Environmental Engineering II
(CE 602)
Treatment of Sewage

Dr. Somenath Mondal
National Institute of Technology, Jamshedpur
Septic Tank

Terminology

• **Effluent** - The supernatant liquid discharge from a septic tank.

• **Scum** - The greasy and other substances floating on the surface of sewage.

• **Supernatant Liquor** - The layer of liquid overlying the settled solids which have separated from it.

• **Septic Tank** - A water-tight single storeyed tank in which sewage is retained sufficiently long to permit sedimentation.

• basically a sedimentation tank with some degree of solid destruction due to sedimentation and subsequent anaerobic digestion.

• Septic tanks are ordinarily designed for 24 h liquid retention time at average daily flow
Septic Tank

Important Points

• Surface and subsoil water should not find way into the septic tank.
• Normally, the septic tanks are designed for foul sewage (faecal matter and urine)
• Under no circumstances should effluent from a septic tank be allowed into an open channel drain or body of water without adequate treatment.
• Wastes containing excessive detergents, grease and disinfectants should not be treated in septic tank as they adversely affect the anaerobic decomposition.
• Where the incoming drain is steep due to site conditions, the last section of the drain, at least 12 m in length should not be laid at a gradient not steeper than 1 : 50 in order to minimize turbulence in the tank.
• When the pumping arrangement is provided before the septic tanks the sewage from the pump should not be discharged directly into the septic tank.
Septic Tank

Components
# Septic Tank

Characteristics of household wastewater to be considered for septic tank design

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average flow per capita</td>
<td>100 - 160 L/day</td>
</tr>
<tr>
<td>Peak flow per capita</td>
<td>170 - 270 L/day</td>
</tr>
<tr>
<td>BOD per capita</td>
<td>0.045 kg/day</td>
</tr>
<tr>
<td>Suspended solids per capita</td>
<td>0.070 – 0.090 kg/day</td>
</tr>
<tr>
<td>Soluble solids per capita</td>
<td>0.035 kg/day</td>
</tr>
<tr>
<td>Sludge accumulation per capita</td>
<td>0.073 m³/year</td>
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</tbody>
</table>
Septic Tank

Typical sketch of septic tank
Septic Tank

Design consideration of septic tank

• **Pipe Diameter** - For practical considerations, a minimum nominal diameter of 100 mm is recommended.

• **Location** - Septic tank should be located at a place open to sky, as far away as possible from the exterior of the wall of building and should not be located in swampy areas or areas prone to flooding. It should also be accessible for cleaning.

• **Sewage flow** - The flow of sewage is considered to be proportional to the number of fixture units discharging simultaneously. One fixture unit is treated as equivalent to the flow of 10 L/min. This is equivalent to the discharge generated from one water closet (WC) when flushed. The number of fixtures discharging simultaneously depends on the population served. For example for the population of 5 persons, number of fixtures will be one and probable peak discharge will be 10 L/min. Similarly for population of 10, 20, and 30 numbers of fixtures will be 2, 3, and 4, and probable peak discharge will be 20 L/min, 30 L/min, and 40 L/min, respectively.
Septic Tank

Design consideration of septic tank

• **Sedimentation**- The surface area of the tank required will be 0.92 \( m^2 \) for every 10 litres per minute of peak flow rate at a temperature of 25 °C.

• A minimum depth of sedimentation shall be 250 to 300 mm.

• **Sludge Digestion** - Per capita suspended solids entering the tank may be taken as 70 g/day.

• The capacity required for sludge digestion is 0.033 \( m^3 \) per capita at 25°C.

• Volume of digested sludge is normally 0.00021 \( m^3 \) per capita per day.

• It is assumed that 60% of the solids will be removed in the tank, out of which 70% solids will be volatile, with 5% solid content i.e., 95% water content. The volume of fresh sludge = 0. 84 L/Capita day.
Septic Tank

Design consideration of septic tank

- **Volume required for sludge and scum storage:** For interval of 1 year of sludge cleaning, a sludge storage capacity of \(0.0002 \times 365 = 0.073 \ m^3 / cap\) is required. The 25 to 50 mm of seed volume should be considered, and care should be taken while withdrawing the sludge to leave this volume of sludge to act as seed. No separate depth is provided for this.

- **Total Capacity:** Hence the total capacity of the septic tank will be equal to sum of the above three requirements, plus a minimum free board of 0.3 m should be provided.

- **Detention time:** The detention time of 24 to 48 h is provided for average flow conditions

- **Ventilating Pipe** - Every septic tank shall be provided with ventilating pipe of at least 50 mm diameter. The top of the pipe shall be provided with a suitable cage of mosquito proof mesh
Septic Tank

Design consideration of septic tank

• **Dimensions of Septic Tank:** Septic tank shall have minimum width of 750 mm, minimum depth of one metre below water level and a minimum liquid capacity of 1 000 litres.

• For rectangular septic tanks, the length of the tank shall be 2 to 4 times the width.

• For circular tanks the minimum diameter shall not be less than 1.35 m and operating depth shall not be less than 1.0 m

Other details of Septic Tank

• Septic tanks are provided with water tight cover, along with ventilation pipe extending up to 2.0 m above the highest building in the 20 m radius.

• Inlet and outlet pipes are located on opposite walls with baffle to avoid exit of floating matter.
Septic Tank

Disposal of the Effluent from the septic tank

- Effluent coming out from the septic tank contains large amount of putrescible organic matter (200 to 250 mg/l) and high BOD (100 to 200 mg/l)

Three methods are practiced

1) Soil absorption system
2) Biological Filters
3) Upflow anaerobic filters
Imhoff Tank

Definition
An Imhoff tank is an improvement over septic tank
- Incoming sewage is not allowed to get mixed up with the sludge produced
- The outgoing effluent is not allowed to carry with it large amount of organic load
- It is also known as two storeyed tank or two storey digestion tank

Design Considerations
- **Sedimentation Chamber**: Rectangular in shape
  - i) Detention period = 2 to 4 hours
  - ii) Flowing through velocity ≤ 0.3 m/min
  - iii) Surface loading = should not exceed 30,000 lit/m² of plan area.

May be increased to about 45,000 lit/m²/day for effluent coming from activated sludge plant, where recirculation is adopted
Imhoff Tank

The Imhoff Tank is a type of sewage treatment system that combines primary treatment with sludge settling. It consists of several chambers arranged in a rectangular or square shape. The tank is divided into multiple sections, each with its own function:

1. **Raw Inlet**: The raw sewage enters the tank at the top.
2. **Hanging Baffle**: Helps in distributing the sewage evenly across the tank.
3. **Depth of Sedimentation Chamber**: This chamber is designed to separate settled solids from the liquid effluent.
4. **Effluent**: The clarified liquid leaves the tank through the outlet.
5. **Sludge Chamber**: The sludge settles to the bottom and is periodically removed.
6. **Cast Iron Desludging Pipe**: Connects the sedimentation chambers and facilitates sludge removal.
7. **Arrangement for Reverse Flow**: Helps in maintaining the flow of sewage and preventing backflow.

The dimensions and key features are detailed in the diagram, including the depth of the various sections, the diameter of the desludging pipes, and the overall dimensions of the tank. The Imhoff Tank is an efficient and cost-effective method for treating sewage in rural and semi-urban areas.
Imhoff Tank
Design Considerations

• Length of the tank is usually not more than 30 m
• Length to width ratio may vary between 3 to 5
• Total depth of 9 to 11 m has been proven to be sufficient
• Depth pf sedimentation chamber as 3 to 3.5 m , free-board 45 cm

Digestion Chamber
• Chamber generally designed for a minimum capacity of 57 litres per capita

Scum Chamber
• The surface area of the scum chamber should be about 25 to 30 % of the horizontal projection of top digestion chamber.
• Width of the vent should be 60 m or more
Rural Sanitation and Sulabh sauchalaya

Pit Privy

• Pit privies still exist in large number in rural areas particularly in developing countries and underdeveloped countries.

• A typical privy consists of a pit of about 1.0 m$^2$ by 1.25 m deep, lined with rough boards on the sides and covered with a reinforced concrete slab.

• A concrete riser supports the seat and ventilator pipe conveys odours through the roof.

• The slab rests on the concrete curb to which the house is bolted.

• Earth is banked around the curb to prevent surface runoff from entering pit.

• For average family size such privy will serve for about 10 years.

• Cleaning is not practical and new privy should be dug once the old is full.

• Pit privies with heavy use are often lines with concrete and have an access door at the rear of the unit. This permits the contents to be removed and hauled to a municipal treatment plant or suitable disposal site.
Rural Sanitation and Sulabh sauchalaya

Pit Privy

Fig. 21.1. Pit Privy.
Rural Sanitation and Sulabh sauchalaya

Aqua privy

• In an aqua privy, urine and faeces are dropped into a water-tight tank which stores and decomposes the excreta in the absence of oxygen (i.e. anaerobically) as in a septic tank

• The aqua privy may be located above ground level or partly above and partly below

• The contents of the tank have no contact with the ground

• Unlike the septic tank, the aqua privy does not require much water; but each day a quantity equivalent to that of the added cleansing water has to be evacuated from it, and therefore provision must be made for a means of draining off effluent. This effluent should not be allowed to run into open fields or gardens

• Aqua privies may be recommended whenever the supply of water is limited, although they do not always work satisfactorily

• Mosquitoes (for instance Culex species, which is responsible for the transmission of filariasis) have been known to breed in the vicinity of this type of latrine
Rural Sanitation and Sulabh sauchalaya

Aqua privy

Mosquito-proof wire-netting cover

Door

Manhole

Effluent pipe

Cement-plastered digestion chambers
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Bore Hole Latrine

• A bored-hole latrine is a hole drilled in the ground to receive and store the excreta
• It is suitable for stable, permeable soil, free of stones, and where the groundwater is deep beneath the surface
• However, bore-hole latrines do present sanitary and health hazards, and expert advice should be sought before they are constructed
• It consists of a hole covered by a one seat latrine box. Borehole latrines have an augured hole instead of a dug pit and may be sunk to a depth of 10 m or more, although a depth of 4 - 6 m is usual
• Augured holes, 300-500 mm in diameter, may be dug quickly by hand or machine in areas where the soil is firm, stable and free from rocks or large stones
• While a small diameter is easier to bore, the life of the pit is very short. For example a 300-mm diameter hole with 5 m deep will serve a family of five people for about two years
Rural Sanitation and Sulabh sauchalaya

Bore Hole Latrine

• The small diameter of the hole increases the likelihood of blockage, and the depth of augured hole increases the danger of groundwater contamination

• Even if the hole does not become blocked, the sides of the hole become soiled near the top, making fly infestation probable

• borehole latrines are convenient for emergency or short-term use, because they can be prepared rapidly in great numbers, and light portable slabs may be used

• The holes should be lined for at least the top half-meter or so with an impervious material such as concrete or baked clay, but the pit is not lined all the way at the bottom

• Because of the small diameter and short life, the full depth is not usually lined. Improved type of bore hole latrine will also avoid fly nuisance and odour
Rural Sanitation and Sulabh sauchalaya

Bore Hole Latrine
Rural Sanitation and Sulabh sauchalaya

Dug well Latrine

• It is similar to that of bored-hole latrine but only difference is in the diameter of the hole

• In dug well privy 75 cm x 75 cm x 360 cm pit is excavated, which is lined with honey comb brick work or stone work, to absorb the liquid waste

• The human excreta from unsewered area are collected in dug well type latrine
Dug well Latrine