Sedimentation is removal of particulate materials suspended in water by quiescent settling due to gravity.

Commonly used unit operation in water and wastewater treatment plants.
**SEDIMENTATION**

Diagram showing particles in discrete and flocculating forms, with size, shape, and weight as factors. 

**TYPES OF SEDIMENTATION**

- **Type I: Discrete particle settling**
  - No interaction between particles
  - Settling velocity is constant for individual particles
  - Dilute solid’s concentration
  - Examples: presedimentation in water treatment, grit removal in wastewater

- **Type II: Flocculent settling**
  - Particles collide and adhere to each other resulting in particle growth
  - Dilute solid’s concentration
  - Examples: coagulation/flocculation settling in water treatment and primary sedimentation in wastewater treatment
TYPES OF SEDIMENTATION

- **Type III: Hindered or zone settling**
  - Particles are so close together movement is restricted
  - Intermediate solids concentration
  - Solids move as a block rather than individual particles
  - Fluidic interference causes a reduction in settling velocity
  - Distinguishable solids liquid interface
  - Intermediate solids concentration
  - Example: settling of secondary effluents

- **Type IV: Compression settling**
  - Particles physically in contact
  - Water is squeezed out of interstitial spaces
  - Volume of solids may decrease
  - High concentration of solids (sludges)

DISCRETE PARTICLES SETTLING (Type 1)

- Characteristics of the particles
  - Size and shape
  - Specific gravity

- Properties of the water
  - Specific gravity
  - Viscosity

- Physical environment of the particle
  - Velocity of the water
  - Inlet and outlet arrangements of the structure
**DISCRETE PARTICLES SETTLING (TYPE 1)**

\[ F_{\text{net}} = mg - F_d - F_b \]
\[ F_{\text{net}} = 0 \]

\[ v_s = \sqrt{\frac{4 (\rho_s - \rho_w) gd}{3 \rho_w C_D}} \]

- \( R_e < 1 \), \( C_d = 24/R_e \) (Laminar flow)
- \( 1 < R_e < 10^4 \), \( C_d = 24/R_e + 3/(R_e)^{1/2} + 0.34 \) (Transition)
- \( 10^3 < R_e < 10^4 \), \( C_d = 0.4 \) (Turbulent)

---

**STOKE’S LAW**

- For \( R_e < 1 \) (laminar flow) and
- \( R_e = \rho_w v_s d/\mu \) (for perfect sphere),

Stoke’s law:

\[ v_s = \frac{gd^2 (\rho_s - \rho_w)}{18 \mu} \]
\[ v_s = \frac{gd^2 (S_g - 1)}{18 \nu} \]
**EXAMPLE**

Estimate the terminal settling velocity in water at a temperature of 15°C of spherical silicon particles with specific gravity 2.40 and average diameter of (a) 0.05 mm and (b) 1.0 mm.

**SOLUTION**

- Step 1. Using Stokes equation for (a) at T= 15°C

\[
\rho = 999 \text{ kg/m}^3, \text{ and } \mu = 0.00113 \text{ N s/m}^2 \\
d = 0.05 \text{ mm} = 5 \times 10^{-5} \text{ m} \\
\]

\[
u = \frac{g(\rho_p - \rho)d^2}{18\mu} \\
= \frac{9.81 \text{ m/s}^2 (2400 - 999) \text{ kg/m}^3 (5 \times 10^{-5} \text{ m})^2}{18 \times 0.00113 \text{ N s/m}^2} \\
= 0.00169 \text{ m/s} 
\]
**SOLUTION...**

- Step 2. Check with the Reynolds number

\[
R = \frac{\rho ud}{\mu} = \frac{999 \times 0.00169 \times 5 \times 10^{-5}}{0.00113} \\
= 0.075
\]

(a) **The Stokes’ law applies, since R < 2.**

- Step 3. Using Stokes’ law for (b)

\[
u = \frac{9.81 (2400 - 999) (0.001)^2}{18 \times 0.00113} \\
= 0.676 \text{ m/s}
\]

---

**SOLUTION...**

- Step 4. Check the Reynolds number

Assume the irregularities of the particles \( \phi = 0.85 \)

\[
R = \frac{\phi \rho ud}{\mu} = \frac{0.85 \times 999 \times 0.676 \times 0.001}{0.00113} \\
= 508
\]

Since \( R > 2 \), the Stokes’ law does not apply. Use Eq. 1 to calculate \( \nu \)
**SOLUTION...**

- **Step 5.** Re-calculate $C_d$ and $v$

\[
C_d = \frac{24}{R} + \frac{3}{\sqrt{R}} + 0.34 = \frac{24}{508} + \frac{3}{\sqrt{508}} + 0.34
\]

\[
= 0.52
\]

\[
u^2 = \frac{4g(\rho_p - \rho)d}{3C_d\rho}
\]

\[
u^2 = \frac{4 \times 9.81 \times (2400 - 999) \times 0.001}{3 \times 0.52 \times 999}
\]

\[u = 0.188 \text{ m/s}
\]

- **Step 6.** Re-check Re

\[
R = \frac{\phi \rho ud}{\mu} = \frac{0.85 \times 999 \times 0.188 \times 0.001}{0.00113}
\]

\[= 141
\]

- **Step 7.** Repeat step 5 with new R

\[
C_d = \frac{24}{141} + \frac{3}{\sqrt{141}} + 0.34
\]

\[
= 0.76
\]

\[
u^2 = \frac{4 \times 9.81 \times 1401 \times 0.001}{3 \times 0.76 \times 999}
\]

\[u = 0.155 \text{ m/s}
\]
**SOLUTION...**

- Step 8. Re-check Re

\[
R = \frac{0.85 \times 999 \times 0.155 \times 0.001}{0.00113} = 116
\]

- Step 9. Repeat step 7

\[
C_d = \frac{24}{116} + \frac{3}{\sqrt{116}} + 0.34
\]

\[
= 0.72
\]

\[
\mu^2 = \frac{4 \times 9.81 \times 1401 \times 0.001}{3 \times 0.72 \times 999} = 0.160 \text{ m/s}
\]

(b) The estimated velocity is around 0.16 m/s

---

**SETTLING COLUMN**

\[
v_0 = \frac{\text{Distance traveled}}{\text{time of travel}} = \frac{Z_0}{t_0}
\]

\[
v_p = \frac{\text{Distance traveled}}{\text{time of travel}} = \frac{Z_p}{t_0}
\]

\[
t_0 = \frac{Z_0}{v_0} = \frac{Z_p}{v_p} \quad \text{and} \quad \frac{v_p}{v_0} = \frac{Z_p}{Z_0}
\]
**GENERALLY**

- All particles with \( d \geq d_o \), such that \( v \geq v_o \), will arrive at or pass the sampling port in time \( t_o \).
- A particle with \( d_p < d_o \) will have a terminal settling velocity \( v_p < v_o \) and will arrive at or pass the sampling port in time \( t_o \), with original position at, or below a point \( Z_p \).
- If the suspension is mixed uniformly then the fraction of particles of size \( d_p \) with settling velocity \( v_p \) which will arrive at or pass the sampling port in time \( t_o \) will be \( \frac{Z_p}{Z_o} = \frac{v_p}{v_o} \).
- Thus, the removal efficiency of any size particle from suspension is the ratio of the settling velocity of that particle to the settling velocity \( v_o \) defined by \( Z_o/t_o \).

**PROCEDURE – SETTLEABLILITY ANALYSIS**

- Usually 2m high column
- Mix the suspension thoroughly
- Measure initial SS concentration, \( C_o \)
- Measure concentrations at certain intervals, \( C_i \)
- All particles comprising \( C_1 \) must have settling velocities less than \( Z_o/t_1 \). Thus the mass fraction of particles with \( v_1 < Z_o/t_1 \) is

\[
\chi = \frac{C_1}{C_o}
\]
PROCEDURE – SETTLEABLILITY ANALYSIS

For a given detention time $t_0$, an overall percent removal can be obtained.

All particles with settling velocities greater than $v_0 = Z_0/t_0$ will be 100 percent removed.

- Thus, $1 - x_o$ fraction of particles will be removed completely in time $t_0$. The remaining will be removed to the ratio $v/v_0$, corresponding to the shaded area in Fig. 4.2. If the equation relating $v$ and $x$ is known the area can be found by integration:

$$X = 1 - x_o + \int_0^{x_o} \frac{v_i}{v_o} \, dx$$
EXAMPLE: SETTLING COLUMN ANALYSIS OF TYPE-1 SUSPENSION

- A settling analysis is run on a type-1 suspension. The column is 2 m deep and data are shown below.

<table>
<thead>
<tr>
<th>Time, min</th>
<th>0</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>130</th>
<th>200</th>
<th>240</th>
<th>420</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conc. mg/L</td>
<td>300</td>
<td>189</td>
<td>180</td>
<td>168</td>
<td>156</td>
<td>111</td>
<td>78</td>
<td>27</td>
</tr>
</tbody>
</table>

- What will be the theoretical removal efficiency in a settling basin with a loading rate of 25 m$^3$/m$^2$-d (25m/d)?

SOLUTION

- Step 1. Calculate mass fraction remaining and corresponding settling rates

\[ x = \frac{C_i}{C_o} = \frac{189}{300} = 0.63 \]

<table>
<thead>
<tr>
<th>Time, min</th>
<th>60</th>
<th>80</th>
<th>100</th>
<th>130</th>
<th>200</th>
<th>240</th>
<th>420</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass fraction remaining</td>
<td>0.63</td>
<td>0.60</td>
<td>0.56</td>
<td>0.52</td>
<td>0.37</td>
<td>0.26</td>
<td>0.09</td>
</tr>
<tr>
<td>( V_t \times 10^2 ), m/min</td>
<td>3.0</td>
<td>2.5</td>
<td>2.0</td>
<td>1.55</td>
<td>1.0</td>
<td>0.83</td>
<td>0.48</td>
</tr>
</tbody>
</table>
**SOLUTION**

- **Step 2.** Plot mass fraction vs. settling velocity

- **Step 3.** Determine $v_o$
  - $v_o = 25 \text{m}^3/\text{m}^2.\text{d} = 1.74 \times 10^{-2} \text{ m/min}$

- **Step 4.** Determine $x_o = 54\%$
**SOLUTION**

- **Step 5.** $\Delta x \cdot v_t$ by graphical integration

![Graphical Integration Diagram]

- **Step 6.** Determine overall removal efficiency

\[
x = 1 - x_o + \sum \frac{\Delta x \cdot v_t}{v_o}
\]

\[
= 0.46 + \frac{0.46}{1.74} = 0.72
\]

**SOLUTION...**

- **Step 5.** $\Delta x \cdot v_t$ by graphical integration

<table>
<thead>
<tr>
<th>$\Delta x$</th>
<th>$v_t$</th>
<th>$\Delta x \cdot v_t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.06</td>
<td>1.50</td>
<td>0.09</td>
</tr>
<tr>
<td>0.06</td>
<td>1.22</td>
<td>0.07</td>
</tr>
<tr>
<td>0.1</td>
<td>1.00</td>
<td>0.10</td>
</tr>
<tr>
<td>0.1</td>
<td>0.85</td>
<td>0.09</td>
</tr>
<tr>
<td>0.1</td>
<td>0.70</td>
<td>0.07</td>
</tr>
<tr>
<td>0.06</td>
<td>0.48</td>
<td>0.03</td>
</tr>
<tr>
<td>0.06</td>
<td>0.16</td>
<td>0.01</td>
</tr>
</tbody>
</table>

$\sum \Delta x \cdot v_t = 0.46$
TYPE-2 SETTLING

- Involves flocculating particles in dilute suspension
- The Stock’s Equation cannot be used → flocculating particles
- Column settleability analysis with some alteration to that of type-1 settling
  - samples will be taken at several depths at several time intervals and analyzed for suspended-solids concentrations.

Mass fraction removed is calculated as: $x_{1/g} = \left(1 - \frac{C_{1/g}}{C_0}\right) \times 100$
**EXAMPLE: SETTLING COLUMN ANALYSIS OF FLOCCULATING PARTICLES.**

A column analysis of a flocculating suspension is run the apparatus shown below. The initial solids concentration is 250 mg/L. The resulting matrix is shown below. What will be the overall removal efficiency of a settling basin which is 3 m deep with a detention time of 1 h and 45 min?

<table>
<thead>
<tr>
<th>Depth, m</th>
<th>Time of sampling, min</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>0.5</td>
<td>133*</td>
</tr>
<tr>
<td>1.0</td>
<td>180</td>
</tr>
<tr>
<td>1.5</td>
<td>203</td>
</tr>
<tr>
<td>2.0</td>
<td>213</td>
</tr>
<tr>
<td>2.5</td>
<td>220</td>
</tr>
<tr>
<td>3.0</td>
<td>225</td>
</tr>
</tbody>
</table>

*Result of suspended solids test on sample C_i, mg/L

**SOLUTION**

**Step 1.** Determine the removal rate at each depth and time

\[
x_{ij} = (1 - \frac{C_i}{C_o}) \times 100
\]

\[
x_{11} = (1 - \frac{133}{250}) \times 100 = 47
\]
SOLUTION...

Step 2. Plot the isoconcentration lines
Step 3. Construct vertical line at $t_0 = 105$ min

SETTLING TANKS /SEDIMENTATION TANKS

- The principle involved in these tanks is reduction of velocity of flow so that the particles settle during the detention period.
- Such tanks are classified into,
  - Fill and draw types tanks (batch-process)
  - Continuous flow tanks.
SETTLING TANKS /SEDIMENTATION TANKS

- Depending on their shape, sedimentation tanks may be classified as,
  - circular,
  - rectangular, and
  - square.
- Depending on the direction of flow, as
  - horizontal flow—longitudinal, radial flow
  - Vertical flow—circular (upward flow)

LONG-RECTANGULAR BASINS

- Long rectangular basins are commonly used in treatment plants processing large flows.
  - hydraulically more stable, and flow control through large volumes is easier with this configuration.
LONG-RECTANGULAR TANK

- **Inlet zone**: In which baffles intercept the oncoming water and spread the flow.
- **Outlet zone**: In which water flows upward and over the outlet weir.
- **Settling zone**: Which occupies the remaining volume of the tank.
- **Sludge zone**: Which extends from the bottom of the tank to just above the scraper mechanism.

**Detention time**. Is the theoretical time that the water is detained in a settling basin. It is calculated as the volume of the tank divided by the rate of flow, and is denoted as $\theta = \frac{V}{Q}$.

\[
\begin{align*}
\text{Settling velocity} &= \frac{\text{tank depth}}{\text{detention time}} \\
\nu_o &= \frac{H}{\theta} = \frac{H}{V/Q} = \frac{H x Q}{LB x H} = \frac{Q}{A_s} \\
\therefore \nu_o &= \frac{Q}{A_s}
\end{align*}
\]

$\nu_o$ or $Q/A_s$ is called **overflow rate** or **surface loading rate** or **surface overflow rate** (SOR).
**REMOVAL EFFICIENCY OF PARTICLES**

- A particle initially at height $h$ with settling velocity of $v_{sh}$ will just be removed by the time it has traversed the settling zone.
- Particles initially at heights less than $h$ will also be removed and those at greater heights will not reach the bottom before reaching the outlet zone.
- All particles with settling velocity $v_s < v_{sh}$ are removed partly, depending on their position at a height from the top of the sludge zone.
- The efficiency of removal of such particles is given by $h/H$.

$$\frac{h}{H} = \frac{v_{zh} x \theta}{v_o x \theta} = \frac{v_{zh}}{v_o} \quad \Rightarrow \quad \frac{h}{H} = \frac{v_{zh}}{Q/A_z}$$

The greater the surface area, the higher the efficiency.

**CIRCULAR BASINS**

- The flow enters at the center and is baffled to flow radially toward the perimeter.
- The horizontal velocity of the water is continually decreasing as the distance from the center increases → the particle path is a parabola.
- Simple sludge removal mechanisms
- require less maintenance
- no excessive weir overflow
SHORT-CIRCUITING AND REDUCTION OF EFFICIENCY

- Theoretically detention time, $\theta = V/Q$.
- But in real flow detention time is not $V/Q$.
- **Short-circuiting**: the deviation of actual flow of the tank from the flow pattern of an ideal tank
  \[
  \frac{\text{flow through period}}{\text{theoretical detention time}}
  \]
  - Efficiency of displacement = magnitude of short-circuiting x 100.
- It should be greater than 30%.
- Currents induced by the inertia of oncoming fluid, turbulent flow, wind stresses and density, and temperature gradient reduces the settling basin efficiency.

INLET ZONE

- *Inlets* should be designed to dissipate the momentum and accurately distribute the incoming flow
OUTLET STRUCTURE

- consist of an overflow weir and a receiving channel or launder.
- The launder → to the exit channel or pipe.
- re-suspension of settled solids must be prevented
- flow velocity in upward direction has to be limited
- Increase the length of the overflow → overflow weir

DESIGN DETAILS

- Detention period: for plain sedimentation: 3 to 4 h, and for coagulated sedimentation: 2 to 2 1/2 h
- Velocity of flow: < 18 m/h (horizontal flow tanks)
- Tank dimensions: L : B : 3 to 5 : 1
  - Generally L = 30 m (common) maximum 100 m.
  - Breadth: 6 m to 10 m.
  - Circular: Dia < 60 m, Generally 20 to 40 m
- Depth 2.5 to 5.0 m (3 m)
- Surface loading (or) overflow rate or (SOR)
  - For plain sedimentation- 12,000 to 18,000 1/d/m²
  - for thoroughly flocculated water 24,000 to 30,000 1/d/m²
  - horizontal flow circular tank 30,000 to 40,000 1/d/m²
- Slopes: Rectangular 1 % towards inlet and circular 8%
- Weir loading rate, m³/m/d < 248
**EXAMPLE**

- Find the dimensions of a rectangular sedimentation basin for the following data:
  - Volume of water to be treated = 3 MLD
  - Detention period = 4 hrs
  - Velocity of flow = 10 cm/min

**SOLUTION**

Detention time = 4 hours = 240 min.
Velocity of flow = 10 cm/min.

\[ \therefore \text{Length of tank} = 0.10 \times 240 = 24 \text{ m.} \]

Volume of water in 4 hours

\[
V = \frac{3 \times 10^6}{10^3} \times \frac{4}{24} = 500 \text{ m}^3
\]

\[ \therefore \text{Cross-section area} \]

\[ A = \frac{V}{L} = \frac{500}{24} = 20.8 \text{ m}^2 \]

Assume a working depth of 3 m.

\[ \therefore \text{Width of tank} = \frac{20.8}{3} \approx 7 \text{ m.} \]

Provide an extra depth of 1 m for sludge storage and 0.5 m for free board making a total depth = 3 + 1.5 = 4.5 m.

Hence provide a settling tank of size 24 m x 7 m x 4.5 m.
**SOLUTION**

*Check:

Volume of water per hour

\[ \frac{3 \times 10^8}{24} \]

\[ = \left( \frac{3 \times 10^8}{24} \right) \times \frac{1}{24 \times 7} \]

\[ = 744 \text{ litres/hour/m}^3 \text{ which is satisfactory.} \]

**EXAMPLE**

*Design a circular basin.* A circular sedimentation tank is to have a minimum detention time of 4 h and a maximum overflow rate of 20 m³/m².d. Determine the required diameter of the tank and the depth if the average flow rate through the tank is 6 ML/d.
**Solution**

- $V=6000 \times 4/24 = 1000$
- $\text{Depth}=20 \times 4/24 = 3.33 = 3.5\text{m}$
- $A_s=V/d=1000/3.5=285.7\text{m}^2$
- $A_s=\pi D^2/4$
- $Diameter=19\text{m}$
- Hence provide 5 m deep (1 m for sludge and 0.5 m free board) by 19 m diameter tank

**Example**

Design a long-rectangular settling basin for type-2 settling. A city must treat about 15,000 m$^3$/d of water. Flocculating particles are produced by coagulation, and a column analysis indicates that an overflow rate of 20 m/d will produce satisfactory removal at a depth of 2.5 m. Determine the size of the required settling tank.
**High-Rate Settling Modules**

- Small inclined tubes or tilted parallel plates which permit effective gravitational settling of suspended particles within the modules.
- Surface loading $\rightarrow$ 5 to 10 m/h

**Tube Settlers**

- Take advantage of the theory that surface overflow loading, which can also be defined as particle settling velocity, is the important design parameter.
- Theoretically, a shallow basin should be effective.
- Use tubes of 25 to 50 mm diameter
- At a 60° angle provide efficient settling
Tube Settlers

Flow Diagram

Plate/Lamella Plate Settler

- Taking advantage of the theory that settling depends on the settling area rather than detention time.
- Distance between plates is designed to provide an upflow velocity lower than the settling velocity of the particles,
- The effective settling area is the horizontal projected area
**Plate / Lamella Plate Settler**

1. Untreated inflow
2. 3 Flow into lamella
4. Treated flow over V-notch
5. Top of lamella
6. Treated water outflow
7. Sludge collection

**Design of Inclined Settlers**

\[
v = \frac{Q}{A \sin \theta}
\]

\[
u = \frac{Qw}{A(H \cos \theta + w \cos^2 \theta)}
\]
**Example**

A water treatment work treats 1.0 m$^3$/s and removes flocs larger than 0.02 mm. The settling velocity of the 0.02mm flocs is measured in the laboratory as 0.22 mm/s at 15 °C. Tube settlers of 50 mm square honeycombs are inclined at a 50° angle and its vertical height is 1.22 m. Determine the basin are required for the settler module.

**Solution**

- Step 1. Determine the area needed for the settler modules

  \[ Q = \frac{(1 \text{ m}^3/\text{s})}{2} = 0.5 \text{ m}^3/\text{s} = 30 \text{ m}^3/\text{min} \]
  \[ w = 50.8 \text{ mm} = 0.0508 \text{ m} \]
  \[ H = 1.22 \text{ m} \]
  \[ \theta = 50^\circ \]

  \[ u = \frac{Qw}{A(H \cos \theta - w \cos^2 \theta)} \]

  \[ = \frac{0.5(0.0508)}{A(1.22 \times 0.643 + 0.0508 \times 0.643^2)} \]

  \[ = \frac{0.312}{A} \]
**Solution**

- A safety factor of 0.6 may be applied to determine the designed settling velocity. Thus,
  
  \[ \frac{u}{A} = 0.6 \times 0.00022 \text{m/s} = \frac{0.0312}{A} \Rightarrow A = 236 \text{m}^2 \text{ (use 240 m}^2\text{)} \]

- **Step 2.** find surface loading rate \( Q/A \)
  
  \[ \frac{Q}{A} = \frac{(0.5 \times 24 \times 60 \times 60 \text{m}^3 \text{d})}{240 \text{m}^2} = 180 \text{m}^3/(\text{m}^2 \text{d}) \]

- **Step 3.** Compute flow velocity in the settlers
  
  \( v = \frac{Q}{A} \sin \theta = 180/0.766 \)

  = 235 m/d

  = 0.163 m/min

  = 0.0027 m/s

**Solution**

- **Step 4.** Determine size of the basin
  
  - Two identical settling basins are designed. Generally, the water depth of the tank is 4 m. The width of the basin is chosen as 8.0 m. The calculate length of the basin covered by the setter is
    
    \( l = 240 \text{ m}^2/8 \text{ m} = 30 \text{ m} \)

  - In practice, one-fourth of the basin length is left as a reserved volume for future expansion, to settle heavy flocs, for access and improve inlet condition. The total length of the basin should be
    
    \( 30 \text{ m} \times \frac{4}{3} = 40 \text{ m} \)
**SOLUTION**

- **Step 5. Check horizontal velocity**
  \[ Q/A = (30 \text{ m}^3/\text{min})/(4 \text{ m} \times 8 \text{ m}) = 0.938 \text{ m/min} \]

- **Step 6. Check Reynolds number (R) in the settler module**

  \[
  \text{Hydraulics radius } r = \frac{0.0508^2}{4 \times 0.0508} = 0.0127 \text{m}
  \]

  \[
  R = \frac{vr}{\mu} = \frac{(0.0027 \text{m/s})(0.0127 \text{m})}{0.000001131 \text{m}^2 \text{s}}
  \]

  \[ 30 < 2000, \text{thus it is a lamella flow OK!} \]

---

**SOLUTION**

- **Step 7. Launder dimension**
  - Provide 3 launders for each basin. The launder must cover the entire length of the settler module; thus the length of the launder is 30 m. the flow rate in each launder trough is \(0.5/3 = 0.167 \text{ m}^3/\text{s}\)
  - For a rectangular trough section
  - \(Q = 1.38 \text{ bh}^{1.5}\)
  - Select the width (b) as 0.5 m
  - Thus \(h = 0.39 \text{ m}\)
  - Make the interior height of the launder 0.5 m (0.11 m freeboard)
FIELD TRIP: DEC., 24TH TO 26TH, 2010

Wenji

Adama, Nazareth

Addis Ababa

Gilbel Gibe 3

AAiT Water Treatment By Zerihun Alemayehu