Septic System

Septic Tank

- Household wastewater is retained 1-3 days
- Solids settle to the bottom of the tank (digested anaerobically)
- A thick crust of scum is formed (helps anaerobic conditions)
- Some sludge accumulates → desludged (every 1-5 years)
- Effluent → on-site or off-site by settled sewerage for populations up to about 300.
Septic Tank

- Length to breadth ratio = 2-3 : 1
- (Liquid) depth at least 0.9 m (but not more than 2 m)

- Drainfield:
  - Depth: ~ 0.7 m
  - Width: 0.2 m (min)

Appropriateness

- Most appropriate in low- to medium-density urban areas.
- Not an option for low-income areas

Tank Design

Four zones:
- scum storage
- sedimentation
- sludge digestion
- digested sludge storage zone.

Septic Tank

- DESIGN EXAMPLE
  Design a septic tank and drainfield to serve a family of six whose sewage production is 100 l/cd. The design temperature is 25°C, and the soil is a sandy loam.
Overall design capacity

\[ V = V_{sc} + V_{h} + V_{d} + V_{sl} \]

Since \( V_{sc} \) is around 0.4\( V_{sl} \), this becomes:

\[ V = V_{h} + V_{d} + 1.4V_{sl} \]

Scum storage

- Scum accumulates at ~ 30-40% the rate sludge accumulates.
- Therefore, the \( V_{sc} \approx 0.4 \times V_{sl} \)

Sedimentation

- \( t_{h} = 1.5 - 0.3 \log (Pq) \)
- \( V_{h} = 10^{-3} Pq t_{h} \)

The time required to permit sedimentation << with the number of people served.
- \( t_{h} = 1.5 - 0.3 \log (Pq) \)
- \( P = \text{Population} \)
- \( q = \text{wastewater flow per person, l/day} \)
- \( t_{h} \geq 0.2 \text{ day} \)
- The tank volume for sedimentation (\( V_{h} \)):
  \[ V_{h} = 10^{3} Pq t_{h} \]

Sludge digestion

- \( t_{d} = 30 \times (1.035)^{35-T} \)
- \( V_{d} = 0.5 \times 10^{-3} P t_{d} \)

The time needed for anaerobic digestion, \( t_{d} \) days varies with temperature

\( V_{d} = \) Grafik vs Temperatur
Digestion

- The time needed for anaerobic digestion, \( t_d \) days:
  \[
  t_d = 30 \times (1.035)^{35-T}
  \]
- The volume of fresh sludge is around 1 liter/person.day. This is digested in \( t_d \) days when it passes to the sludge storage zone. So the average volume of digesting sludge present during the period \( t_d \) is 0.5 l/cd.
- Thus, the volume of the sludge digestion zone, \( V_d \):
  \[
  V_d = 0.5 \times 10^{-3} P_t d
  \]

Sludge storage

- The volume depends on:
  - the rate of accumulation of digested sludge (\( r \), m\(^3\)/person.year) and
  - The interval between desludging operations (\( n \), years)
- For \( n < 5 \):
  - \( r = 0.06 \) m\(^3\)/person.year
- For \( n > 5 \):
  - \( r = 0.04 \) m\(^3\)/person.year
- The sludge storage volume, \( V_s \):
  \[
  V_s = r P_n
  \]

Digested sludge storage

Choosing \( n = 2 \) years
and \( r = 0.06 \) m\(^3\) per person per year:

\[
V_{sl} = r P_n
\]

Overall effective tank volume

\[
V = V_h + V_d + 1.4V_{sl}
\]
Two-compartment septic tanks

- Disposed of on-site, it is best to use a two-compartment tank: minimizes the suspended solids content of the effluent.
- Settle again in the more quiescent second compartment.
- Effective tank volume normally:
  - 2/3 for the first compartment
  - 1/3 for the second compartment.

Design Example 2

- Design a septic tank for a family of twelve which has a water consumption or 100 l/c/d. Effluent disposal is to be by subsurface irrigation in a drainfield.

Solution

Assume that the waste flow is 80 per cent of the water consumption and that all of this enters the septic tank. Allowing 3 d retention at start-up, the tank volume is:

\[
(0.08 \text{ m}^3/\text{p} \cdot \text{d}) \times (12 \text{ people}) \times (3 \text{ d retention}) = 2.9 \text{ m}^3
\]

Say 2.9 m long x 1 m wide x 1 m deep with the inter-compartmental wall 1.9 from the inlet end.

Design Example 3

- Alternative design procedure:

  Assume that the sludge accumulation rate is 0.04 m³/cap/yr as above but chose the desludging interval to be n years (n may be 2, 3, 5 or 10 years). Then the tank volume is given by:

\[
3 \times (0.04 \text{ m}^3/\text{cap-yr}) \times (n \text{ yr}) \times (12 \text{ people})
\]

The factor 3 is introduced as the tank is one-third full of sludge just prior to desludging. Thus if n were chosen as 3 years, the tank volume would be 4.3 m³.

The retention time at start up would be

\[
= 4.3 \text{ m}^3/[(0.08 \text{ m}^3/\text{cap}.\text{d}) \times (12 \text{ people})] = 4.5 \text{ days} \quad \text{(satisfactory)}
\]

- DESIGN EXAMPLE

Design a drainfield to serve a family of six whose sewage production is 100 lcd. The design temperature is 25°C, and the soil is a sandy loam.
Drainfield design

The long-term infiltration rate for a sandy loam is 30 l/m² per day (from the table):

\[ \text{The trench sidewall infiltration area:} \]
\[ = \frac{\text{effluent flow, l/day}}{\text{infiltration rate, l/m² per day}} \]
\[ = \frac{100 \times 6}{30} = 20 \text{ m²} \]

Drainfield design

Take the effective trench depth as 0.7 m.

The total trench length (2 sides):
\[ = \frac{3}{2} \times (20/0.7) = 15 \text{ m} \]

(3 trenches in series, each 5 m in length)
Potongan Memanjang

Typical Design
Scope

- sanitary plumbing fixtures connected to drain pipes that enable sewage and sullage wastes to be conveyed from the fixtures to the tank,
- a pumping sump,
- a sewage treatment tank,
- a distribution box,
- an effluent disposal system,
- a surface and subsurface effluent irrigation or disposal system.

Requirement

- Scum zone
  - Detention zone
    - Minimum 24 hours: 60-70% Suspended Solid removal
    - 30% BOD
- Sludge Zone

Effectivities

- any storm water: roof and rainwater tank overflow, and surface drainage waters,
- any backup waters from a swimming pool or water softener,
- any sanitary napkin, clothing or plastic material or liner,
- any petrol or other flammable or explosive substance whether solid, liquid or gas,
- any disinfectant or deodorant, antiseptic or germicide powder or fluid, unless specifically

Examples

Design a septic tank suitable for a household with up to eight occupants in a low-density housing area in which the houses have full plumbing, all household wastes go to the septic tank and the nominal water supply is 200 l per person per day. Water is used for anal cleaning and the ambient temperature is not less than 25°C for most of the year.

Volume of liquid entering the tank each day

\[ A = P \times q \]

Where:
- \( A \) = volume of liquid to be stored in the septic tank
- \( P \) = number of people using the tank
- \( q \) = sewage flow = 90% of the daily water consumption per person (Q).
- \( Q = 0.9 \times 200 = 180 \) litres per person per day.
- Therefore \( A = 8 \times 180 = 1440 \) litres
The volume of sludge and scum is given by

\[ B = P \times N \times F \times S \]

where

- **B** = volume of sludge and scum
- **P** = number of people using the tank
- **N** = period between desludgings
- **F** = sizing factor (see Table 6.2)
- **S** = sludge and scum accumulation rate (see Chapter 6)

Assume **N** is 3 years; from Table 6.2, **F** = 1.0; as all wastes go to septic tank **S** = 40 L per person per year.

\[ S = \text{the rate of sludge and scum accumulation which may be taken as 25 litres per person per year for tanks receiving WC waste only, and 40 litres per person per year for tanks receiving WC waste and sullage.} \]

\[ B = 8 \times 3 \times 1.0 \times 40 = 960 \text{ litres} \]

**Assume**: liquid depth = 1.5 m

**Assume tank width is W m**

**Assume two compartments, length of first = 2W**

**length of second = W**

**Volume of tank (V) = 1.5 \times (2W + W) \times W = 4.5 W^3**

**Thus 4.5**

\[ W^3 = 2.4 \text{ m}^3 \]

\[ W = 0.73 \text{ m} \]

**Therefore:**

- width of tank = 0.73 m
- length of first compartment = 1.46 m
- length of second compartment = 0.73 m
- Depth of tank from floor to soffit of cover slab = liquid depth + freeboard
  - = 1.5 + 0.3
  - = 1.8 m

**Konstruksi**

- **Capacity**
  - shall be calculated using the depth (D)
- **Operating Depth**
- **Shape**
  - cylindrical or rectangular,
- **Inlet Fitting**
- **Outlet fitting**
- **Provision for Scum**
- **Access Opening Covers**
- **Inspection Covers**
- **Partition Walls/baffles**
  - the effective capacity of the first chamber is twice that of the second chamber
- **Septic Tank Venting**

**Air Gap**

- 220mm for septic tanks less than or equal to 5000 litres capacity,
- 300mm for septic tanks between 5000 - 10000 litres capacity,
- 400mm for septic tanks greater than 10000 litres capacity.

**Access Openings**

- Rectangular: 900mm x 500mm
- Cylindrical: 500mm in diameter.
**Potongan memanjang dan melintang**

**SETBACK DISTANCES TO SURFACE FEATURE**

<table>
<thead>
<tr>
<th>Surface Feature</th>
<th>Minimum Distance Required to Avoid the Discharge of Pollutants</th>
<th>Maximum Distance Required to Avoid the Discharge of Pollutants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage line</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Arterial boundary</td>
<td>1.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Swimming pool</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Underground water tank</td>
<td>0.5</td>
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<tr>
<td>Septic tank</td>
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<td>50.0</td>
</tr>
<tr>
<td>Cutting</td>
<td>15.0</td>
<td>No restriction</td>
</tr>
<tr>
<td>Watercourse</td>
<td>10.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Lane, sewer, etc</td>
<td>50.0</td>
<td>100.0</td>
</tr>
<tr>
<td>fon; water supply, well; water tanks; etc.</td>
<td>500.0</td>
<td>1000.0</td>
</tr>
<tr>
<td>Water well / reservoir</td>
<td>200.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Dispersal of pollution from its source

1. Source of pollution: Septic tank, soakaway
2. Pollution cone
3. The cone of chemical pollution continues to spread until about 25 metres from the source, and then gradually reduces to almost nothing at a distance of about 100 metres.
If there is too much clay in the soil?
• the waste may percolate poorly.
If the soil contains too much sand and large particles?
• waste-water may pass through to the groundwater without being treated by soil microbes.
• Soil profiles made of sand, silt and clay work best.
• Soil treatment occurs best when above the water table and the soil is relatively dry with oxygen present.
• Water at greater depths allows wastewater to remain in the unsaturated soil, where it can be treated most effectively before reaching groundwater.

Septic systems need space..

Only part of the microorganisms and chemicals are removed from waste water as it moves downward. Even properly operating systems can discharge some phosphates, nitrates and bacteria or viruses into the groundwater. To reduce loading of groundwater with effluent, install systems on lots with adequate space.

Proper design and use is important. Septic systems are designed to treat and dispose of a specific volume and type of wastewater in the conditions found at the site.

The system must not be overloaded.

Hazardous chemicals or large amounts of grease should not be disposed in septic systems.

Kitchen grease should be placed in the garbage, not the septic tank. Water conservation extends the life of the system.

Routine maintenance is critical.

Septic tanks must eventually be pumped. Sludge and scum accumulate and, if allowed to remain, will eventually cause the tank to overflow and clog the drainfield.