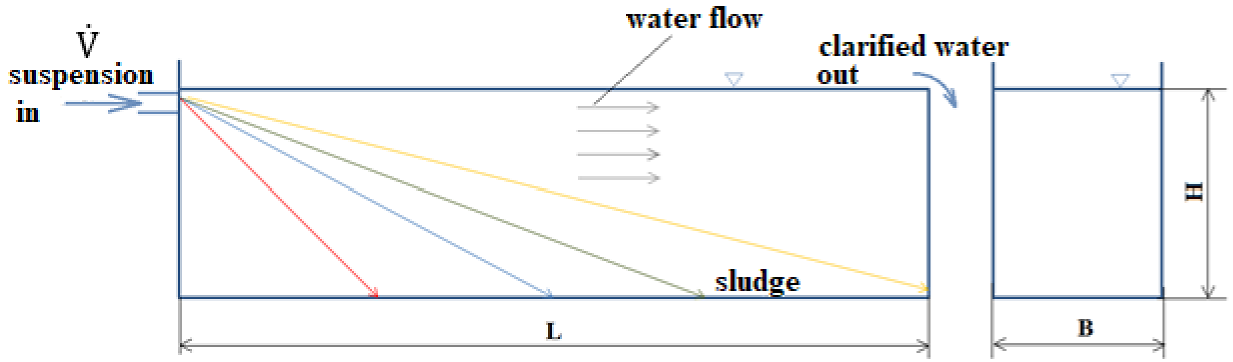
b) $v_{sg} \sim \frac{1}{\mu_F}$

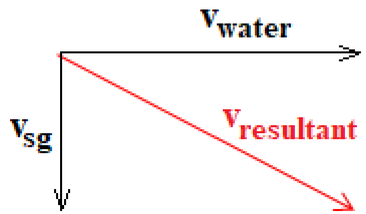
c) $v_{sg} \sim g$

Criteria of Stokes formula:

- Re<1,
- spherical shape,
- free settling.

RECTANGULAR HORIZONTAL FLOW SETTLEMENT TANK





Settling time:

$$t_s = \frac{H}{v_{sg}}$$

Detention time in the basin:

$$t_d = \frac{L}{v_{water}}$$

$$v_{water} = \frac{\dot{V}}{BH \cdot}$$

$$t_d = \frac{L \cdot B \cdot H}{\dot{V}}$$

$$t_s \leq t_d$$

$$\frac{H}{v_{sg}} \leq \frac{L \cdot B \cdot H}{\dot{V}}$$

$$L \geq \frac{\dot{V}}{v_{sg} B}$$

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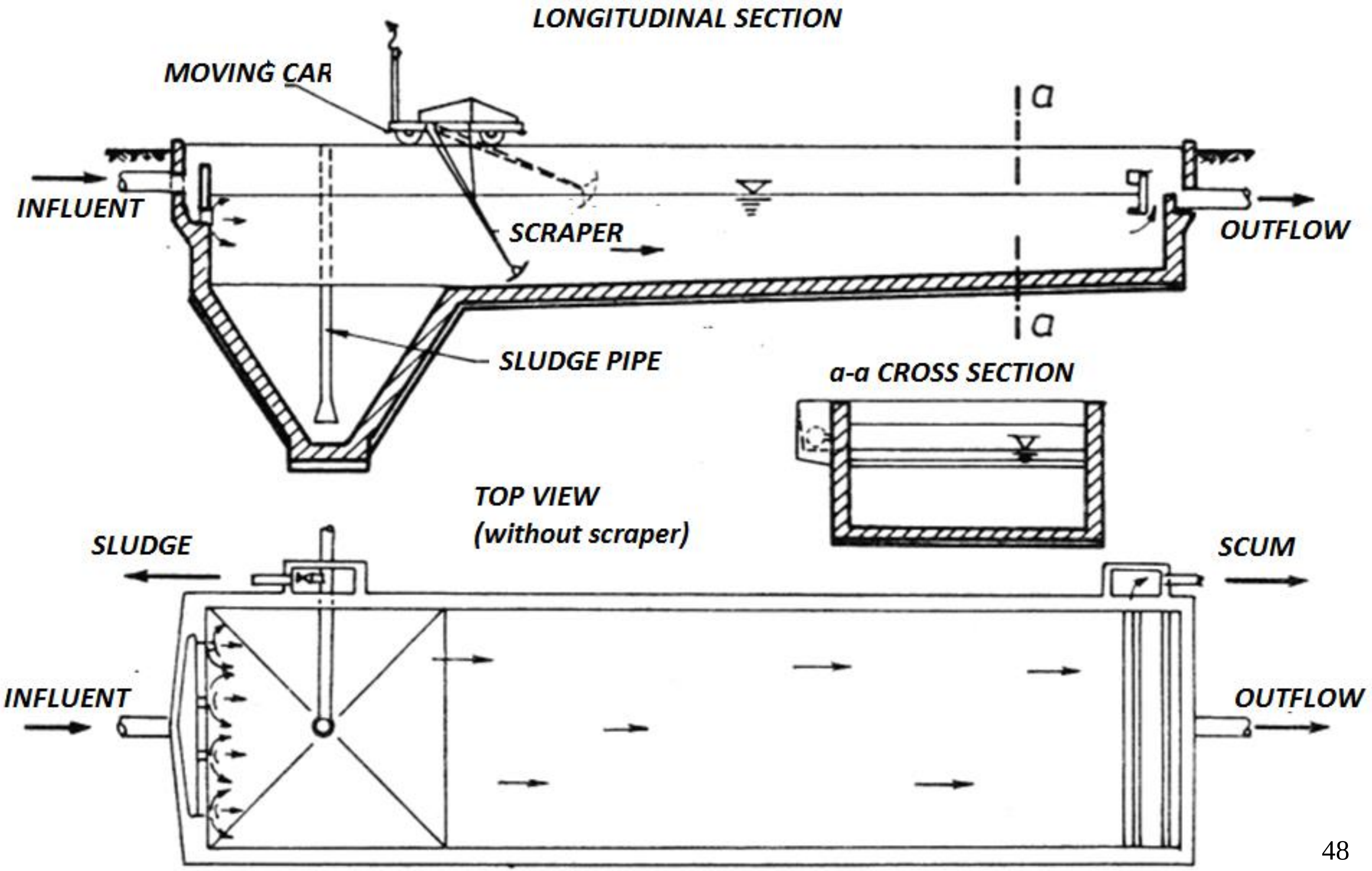
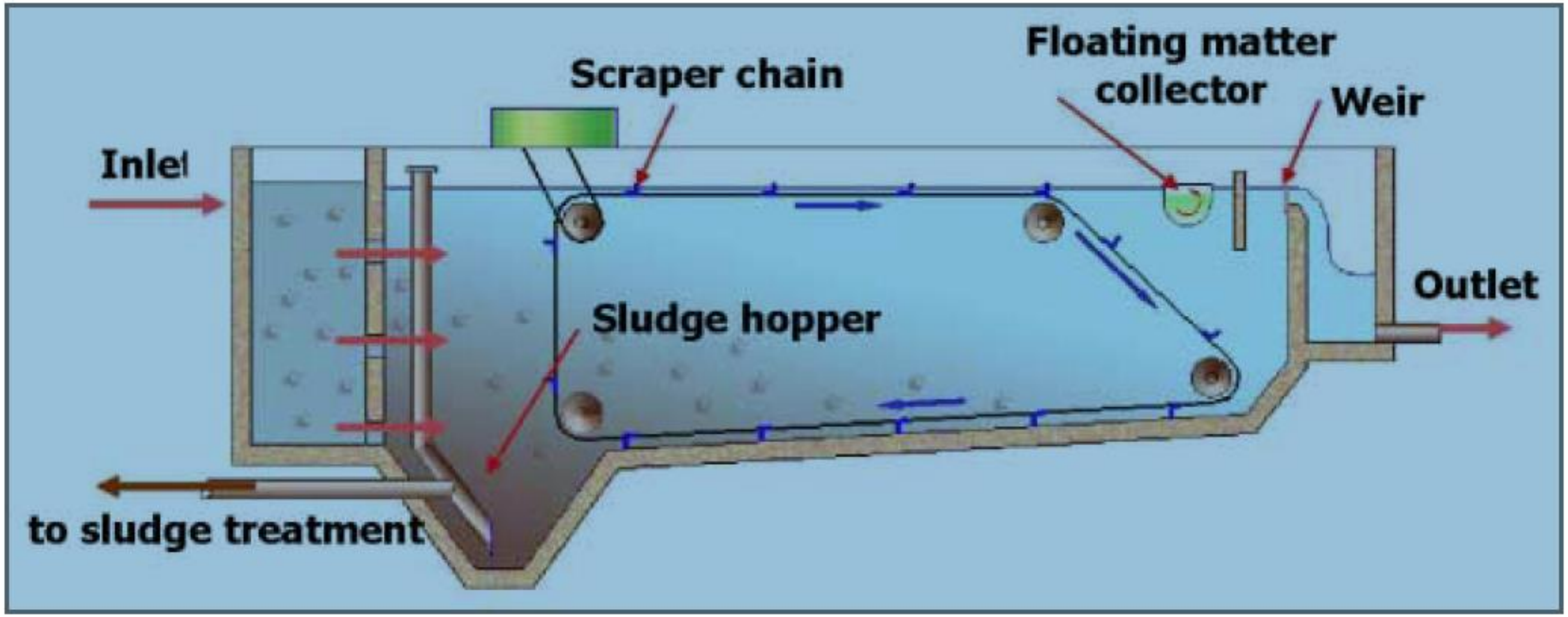
RECTANGULAR HORIZONTAL FLOW SETTLEMENT TANK



RECTANGULAR HORIZONTAL FLOW SETTLEMENT TANK



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RECTANGULAR HORIZONTAL FLOW SETTLEMENT TANK (CLARIFIER)

RECTANGULAR HORIZONTAL FLOW SETTLEMENT TANK

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RECTANGULAR HORIZONTAL FLOW SETTLEMENT TANK

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Outflow weir

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Clarified water at outflow weir

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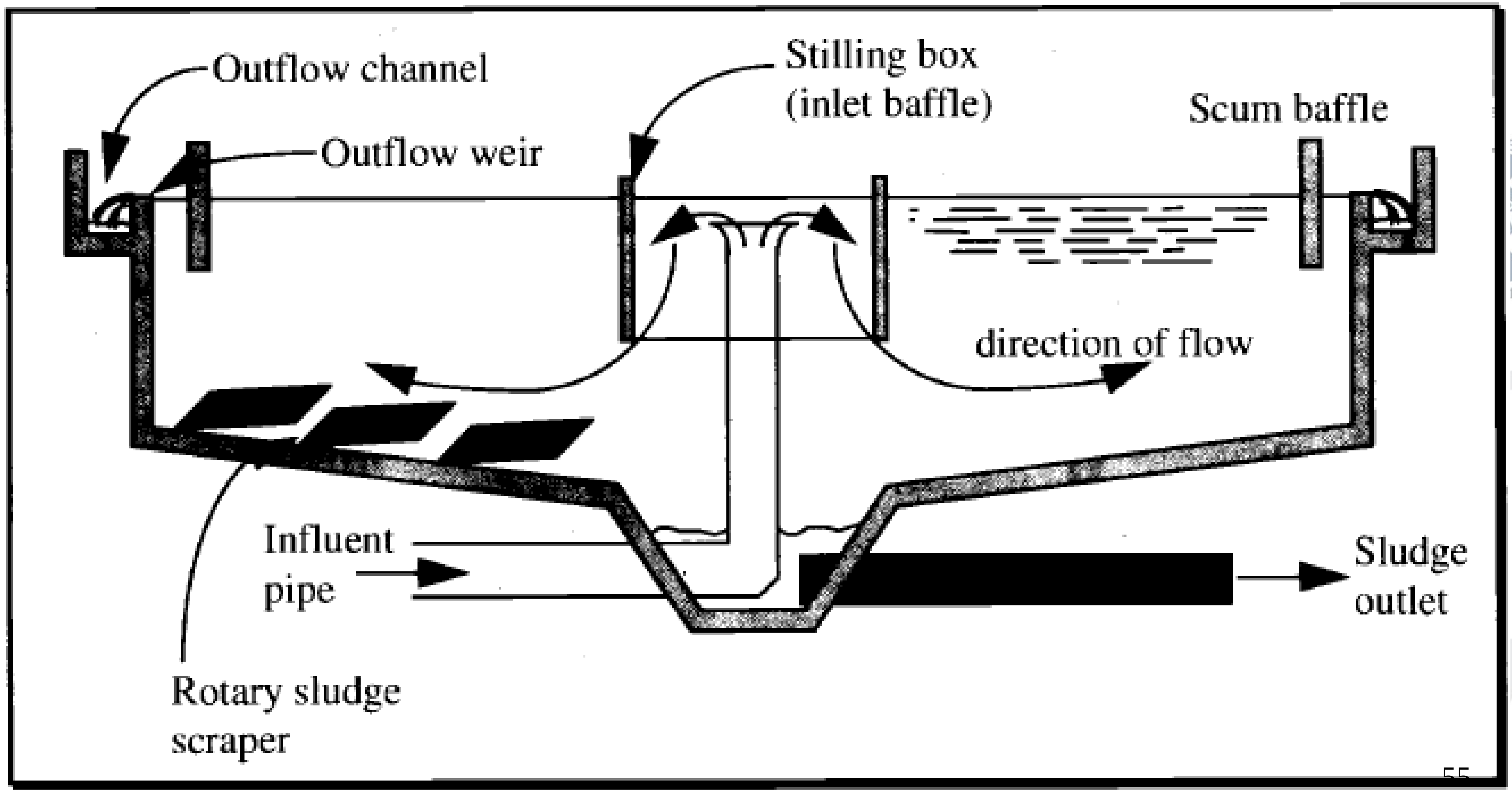
CIRCULAR RADIAL FLOW SETTLEMENT TANK



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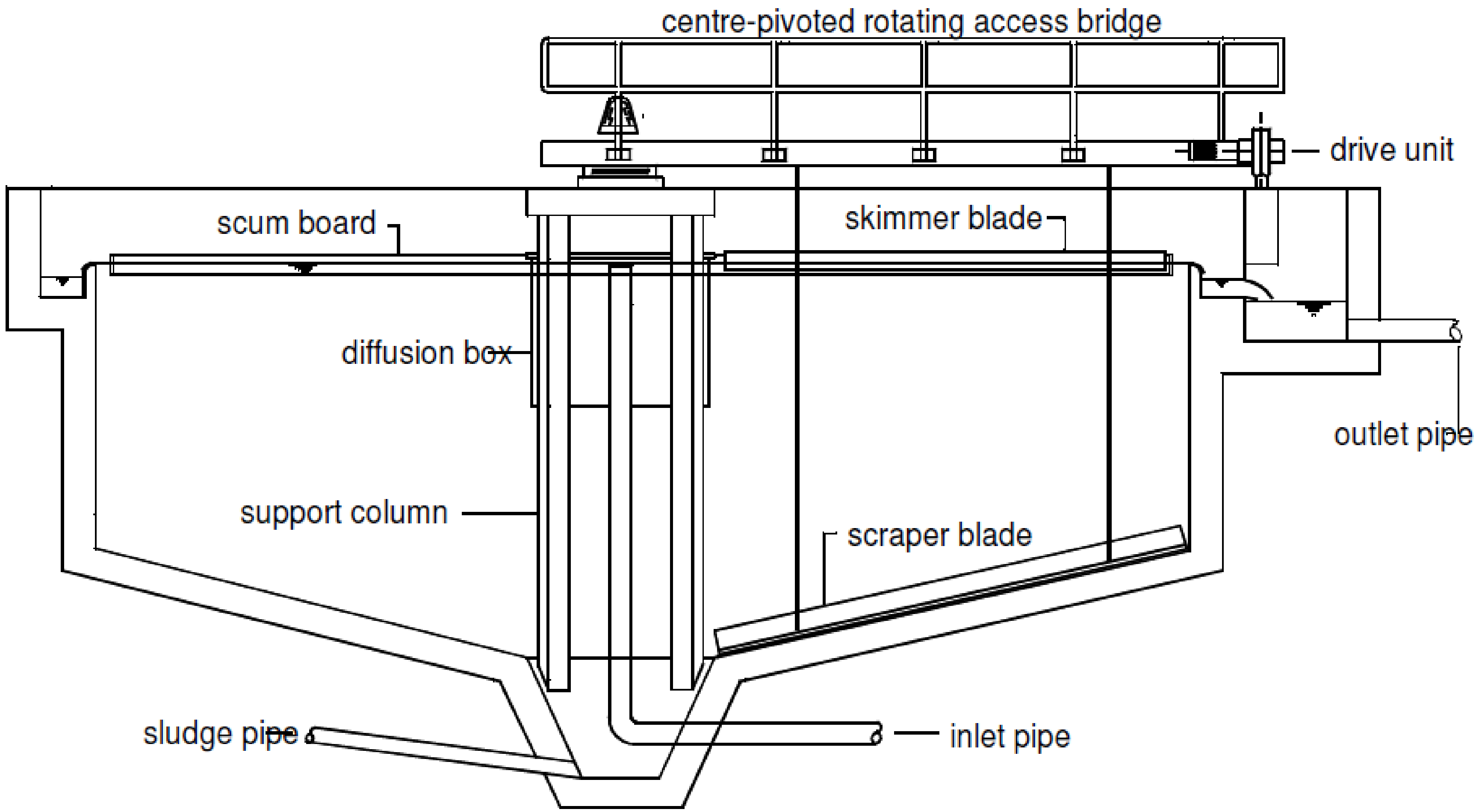
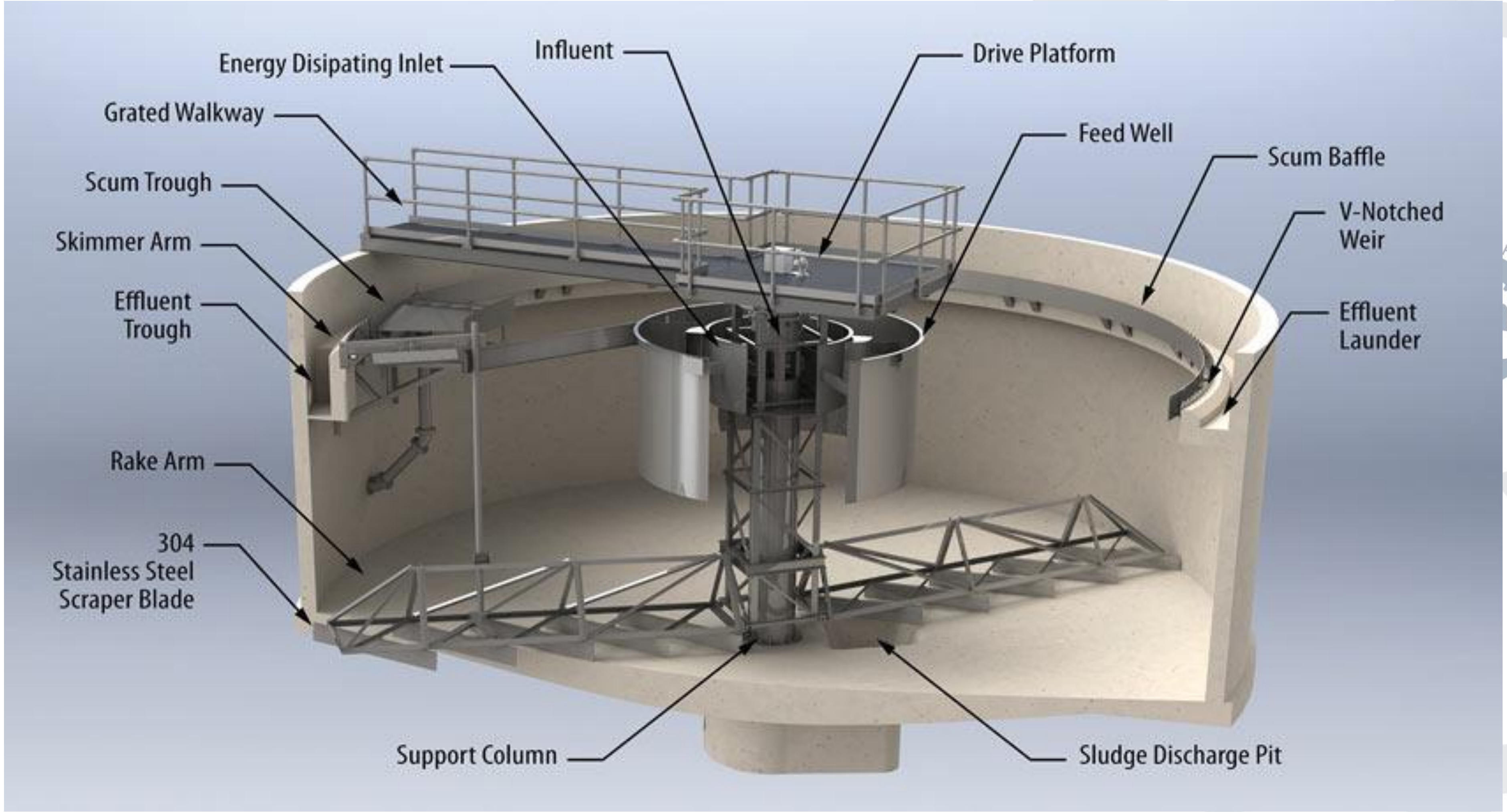
CIRCULAR RADIAL FLOW SETTLEMENT TANK



CIRCULAR RADIAL FLOW SETTLEMENT TANK



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CIRCULAR RADIAL FLOW SETTLEMENT TANK

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CIRCULAR RADIAL FLOW SETTLEMENT TANK

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Mechanically cleaned waste water

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Thank you for your attention!

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