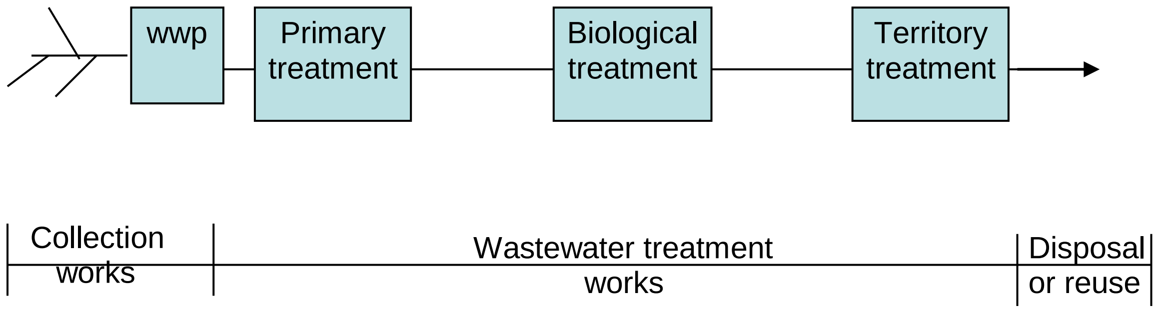
Wastewater Treatment



Primary treatment:

The treated wastewater must be disposed in the sea.

Primary + Secondary treatment:

The treated wastewater can be disposed to drain.

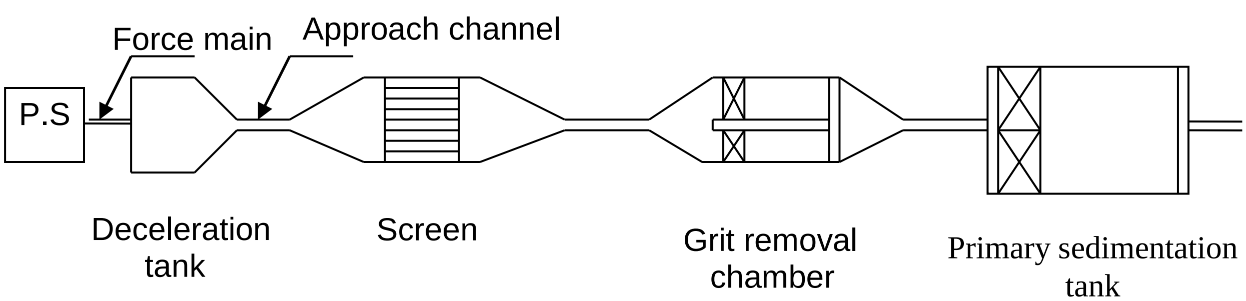
Primary + Secondary + tertiary treatment:

The treated wastewater may be used for irrigation.

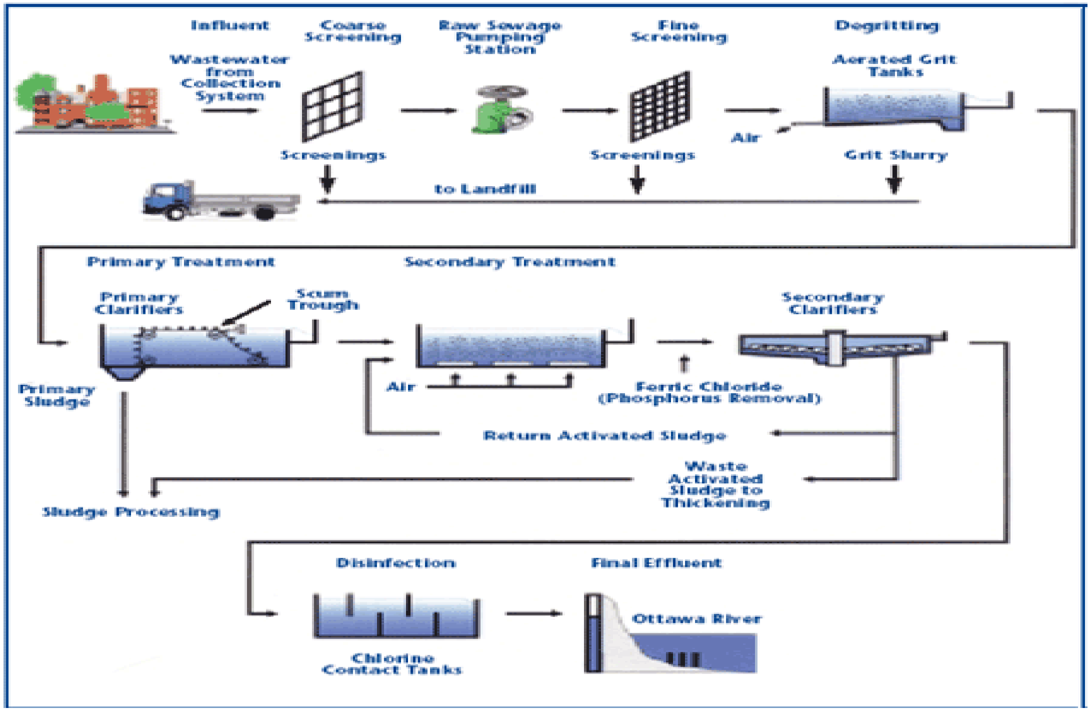
Primary wastewater treatment:

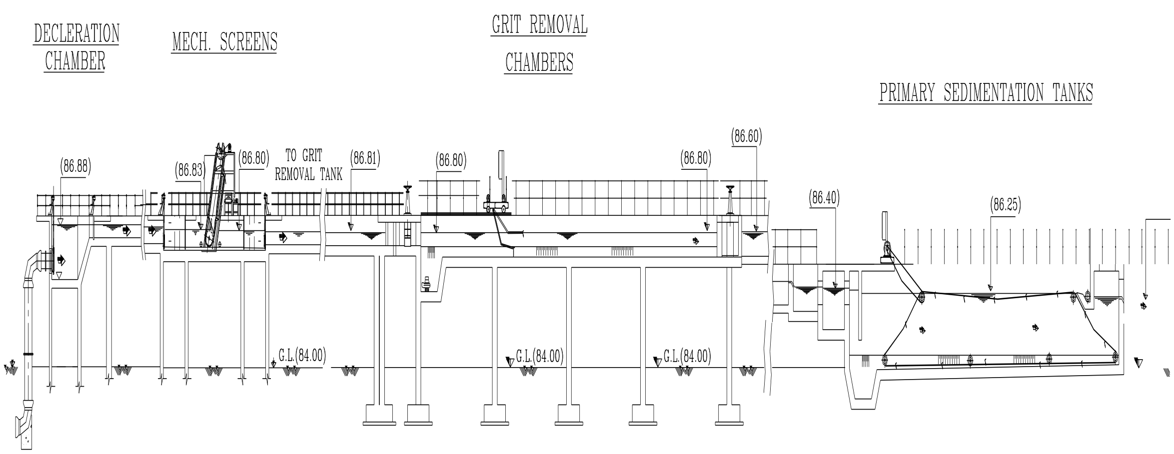
Purpose :

Removal of settleable suspended solids (organic or inorganic).



Flow line in wastewater treatment plant





Flow line in primary wastewater treatment

Deceleration tank:

Purpose:

Reduce the velocity of the sewage before screen to prevent escaping of removal matters.

Design criteria:

1- T = 5 - 60 sec

2- V = 0.6 - 1.2 m/s

3- L = 3 B

4- Qd = Qmax summer

= 0.8 x P.F.F x 1.2 x Qave

Qmin = Qmim winter

= 0.8 x M.F.F x 0.7 x Qave

$$P.F.F. = 1 + \frac{14}{4 + \sqrt{\frac{pop}{1000}}} \qquad \text{For population} \succ 80000\,\text{capita}$$

$$P.F.F. = \frac{5}{(\frac{population}{1000})^{0.2}} \qquad \textit{For population} \leq 80000\,\textit{capita}$$

$$M.F.F. = 0.2\left(\frac{pop}{1000}\right)^{0.167}$$

Approach channel:

Purpose:

Transmit sewage to screen with suitable velocity.

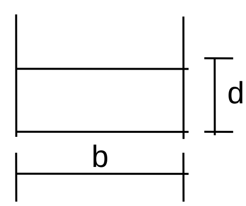
Design criteria:

1- velocity = 0.6 - 1.5 m/sec

$V = 1/n\ R^{2/3}\ S^{1/2}$ n = 0.015

2- $Q_d = Q_{max\ summer}$

$= 0.8 \times P.F.F \times 1.2 \times Q_{ave}$



$Q_d = A.V$

$A = b \times d$ $b = 2d$ $\therefore\ A = 2\,d^2$

To get Smin assume Vmin = 0.6 m/sec

$$A_{\min} = \frac{Q_{\min}}{V_{\min}} = \frac{Q_{\min}}{0.6}$$

$$b \times d_{\min} = \frac{Q_{\min}}{0.6} \quad \rightarrow d_{\min}$$

$$V_{\min} = \frac{1}{n} R^{2/3} S^{1/2}$$

$$R_{\min} = \frac{A_{\min}}{P_{\min}} = \frac{b \times d_{\min}}{b + 2d_{\min}}$$

$$\rightarrow S_{\min}$$

<u>Screen:</u>

<u>Purpose:</u>

Removal of large floating objects such as plastic, metals, wood, paper….ext.

Mechanical screen

Manual screen

Types of screen:

With regard to spacing between bars:

1- Coarse screen: spacing between bars 2.5 – 7.5 cm (5 cm).

2- Fine screen: spacing between bars 1 - 5 cm (2.5).

With regard to cleaning:

1- Manual screen

2- Mechanical screen.

Design criteria:

1- Net area = (2 - 3) area of approach channel

2- ϴ = 30◦ - 60◦

3- Depth of screen = depth of approach channel

4- No. of screens ⩾ 2

5- Dimension of bars

Φ (diameter of bars) = 10 - 19 mm

S (spacing between bars) = 2.5 - 5   cm

6- Horizontal velocity before screen V1 ⩾ 0.6 m/s

7- Velocity through screen V2 ⩽ 1.5 m/s

$$Head\ loss\ through\ screen = 1.4\frac{V_2^2 - V_1^2}{2g} \qquad \le 10\ cm$$

Example:

For a city of average water consumption 250 l/c/d and population 400000 capita. Design the primary treatment units.

Solution:

$$Q_{ave} = \frac{0.8 \times q_{ave} \times population}{1000 \times 24 \times 60 \times 60}$$

$$= \frac{0.8 \times 250 \times 400000}{1000 \times 24 \times 60 \times 60} = 0.93 \quad m^3/s$$

$$P.F.F = 1 + \frac{14}{4 + \sqrt{\frac{p}{1000}}}$$

$$P.F.F = 1 + \frac{14}{4 + \sqrt{\frac{400000}{1000}}} = 1.58$$

$$M.F.F = 0.2(\frac{P}{1000})^{0.167}$$

$$M.F.F = 0.2(\frac{400000}{1000})^{0.167} = 0.54$$

$$Q_d = P.F.F \times (1.2 \times Q_{ave})$$

$$= 1.58 \times 1.2 \times 0.93 = 1.75 \quad m^3/s$$

$$Q_{\min} = M.F.F \times (0.7 \times Q_{ave})$$

$$= 0.54 \times (0.7 \times 0.93) = 0.35 \quad m^3/s$$

$$Practecally\ take\ P.F.F = 1.5\ and\ M.F.F = 0.5$$

Design of approach channel:

Assume v= 1.2 m/s

Q_d = A x v

A = Q_d / v

= 1.75 /1.2 = 1.46 m^2

A = b x d

For best hydraulic section b =2d

A = 2d x d

1.46 = $2d^2$

d = 0.85 m , b = 2 x 0.85=1.7 m

Area actual = b x d = 0.85 x 1.7 = 1.45 m^2

$$v = \frac{1}{n} R^{2/3} S^{1/2}$$

$$\frac{Q_d}{A} = \frac{1}{n} R^{2/3} S^{1/2}$$

$$\frac{1.75}{1.45} = \frac{1}{0.015} (\frac{1.45}{1.7 + 2 \times 0.85})^{2/3} S^{1/2}$$

$$S = 1.03\,\%o$$

$$Assume\, v_{\min} = 0.6 \quad m/s$$

$$A_{\min} = \frac{Q_{\min}}{v_{\min}} = \frac{0.35}{0.6} = 0.58 \quad m^2$$

$$A_{\min} = b \times d_{\min}$$

$$0.58 = 1.7 \times d_{\min}$$

$$d_{\min} = 0.34 \quad m$$

$$V_{\min} = \frac{1}{n} R_{\min}^{2/3} S^{1/2}$$

$$0.6 = \frac{1}{0.015} (\frac{0.58}{1.7 + 2 \times 0.34})^{2/3} S_{\min}^{1/2}$$

$$S_{\min} = 0.54\,\%o$$

Design of deceleration tank:

Assume T=30 sec   T= 5 – 60 sec

V= Q_d x T

= 1.75 x 30 = 52.5 m^3

Assume L = 3 B

d = depth of approach channel = 0.85 m

V = A x d

52.5 = 0.85 x B x 3B

B = 4.53 m   , L = 13.61 m

Design of screen:

Assume:

- Net submerged area of screen = 2 x area of approach channel
  - Depth of wastewater in screen (d) = depth of wastewater in approach channel.

    = 0.85 m
  - Spacing between bars = 5 cm
  - Width of bars = 10 mm = 1 cm
  - Length of submerged screen (L) = d / sinθ

    = 0.85 / sin 45° = 1.2 m

Area of spacing = L x b

= 1.2 x 0.05 = 0.06 m2

Net submerged area = 2 x A of approach channel

= 2 x 1.45 = 2.9 m2

No. of spacing = net submerged area / area of one spacing

= 2.9 / 0.06 = 48 space

Take 2 screens

No. of spacing in each screen = 24 space

No. of bars = No. of spacing + 1

= 24 + 1 = 25 bars

Width of screen (B) = total width of spacing + total width of bars

= 24 x 0.05 + 25 x 0.01 = 1.45 m

Chicks:

$$v_1 = \frac{Q_d}{A}$$

$$v_1 = \frac{Q_d}{n \times B \times d} = \frac{1.75}{2 \times 1.45 \times 0.85} = 0.71 \quad m/s \quad \succ 0.6 \; safe$$

$$v_2 = \frac{Q_d}{n \times d \times spacing \times no.of \; spacing}$$

$$= \frac{1.75}{2 \times 0.85 \times 0.05 \times 24} = 0.86 \quad m/s \prec 1.5 m/s \; safe$$

Head loss through screen

$h_L =$

$2g$

$1.4((0.86)^2 - (0.71)^2)$