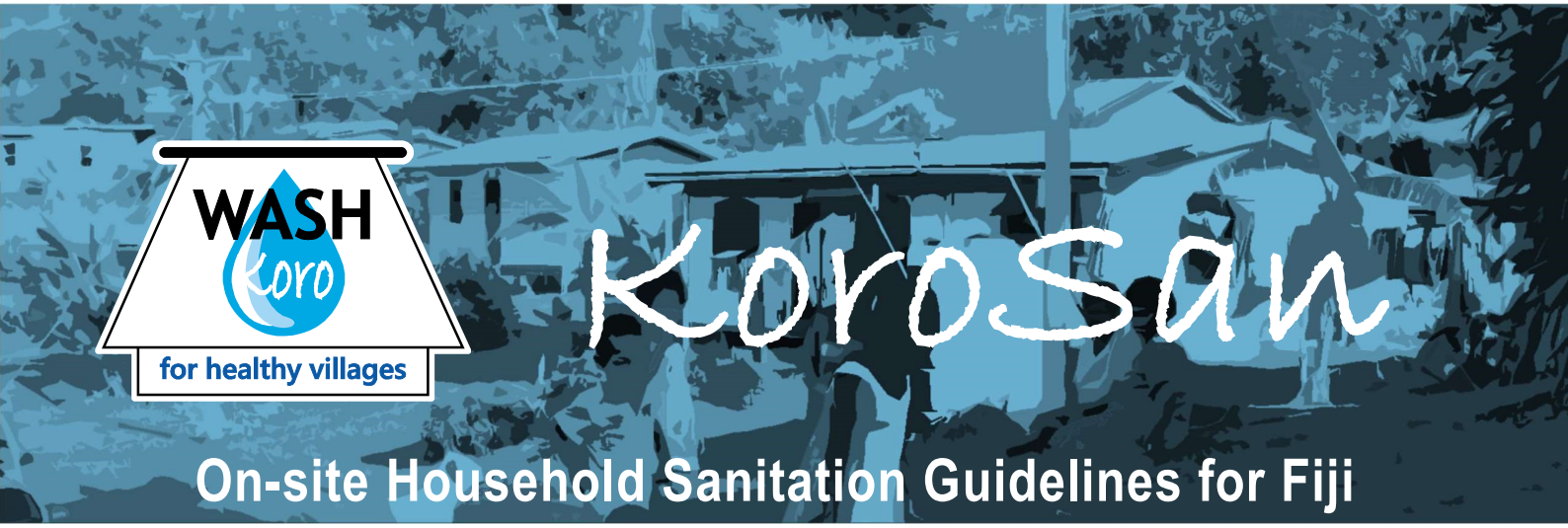


#3 SEPTIC TANK CONSTRUCTION USING CONCRETE BLOCKS

1 PURPOSE

A safe, sustainable, effective and affordable sanitation system is an essential service for the health and wellbeing of all people. This guideline is aimed at rural dwellings, clusters of dwellings, schools or community buildings in Fiji that are not serviced by a reticulated sewer service. Septic tanks are widely used for initial on-site treatment of human wastewaters before further treatment and/or soil infiltration. This guideline provides basic information for septic tank construction using reinforced concrete blocks. It is based on the joint Australian and New Zealand standards (AS/NZS 1546:2008 Pt 1 and AS/NZS1547:2008). Prefabricated septic tanks (concrete and plastic) are also available and may be a preferred option providing they are of sufficient quality and suitable size (as outlined in this guideline).

Key requirements for a septic tank are:

- Sufficient septic tank capacity for the wastewater load discharging each day into the tank.
- Robust materials and construction suitable for below ground installation and long lifetime.
- Water-tight so it will not leak.
- Provision for sludge removal.

Approval for the construction and/or installation of household wastewater treatment systems, such as septic tanks and associated land application systems or discharges, should be obtained from your Provincial Council for authorisation by the Ministry of Health and the Department of Water and Sewage.

2 WHAT IS A SEPTIC TANK?

Septic tanks are commonly used around the world as the first stage of on-site wastewater management systems (see Figure 1). As wastewater flows through a septic tank, solids (such as faeces) settle to the bottom to form sludge, and floating scums (e.g., oils and fats) are retained in the top of the tank allowing the liquid component to exit through the outlet (see Figure 2). This effluent is still highly contaminated and contain high concentrations of faecal microorganisms (such as bacteria, viruses, parasitic worms and protozoa) that can be dangerous to human health. The septic tank should, therefore, discharge to a suitable land application system that will mitigate significant risks by providing further treatment and soil infiltration of the effluent.

The sludge and scum that accumulates in the septic tank slowly breaks down, but a portion accumulates in the tank and must be periodically removed. This accumulated sludge and scum, known as septage, is normally sucked-out by a septic tank cleaner truck and then disposed of to a proper treatment and disposal facility. Based on research for temperate climates, this is generally required every 3–5 years, once the sludge and scum occupies half the depth or more of the septic tank. In warmer tropical climates it is expected that the required pump-out frequency will be more than 3-5 years.

3 WATER SUPPLY FOR FLUSHING

Flushed toilet systems increase the demand on the village water supply system. An adequate and reliable water supply is an essential requirement before installing flush toilets. For example, the daily volume of water needed for a flush toilet will be about 30 to 40 litres for every person living in the house. Flushing toilets soon become smelly and a serious health risk when water is not available. Other toilet options are available that do not rely on water-flushing. See KoroSan #6 and Live and Learn, guidelines, *Clean Communities* (2011).

Figure 1: Components of a water-flushed toilet on-site wastewater management system.

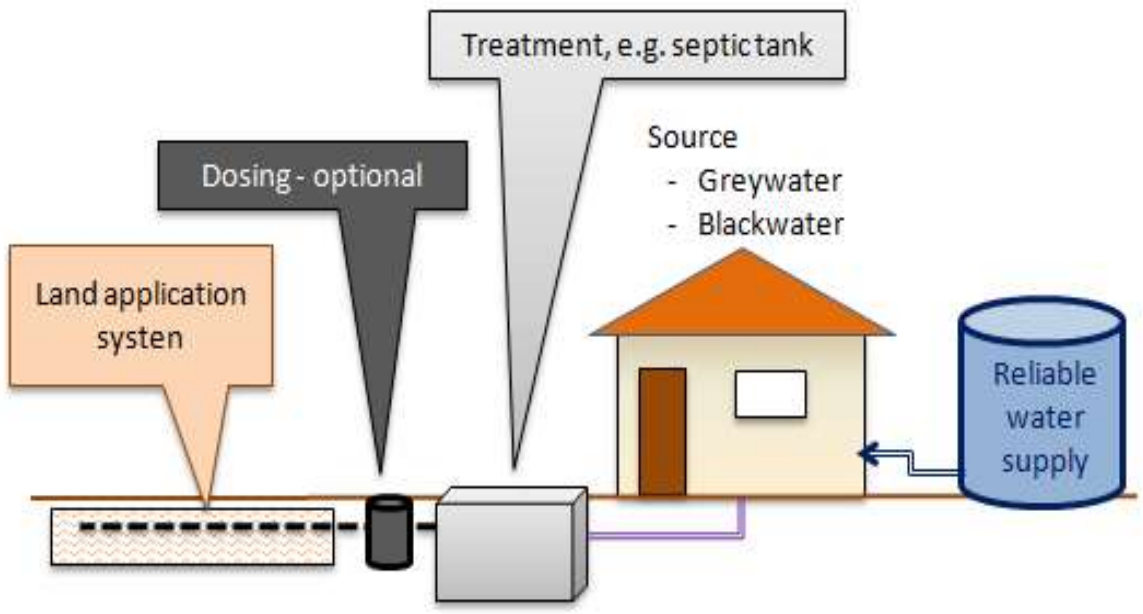


Figure 2: Typical two chamber septic tank for treatment of household blackwater. An outlet filter is recommended to reduce outflow of solids. Further treatment and safe discharge of the effluent is still required after the septic tank.

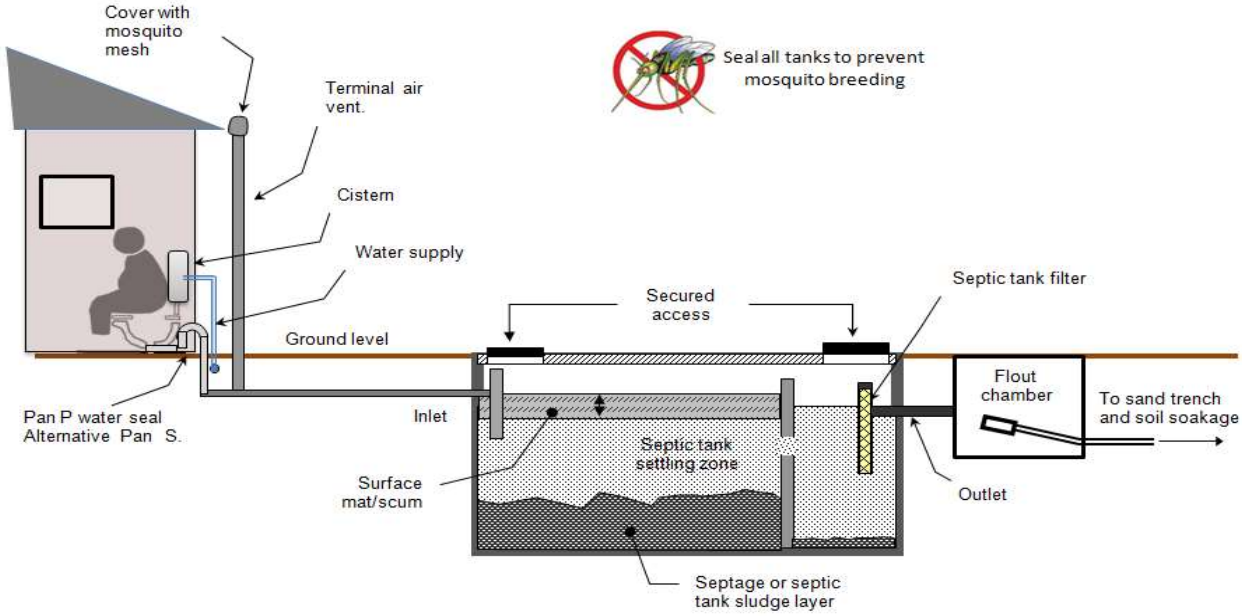
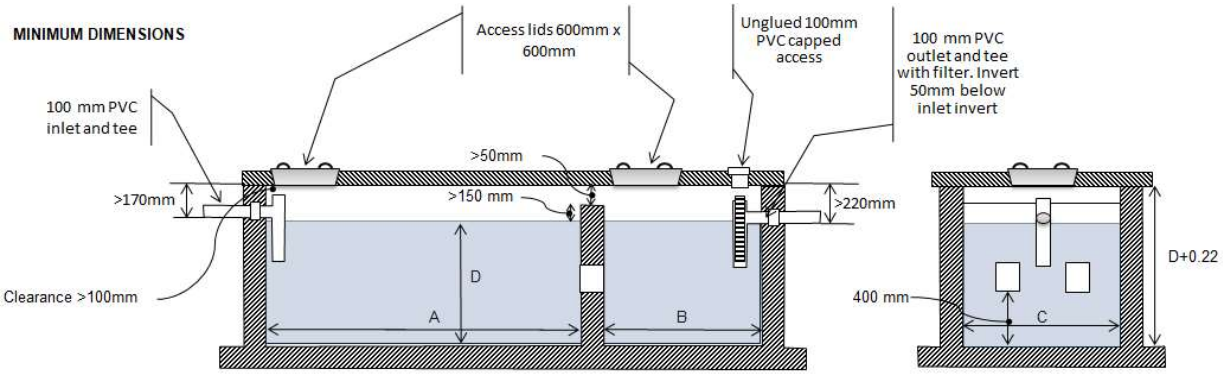
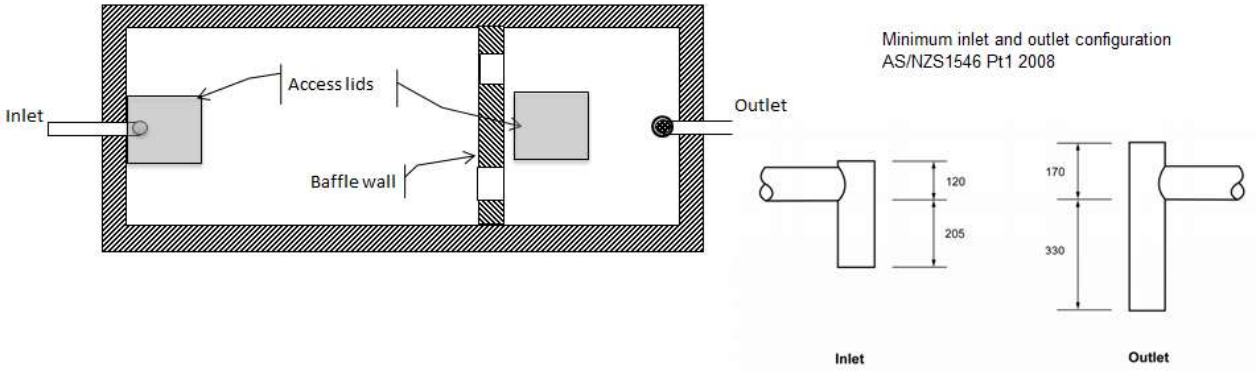


Figure 3: Typical two chamber septic tank configuration.

Side and end elevation



Plan view



4 WHERE SHOULD MY SEPTIC TANK BE LOCATED?

Careful thought must be given to choosing a suitable site for a septic tank. Septic tanks are normally completely or partially buried in the ground. It is preferable to locate the septic tank close to toilet and wastewater drains coming from the house to reduce the cost of drains and trenches. Other factors that must also be considered are:

- The septic tank should not be closer than 1.5 m from any building foundation, 3 m from any window opening or tree, and 2 m from any land boundary. Where there are sandy soils that could collapse during construction and undermine building foundations a 3m distance is recommended.
- The septic tank is to be located to provide the required minimum fall (or slope) for the drain or drains leading into the tank. The reason for a minimum fall is to avoid deposition of waste solids in the pipe, risking clogging. Typically, the minimum fall for a 100mm drain is 1:80 (125 mm drop for each 1 m length of pipe), however for details on the required fall refer to Section DF6 in the National Building Code, Fiji Islands, 1990.
- Do not locate the septic tank in flood prone areas, or where the groundwater is at less than 1 m below the bottom of the septic tank. Avoid areas where water storage tanks overflow or stormwater discharges from roofs.
- Do not install septic tanks where vehicles (cars, trucks) travel or park as they may damage the tank.
- Ensure the tank is located for good access for periodic sludge removal.
- Odours from septic tanks are minimised by installing a terminal vent as shown in Figure 2. However, it is also sensible to locate the septic tank where the effect of the odours will be minimised.

  Note that if a septic and outflow pipes are well constructed, are water-tight and do not leak, there is minimal risk to groundwater and wells from the septic tank itself. A substandard septic tank that may leak, is a substantial risk if sited too close to wells and other sensitive public facilities. Such tanks should be decommissioned and replaced with a water-tight septic tank.

5 HOW BIG DOES MY SEPTIC TANK NEED TO BE?

Septic tanks can be used for wastewater just from flush toilets (blackwater) or for combined wastewater from toilets plus sinks, washing machines, tubs, wash stands, showers and baths (combined black and greywater[1]). Because of the greater volume generated, larger septic tanks are required for combined black and grey water. The size must also be adjusted for the number of people in the household using the facilities. Typical daily volumes are 30–45 L/person for blackwater and 80 to 180 L/person for combined black and greywater. If taps are leaking or toilet cistern valves broken, the

[1] Greywater is generally less polluting than blackwater, but is still dangerous to human and environmental health and needs to be managed properly (see KoroSan # 7).

above daily volumes may be significantly higher. Care should, therefore, be taken to fix any leakages to avoid excess burden on septic tanks and subsequent land treatment systems.

The recommended size of a septic tank is a function of the volume of wastewater it receives each day. This volume will depend on the number of people occupying the dwelling and whether it receives black water only, or both black and grey water. Well-constructed septic tanks last for a long time and are difficult to alter once in the ground. Therefore, they should be sized for the potential number of people that could live in the house (based on size and number of rooms) rather than just the number of people currently occupying the house.

Recommended dimensions for two chamber septic tanks are illustrated in Figure 3. The tanks are dimensioned to provide working capacities based on international best practice codes and standards, as adopted in New Zealand and Australia (e.g., AS/NZS 1547:2012). Table 1 is for a two-chamber septic tank receiving both blackwater and greywater from a domestic dwelling (assuming a daily wastewater volume of 180 L/house occupant), while Table 2 is for a two-chamber septic tank receiving blackwater only from a domestic dwelling (assuming a daily blackwater volume of 45 L/house occupant). Note that the tank capacities given in these tables refer to "working capacity". This is the liquid volume within the tank below the outlet invert.

For a two-chamber septic tank, the first chamber needs to about 2/3^{rds} of the total tank volume and, the second chamber about 1/3rd of the total tank volume. For blackwater only, it is sometimes recommended that the first chamber is 75% of the total tank volume.

Table 1: Required septic tank capacities for combined black and grey water. A–D refer to key dimensions shown in Figure 3.

No. of occupants	*A (m)*	*B (m)*	*D (m)*	*C (m)*	*Working capacity (Litres)**
1–5	1.4	0.8	1.0	1.2	2640
6–8	1.6	0.8	1.2	1.4	4030
9–10	1.8	1.0	1.2	1.4	4700

* This is the actual liquid volume held within the tank below the outlet invert.

Table 2: Required septic tank capacities for black water only. A–D refer to key dimensions shown in Figure 3.

No. of occupants	*A (m)*	*B (m)*	*D (m)*	*C (m)*	*Working capacity (Litres)**
1–5	1.2	0.6	0.9	1.0	1620
6–8	1.6	0.8	1.0	1.0	2400
9–10	1.8	0.8	1.0	1.2	3120

* This is the actual liquid volume held within the tank below the outlet invert.

PROJECT IMPLEMENTATION

Project implementation will include the following:

- Choose and confirm the preferred location for the septic tank
- Plan the project, including:
  - determining, ordering and arranging delivery of all required materials
  - consulting home occupier and land owners
  - considering health and safety issues and planning to minimise risks to villagers (particularly children), construction workers and tradespeople.
  - arranging labour.
- Digging the pit for the septic tank. The depth will depend on the depth of the septic tank and providing the necessary fall (at least 1:80) from the toilet to the inlet to the septic tank. The width and length of the pit should be at least 2 m longer than the width and length of the septic tank.
- The base of the pit is to be level. As noted below if the base soil is sand then a perimeter footing must first be poured.
- The septic tank floor boxing is then installed and reinforcing positioned (refer Table 3).
- Concrete is mixed and poured.
- When the concrete floor is set, the block walls of the septic tank should be constructed. Reinforcing is to be installed (refer Table 3).
- All external wall blocks are to be completely filled with concrete.
- Plaster inside the external walls and joins of the septic tank.
- When the plaster has dried and set, carry out a leakage test by filling the septic tank with water, marking the water level and allowing to stand for at least 24 hrs. The water level in the tank should not drop by more than 1 cm over 24hrs
- Empty septic tank and repair any leakage.
- Once the septic tank is water-tight, install the dividing wall.
- Boxing for the septic tank roof and access lids is then to be installed and roof reinforcing positioned (Table 3).
- Pour the concrete roof slab.
- Pour the concrete access lids.
- Install all pipework to and from the septic tank.
- Install septic tank filter and connect septic tank to the toilet.
- Install access lids and seal edges with mortar.
- Install the land application system. Refer to KoroSan #4.
- Carryout a flow test on the completed system and check for any leakage. Repair if necessary.

6 SEPTIC TANK CONSTRUCTION SPECIFICATIONS

6.1 SEPTIC TANK FLOOR

The septic tank floor needs to be constructed with poured reinforced concrete 100 mm deep and reinforced as specified in Table 3. Steel reinforcing grid should be positioned 30 mm below the surface of the floor. The top of the floor should be level. If the soil base is sand then the 200 x 200 mm reinforced footing under the perimeter of the floor is required.

POURED CONCRETE SPECIFICATION

Mix three parts gravel, two parts clean sand (washed clean of any salt contamination, one part cement mix and add water as required. Only add sufficient water to effectively mix and work the concrete – strength is reduced by addition of excessive water. Sand is to be clean and free of fines (silt and clay). If beach sand (rather than river sand) is used it must be well washed to remove any salt contaminants.

If builders' mix is available (one part clean gravel to two parts clean sand) then the cement ratio should be 1 part cement to 4-5 parts of builders' mix. The builders' mix used must be clean, without silt and clay fines. To determine whether or not the builders mix has fines, place a handful in a glass of water and shake. If the water becomes significantly dirty/cloudy this indicates an excess of fines. The builders mix will need to be washed. This can be done by half filling a polypropylene sack with the builders' mix, submerge in fresh water (not sea water), vigorously shake and wash out fines.

REINFORCING

Table 3, provides the reinforcement requirements for the construction of a septic tank.

Table 3: Reinforcing requirements.

Block wall thickness	Height of tank (m)	Vertical bars Walls	Horizontal bars Roof	Horizontal bars Floor
140 mm (6″)	1.0 – 1.4	D10 @ 400	D10 @ 250 x 250	D10 @ 300 x 300
190 mm (8″)	1.6 – 2.0			

6.2 SEPTIC TANK WALLS (INCLUDING INTERNAL BAFFLE WALL)

Septic tank walls are constructed from concrete blocks (Figure 4) reinforced by steel bars as outlined in Table 3. The basic concrete block dimensions are to be 400 mm long and 200 mm high.

- For a septic tank up to 1.4 m high, the concrete blocks to be used are to be 140 mm wide.
- For septic tank depths greater than 1.4 m deep and up to 2 m deep, the concrete bock must be at least 190 mm wide.

MORTAR SPECIFICATION FOR BLOCK-LAYING

- Mix 5-6 parts clean sand (as specified above), one part lime and one part cement mix and add water as required.

- All blocks are to be reinforced as specified in Table 2 and all external wall blocks are to be filled with concrete. To achieve a water-tight septic tank it is important to fill all external blocks with concrete. To aid with block filling and improve water-tightness, a concrete additive and expansion agent such as Sika Cavex™ (or an equivalent) should be added to the concrete mix.

PLASTERING THE INSIDE WALLS AND CORNERS IS IMPORTANT TO ACHIEVE WATER-TIGHTNESS

- Apply a layer of spatterdash (one part of cement to one and a half parts of coarse sand with enough water) to create a rough surface for the application of the plaster layer.
- The plaster mix should be three parts clean sand (as specified above), one part lime and one part cement mix and add water as required. Apply the plaster to a 10 mm thickness and finish off with a steel trowel until you achieve "fat" to the surface (gloss finish). For the corners use a small glass bottle instead of a steel trowel.
- Once the tank is water-tight (see below), the internal baffle wall can be constructed to divide the tank into two compartments. The baffle wall should be situated no less than two-thirds of the length of the tank from the inlet end and finish at least 50 mm below the top of the tank over at least one third of its length. The compartments need to be connected by two openings in the baffle wall at least 200 mm wide, set 400 mm above the floor of the septic tank.

TESTING TANK WATER-TIGHTNESS

- Before constructing the roof the water-tightness of the septic tank needs to be tested by filling the tank, marking the water level and allowing it to stand over at least a 24 hour period. The water level in the tank should not drop by more than 1 cm over 24 hrs.

Figure 4: Septic tank under construction.

Note: In this photo the internal baffle has been installed before the internal walls have been plastered. **This is not recommended.**

6.3 INLET, OUTLET AND EFFLUENT FILTER

Details of the septic tank inlets and outlets are illustrated in Figures 4 and 6. The inlet and outlet pipes must be well sealed into the concrete walls, and be separated by at least 1200 mm. The fitting of a septic tank filter in the outlet from the septic tank is recommended (Figure 5). There are a range of different filters available on the market. The filter chosen needs to be effective, durable and easily serviced.

6.4 SEPTIC TANK ROOF

The septic tank roof needs to be constructed with poured reinforced concrete, 100 mm deep. Reinforcing grid, as specified in Table 3, is to be positioned at least 30 mm above the base of the roof. Figure 5 shows set-up prior to pouring concrete, with removable timber support overlain by polythene plastic liner and reinforcing grid suspended above base of roof.

Access lids (Figures 3, 6, and 7) are needed to provide ready access to the septic tank filter and allow periodic removal of excess sludge. The lid must be water and air-tight. Suitable options include a concrete slab or plate of adequate strength sealed in place with concrete mortar. Easy access to the lids is required for servicing. Above the outlet pipe, an unglued PVC cap access port is required to allow removal and cleaning of the filter.

Figure 5 Septic Tank filter being inserted into an outlet tee.

Figure 6: Septic tank roof under construction.

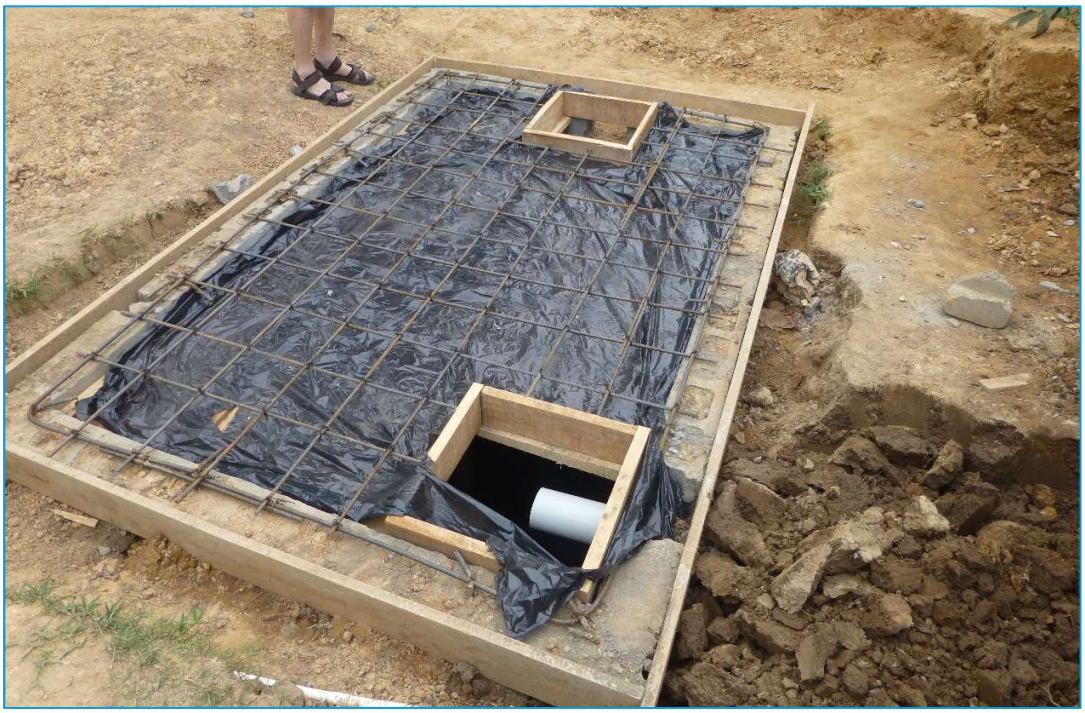


Figure 7: Completed household blackwater septic tank for 6-8 people. Dosing chamber and land application system vents are visible on far side of tank.

WORKMANSHIP

All pipe work, tank construction or sanitary fixtures and fittings installed in connection with a septic tank, water supply or similar system, must be carried out by or under the supervision of a suitably qualified and experienced tradesperson. All drains, (including vents, gulley traps and fittings) between the dwelling and the septic and from the septic tank to the land application system are to be installed in accordance with the requirements of Section DF6 in the National Building Code, Fiji Islands, 1990

7 POTENTIAL NUISANCES FROM SEPTIC TANKS

7.1 SMELLS

Septic tanks will sometimes generate smells. This is why it is important to vent them correctly and keep them well sealed. Sometimes the smell can become very foul and objectionable. This can be caused by over-loading or flushing toxic chemicals and antibiotic medicines that kill off septic tank bacteria.

7.2 OVERFLOWS AND LEAKAGE

Exposed effluent has a very high health risk. If overflow or leakage occurs, the area must be immediately isolated with barriers and warning signs put in place to prevent any human or animal contact with the exposed effluent. The cause of the exposed effluent must be fixed as soon as possible by a qualified tradesperson. The exposed effluent may result from a failed or blocked land application system and consequent flooding and overflowing of the septic tank, broken and leaking drains, or a damaged and leaking septic tank.

7.3 MOSQUITO BREEDING

Unless most carefully sealed during construction, septic tanks may become prolific breeding places for mosquitoes, including those that spread Dengue Fever. Check to make sure the septic tank is air tight and that there are no entry points for mosquitoes. Securely cover air vents with mosquito-proof mesh to stop insect entry and repair all cracks and holes in septic tanks. Spraying the septic tank surface with a suitable insecticide may be necessary. Ensure that the insecticide will not significantly affect the biological functioning of the septic tank or land application system.

See KoroSan #4 & #5 on how to operate and maintain your septic tank and providing land disposal systems for safe management of septic tank effluent.

REFERENCES

AS/NZS 1547:2012. On-site domestic wastewater management. Australian and New Zealand Standards. https://www.standards.govt.nz/

Auckland Council. 2004. On-site wastewater disposal from households and institutions. Auckland Council. Technical Report 58. (TP58). (in revision from 2016) http://www.aucklandcouncil.govt.nz/.

National Building Code, Fiji Islands, 1990[2] http://www.health.gov.fj/wp-content/uploads/2018/02/Fiji-National-Buiding-Code.pdf

[2] Department of Building and Government Architect advise that this code is currently under review. (2 May 2017)..

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For more information contact:

The Department of Water and Sewage.
The Ministry of Health, or your local
Provincial Council

KoroSan Guidelines

The WASH w project has produced the following series of technical and participatory guidelines to help mobilise villages and settlements to improve their water supply, sanitation and hygiene. These guidelines may be freely disseminated provided the source is acknowledged.

KoroSan #	Title
1	Choosing a village wastewater management service
2	Site, soil and wastewater flow assessment
3	Septic tank construction using concrete blocks.
4	Land application systems
5	Maintaining your septic tank and land application system
6	Water-less ecoVIP2 toilet
7	Greywater management
8	Village participation in water and sanitation actions

KoroSan – for healthy villages