Septic Tank
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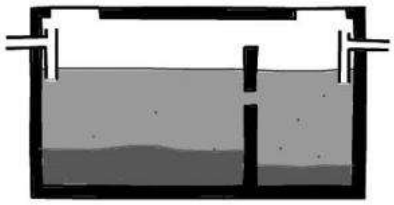


A septic tank is a watertight chamber made of [no-ecompendium]brick work, [/no-ecompendium]concrete, fibreglass, PVC or plastic, through which blackwater [no-ecompendium]from cistern or pour-flush toilets [/no-ecompendium]and greywater [no-ecompendium]through a pipe from inside a building or an outside toilet [/no-ecompendium]flows for primary treatment. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate. [no-ecompendium]Effluent is infiltrated into the ground or transported via a sewer to a (semi-)centralised treatment plant. Accumulating faecal sludge needs to be dug out the chamber regularly and correctly disposed of. [/no-ecompendium]

In	Out
Blackwater, Brownwater, Greywater	Blackwater (settled, Effluent), Faecal Sludge, (Biogas)

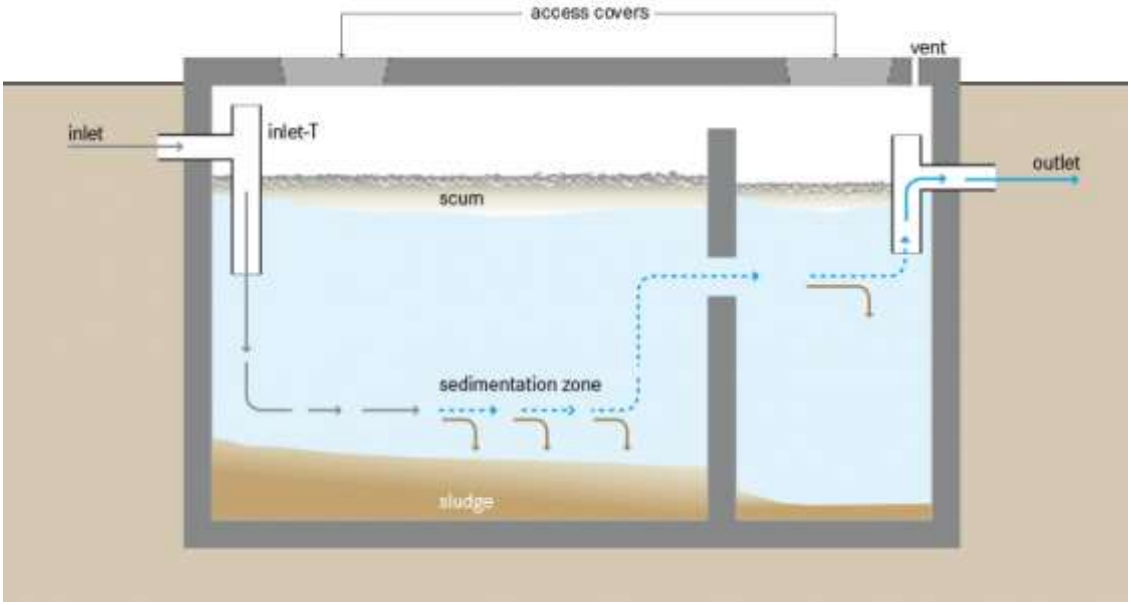
[no-ecompendium]

Introduction

The septic tank is the most common small-scale decentralised treatment unit for grey water and blackwater from cistern or pour-flush toilets. It is basically a sedimentation tank. Its shape can be rectangular or cylindrical.

Septic tanks are used for wastewater with a high content of settleable solids, typically for effluent from domestic sources, but they are also suitable for other wastewater of similar properties (SASSE 1998). [/no-ecompendium]Liquid flows through the tank and heavy particles sink to the bottom, while scum (mostly oil and grease) floats to the top. Over time, the solids that settle to the bottom are degraded anaerobically. However, the rate of accumulation is faster than the rate of decomposition, and the accumulated sludge and scum must be periodically removed. The effluent of the septic tank must be dispersed by using a Soak Pit[no-ecompendium], evapo-transpiration mound[/no-ecompendium] or Leach Field, or transported to another treatment technology via a Solids-Free Sewer[no-ecompendium], simplified sewer or solids-free sewer. For secondary treatment e.g. surface flow, horizontal or vertical flow constructed wetlands) are suitable. Sludge must be emptied regularly (see also human-powered or motorized emptying) and treated for safe disposal or reuse. It can be dried in planted or unplanted drying beds, settling or thickening ponds. If the sludge is dried or composted, it can be applied in agriculture as valuable nutrient-rich soil amendment (see also pplication of pit humus and compost or application of sludge). There exist also several new processes to produce fertilizer from sludge.

When septic tanks are used as a primary settling treatment in DEWATS systems, they are generally followed by anaerobic filters, anaerobic baffled reactors ABRs, horizontal, surface flow or vertical flow constructed wetlands (planted gravel filters) and maturation ponds. In any case, water is needed to pour and bring the wastes to the septic tank (5 to 40 L of water per day per person, DFID 2003)[/no-ecompendium].[no-ecompendium]



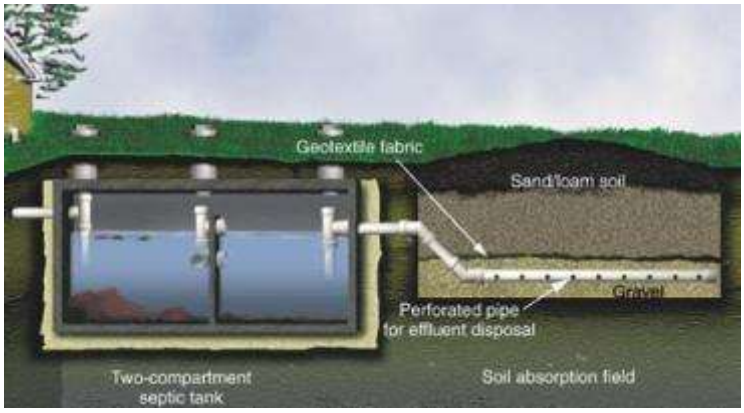
Overview scheme of a septic tank. Solids settle out and undergo anaerobic digestion, the effluent with suspended and dissolved pollutants flows through. A venting pipe can evacuate the biogas formed during anaerobic digestion. Source: TILLEY et al. (2014)

[/no-ecompendium]Generally, the removal of 50% of solids, 30 to 40% of BOD and a 1-log removal of E. coli can be expected in a well-designed and maintained septic tank, although efficiencies vary greatly depending on operation and maintenance and climatic conditions.

Design Considerations

A septic tank should have at least two chambers[no-ecompendium] made out of concrete or brick work[/no-ecompendium]. [no-ecompendium]Pre-fabricated concrete rings, PVC or fibreglass septic tanks are also available and may be less expensive in some contexts (WSP 2008). [/no-ecompendium]The first chamber should be at least 50% of the total length[no-ecompendium] (SASSE 1998)[/no-ecompendium], and when there are only two chambers, it should be two thirds of the total length. Most of the solids settle out in the first chamber. The baffle, or the separation between the chambers, is to prevent scum and solids from escaping with the effluent. A T-shaped outlet pipe[no-ecompendium], the lower arm of which dives 30 cm below water level (SASSE 1998),[/no-ecompendium] further reduces the scum and solids that are discharged.[no-ecompendium]

Over time, anaerobic bacteria and microorganisms start to digest the settled sludge anaerobically, transforming it into CO_2 and CH_4 (biogas) and some heat. Optimal physical treatment by sedimentation takes place when the flow is smooth and undisturbed. Biological treatment by anaerobic digestion is optimised by a quick and intensive contact between the new inflow and old sludge, particularly when the flow is turbulent. Depending on the way the new influent flows through the tank, different treatment effect predominate. With a turbulent flow, the degradation of suspended and dissolved solids starts more quickly; however, more suspended solids are discharged with the effluent. This leads to bad odours, as active solids that are not completely fermented leave the tank (SASSE 1998). The contact and hence degradation is slower when the flow is less turbulent, but also less suspended solids leave the tank. The gases produced during anaerobic digestion must be allowed to escape. If the drainage system of the house or other building has a ventilation pipe at the upper end, gases can escape from the septic tank along the drains. If the drainage system is not ventilated, a screened vent pipe should be provided from the septic tank itself (WHO 1992).

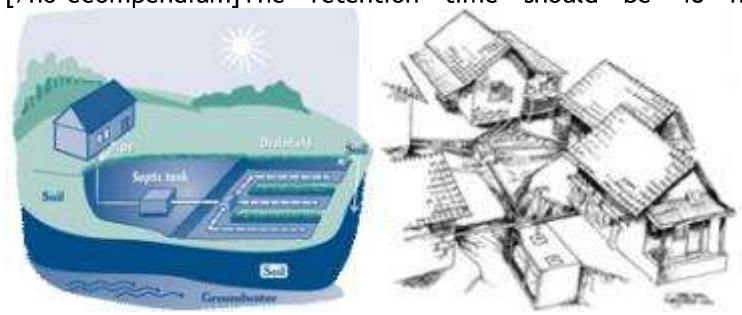


A septic tank as primary treatment, followed by a leach field. Source: U.S. EPA (n.y.)[/no-ecompendium]

Accessibility to all chambers (through access ports) is necessary for maintenance. Septic tanks should be vented for controlled release of odorous and potentially harmful gases.

The design of a septic tank depends on the number of users, the amount of water used per capita, the average annual temperature, the desludging frequency and the characteristics of the wastewater[no-ecompendium] (SASSE 1998)[/no-ecompendium]. [no-ecompendium]Normally, the chambers are all of the same depth (between 1.5 to 2.5 m), but sometimes the first chamber is made deeper as the others. Approximately 80 to 100 L should be provided per domestic user (SASSE 1998), but most countries provide a national standard for tank volume per domestic user. For help on dimensioning of septic tank, an exercise is given in Eawag Sandec 2008 and Excel spreadsheets are available in SASSE 1998.

[/no-ecompendium]The retention time should be 48 hours to achieve moderate treatment.[no-ecompendium]

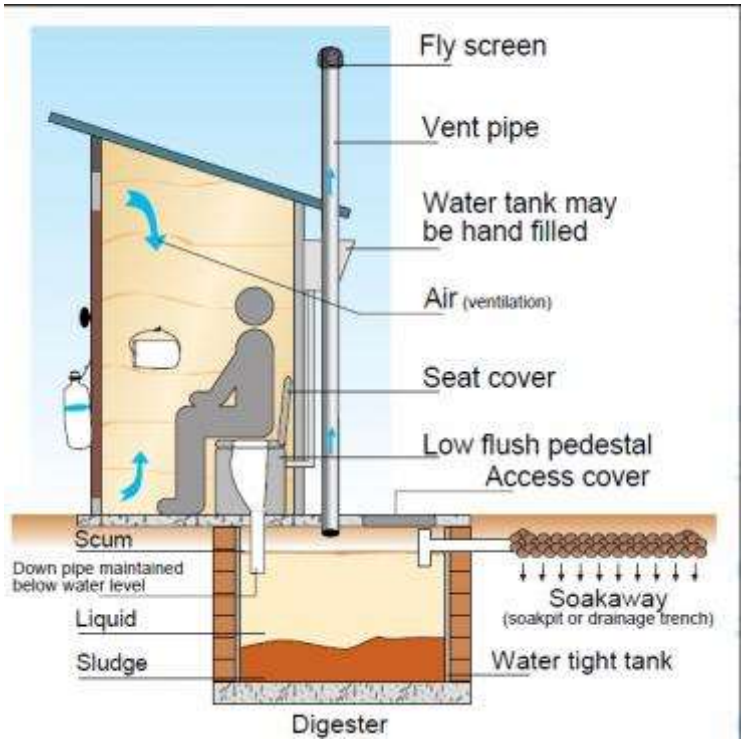


Septic tank receiving black- and grey water from a housing (left) and a septic tank collecting wastewater from several housing as a primary treatment before a small bore sewer system (right). Sources: U.S. EPA (2014) (left) and SANIMAS (2005) (right).

A septic tank will remove 30 to 50% of BOD (Biological Oxygen Demand), 40 to 60% of TSS (Total Suspended Solids) (UNEP 2004) and result in an abatement of 1 log units E. coli (a faecal indicator bacteria) (TILLEY et al. 2008) although efficiencies vary greatly depending on the influent concentrations and climatic conditions. [/no-ecompendium]The retention time should be 48 hours to achieve moderate treatment.

[no-ecompendium]

Aquaprivy



Toilet with aquaprivy and soak pit. Source: WAaF (2002)[/no-ecompendium]

A variation of the septic tank is called an Aquaprivy. This is a simple storage and settling tank that is located directly below the toilet so that the excreta fall into it[no-ecompendium] through a pipe. The bottom of the pipe is submerged in a liquid in the tank, forming a water seal to prevent escape of flies, mosquitoes and smell (WHO 1992). The tank functions like a septic tank. The effluent usually infiltrates into the ground through a soak pit and accumulated solids (sludge) must be removed frequently (WHO 1992). In any case, the accumulating sludge must be treated[/no-ecompendium]. The Aquaprivy has a low treatment efficiency.

[ecomp-appropriateness]

Health Aspects/Acceptance

Under normal operating conditions, users do not come in contact with the influent or effluent. [no-ecompendium]Many of the problems with septic tank systems arise because no adequate consideration is given to the disposal of the tank effluent. Since the effluent from septic tanks is anaerobic, it is likely to contain large numbers of pathogens, which can be a potential source of infection (WHO 1992). [/no-ecompendium]Effluent, scum and sludge must be handled with care as they contain high levels of pathogenic organisms. [no-ecompendium]Motorized emptying in a vacuum truck or a manual technology like a sludge gulper can decrease the health risks.[/no-ecompendium]

Users should be careful when opening the tank because noxious and flammable gases may be released. [no-ecompendium]Thus, open fire should be avoided when opening the septic tank.

Costs considerations

Construction costs of septic tanks are relatively low compared to other water based systems. However, they are much more expensive than for dry or composting toilets and unlikely to be affordable for poorer people in society. They also require sufficient piped water to flush all the wastes through the drains and manual or mechanical (vacuum or gulper) de-sludging needs to be done periodically. Engineers must prepare design and layout, while unskilled labourers can carry out construction if a mason supervises the work.

[/no-ecompendium]

Operation & Maintenance

[no-ecompendium]To start up a septic tank it should be "seeded" with sludge from a tank that has been operating for some

time to ensure that the necessary microorganisms responsible for anaerobic digestion are present (WHO 1992).

[/no-ecompendium]Because of the delicate ecology, care should be taken not to discharge harsh chemicals into the septic tank. Scum and sludge levels need to be monitored to ensure that the tank is functioning well. [no-ecompendium]De-sludging is needed when 1/2 to 2/3 of the total depth between the water level and the bottom of the tank are occupied by sludge and scum (WHO 1992). One of the difficulties with septic tanks is that when the tank is almost full of solids, the inflow scours a channel through the sludge and passes through the tank in a matter of minutes rather than remaining in the tank for the required retention time (SASSE 1998). [/no-ecompendium]Generally, septic tanks should be emptied every 2 to 5 years. This is best done by using a Motorized Emptying and Transport technology, but Human-Powered Emptying can also be an option. [no-ecompendium]This is an unpleasant work and care must be taken to ensure that sludge is not spilled around the tank during emptying, as the removed sludge from a septic tank includes fresh sludge and presents a risk of transmission of diseases of faecal origin. The faecal sludge needs to be dehydrated (see also planted or unplanted drying beds, settling or thickening ponds) and further treated (e.g. small or large scale composting, anaerobic digestion). Before that, the faecal sludge can also be further separated from the liquid in drying beds or settling. The separated effluents from these systems should be treated in waste stabilisation ponds (WSP) or constructed wetlands (surface flow, horizontal or vertical flow). Regular de-sludging activities require well-organised community or public/private service provider. [/no-ecompendium]

Septic tanks should be checked from time to time to ensure that they are watertight. [no-ecompendium]Routine inspection is also necessary to remove floating debris such as coarse materials and grease, to ensure that there are no blockages at the inlet or outlet and to check whether de-sludging is needed.

At a Glance

Working Principle	Basically a sedimentation tank (physical treatment) in which settled sludge is stabilised by anaerobic digestion (biological treatment). Dissolved and suspended matter leaves the tank more or less untreated.
Capacity/Adequacy	Household and community level; Primary treatment for domestic grey- and blackwater. Depending on the following treatment, septic tanks can also be used for industrial wastewater. Not adapted for areas with high groundwater table or prone to flooding.
Performance	BOD: 30 to 50%; TSS: 40 to 60 %; E. coli: 1 log units HRT: about 1 day
Costs	Low-cost, depending on availability of materials and frequency of de-sludging.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Should be checked for water tightness, scum and sludge levels regularly. Sludge needs to be dug out every 1 to 5 years and discharged properly (e.g. in composting or drying bed). Needs to be vented.
Reliability	When not regularly emptied, wastewater flows through without being treated. Generally good resistance to shock loading.
Main strength	Simple to construct and to operate.
Main weakness	Effluent and sludge require further treatment. Long start-up phase.

[/no-ecompendium]

Applicability

This technology is most commonly applied at the household level. Larger, multi-chamber septic tanks can be designed for groups of houses and/or public buildings (e.g., schools).
A septic tank is appropriate where there is a way of dispersing or transporting the effluent.[no-ecompendium] Effluents form septic tanks can be soil infiltrated in [681-soak pits], a [664-leach field] or mounds. Effluents still contain pathogens

and should therefore not be used for crop irrigation nor should it be discharged to canals or surface water drains (WHO 1992).[/no-ecompendium] If septic tanks are used in densely populated areas, onsite infiltration should not be used, otherwise, the ground will become oversaturated and contaminated, and wastewater may rise up to the surface, posing a serious health risk. Instead, the septic tanks should be connected to some type of Conveyance technology[no-ecompendium] (e.g. [1577-simplified sewer] or [3664-solids-free sewer])[/no-ecompendium], through which the effluent is transported to a subsequent Treatment or Disposal site[no-ecompendium] (e.g. [1845-surface flow], [1847-horizontal] or [1851-vertical flow] constructed wetlands)[/no-ecompendium]. Even though septic tanks are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding.
Because the septic tank must be regularly desludged, a vacuum truck should be able to access the location. Often, septic tanks are installed in the home, under the kitchen or bathroom, which makes emptying difficult.
Septic tanks can be installed in every type of climate, although the efficiency will be lower in colder climates. They are not efficient at removing nutrients and pathogens.
[no-ecompendium]Even though the septic tank is watertight, it should not be constructed in areas with high groundwater tables or where there is frequent flooding (TILLEY et al. 2008).
Aquaprivies can be built indoors and above ground and are appropriate for rocky or flood prone areas where pits or other technologies would not be appropriate, but they require frequent emptying and constant maintenance (TILLEY et al. 2008).[/no-ecompendium]

Advantages

- Can be built and repaired with locally available materials
- No real problems with flies or odours if used correctly
- Simple and robust technology
- No electrical energy is required
- Little space required due to underground construction
- Low operating costs
- Long service life
- Small land area required (can be built underground)

Disadvantages

- High cost compared to dry or composting toilet systems
- Constant and sufficient amounts of piped water required to bring the waste to the treatment unit
- Low reduction in pathogens, solids and organics
- Regular desludging must be ensured
- Only suitable for low-density housing in areas with low water table and not prone to flooding
- Manual cleaning of the tank is highly hazardous and an inhumane task, while mechanical cleansing (vacuum trucks) requires sophisticated instruments
- Effluent and sludge require further treatment and/or appropriate discharge

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For further readings, case studies, awareness raising material, training material, important weblinks or the related powerpoint presentation, see www.sswm.info/category/implementation-tools/wastewater-treatment/hardware/site-storage-and-treatments/septic-tank