On-site Wastewater Management Training Course

# Primary Treatment

# Septic Systems



## Septic Tank

- Is the most common type of domestic primary treatment system
- Use can be traced back to about 1860 in France and about 1900 in Australia/New Zealand
- Current designs have changed little
- Septic systems and trenches provide the only form of wastewater treatment in many rural communities



## Septic Tank

- Provides a quiescent environment in which wastewater can settle and clarify between a settled sludge layer (below) and a surface scum layer (above)
- Accumulated sludge is periodically removed
- Clarified effluent passes downstream to land application or further treatment



## AS/NZS1546:1

Details of septic tanks are provided in AS/NZS1546:1 *On-site domestic wastewater treatment units Part 1: Septic tanks*, which covers:

- Performance requirements and criteria
- Design and fittings
- Materials and testing



## Dimensions

- Up to 2,000L/day (10 persons) or equivalent institution or commercial facility
- Structural engineering design required if;
  - tank >6,000L
  - lid or wall is below ground
  - any internal dimension >1,800mm
  - length of a rectangular tank is >2,400mm, or
  - lid plan area >4.5m$^2$
  - Minimum flow path (inlet –outlet) 1,200mm



## Septic Tanks

- Watertight, durable concrete, glass fibre reinforced resin or plastic tank

Source: Midwest Concrete

Source: Access Septic

Source: Everhard Industries

## Septic Tanks

- Cylindrical, with vertical or horizontal axis, or rectangular in shape


Source: Grahams Concrete Pty Ltd

Source: Tumby Bay Concrete Pty Ltd


Source: Hynds NZ

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## Septic Tank Installation

- In ground, with top of tank at or just above ground surface to prevent stormwater ingress

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## Extensions / Risers

- If installed below ground a watertight riser is fitted to support access and inspection covers

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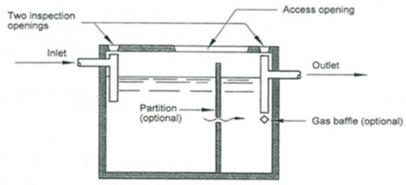
## Septic Tank Access

- Inverted inlet and outlet fittings, with inspection openings above for access and pump-out




Source: Standards Australia

Source: BioSeptic

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## Partitions / Baffles

- May include a partition or baffle divider
- Typically 2:1 upstream:downstream
- Increases flow path
- Assists with hydraulic buffering
- Reduces carry-over of solids
- Capable of pumpout without collapsing or deforming

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## Ground Anchors

- May require ground anchors to prevent hydrostatic uplift
- Hydrostatic flange
- Anchor collar

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## Septic Tank Capacity

All-waste septic tank capacities (AS/NZS1547:2012)

| Persons | Bedrooms | Average daily flow (L) | Tank capacity |
|---|---|---|---|
| 1 - 5 | 1-3 | Up to 1,000L | 3,000L |
| 6 - 7 | 4 | 1,000 - 1,400L | 3,500L |
| 8 | 5 | 1,400 - 1,600L | 4,000L |
| 9 - 10 | 6 | 1,600 - 2,000L | 4,500L |

Source: Standards Australia Standards New Zealand

- Note tank size requirements for larger houses



## Primary Treatment

A number of simple processes operate in a septic tank:

- Sedimentation
- Flocculation
- Flotation
- Anaerobic digestion
- Clarification



## Sedimentation

- Achieved by density settling in quiescent conditions
- Aided by the flocculation of suspended particles into larger aggregates
- Removes >60% of the suspended solids load
- Sludge or biosolids accumulates at base of tank



## Flotation

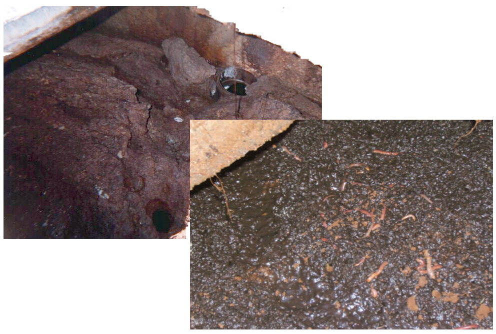
- Fats, oils, grease, surfactants and other low density materials rise to the surface and form a scum layer
- Scum retained in the tank by an inverted outlet pipe (tee) or baffle
- Scum layer precludes oxygen and creates anaerobic conditions which assists in the breakdown of organic solids



## Scum Layer or Crust



## Scum Layer or Crust



## Anaerobic Digestion

- Organic material retained at the base of the tank undergoes microbiologically facilitated facultative and anaerobic decomposition
- Organic material is converted to stable compounds and gases such as carbon dioxide ($CO_2$), methane ($CH_4$) and hydrogen sulphide ($H_2S$)
- Retained sludge comprised mainly of lignous material that is difficult to decompose and will continue to accumulate



## Clarification

- Settled and skimmed wastewater retained within the central portion of the septic tank
- Re-suspension of settled solids is minimised under quiescent conditions
- Tanks are appropriately sized to allow for maximum solids settling
- Effluent is drawn from the clarified liquid between the sludge and scum layers and discharged for further treatment



## Septic Tank

- Provides capacity for a minimum of 24 hours hydraulic residence time for daily flow
- Provides storage capacity for accumulated sludge
- Prevents scum from moving downstream
- Starts microbiological degradation to reduce $BOD_5$, pathogens and settled solids
- Anaerobic processes are slower in colder climates and more frequent desludging may be required



## Sludge Accumulation

- Sludge in a residential all-waste septic tank accumulates at approximately 80L/person/year
- Pumpout interval is determined by tank capacity required for 24-hour residence time for daily load (varies from system to system)
- For example, a 3,000L septic tank provides 24-hour residence time for 1,000L daily load, plus up to 2,000L sludge and scum capacity
  i.e. 5 persons x 80L/person/year x 5 years



## Sludge Accumulation

Assess sludge and scum accumulation in a septic tank using either:

- Sludge Judge
- Sludge Depth Indicator
- Pressure sensor operated septic tank monitoring system



## Sludge Judge

## Sludge Depth Indicator

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## Septic Tank Monitoring System

Comprises:

- Control Panel and Modem
- Tank Sensor
- Apparatus Controller
- Distribution Pit Sensors
- Flow Improvement Control System
- Central Data Repository and Management System

Source: Samaran International

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## Septic Tank Effluent Quality

| Parameter | Untreated domestic wastewater | Primary treated effluent |
|---|---|---|
| $BOD_5$ | 200 - 300 mg/L | ~ 150 mg/L |
| Suspended Solids | 200 - 300 mg/L | ~ 50 mg/L |
| Total Nitrogen | 20 - 100 mg/L | 50 - 60 mg/L |
| Total Phosphorus | 10 - 25 mg/L | 10 - 15 mg/L |
| Faecal Coliforms | $10^3$ - $10^{10}$ cfu/100mL | $10^5$ - $10^7$ cfu/100mL |

Source: NSW DLG

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## Primary Treatment

- Capable of removing approximately 25-35% of the $BOD_5$ load and more than 60% of the suspended solids load in raw domestic wastewater
- Solids accumulate in the base of the septic tank and liquids are discharged for further treatment
- Floating material (scum) accumulates on the liquid surface and provides an air tight seal, creating anaerobic conditions

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## Outcomes

- Moderate reduction in the TN load
- Slight reduction in the TP load
- Limited pathogen removal
- High bacterial counts remain in effluent
- Septic tank effluent not suitable for direct environmental discharge
- Secondary treatment using aerobic processes (AWTS or sand filter etc.) or further treatment in a soil based system is required

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## Improving Septic Tank Performance

- Simplest way to improve the performance of a standard septic tank is to fit or retrofit the outlet with an outlet filter
- Filters of various designs are commercially available and can reduce the impacts of solids carry over to the land application area or secondary treatment system
- Should prevent discharge of solids >3mm particle size and achieve TSS <100mg/L
- Filters have a large surface area to limit clogging and reduce maintenance requirements
- Should be capable of performing with minimal maintenance, however, they do require periodic inspection and cleaning

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## Septic Tank Outlet Filters




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## Fitting a Septic Tank Outlet Filter

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## Fitting a Septic Tank Outlet Filter

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## Cleaning a Septic Tank Outlet Filter



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## Outlet Filter Performance

| | Concentration (mg/L) | | | |
|---|---|---|---|---|
| Parameter | Typical ST effluent | Without effluent filter | With effluent filter | % Improvement |
| $BOD_5$ | 450 | 180 | 130 | 28% |
| TSS | 503 | 80 | 50 | 38% |
| $NH_3$-N | 41 | 40 | 40 | 0% |
| Org. N-N | 29 | 28 | 28 | 0% |
| TKN-N | 70 | 68 | 68 | 0% |
| Org. P-P | 6.5 | 6 | 6 | 0% |
| Inorg. P-P | 11 | 10 | 10 | 0% |
| TP | 17 | 16 | 16 | 0% |
| Oil and grease | 164 | 25 | 15 | 40% |

Source: Crites & Tchobanoglous 1998

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## References


- Care and maintenance of residential septic systems (2002) B3583, University of Wisconsin-Extension.
- Bounds, T.R., “ Design and Performance of Septic Tanks,” Site Characterization and Design of Onsite Septic Systems ASTM STP 901, M.S. Bedinger, A.I. Johnson, and J.S. Fleming, Eds., American Society for Testing Materials, Philadelphia, 1997.
- Stafford, D. and Whitehead J.H. 2005. *Septic Tank Outlet Filters.* In Patterson, R.A. and Jones, M.J. eds. On-site '05 Performance Assessment of On-site Systems. Lanfax Laboratories, Armidale, September 2005.


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## References

- Stafford, D. and Whitehead J.H. 2007. *Performance of Septic Tank Outlet Filters.* In Patterson, R.A. and Jones, M.J. eds. On-site '07 Innovation and Technology for On-site Systems. Lanfax Laboratories. Armidale, September 2007.

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# Septic Tank Calculations

**Question 1.**

A new three bedroom house is supplied with reticulated water and has a 3,000L septic tank installed on construction. Assume that five people occupy the house.

(i) Calculate the daily hydraulic load based on a design hydraulic load of 150L/person/day.

(ii) Calculate the detention time of effluent in the septic tank at the outset.

(iii) If sludge accumulates at the rate of 80L/person/year, calculate the amount of sludge that will accumulate in one year.

**Question 2.**

An older three bedroom house is supplied with reticulated water and is occupied by three people. On inspection, it is determined that the septic tank is of 2,300L capacity, but the tank is half full of sludge.

(i) Calculate the daily hydraulic load based on a design hydraulic load of 150L/person/day.

(ii) Calculate the annual sludge accumulation based on a sludge accumulation rate of 80L/person/year.

(iii) A minimum of 24 hours detention must be maintained in the tank at all times. Calculate the length of time remaining before a pumpout will be required.

# Septic Tank Calculations

## ANSWERS

**Question 1.**

(i) Daily hydraulic load = 5 x 150L/person/day = 750L/day

(ii) Septic tank volume = 3,000L

Daily hydraulic load = 750L/day

Detention time = 3,000L / 750L/day = 4 days

(iii) Occupancy = 5 persons

Sludge accumulation rate = 80L/person/year

Annual sludge accumulation = 5 persons x 80L/person/year = 400L/year

**Question 2.**

(i) Daily hydraulic load = 3 x 150L/person/day = 450L/day

(ii) Occupancy = 3 persons

Sludge accumulation rate = 80L/person/year

Annual sludge accumulation rate = 3 persons x 80L/person/year = 240L/year

(iii) Tank capacity = 2,300L

Daily hydraulic load = 450L

Volume of sludge in tank = 2,300L / 2 = 1,150L

Volume available for further sludge accumulation = 1,150L – 450L = 700L

Sludge accumulation rate = 240L / year

Maximum time remaining prior to pumpout 700L / 240L/year = 2.9 years