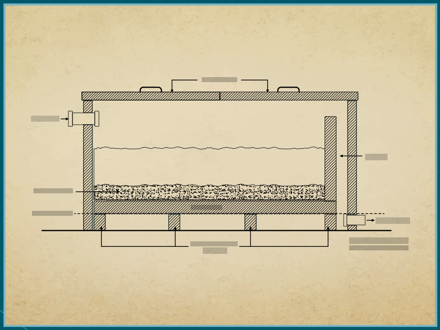
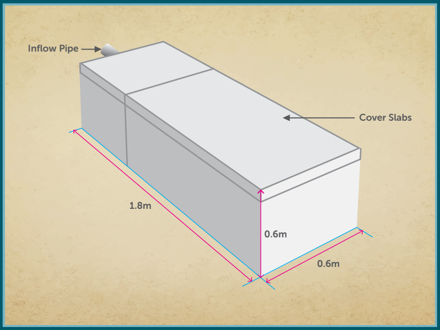
MINISTRY OF SANITATION
AND WATER RESOURCES

BIO-DIGESTER TOILET

CONSTRUCTION AND INSTALLATION MANUAL

JUNE 2020

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ACKNOWLEDGEMENT

This document was prepared by the Ministry of Sanitation and Water Resources through the Greater Accra Metropolitan Area (GAMA) Sanitation and Water Project. The following constitute the team composition for the development of the manual:

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LIST OF ACRONYMS

GAMA	Greater Accra Metropolitan Assembly
KVIP	Kumasi Ventilated Improved Pit
LIUCs	Low Income urban Communities
VIP	Ventilated Improved Pit

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GLOSSARY

Aerobic digestion – breakdown of organic material in the presence of oxygen

Anaerobic digestion – breakdown of organic material in the absence of oxygen

Biosolids: faecal sludge accumulated on the top of porous filters and has been digested/stabilized. It is a term also given to the residue when sludge is dewatered in the bio-digester

Bulking material: dry and fibrous materials such as sawdust, finely chopped straw, peat moss, coconut fibre mixed in bio-digesters in order to prevent odour, absorb urine, and eliminate any fly nuisance.

Desludging: the process of removing sludge from a tank, pit, or other storage unit.

Effluent: the general term for liquid that has undergone some level of treatment and/or separation from solids.

Excreta: consists of urine and faeces that is not mixed with any flushing water. Excreta are small in volume, but concentrated in nutrients and pathogens. Depending on the quality of the faeces, it is solid, soft or runny.

Faeces: refers to (semi-solid) excrement without urine or water

Porosity: the fraction of volume of void space area to total volume of medium.

Porous slab: It is pervious gravel packing bonded by a correct mix of cement and water that is used for solid-liquid separation of blackwater in the bio-digester.

CHAPTER 1

1 INTRODUCTION

1.1 Background

The bio-digester toilet technology is one of the fastest growing toilet options in urban Ghana. The use of bio-digesters has been given a boost by the World Bank funded GAMA Sanitation and Water Project (2014-2020) which seeks to provide improved sanitation to low income urban areas. Currently bio-digesters are the predominant toilet technologies in the low-income communities within GAMA with about 98 % of all constructed household toilets under the project being bio-digesters. The number of variants of the bio-digester has increased over the years with different service providers providing different designs and configuration of the technology. This has necessitated the need for standardization through a construction manual.

1.2 Why this Manual

This manual provides information on the design, siting, installation and maintenance of bio-digesters in Ghana. There is the need for standardization and scaling up of the bio-digester in the country.

1.3 Who can use the Manual?

This manual is to be used by

- Engineers
- Technicians
- Artisans
- House owners
- Entrepreneurs
- Institutions in the WASH sector

CHAPTER 2

2 OVERVIEW OF DIGESTERS

2.1 Types of Digesters

Digesters are typically waste treatment systems designed to digest or treat waste (organic matter) under a controlled aerobic or anaerobic environment to produce usable products such as organic compost, biogas and reusable wastewater. Micro-organisms and/or macro-organism cause the degradation process, which involves fermentation or digestion of the organic matter. There are two major types of digesters: aerobic and anaerobic digesters. Each has different uses along with pros and cons. This manual focuses on aerobic digesters.

2.2 General Principles of operation of Bio-digester Toilets

The bio-digester toilets are on-site toilets designed to rapidly separate human excreta from blackwater for degradation under aerobic conditions through the interaction of micro-organisms and macro-organisms. Bio-digesters typically serve as alternatives to septic tank for the treatment of excreta directly from water closets or pour-flush seats. The blackwater (raw excreta + flush water and anal cleansing material) undergo rapid solid–liquid separation through a porous filter in the bio-digester. Solid materials are retained on the porous filter where it is broken down aerobically by microorganisms and macro-invertebrates. The Bio-digester mimics the decomposition found under forests' floors and other natural environments. The organisms are introduced into the Bio-digester by adding a bit of humus during installation while the macro-invertebrates such as cockroaches come in by themselves. The effluent (liquid) after solid–liquid separation is biologically pre-treated and discharged directly into the subsurface soil via drainfield pipes or soakaway. The bio-digester is illustrated in the schematic below (Figure 1.0).

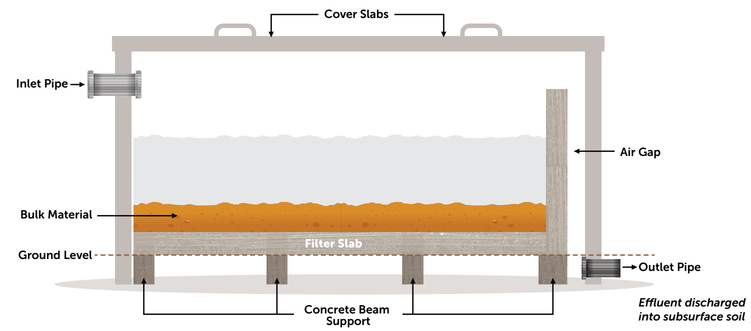


Figure 01: *Schematic of the bio-digester*

A

B

Plate 1: *Internal component of bio-digester* *A. Bulking Matirial* *B. Filter Slab*

Visible outlet pipe in air gap of Bio-digester (For detection of ponding or blockage)

Plate 2: *Outlet pipe in air gap*

2.3 Advantages and Disadvantages of Bio-digesters

2.3.1 Advantages of Bio-digesters

Bio-digesters have numerous advantages among which are:

- Easy and simple to install

  Bio-digester toilets are easier to install and can be built with local materials. They can be installed within 24 hours because the components are usually pre-fabricated (especially the digester). The organizations that promote the use of bio-digester toilets have qualified technical people who do the installation. There is ongoing technical capacity building to make technical support more easily accessible nationwide.

- Provides good sanitation practice

  Bio-digesters need no mechanical or electrical aeration of solid mass to achieve decomposition. They have been designed in such a way that there is no human contact with excreta. Macro-organisms do the turning by creating pores in the organic matter. This allows aeration of the organic matter there by eliminating odour caused by hydrogen sulphide gas. It does not attract insects that spread diseases when installed properly. The designs of the digesters make them impossible for rodents to burrow into digesters unlike conventional pit latrines.

- Minimal maintenance cost

  Bio-digesters require minimum maintenance. There is usually slow sludge build-up within the bio-digesters when installed and used properly; and in systems where sludge accumulates, they are reused as soil conditioner. Therefore, bio-digesters eliminate desludging cost and the possibility of costly site remediation and clean-up (as in the case of septic tanks).

- Minimal space required for installation

  Basic Bio-digester sizes are 0.6m x 0.6m x 1.8m (2ft x 2ft x 6ft) and occupies an area of 1.08 sqm and 0.6m x 0.9m x 1.8m (2ft x 3ft x 6ft) which occupies an area of 1.64 sqm, therefore land-take is minimized. Every household can own a toilet without limitation of space.

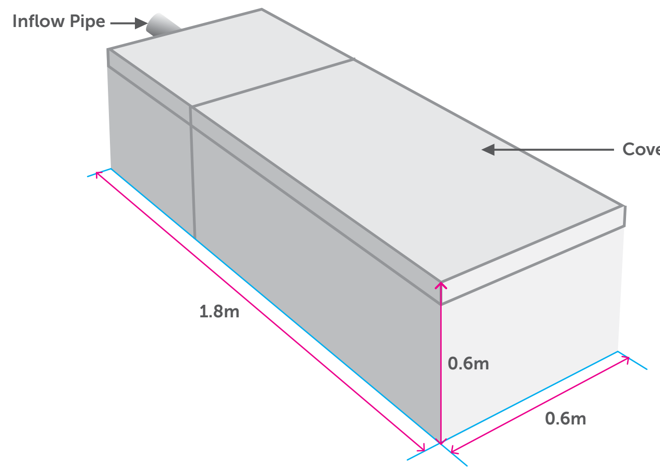


Figure 02: Dimensions of a typical bio-digester

- Environmental friendliness

  Water contamination is minimized when the digesters and effluent pipes are installed above the ground water table and recommended distances from a water source. Waste is treated under complete aerobic conditions eliminating odour and air pollution. The digesters have the potential of reducing greenhouse gas emissions through the avoidance of methane emissions directly into the atmosphere.

- Potable water savings

  Bio-filtered water from digesters could be used for landscaping in the case of normal flush toilets. The micro-flush systems use minimal water for excreta flushing - wastewater from the hand washbasin is channeled from the facility (sink) to the toilet seat to form the water seal and subsequently for flushing the human excreta.

- Resource reuse potential
  The use of bio-digesters give the added advantage of reuse of effluent for various purposes such as horticulture (e.g. wall gardens), aquaculture etc. The decomposed material from the activities of the micro and macro organisms can also be used as compost.

2.3.2 Disadvantages of Bio-digesters

- Wastewater in bio-digesters presents a potential risk to surface water and groundwater (i.e. high-water table areas) if not further treated before discharge.
- Proper operating conditions must be maintained in the digester for maximum benefits.
- The different sizes of Bio-digesters are used by a particular user population; once abused the digester may not work properly (Table 1.0).

2.4 Factors to Consider in Installing a Bio-Digester

2.4.1 Site Selection

Getting the location right is very important in ensuring the use of the facility, reducing risk to environmental contamination and public health. It is crucial to conduct a percolation test to ascertain the ability of the soil to drain well. The following outline key issues to look for during site selection:

1. Do not select a site where water is known to collect after rain.
2. Avoid (where necessary) rocky terrain, unstable ground conditions and depressions with shallow water table.
3. Type of soil specified should be loamy, loose laterite, sandy gravel and should not be waterlogged
4. To prevent water source pollution, the discharge unit should be located away from ground water source based on the following distances:

- 7.5 metres away in areas where highest seasonal water table is more than 5 metres from bottom of discharge unit,
- 15 metres away in areas with highest seasonal water table of 1-5 metres from bottom of discharge unit, and
- 30 metres in areas with highest seasonal water table reaching less than 1 metre from bottom of discharge unit.

5. In the case of flush installation where the water table is high; the outfall effluent line should be at least 0.3 metres above the ground level
6. It should be noted that areas with fissured rock, limestone or very coarse soil have high risk of contamination. Areas with fine soils tend to have less risk of contamination

2.4.2 How to Identify waterlogged areas or poor draining soils

1. Look out for the presence of stagnant water on the land surface

Look out for slimy and green surfaces (i.e. with algae)

Look out for weeds such as elephant grass in the area

Plate 3: *Evidence of waterlogging on land surface*


Plate 4:
Elephant grass indicating waterlogged areas

2. Look out for dampness of walls especially in the dry season
3. If you suspect waterlogging at a site; dig out two or three holes at different locations with depth of 30 cm (1 foot). If water flows freely into them, the soil is waterlogged.

Plate 5:
Quick waterlogging test

4. Moist a sample of the sub-soil and try moulding it with your palm into a long thread; if so, it contains a high amount of clay and will not drain well.

2.4.3 Bio-digester sizes and Number of Users

1. The main variable that controls the design of a digester is its internal volume, which is influenced by the number of users and the loading rate of faecal matter
2. Number of users for a standard bio-digester should be 10 persons; multiple digesters or bigger digesters must be provided where users are more than 10.

S/N	DIGESTER TYPE	ANTICIPATED NUMBER OF USER/DAYS
1	Standard digester	10
2	Large digester	15
3	Special digester	25 -50

Table 1:
User population and digester size

2.4.4 Space Required for a Standard Digester

1. A minimum space of 1.65 sqm is required for installation.
2. Allow for space between the digester and building (between 150mm – 300mm) for general access for service pipes and ease of installation.
3. A standard bio-digester has the following dimensions:

- Length of 1800 mm
- Width of 600 mm
- Depth of 600 mm

2.4.5 Water Required for Flushing

- For micro-flushing the amount of water required for flushing excreta ranges between 0.5 – 1.5 litres per flush
- For the full-flush digester, the amount of water required for flushing ranges between 6 – 9 litres per flush

2.4.6 Effluent Disposal Options

The final effluent from bio-digesters can be managed using

- Pipe drain field in well-drained soils
- Soakaway/or soak pit in well-drained soils but limited land space.
- Sand filters particularly in high water table areas and/or rocky grounds or poorly drained soils. The sand filter comprises of grade of sand media (0.06-2 mm)

Plate 6:
Sand filter installed in a poorly drained area

2.4.7 Depth of installation

Bio-digesters should not be completely buried during installation; and the cover slabs must not be buried to allow easy access into the Bio-digester during maintenance (Plate 7). The digester must have close and continuous interaction with the atmosphere since it is based on aerobic processes. The venting of the Bio-digester is very crucial to allow for release of foul gases out of the toilet room. The base of the effluent management option be it piped drain field or soakaway must be in the unsaturated soil zone. Typical installation depths are as follows:

- Buried – this is possible in well-drained soils such as loamy and sandy soils and areas with very low water table. Top slab should be at least 4 – 6 inches above ground level to prevent runoff from entering into the bio-digester.

Plate 7:
Buried Bio-digester installation

- Partially buried - this is possible in moderately drained soils such as lateritic soils and areas with relatively low water table. Bio-digester is half buried.

Plate 8:
Partially buried Bio-digester

- Surface – this installation style is typical in areas with very high-water table and poorly drained soils. In such instances, borrowed soil material, which is well drained, are placed under the Bio-digester. In addition, sand filters are connected to the Bio-digesters for further polishing of the effluent prior to discharge into surface drains and/or water bodies.

Plate 9:
Surface installation of bio-digester

2.4.8 Types of bulking material

The preferred bulking material used in bio-digesters can be any fibrous carbonaceous material with low moisture content. Examples are coconut fibre, palm fibre, wood shavings, vermicast (dark, homogenous, stabilized bio-solids digested by earthworms) etc. The bulking material creates a good environment for decomposition of waste and lowers concentration of harsh chemicals in flush water.

A

B

Plate 10:
Bulking materials
A. Coconut fibre.
B. Palm kernel fibre

A

B

Plate 11:
A. Wood shavings
B. Vermicast

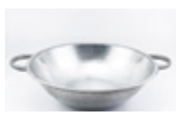
CHAPTER 3

3 CONSTRUCTION OF A TYPICAL BIO-DIGESTER

3.1 Tools & Material list

The basic tools and material that are used for the construction of bio-digesters are presented in the table 2 below. It must however be noted that these may vary depending on the type of construction materials used by households (particularly for the superstructure). The materials for the superstructure may vary depending on household's preference and the availability of local materials. Table 2.0 outlines the list of tools typically used for the construction and installation of bio-digesters.

Table 2: *Tools for construction and installation*

Tools List	Use Production/Installation	Photo
Rubbing Board	Working mortar	
Hand Trowel	Working mortar and concrete	
Wheelbarrow	Volume measurement for mortar/concrete	
Head pan	Used for batching materials for concrete/mortar	
Hacksaw/ hacksaw blade	Cutting rebar to size	
Wire Scissors	Cutting wire	
Shovel	Preparing site, mixing concrete	
Pickaxe	Trenching	
String Line	Marking out dimensions	
Scissors	Cutting of net lining	
Pincers	Tightening wire	
Chisel	Making cuts in concrete slabs	

Tools List	Use Production/Installation	Photo
Spirit Level	Levelling	
Carpenters Saw	Cutting wood	
Measuring Tape	Measuring dimensions	
Masonry square	Accurate measurements	
Hammers	Nailing wood & using chisel, breaking up blocks	
Personal Protective Equipment (PPE)		
Hand Gloves	Protecting hands	
Protective clothing	General body cover	
Safety boots	Protective footwear	

3.2 Material Schedule

Various local materials can be used for the construction of the bio-digester but for the purpose of this manual, these materials are specified. The material schedules are specified for setting out for production, casting and installation.

Formwork is required for the casting of specific sizes of the slab components used in the installation of the bio-digester. Table 3.0 outlines the material schedule for setting out slabs to be casted.

Material	Use
¾" plywood boards	Platform for casting concrete slabs
2" x 2" hardwood	Handles for platforms
1" x 4" hardwood	Bracing of platform
1" Angle Iron	Setting out and casting 1" slabs
11/2" angle iron	Setting out and casting 11/2" slabs
Floor carpet	Casting slabs for smooth finishing

Table 3:
Materials for Setting out for production

In table 4 various materials used for the production of concrete slabs for the bio-digester are outlined.

Material	Use
Binding wire	Tying the mild steel as reinforcement for the slabs
½″ wire mesh	Reinforcement for slabs
3/8″ rebar	Reinforcement for slabs
½″ rebar	Reinforcement for slabs
Rough sand	Casting slabs
¼″ chipping [1]	Casting of slabs
50kg cement	Casting of slabs
Water	Mixing concrete and mortar

Table 4:
Material schedule for casting slabs

The concrete slabs used in the installation of bio-digesters need to have a high compressive strength to withstand abrasion during their transportation. The reinforcement bars provide this strength together with the wire mesh. The wire mesh is typically used to bond the mortar in place to prevent easy breakage during transportation and installation. Plate 12 shows the key production materials in the manufacture of the bio-digester slabs

[1] Range of aggregate size: ¼″ – 5/8″

Steel Bars with Mesh

Sand

Coarse Aggregate

Cement

Plate 12:
Pictorial view of key materials for production: mesh, sand, coarse aggregate, cement and steel bars

The installation of the bio-digester requires mortar for sealing the corners of the assembled concrete slabs and to line the base of the bio-digester to prevent effluent from having direct contact with the ground and groundwater infiltration into the bio-digester (i.e. making the bio-digester water-tight). Pipes and fittings are also required for the construction of the effluent drain field. Table 5.0 outlines the key materials for installation and their uses.

Material	Use
Rough sand	Making mortar for screeding and holding panel slabs
50 kg cement	Making mortar for holding panel slabs to form box
Potable water	Mixing mortar
4″ uPVC pipe[2] or better	Constructing drain field and vent
4″ elbow	For forming bends on constructed drain field
4″ swept tee & cleanout	Used as an inspection chamber on constructed drain field
¼″ chippings	Bedding for constructed drain field

Table 5: *Material for installation of drain fields*

3.3 Construction of Bio-digesters

Bio-digesters are mostly constructed using prefabricated ferrocement concrete as the main building material for the wall slabs and cover slab of the digester. Notwithstanding, other building materials such as sandcrete blocks and or brick may also be used for the walls and concrete slab for the top cover. Construction of a standard digester involves mainly two processes:

- The construction of prefabricated parts such as wall slabs, cover slab and porous concrete
- The installation of all components

3.3.1 Construction of Prefabricated Components

A standard bio-digester has the following dimensions:

- Length of 1800mm
- Width of 600mm
- Depth of 600mm

The detailed sizes of concrete slabs, porous slabs and beams as used in the Bio-digester installation and their construction specifications have been provided in Annex B.

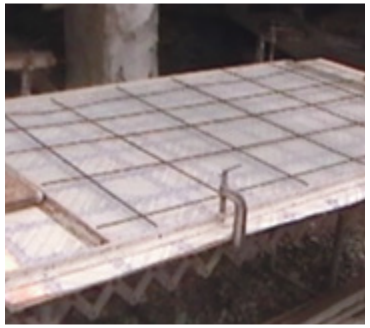
Batching: Cement/Sand/Aggregate/water ratio is 1:3:1:2 (check Annex G for anticipated slab strength)

Materials: Cement, sand, aggregate, water, chicken wire and 3/8″ diameter iron rods

3.3.2 Steps for arrangement of reinforcement for slabs

1. Prepare formwork on a flat working table.
2. Cut 3/8″ sized rebar according to dimensions for concrete slabs.
3. Place them on a flat working table and tie to form square mesh with iron rod spacing of 6″ c/c.
4. Cut chicken mesh and place it on both sides of the square mesh/formed iron rods.
5. Tie the iron rods and chicken mesh together using binding wires at the outer end of the short edge of the formwork.
6. Place spacers between the formwork and formed mesh to all for adequate concrete cover.

[2] Class B pipes preferred for clayey soils and deep excavations. Else Class O pipes are adequate for other soil types



A

B

Plate 13: *Setting out of rebars and chicken mesh*

3.3.3 Steps for fabrication of concrete slabs

1. Batch cement, sand and aggregate (1/4" size) according to specified mix ratio onto a hard surface free from dirt (Plate 14)

Plate 14: *Concrete mixture for slabs*

2. Mix into a uniform mixture and create a gully in the pile to add on water to the right texture of concrete using a water ratio of 2.0. (Plate 15)

Plate 15: *Adding on water for concrete*

3. Gently mix water into pile of cement, sand and aggregate mixture to form the right consistency of concrete

Plate 16: *Mixing concrete into right consistency*

4. Pour concrete into the formwork to occupy half the thickness (depth) of the formwork.

Plate 17: Pouring of concrete into formwork

5. Use the hand trowel to spread the concrete evenly throughout the formwork.

Plate 18: spreading of concrete in formwork

6. Place the mesh and steel bar setup onto the concrete in the formwork.

Plate 19: placement of mesh and steel bar setup onto concrete

7. Pour concrete onto the mesh and steel bar setup and gently work the concrete with the hand trowel to cover the entire setup.

Plate 20: Pouring of concrete onto mesh and steel bar setup

8. Use the hand trowel to rub the surface to obtain a smooth finish.

Plate 21: Working concrete to a smooth surface finish

9. Allow the slabs to cure for 7 days after which it is ready for use.
10. Make sure the slabs are cured by covering them to prevent direct contact with the sun and apparent rain.
11. In the case of slabs used as porous slabs:
12. Use a PVC pipe of diameter ½" – 1" to create holes in the wet concrete after smoothing the surface before curing.
13. Use a drill to create holes uniformly in the cured slabs.

3.3.4 Steps for fabrication of concrete beam supports.

1. Repeat steps for mixing concrete using a mix ratio of 1:3:1:2 similar to the concrete slabs.
2. Set out formwork for concrete beams; 3" x 4" x 23" and pour concrete

Plate 22: Formwork for beam supports for bio-digest

3. Allow beams to cure for 7 days

Plate 23: Pile of concrete beam supports

3.3.5 Steps for fabrication of porous slab

Batching: Cement: Aggregate ratio 1:3

Materials: aggregate (1/4"), cement and water.

1. Prepare formwork on a hard-flat surface (See Annex B for dimensions)
2. Mix cement and aggregate only with a ratio of 1:3.
3. Pour mixture into formwork and compact with a hand trowel to achieve a uniform surface

Plate 24:
Casting of porous slabs

4. Add water such that it does not form slurry or drain off from the mixture.
5. Do not apply too much water to cause the slurry from clogging the pores when cured.
6. Allow porous slabs to cure for 7 days.
7. The aggregate should be sieved to remove dust particles as it can act as a good binding surface to reduce the porosity of the porous slabs.

3.4 Installation of the Bio-digester

3.4.1 Site Preparation

Preparation of the installation site is dependent upon the type of digester to be installed, specifications from the customer and recommendations made from the site survey as described under section 2.4.

1. Clear and level the ground where the digester is to be located and remove the topsoil and debris.
2. A minimum space of 1.65 sqm is required for the installation of the digester. Allow for space behind and on the side of the digester (between 6 – 12") for general access and construction.
3. Make sure all of the materials and tools are at the site before each construction step is started.
4. For standalones (superstructure sitting directly on the digester), the ground is dug in excess of about 5 inches
5. For the standard and large digesters, a level spot on the earth is made for mounting the digester within a depth of 5 inches.
6. Preferably all digesters should be installed on the surface of the ground to help in easy maintenance. However, upon insistence by the customer and other ground conditions, it is recommended that at most 30 % of the digester should be buried.
7. In cases where the digester has to be buried, measures should be put in place to avoid entry of water into the system and for easy future maintenance.

Do not remove any shady trees if they are close to the site. They will absorb nutrients in final effluent.

3.4.2 Setting and marking out

1. Survey the space as per the dimension of the digester.
2. Measure and mark out the space of the digester including the piping space required for drainage.
3. Prepare a level spot on the ground for mounting the bio-digester.

3.4.3 Excavation

Tools and equipment required:

- Measuring tape
- Shovel
- Pickaxe
- Gloves

Activities:

Excavation is done at this point. The excavation should be done as per the gradient set for the digester and the piping.

1. Put on gloves and carefully dig pit within the set-out range using the pickaxe
2. Ensure that dug out soil is kept at a considerable distance from the pit to prevent them from falling back into the pit

Plate 25: *Excavation and clearing of site*

3. Excavate to the required depth
4. Do not increase or decrease the dimensions of the ditch
5. Avoid standing on the edges of the ditches as they might collapse. Protect the areas already excavated to prevent accidents.

3.4.4 Installation of precast bio-digester components

Before the installation commences, the following should be made available.

- precast slabs
- porous slabs, beams
- 1 bag cement
- ¼" stone chippings (6 head pans)

- Sand (4 head pans)
- Bulking material (wood shavings, coconut fibre, palm kernel fibre etc.) – half cement bag. Charcoal may be added in to play the role of odour absorption. The purpose of the bulking materials is to provide good environment for the macro-organisms (worms etc.) to thrive and to prevent the porous filter from clogging.
- Connecting pipes (influent and effluent pipes) including drain field pipes – 4 inches class B (Clayey soils) and/or class O (other soil types where applicable).

The installation processes

1. After digging out trench for bio-digester, place panels to form the box using the mason square to set the corners.

Plate 26: *Forming the Bio-digester box from the slabs.*

2. Use your pliers to tie the binding wires in place to hold the panels firm together.

Plate 27:
How to tie the corners of the Bio-digester

3. Use mortar to secure the corner joints in place.

Plate 28:
Securing bio-digester corners with mortar

4. Mix cement and sand to get a mortar mix of 1:4 and apply in trench.
5. Spread mortar to cover the rectangular surface with a thickness of 2 inches (50mm)

Plate 29:
Screeding the base of the digester

6. Create an opening at the base of one of the smaller panels opposite to the in-let pipe and place the PVC pipe to allow for easy flow of the effluent.

Plate 30:
Fixing of effluent pipe

7. Place a second layer of mortar inside the box; giving it a slope towards the drainage pipe and allow to cure.
8. Place mortar on the outer edges around the base of the panel box to prevent runoff water from flowing into the digester.

9. Dig trench for drain field pipes and spread aggregates in the trench to prevent clogging at the base and extend the effluent pipe at the base of the bio-digester for the drain field pipe.

Plate 31: Pipe drain field installation

10. After the inside screeding is dry, place and position the concrete beams in the digester.

Plate 32: Placing of concrete beam supports.

11. Place the two (2) porous slabs/perforated concrete slabs on the concrete beam to create an air gap between the screeding and the porous slab; there is always about 6 inches space between the laid porous slabs and the bio-digester box.

Plate 33: Placement of filter slabs- left: pervious concrete, right: slab with roles

12. Place a mesh lining on top of the porous slabs and secure the corners with mortar. Lay 3 - 4 course beams on the edge of one side of the porous slabs, creating an air gap between the porous slabs and one side of the bio-digester box.

Plate 34: Covering of filter slabs with net.

13. Connect the influent pipe (in-let) into the Bio-digester; 4" below the top of the digester slab.

14. Add bulking material (sawdust, or coconut fibres or palm kernel fibre) on top of the net. Volume to add should approximate half the volume of a 50kg bag of ordinary cement.

Plate 35: *Adding of bulking material, left: coconut fibre, right: wood chips*

15. Cover the top with concrete slab. Seal completely.

Plate 36: *Placement of top cover slabs*

3.4.5 Installation using sandcrete block/brick (In-situ)

Construct strip foundation

1. Dig out the footings inside the marked area for the strip foundation making them 6 inches deep and 1 foot wide.

2. The dimensions of the strip foundation must be 6 feet 10 inches (length) by 2 feet 10 inches (width) to obtain an internal dimension of 6 feet by 2 feet (i.e. using at least 4 inches sandcrete blocks for instance)
3. Place the sandcrete blocks using 3:1 mortar (3 shovels sand, 1 shovel cement) and filling them with same mortar mix to form the Bio-digester box (Plate 37).

Plate 37: *Blockwork for Bio-digester*

4. The Bio-digester box (standard digester) will be four courses high. Remember the height of the blockwork should be guided by the invert of the influent pipe from the toilet. The influent pipe should enter at a point at least 4 inches below the cover slab.
5. Create an opening at the bottom of the wall of the digester and insert the PVC drainage pipe that will channel effluent out of the digester. The location depends on where the drain field pipe/soak pit will be placed. The hole can also be cut out with a cold chisel.

Plate 38: *Final level of blockwork for Bio-digester*

6. Render/plaster the inside of the blockwork bio-digester box with a very thin coat (0.5 – 1 inch) of 1:3 mortar mix. Be sure to wet the walls with a wet foam before applying the mortar.

Plate 39: *Rendering of inside wall of Bio-digester*

7. Place a layer of mortar inside the box (3 – 4 inches thick); giving it a slope towards the drainage pipe and allow to cure.

8. After the inside screeding is dry, insert and position the concrete beams in the digester.
9. Repeat steps 11 to 14 for the slab digester construction.
10. Cover the top with concrete slab. Seal completely.
11. Render/plaster the outside of the blockwork bio-digester box with a very thin coat (0.5 – 1 inch) of 1:3 mortar mix. Be sure to wet the walls with a wet foam before applying the mortar.

Plate 40: *Blockwork bio-digester before outside rendering*

Details of the material schedule have been provided in Annex E.

3.5 Common mistakes to avoid during installation

- The total drain field pipe length for a standard Bio-digester should be 9 m. Arrangement of installation is dependent on the space available for the drain field but typically laid in series.

Plate 41:
Short drain field pipe less than designed length

- Do not install the drain field pipe on the surface. The drain field pipe should be below the ground level with a cover of at least 8 inches.

Plate 42:
Drain field pipe without adequate soil cover

- The invert of the influent pipe should never be below the two-thirds of the total depth of the bio-digester.

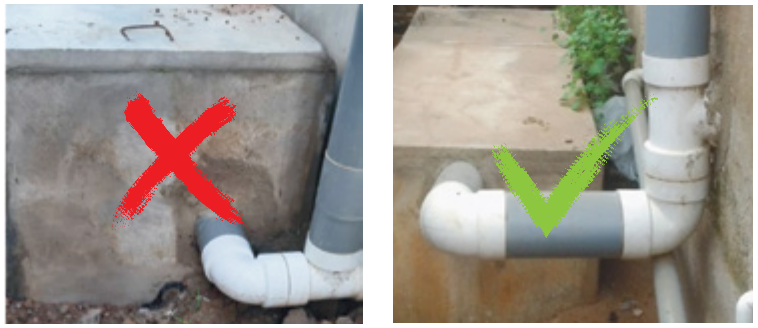


Plate 43:
left: Influent pipe below porous slab, right: Correct position of influent pipe

3.6 Building a privy/toilet room with the Bio-digester

- The privy can be located on top of the bio-digester (using the sato pan or micro-flush seat) or offset from the digester (using the water closet seat or pour-flush seat).
- If there is an existing external structure, a p-trap seat is recommended since a digester cannot be installed under the foundation in this case.
- The privy/toilet room can be constructed with readily available materials such as plaster board, plywood, concrete panels, bricks, sandcrete blocks etc.
- The vent pipe should always go over the roof (at least 500mm above the roof)
- There are many choices for materials as well as designs, a sample of design options are provided below:

Plate 44:
left: Concrete superstructure, middle: blockwork superstructure and far right: alucobond superstructure.

3.6.1 Fitting of pipes and appurtenances

Setting and fixing the toilet seat, U-trap and the drain field

- The toilet seat can be a sato pan (Plate 45), micro flush, ceramic pour-flush seat (Plate 48) and ceramic water closet seat
- The toilet seat (pan) and the U-trap should be fixed in place and set in lean concrete 1:3:5 mix and the floor around the pan carefully screeded and smoothened with 1:3 cement mortar
- Lay the drainpipe connecting the U-trap to the bio-digester. The fall (gradient) on the pipe should be at least 1 in 25
- Apply mortar around the pipe through the digester walls and backfill around the pipe.

Plate 45:
Sample of the sato pan seat

Plate 46:
P-trap seat connection to Bio-digester

Plate 47:
S-trap seat connection in well-drained soil

Plate 48:
S-trap pour flush into Bio-digest

Installation of a vent pipe

Installation of the vent pipe is critical to the operation of bio-digesters. The vent pipe provides an escape route for odorous gases and water vapour to leave the system. This helps to eliminate or significantly reduce the odour that may be in the privy room especially for micro-flush systems. The top of the vent pipe should extend 500mm above the roof and should be covered with fly trap. This is done to prevent flies that gets access to or enter the digester from escaping through the vent pipe.

Plate 49: influent pipe from toilet seat and vent pipe

Installation of Vent Pipe through the exterior wall using 2 – 45° elbows.

1. The vent pipe should be fixed in place vertically and made to go above the roof of the superstructure.
2. The lower end of the vent pipe should be fixed onto a tee on the pipeline connecting the toilet seat to the digester to allow the gases to easily escape through the pipe
3. Drill a hole (3 or 5 inches when using a 2 inch or 4-inch vent pipe respectively) at a 45° angle through the wall where marked in the previous step.
4. Insert a short cut of the pipe through the wall and secure in place with mortar.
5. Insert a swept tee on the end of the pipe in the wall and connect drainpipe into the bio-digester.
6. Measure the distance from the top of the vent pipe opening on the toilet to the roof and connect a pipe against the wall; holding it in place with a wall clip.
7. Insert a 45° elbow on the vertical vent pipe below the roof and shoot a short pipe to direct it horizontally just to the edge of the roof.
8. Insert another 45° elbow and continue the pipe upward.
9. Fix the vent cap with the fly trap at the end of the pipe.

Vent cap with netting on the vent pipe

Joint showing 2 - 45° elbow to offset vent pipe from roof

Clip securing vent pipe to superstructure

Joint where vent pipe connects to digester

Plate 50: Vent pipe through the exterior wall

3.7 Effluent Management for well drained soils

The final effluent from bio-digesters are managed using soakaway/pit, box drain field, pipe drain field and sand filter. The soil absorption capacity should be known prior to the installation of the effluent management option. The most important thing that needs to be considered in constructing a drain field is the permeability of the soil. A drain field should not be located in a poor drainage area. Refer to Annex A for percolation test.

3.7.1 Constructing a soakaway/soak pit

1. Mark out the position of the soakaway/pit as 0.9 m x 0.9 m at a minimum depth of 1.2 m
2. Excavate pit for soakaway/soak pit
3. Level the base of the pit and apply mortar as strip foundation for the blockwork.
4. Line the inside of the pit with layers of 5 inches or 6 inches solid quarry blocks or bricks to form a box.
5. The centre of the base should be left unlined (i.e. no mortar covering) to allow effluent to seep through the base.
6. The first three courses of blockwork or brickwork from the base should have weep holes in the mortar joints for draining effluent through the side walls into the surrounding soil.
7. No weep holes should be left in the subsequent blockwork beyond the first three courses to prevent runoff infiltration.
8. Connect a pipe piece from the digester into the soakaway.
9. Fill in the spaces with mortar around the pipe entering the blockwork.
10. Cover the soakaway with a reinforced cover slab and seal the joints with mortar
11. The soakaway should be at least 3m from any building.

3.7.2 Constructing a Box Drain field

Dig the trench for the box drain field and/or the pipe drain field.

1. The box drain field consists of a box formed from porous slabs with a pipe connection from the bio-digester into the box (Plate 51). It is installed in well-drained soils. It can be combined with a pipe drain field in instances of heavy hydraulic loading.
2. The pipe drain field consists of a series of perforated pipes installed in a trench lined with aggregates.
3. The box drain-field dimensions are 0.6m wide by 1.0m long by 0.6m deep below ground level.
4. The distance from the digester to the box drain-field depends on site conditions.
5. The pipe drain-field for a standard digester is typically 9 m length and should be laid in series. In the case of the micro flush installation, the drain field pipe is 3 m long.

Bio-digester

Plate 51: *Bio-digester connected to a box drain field*

Box drainfield

3.7.3 Constructing a Pipe Drain field

The pipe drain field consists of a series of perforated pipes installed in a trench lined with aggregates. The pipe drain-field for a standard digester is typically 9 m length and should be laid in series. In the case of the micro flush installation, the drain field pipe is 3 m long.

Typical steps for constructing a pipe drain field are as follows;

1. Excavate either a 9m long trench or 2 No. 4.5m long trenches for the drain field depending on the space available.
2. Ensure to tilt the trench downward slightly to prevent pooling of the effluent at the bottom before rising.
3. Each trench should be 0.3m wide and 0.4m deep.
4. Place ¼" chippings along the bottom of the trench to a depth of at most 0.2m.
5. Place the perforated pipe from the digester on the chippings along the trench.

Plate 52: *Laying of perforated pipe on bed of chippings*

6. Fix a clean out between the bio-digester and the drain field pipe. The purpose of the clean out is for checking the condition of the drain field.
7. Fill the trench with more ¼" chippings to cover the pipe entirely.

Plate 53: *covering the perforated pipe with chippings*

8. Drape a cloth over the chippings. The purpose of the cloth is to prevent dirt and sand from clogging the perforations on the pipe.
9. Fill the rest of the trench with soil and compact to ensure it is level with existing ground.

3.7.4 Effluent management methods in poorly drained/waterlogged soils

The final effluent from bio-digesters installed in poor draining soils can be managed using Up flow sand filter with blocks/bricks, Up flow plastic sand filter, artificial filtration bed with perforated PVC pipes and red laterite soil.

A. Procedure for constructing an Up-flow sand filter with Blocks/bricks:

1. Dig out a pit of say, 0.9 m x 0.6 m with a depth of 0.8 m maximum.
2. Line the inside of the pit with two layers of 5 inches or 6 inches solid quarry blocks to form a box.
3. Connect a pipe piece from the digester (inlet pipe) into the box.
4. Connect an overflow pipe opposite to the inlet pipe to the box. The level of the overflow pipe should be lower than the inlet pipe. The outlet pipe can be directed into an open sewer.
5. Fill in the spaces with mortar around the pipe entering the blockwork.
6. Lay thick damp proof "black" rubber inside pit and over the edge of the blocks.
7. Fill with aggregate/coarse sand to prevent frequent clogging.

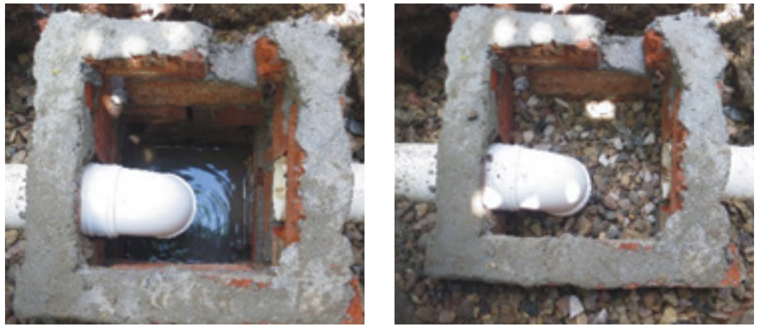


Plate 54: *Traditional up-flow sand filter*

B. Up flow plastic sand filter: This is a commercial unit that is currently being manufactured and supplied by Duraplast Ghana.

1. These are prefabricated sand filters using plastic material
2. This filter is partitioned into two sections with the base of the partition wall perforated to allow effluent to move from one section to the other through the base.
3. The section one contains media made from coarse sand and/or gravels while the section two contains fine sand
4. Effluent moves down the section one and climbs up into the second chamber, thus the term Upflow sand filter.
5. The effluent is cleaned through the action of sedimentation and filtration before it is piped into an open sewer.

Plate 55:
up flow sand filter

3.8 Seeding of bio-digester

Seeding is the addition of biological inoculum/substance to trigger accelerated decomposition of faecal matter in the bio-digester.
It involves the addition of active micro or macro-organisms to a new bio-digester.
Different seeding options are available on the market. These include;

- Macro-organisms, mostly earthworms with humus
- Cultured enzymes/bacteria products

This manual focuses on the use of macro-organisms, mainly local earthworms (Eudrilus eugeniae popularly known as African Nightcrawler) with humus/biosolids for seeding or Eisenia fetida.

3.8.1 Procedure for seeding the biodigester with worms and humus

1. After Bio-digester installation, inform user to notify you 1 - 2 weeks after start of use of facility. This allows the faeces to stabilise before worms can start acting on first set of substrates. Worms do not feed on "fresh" faeces.
2. Apply worms (50 – 100 No.) per Bio-digester with 500 grams of humus at start-up. The humus acts as an initial bedding material for the worms.
3. Gently drop worms with humus into the bio-digester away from the point of discharge of the faecal matter. Worms always migrate to the feed substrate.

Plate 56:
Earthworms used for seeding

3.8.2 When to seed

1. Seeding generally is recommended as a start-up practice, within two weeks of use.
2. Re-seed the bio-digester when submerged fully with water over a week after

resolving a drainage problem.

3. Re-seed the bio-digester when after a long period of use, you observe flies hovering around the vent (See chapter 4).

3.9 Handwashing Facilities

The provision of water for washing is an important selling point for new sanitation technologies in urban slums.

Figure 3: *Micro flush seat with handwashing facility*

Figure 4: *Full flush seat with handwashing basin*

CHAPTER 4

4 OPERATIONS AND MAINTENANCE

The requirements for operation and maintenance of the bio-digester is minimal and can be handled by users.

4.1 Anal cleansing material

- The only acceptable anal cleansing material to be used should be soft tissue paper.
- The flushing of cement paper, newspaper, corn cobs, sanitary pads, condoms into the bio-digester can cause it to fill-up faster.
- Tissue paper for anal cleansing can be flushed into the bio-digester.

4.2 Household cleaning agents

- Household cleaning agents like bleach, and other antiseptics and bar soap can be used and should only target the toilet seat to kill germs and other microbes. Application should be as indicated on labels e.g. 20 mL (i.e. cup of bottle) to 15 litres of water for cleaning.
- Cleaning agents such as bar soap, powdered soap, liquid soap, bleaches and other antiseptics with pH ranges between 6 -11 can be used.
- Water should be used to rinse the seat after cleaning. The rinsing and flushing with water dilute the concentration of the active ingredients in these cleaning reagents there by lowering their effect on the performance of the bio-digester.

- The efficiency and effectiveness of the bio-digester could be compromised if a user deliberately or accidentally pours the concentrated chemicals agents through the toilet bowl.

4.3 Check-ups and monitoring

- It is recommended that major maintenance practices should be done at least once every year to ascertain the state of the bio-digester.
- Routine inspection should be done to determine the level of accumulated sludge, structural defect among other things. It is recommended that a professional is contacted to carry out the system inspection and if necessary, the maintenance of the system.
- Inspection should be done by carefully opening the cover slab after which, the cover slab should be fitted back and all spaces covered with mortar. A cleanout should be fixed on the cover slab for easy access and inspection.

cleanout on cover slab

Plate 57: *Cleanout on the cover slap for easy access*

- Call a certified bio-digester service provider for servicing if submerged with water.
- On a weekly basis, open the cleanout on the bio-digester to see if water is retained in the digester especially during the rainy seasons.

Cleanout installed on buried drain field

Plate 58: *cleanout for inspection of buried drain field*

4.4 How to Resolve Full Digesters

The bio-digester may malfunction when not properly used or maintained. The bio-digester should be allowed to fallow for at least 3 days before servicing.

Over Usage

- A standard bio-digester is designed to accommodate a maximum of;
  - 10 users when operated as a full flush unit and
  - 15 users when operated as a micro-flush.
- Over usage therefore occurs when said number of users is exceeded for a particular design.
- The failure of microbes to completely consume excreta fed into the digester due to the introduction of more excreta in the bio-digester than the required

amount will lead to accumulation.

- Excess faeces accumulation in the digester will result in it filling quicker and overflowing into the drain field.

Remedy

- Construct additional bio-digester to share the load between the two bio-digesters.

Accumulation of non-biodegradable solids

- Non-biodegradable solids listed below should NEVER be flushed into the bio-digester:
    - sand particles,
    - stones,
    - plastics,
    - sanitary pads,
    - condoms,
    - disposable diapers,
    - towels,
    - rags,
    - panties etc.
- These solids cannot degrade and accumulates inside the bio-digester leading to the rapid filling of the bio-digester.

Remedy

- Place a user guide of things not to use in the bio-digesters to educate users on their proper usage.

SAMPLE TOILET USER GUIDE

Microbial Decay

- Microbial decay may occur when harmful chemicals are flushed into the bio-digester causing the death of microorganisms.
- The following chemicals should not be flushed into the digester: oil and grease, fuel, paint solvents, drain cleaners, floor cleaners, toilet bowl cleaners, waxes, polishes, coating or strippers etc.
- However, the use of small amount of toilet cleaners is permissible.
- The use of these chemicals should be targeted at only cleaning the toilet seat after which it is flushed with excess amount of water to minimise its effect on microbes.

Remedy

- Users should be educated to avoid the introduction of hazardous and concentrated chemicals into the bio-digester.

4.5 How to Detect A Malfunctioning Bio-digester

The following could be detected when a bio-digester malfunctions:

- Odour around the immediate environment of the bio-digester.
- Flies hovering around the mouth of the vent pipe.
- drain field pipe submerged with water (implies drain field is not draining well) and/or faeces (implies porous filter is clogged) overflowing through air gap into drain field pipe.

Plate 59: *Cleanout on drain field with water/ faeces*

- Wet spots on the walls of the bio-digester and immediate surrounding

Plate 60: *Wet spot on walls and around digester*

- Gurgling sounds in the plumbing system.
- Slow draining fixtures and submerged Bio-digester.

Plate 61: *Ponding in bio-digeste*

- Backflow of water into the toilet seat.
- Overflowing sewage or excreta from the bio-digester.

Insect control

- The presence of insects in and around your bio-digester is usually an indication of excess moisture. If there is excess moisture you will need to remedy this situation to be able to completely remove the insects from your toilet.

Remedy

- Use appropriate bulking material and/or replace bulking material.
- Check and make sure the drain field pipe is working well
- Re-seed the bio-digester

4.6 Dos and Don’ts of a Bio-digester

To extend the life of your bio-digester, the following dos and don’ts should be followed:

4.6.1 Dos

1. **Inspect your system every year** - The system is expected to be inspected by a professional every year to access its state and its functionality.

2. **Practice water conservation** -The less wastewater you produce, the less strain on your system. By reducing your water use, you can extend the life of your soakaway and decrease the possibility of system failure.

3. **Check with a certified installer** for help when faced with problems.

4. **Flushing your tissue paper** into the bio-digester helps with decomposition.

4.6.2 Don’ts

1. **Don’t put the following into your system:**
   - Fats or grease
   - Motor oils or fuels
   - Disposable diapers
   - Coffee grounds, eggshells, nut shells
   - Sanitary napkins, tampons or condoms
   - Paper towels or rags
   - Paints or chemicals

2. **Don’t poison your bio-digester -** Drain cleaners, floor cleaners, toilet bowl cleaners, paints solvents, waxes, polishes, coating or strippers may be harmful to microbes in the system and also contaminate ground or surface water as well. Therefore, avoid if possible, putting harsh chemicals into digesters.

3. **Don't add foreign materials into the system -** If garbage is added into the system, more frequent desludging of the digester will be required.

4. **Do not add grey water to the system-** Separate your bath, laundry and kitchen wastewater from the bio-digester.

5. **Keep all runoff away from your system -** Water from roofs, drains, and roads will flood the system and cause spillage.

4.7 How to service the digester

Under optimal conditions and operations, a bio-digester could be full after twenty (20) years. This projection was determined based on the use of the very first installation. By 10 years the bio-digester had sludge build up to half the depth from the cover slab to the porous filter. However, due to abuse (i.e. over-use) which compromises the bio-digester, it could get full before its normal period.

Plate 62:
left: Inside of failed bio-digester, right: inside of a well-functioning bio-digester

Before servicing, the bio-digester should be left fallow for at least 3 days.

Procedure for serving the digester:

1. Wear protective equipment such as gloves, nose mask, safety boot;
2. Place sheet of plastic in front of the toilet (should be firm to prevent breaking with the load);
3. Open cover slab (seek expert advice before opening);
4. Plug the inlet pipe with a 4 inches end cap to ensure there is no flush into the bio-digester (Ideally, tape the seat cover to prevent use during servicing)
5. Make sure all water is drained in the bio-digester;
6. Use a shovel to scoop 90% of the sludge into the garbage bag without breaking the mesh lining on the porous slab
7. Decompose it for compost with other organic kitchen waste or burry it around ornamental trees and plants and cover it with a minimum of 6" topsoil.
8. Check whether any compost material has spilled around the toilet. If this is the case, while wearing rubber gloves, clean up the spilled material and empty it back into the bio-digester
9. Fold up the plastic sheet and dispose appropriately.

4.8 Common Problems with the Bio-Digester

Problem	Solution
Clogging of porous filter	Replace porous concrete
Blockage of effluent lines	Removal of unwanted substances from effluent lines by rodding
Flooding of soak pit	Fix an extended pipe drainfield as an outlet on the soak pit

4.9 Frequently Asked Questions (FAQs)

- **What is the average volume of water that can be flushed a day so that the bio-digester will not be compromised?** – The Bio-digester can receive as many flushes as can be used by 10 users in a day provided the drain field is installed properly and the soil is well-drained.

- **Can bio-digesters be used as dry toilets as in the case of KVIPs?** – No. The Bio-digester has macro-organisms/microbes, which require some amount of moisture to thrive and effectively degrade the substrate. In addition, the water seal act as a barrier to prevent odour and macro-organism coming out of the digester.

- **Can grey water be connected to the bio-digester?** – No. The drain field is designed for flushes for at least 10 users per day. Additional hydraulic loading from the baths, laundry, kitchen (with oils for instance) can cause frequent flooding of the digester.

- **What happens when bio-digester is full and how should one desludge?** – A detailed procedure has been outlined in the section "what to do when Bio-digester is full"

- **What is the desludging frequency of the bio-digester?** – The Bio-digester has been designed not to be desludged (e.g. Using cesspit emptiers). When the Bio-digester is properly installed and used, the rate of fill is negligible. Unless it is abused, it is anticipated to fill up between 3 – 5 yrs. Otherwise a projection of 10-20 years has been proposed based on the performance of the oldest installation.

- **Is it only households that use the bio-digester?** – No, the Bio-digester can also be used by institutions such as schools and offices. In this case the digester is designed based on the expected number of users (e.g. multiple or bigger Bio-digesters are proposed).

- **Can anal cleansing material be flushed into the bio-digester?** – Yes. Soft tissue paper can be flushed into the Bio-digester as it acts as a source of carbon which is crucial for biodegradation of organic waste. Remember to adhere to the recommended list of anal cleansing material specified in the manual.

- **What is the life span of the bio-digester?** – The life span of the Bio-digester depends on the functionality of the drain field and adhering to the number of users per a particular size configuration. Once these are observed, the Bio-digester should last up to 10 years for the filter replacement and up to 20 years for the lifespan of concrete products.

ANNEXES 5

ANNEX A: PERCOLATION TEST

1. Dig at least six test holes. The holes should have the following characteristics:
   - Evenly spaced, approximately 30-40 feet apart, but not less than 30 feet, in the area to have the digester installed.
   - At least six inches in diameter.
   - At least 24 inches in depth.
   - No closer than 75 feet to the nearest water well or proposed water well.
   - Not closer to a 48-inch test hole.
   - No closer than 20 feet to any building.
   - Not located in any flood plain area.

2. Dig a 48-inch test hole in the lowest part of the test area.

3. The bottom and sides of each of the 24-inch test hole should be roughened with a saw blade, knife, or other sharp instrument.

4. All loose soil from the bottom of the holes should be removed.

5. Fill each of the 24-inch test holes with water and refill as necessary to maintain a minimum depth of 12 inches for a period of at least four hours. This is the pre-soak. The pre-soaking must be conducted between 12 noon and 4 o'clock p.m. the day before the test. Note: DO NOT put any water in the 48-inch test hole.

The following steps should follow the previous steps described above.

6. In advance of the test one wooden stick for each 24-inch test hole is prepared as follows: Pound three nails into each stick. The first nail should be three inches from the bottom of the stick, the second nail six inches above the first nail, and the third nail is 20 inches above the second nail.

7. On the morning of the percolation test (i.e. the day following the pre-soak), the test holes should be cleaned out of any loose soil or silt that accumulates at the bottom of the holes during the pre-soak. Drive each of the prepared sticks through the 6 inches test holes such that the first nail rests on the bottom and the stick stands by itself.
8. Fill each test hole with water to the level of the second nail on the test stick (which should be exactly six inches). After one hour, measure how far the water has dropped in each test hole. Refill the holes with water to the level of the second nail. This process should be repeated for at least three more hours. Note: In very porous soils, the water in the test holes may seep away in less than an hour. When this happens, we may go to half-hour or even ten-minute readings. A test may also be extended to five or more hours if the last three readings are inconsistent.

ANNEX B: CONSTRUCTION PROCESS OF THE BIO-DIGESTER COMPONENTS

Table 6: *Construction of Bio-digesters wall slabs*

ITEM:	1.8 m x 0.6m **Wall Slab**	
QUANTITY:	2	
MATERIALS REQUIRED:	**TOOLS REQUIRED:**	**UNIT PROCESS:**
» 2"x 2" hard wood » 1" x 4" hard wood » ¾ plywood » 3" Nails » Wire mesh » ¼ iron rod » Binding wire » Cement » Sand » Water	» Measuring tape » Carpentry square » Hammer » Handsaws » Spirit Level » Shovel » Trowel and wooden floats » Head pan	» A 1800x600mm wood formwork is formed with the base made of ¾ plywood and the wall of 2" x 2" hard wood » 4No. 1750mm long ¼ iron rod is then laid on the wire mesh horizontally and another 4No. 580mm long ¼ iron rod is laid across them, each with 100mm intervals » Another 1750 x580mm wire mesh is then laid on top of the iron roods » A concrete mixture of sand, aggregate, cement and water ratio of 3:1:1:2 is then poured in the formwork and compacted and allowed to cure for 3days.

ITEM:	0.6m x 0.6m **Wall Slab**	
MATERIALS REQUIRED:	**TOOLS REQUIRED:**	**UNIT PROCESS:**
» 2"x 2" hard wood » 1" x 4" hard wood » ¾ plywood » 3" Nails » Wire mesh » ¼ iron rod » Binding wire » Cement » Sand » Water	» Measuring tape » Carpentry square » Hammer » Handsaws » Spirit Level » Shovel » Trowel and wooden floats » Head pan	» A 600x600mm wood formwork is formed with the base made of ¾ plywood and the wall of 2"x 2" hard wood » 4No. 580mm long ¼ iron rod is then laid on the wire mesh horizontally and another 4No. 580mm long ¼ iron rod is laid across them, each with 100mm intervals » Another 580 x580mm wire mesh is then laid on top of the iron roods » A concrete mixture of sand, aggregate, cement and water ratio of 3:1:1:2 is then poured in the formwork and compacted and allowed to cure for 3days.

The cover slab is divided into two components. Cover slab 1 has dimension 1200x600mm while cover slab 2 has 600x600mm as the dimension. The table below describes the material and tools required and the process of constructing the cover slab.

Table 7: *Construction of Bio-digesters wall slabs*

ITEM:	1.2m x 0.6m **Cover Slab 1**	
QUANTITY:	1	
MATERIALS REQUIRED:	**TOOLS REQUIRED:**	**UNIT PROCESS:**
» 2"x 2" hard wood » 1" x 4" hard wood » ¾ plywood » 3" Nails » Wire mesh » ¼ iron rod » Binding wire » Cement » Sand » Water	» Measuring tape » Carpentry square » Hammer » Handsaws » Spirit Level » Shovel » Trowel and wooden floats » Head pan	» A 1200x600mm wood formwork is formed with the base made of ¾ plywood and the wall of 2" x 2" hard wood » 4No. 1150mm long ¼ iron rod is then laid on the wire mesh horizontally and another 4No. 580mm long ¼ iron rod is laid across them, each with 100mm intervals » Another 1150 x580mm wire mesh is then laid on top of the iron roods » A concrete mixture of sand, aggregate, cement and water ratio of 3:1:1:2 is then poured in the formwork and compacted and allowed to cure for 3days.

ITEM:	600X600mm **Cover slab**	
MATERIALS REQUIRED:	**TOOLS REQUIRED:**	**UNIT PROCESS:**
» 2"x 2" hard wood » 1" x 4" hard wood » ¾ plywood » 3" Nails » Wire mesh » ¼ iron rod » Binding wire » Cement » Sand » Water	» Measuring tape » Carpentry square » Hammer » Handsaws » Spirit Level » Shovel » Trowel and wooden floats » Head pan	» A 600x600mm wood formwork is formed with the base made of ¾ plywood and the wall of 2"x 2" hard wood » 4No. 580mm long ¼ iron rod is then laid on the wire mesh horizontally and another 4No. 580mm long ¼ iron rod is laid across them, each with 100mm intervals » Another 580 x580mm wire mesh is then laid on top of the iron roods » A concrete mixture of sand, aggregate,

		cement and water ratio of 3:1:1:2 is then poured in the formwork and compacted and allowed to cure for 3days.

Table 8: Construction of Porous Slabs and Beams

ITEM:	580x580x50mm **Porous Slab**	
QUANTITY:	2	
MATERIALS REQUIRED:	**TOOLS REQUIRED:**	**UNIT PROCESS:**
» 2"x 2" hard wood » 3" Nails » Wire mesh » Cement » Coarse aggregate » Sand » Water	» Measuring tape » Carpentry square » Hammer » Handsaws » Spirit Level » Shovel » Trowel and wooden floats » Head pan	» A 580x580mm wood formwork is formed with 2"x 2" hard wood » A 530x530mm wire mesh is then placed in the formwork. » A concrete mixture of Coarse aggregate, Small aggregate, Cement, Water ratio of 2:1:1:0.3 is then mixed and poured into the formwork. » The concrete is then compacted and allowed to cure for 3 days

ITEM:	290x580x50mm **Porous slab**	
MATERIALS REQUIRED:	**TOOLS REQUIRED:**	**UNIT PROCESS:**
» 2"x 2" hard wood » 3" Nails » Wire mesh » Cement » Coarse aggregate » Sand » Water	» Measuring tape » Carpentry square » Hammer » Handsaws » Spirit Level » Shovel » Trowel and wooden floats » Head pan	» 290x580mm wood formwork is formed with 2"x 2" hard wood » A 240x530mm wire mesh is then placed in the formwork. » A concrete mixture of Coarse aggregate, Small aggregate, Cement, Water ratio of 2:1:1:0.3 is then mixed and poured into the formwork. » The concrete is then compacted and allowed to cure for 3 days

ITEM:	100x580x75mm **Porous Beam**	
QUANTITY:	8	
MATERIALS REQUIRED:	**TOOLS REQUIRED:**	**UNIT PROCESS:**
» 2"x 2" hard wood » 3" Nails » Wire mesh » Cement » Coarse aggregate » Sand » Water	» Measuring tape » Carpentry square » Hammer » Handsaws » Spirit Level » Shovel » Trowel and wooden loats » Head pan	» A 100x580mm wood formwork is formed with 2"x 2" hard wood » A 70x530mm wire mesh is then placed in the formwork. » A concrete mixture of Coarse aggregate, Small aggregate, Cement, Water ratio of 2:1:1:0.3 is then mixed and poured into the formwork. » The concrete is then compacted and allowed to cure for 3 days

ITEM:	100x580x75mm **Concrete Beam**	
	4	
MATERIALS REQUIRED:	**TOOLS REQUIRED:**	**UNIT PROCESS:**
» 1" x 4" hard wood » ¾ plywood » 3" Nails » Wire mesh » ¼ iron rod » Binding wire » Cement » Sand » Water	» Measuring tape » Carpentry square » Hammer » Handsaws » Spirit Level » Shovel » Trowel and wooden floats » Head pan	» A 100x580mm wood formwork is formed with the base made of ¾ plywood and the wall of 1" x 4" hard wood » A concrete mixture of sand, aggregate, cement and water ratio of 3:1:1:2 is then poured in the formwork and compacted » The concrete is then allowed to cure for 3days.

ANNEX C: ESTIMATES FOR CONSTRUCTION AND INSTALLATION OF PRE-CAST BIO-DIGESTERS

5.3.1 Production costs

Table 9: *Quantities for production formwork*

s/n	Description	Unit	Qty	Rate	Amount
	Production				
1	3/4" plywood	No	6		
2	2 x 2 hardwood	No	8		
3	1" angle iron	No	3		
4	11/2" angle iron	No	3		
5	Carpet	GHS/m2	17.5		

Table 10: *Quantities for Slab Production*

s/n	Description	Unit	Qty	Rate	Amount
1	Basin	No	1		
2	3/4" clip (wash-hand basin)	No	2		
3	3/4" elbow	No	6		
4	3/4" pipe	No	1		
5	Toilet seat	No	1		
6	Fixing (Plumber)	man-day	1		

5.3.2 Installation costs

Table 11: *Quantities for toilet seat and hand wash basin*

s/n	Description	Unit	Qty	Rate	Amount
1	Basin	No	1		
2	3/4" clip (wash-hand basin)	No	2		
3	3/4" elbow	No	6		
4	3/4" pipe	No	1		
5	Toilet seat	No	1		
6	Fixing (Plumber)	man-day	1		

Table 12: *Quantities for Vent Pipe Installation*

s/n	Description	Unit	Qty	Rate	Amount
1	4" pipe	No	1		
2	4" elbow	No	2		
3	Vent cap	No	1		
4	4" clip	No	1		

Table 13: *Quantities for Drain Field Pipe Installation*

s/n	Description	Unit	Qty	Rate	Amount
1	1/4" chipping	m3	0.144		
2	4" pipes for drain field	No	3		
3	4" bends	No	4		
4	Swept tee	No	1		
5	Cleanout	No	1		

Table 14: *Quantities for other installation materials*

s/n	Description	Unit	Qty	Rate	Amount
1	Cement	bag	1		
2	Sand	m3	0.072		
3	Bulking material	Cement bag	0.5		
4	Seeding material	Item			

5.3.3 Other Costs

Table 15: *Quantities for support and other costs*

s/n	Description	Unit	Qty	Rate	Amount
1	Workmanship	man-day	1		
2	Miscellaneous	item	2		
3	Material delivery	Trip	6		
4	Purchase of materials	item	1		
5	Margins (staff support, electricity, water etc.)	%	1		
6	Maintenance		1		
7	Seeding				
8	Site inspection				

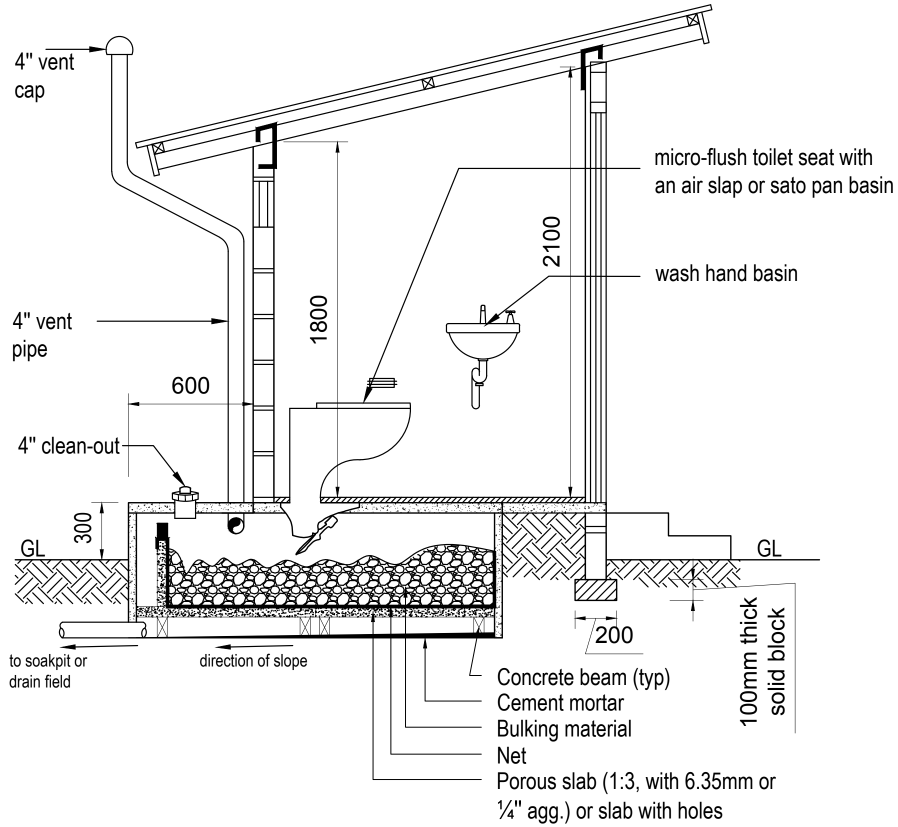
ANNEX D: ESTIMATES FOR CONSTRUCTION OF IN-SITU SANDCRETE BLOCK BIO-DIGESTER

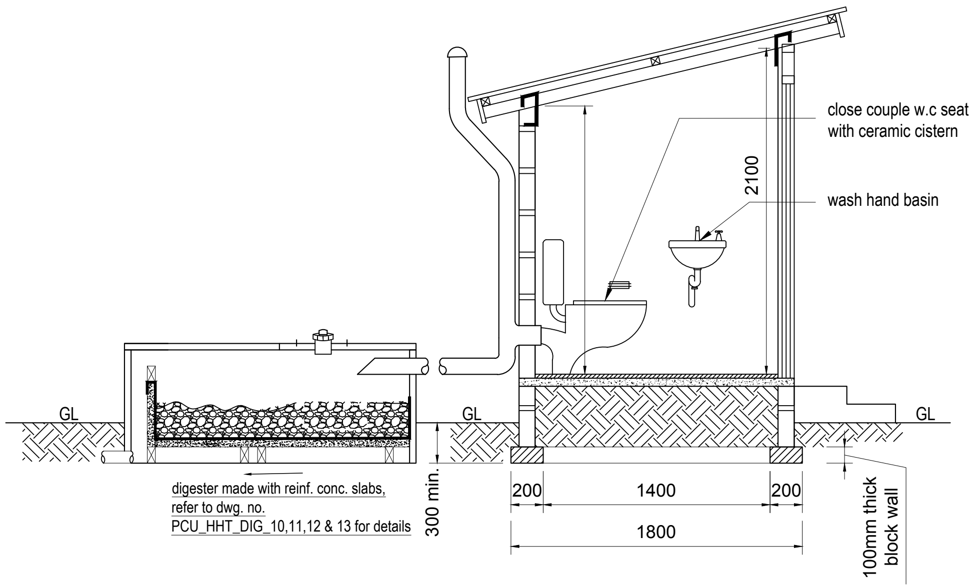
s/n	Description	Unit	Qty	Rate	Amount
	Cover slab & Porous slab production only				
1	Chicken mesh	m2	2		
2	3/8" rebar	No	1.5		
3	Cement	bag	0.5		
4	Sand	m3	0.03		
5	Aggregate	m3	0.04		
6	Labour for casting	man-day	1		
	INSTALLATION MATERIAL				
A	Handwash Basin & seat				
1	Basin	No	1		
2	3/4" clip (wash-hand basin)	No	2		
3	3/4" elbow	No	6		
4	3/4" pipe	No	1		
5	Toilet seat	No	1		
6	Fixing (Plumber)	man-day	1		

s/n	Description	Unit	Qty	Rate	Amount
B	Vent Pipe				
1	4" pipe	No	1		
2	4" elbow	No	2		
3	Vent cap	No	1		
4	4" clip	No	1		
C	Drain field construction				
1	1/4" chipping	m3	0.144		
2	4" pipes for drain field	No	3		
3	4" bends	No	4		
4	Swept tee	o	1		
5	Cleanout	No	1		

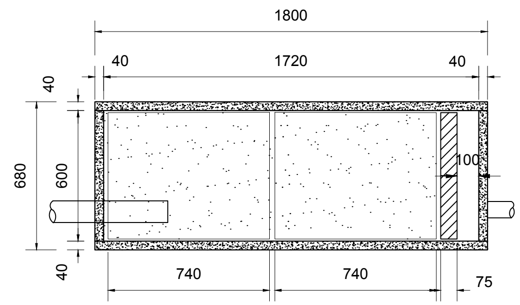
s/n	Description	Unit	Qty	Rate	Amount
	INSTALLATION MATERIAL				
	In Situ construction (Excavation, Block laying, rendering, screeding)				
1	5 inches sandcrete blocks	No	40		
2	Cement	bag	3.5		
3	Sand	m3	0.55		
4	1/4" chipping	m3	0.28		
5	Excavation for strip foundation	man-hr	0.2		
6	Workmanship for block laying	man-day	1		
7	Workmanship for rendering& screeding	man-day	1		
F	Other cost				
1	Maintenance	Item			
2	Seeding	Item			
3	Site inspection	Item			
4	Purchase of materials	item			
5	Bulking material	Item			

ANNEX E: TECHNICAL DRAWINGS

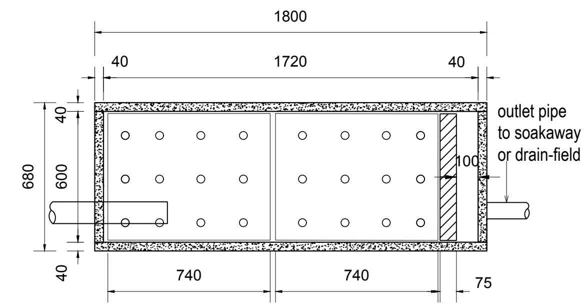




REINF. CONCRETE SLAB DIGESTER - ORIENTATION 1

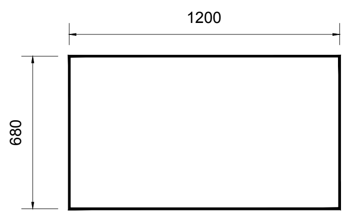


Digester made with reinf. conc. slabs and porous slabs
Bulking material not shown for clarity



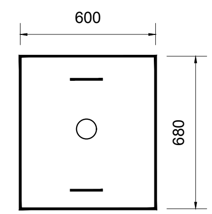
Digester made with reinf. conc. slabs and slabs with holes
Bulking material not shown for clarity

TOP SLABS



Top cover slab type 1 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4

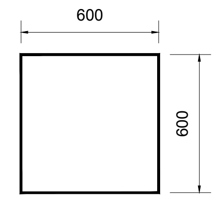
Qty. 1no.



Top cover slab type 2 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4, clean-out and handle fix in.

Qty. 1no.

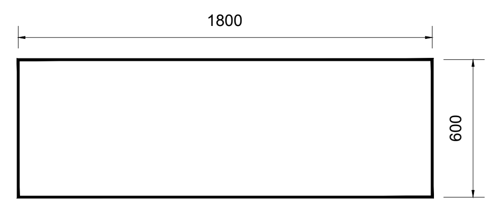
SIDE/WALL SLABS (Type 2)



Side wall slab type 2 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4

Qty. 2no.

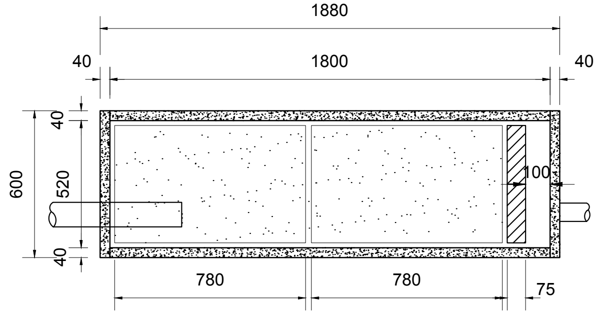
SIDE/WALL SLABS (Type 1)



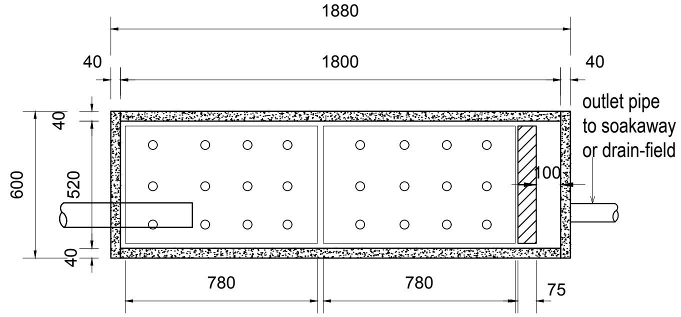
Side wall slab type 1 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4

Qty. 2no.

REINF. CONCRETE SLAB DIGESTER - ORIENTATION 2

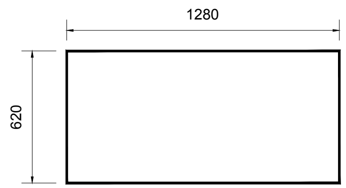


Digester made with reinf. conc. slabs and porous slabs
Bulking material not shown for clarity



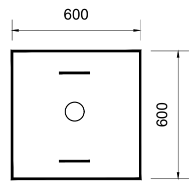
Digester made with reinf. conc. slabs and slabs with holes
Bulking material not shown for clarity

TOP SLABS



Top cover slab type 1 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4

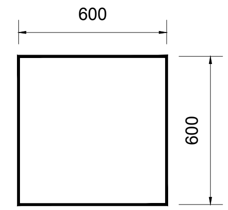
Qty. 1no.



Top cover slab type 2 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4, clean-out and handle fix in.

Qty. 1no.

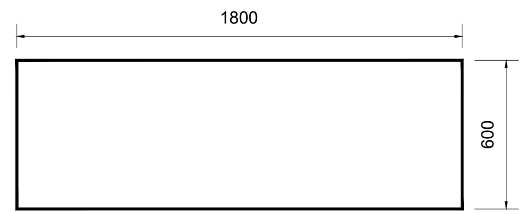
SIDE/WALL SLABS (Type 2)



Side wall slab type 2 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4

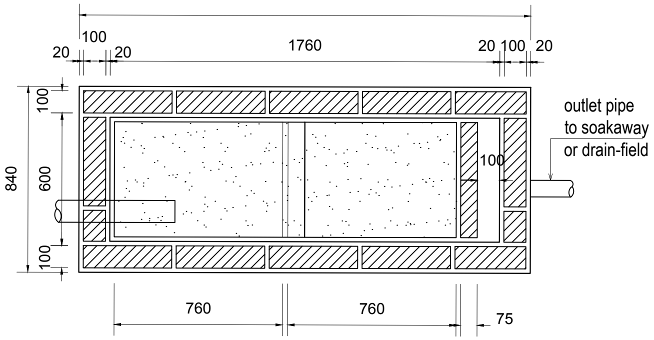
Qty. 2no.

SIDE/WALL SLABS (Type 1)

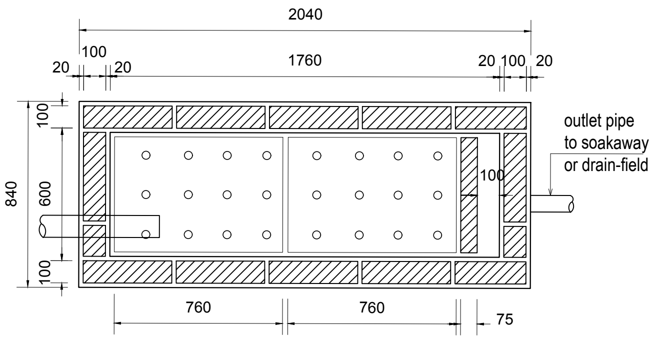


Side wall slab type 1 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4

Qty. 2no.

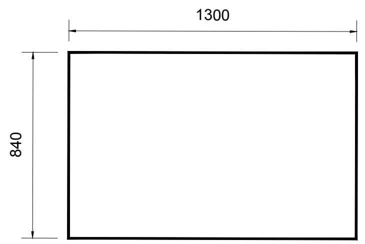


Digester made with 100mm solid blocks and porous slabs
Bulking material not shown for clarity



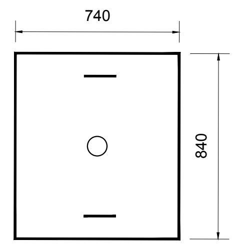
Digester made with 100mm solid blocks and slabs with holes
Bulking material not shown for clarity

TOP SLABS



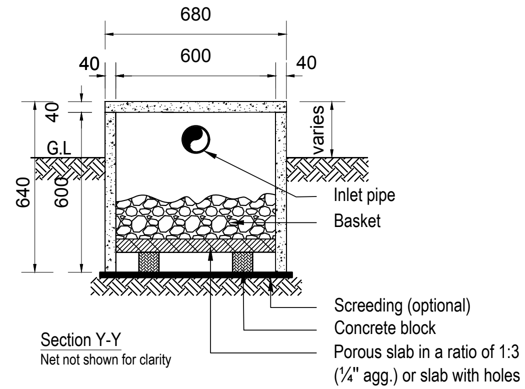
Top cover slab type 1 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4

Qty. 1no.

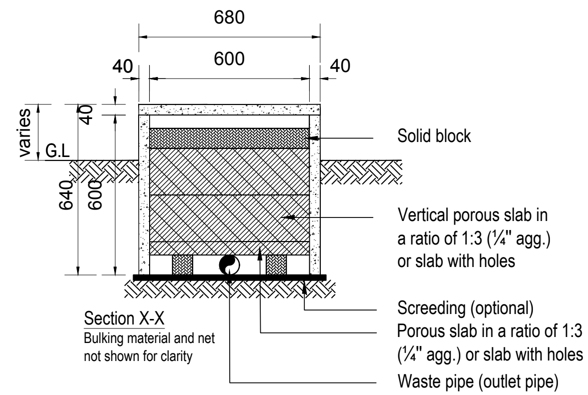


Top cover slab type 2 with 8mm reinf. rod of 100mm intervals at each way, laid on a 25mm x 25mm welded wire mesh with a thickness of 40mm concrete in a mix ratio of 1:2:4, clean-out and handle fix in.

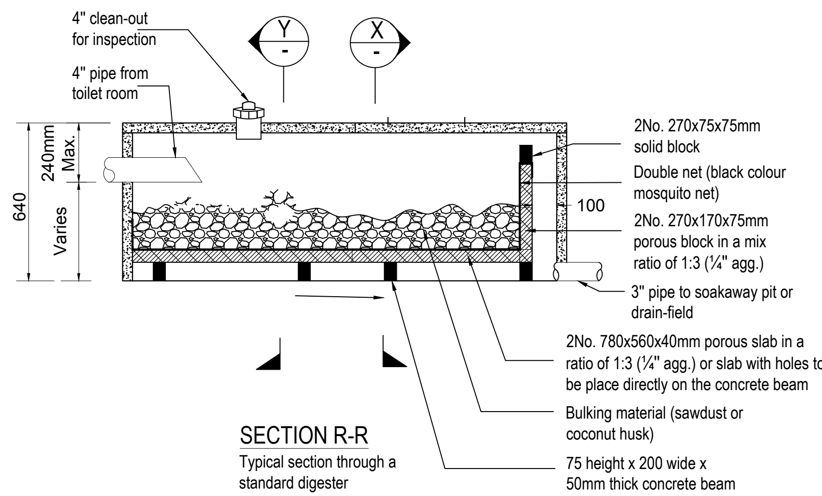
Qty. 1no.



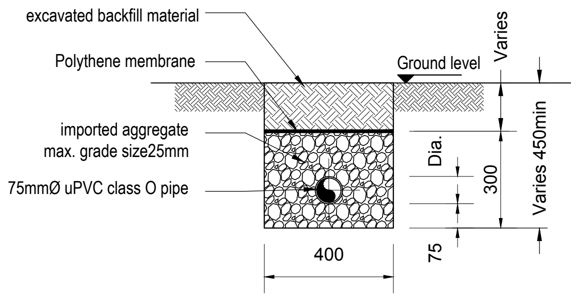
Section Y-Y
Net not shown for clarity



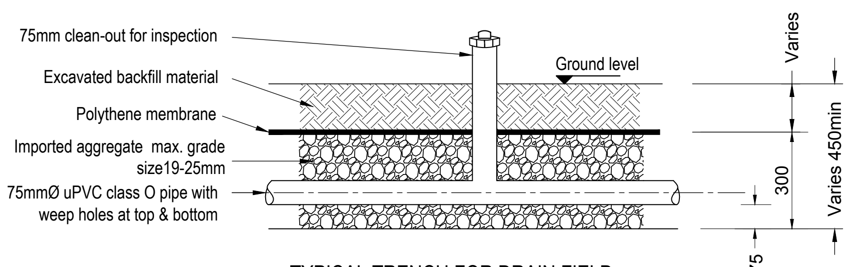
Section X-X
Bulking material and net not shown for clarity



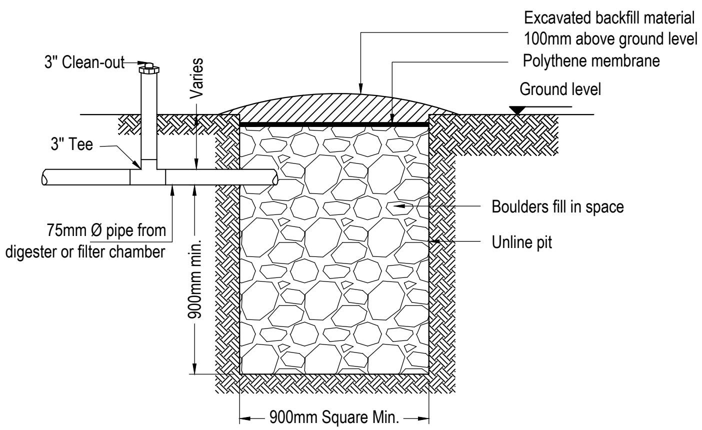
SECTION R-R
Typical section through a standard digester



TYPICAL TRENCH FOR DRAIN FIELD
1:20



TYPICAL TRENCH FOR DRAIN FIELD
1:20



UNLINED SOAKPIT

ANNEX F: CONVERSION FACTORS

METRIC LENGTH CONVERSIONS					
1 centimetre	=	10 millimetres	1 cm	=	10 mm
1 decimetre	=	10 centimetres	1 dm	=	10 cm
1 metre	=	100 centimetres	1 m	=	100 cm
1 metre	=	10 decimetres	1 m	=	10 dm
1 inch	=	2.54 centimetres	1″	=	2.54 cm
1 centimetre	=	0.39 inches	1 cm	=	0.39″
1 foot	=	0.304 meters	1′	=	0.308 m
1 metre	=	3.28 feet	1 m	=	3.28′
1 foot	=	12 inches	1′	=	12″
1 inch	=	0.083 foot	1″	=	0.083′

ANNEX G: RECOMMENDED SLAB STRENGTH

Description	Concrete Mix (Cement: Sand: Aggregate)	Compressive strength
This is a **low-strength concrete** mix and is suitable for house foundations that are not reinforced, and for boundary walls and freestanding retaining walls.	1:4:4	15 N/mm2
This is a **medium strength concrete** and is suitable for reinforced foundations, light-duty house floors, patio slabs, footpaths, steps, driveways and garage floors.	1:3:3	25 N/mm2
This is a **high strength concrete** and is suitable for suspended structural beams, pre-cast beams and flagstones, heavy-duty workshop floors and suspended reinforced floors.	1:2:2	30 N/mm2

ANNEX H: STAKEHOLDERS ENGAGED

Name	Organisation	Position
Samuel A. Sarpong	CONIWAS	Programme Officer
Florence S. Kuukyi	AMA	Director, Metro
Alfred Amoako	Colan Consult	Civil Engineer
A. TED Y. Annang	IESS, University of Ghana, Legon	Senior Research Fellow
Emefa Arko	CPES	R & D Manager
Darimani Ibrahim	AMA	Assistant Engineer
Gabriel Mensah	NVTI	H.O. D. Masonry
Richard Dugah	Colan Consult	Wash Engineer
Joana Juliet Appiah	JANAP Limited	Managing Director
Michael Anim Aban	TREND	Project Manager
Angela Hayford	CWSA	WSE
Donald Neequaye	CWSA	Intern
Rose Boahemaa Pinko	Macksams	Engineer
Graham Sarbah	AMA	Coordinator
Kobina Mensah Afful	UNICEF	Consultant, MRP
Bertha Essel	TMA	Project Coordinator
Harold Esseku	World Bank	Representative
Bernard Quarshie	CONIWAS	Contractor
Michael Akumfi-Ameyaw	AdMA	Project Coordinator
Charles Damtse	GCMA	Project Coordinator
Clement Gyato	Okrugyato Enterprise Ltd	General Manager

Name	Organisation	Position
Patience Akasreku	WGMA	Project Coordinator
Bridget S. Diapim	ABCMA	MEHO
Francis Xavier Anowie	Global Communities	Engineer
Fred Blessed Dumasi	GSMA	MEHO
Olivia Mariama Braimah	ANMA	MEHO
Harriet Krakwe	ABNMA	MEHO
Benjamin A. Offei	PCU	Assistant Engineer
Raymond Odai	TMA	Field Engineer
Josiane Nikiema	IWNI	Senior Researcher
Helen Essandoh	Dept of Civil Eng. KNUST	Senior Lecturer
Kwame Attua	Mas Premium	Project Coordinator
Charles Zuttah	COMSANS	Operations Manager
Gilbert M. Atta-Boakye		Coach
Rachel Anti	PCU	Assistant Engineer
Francis Kwakye	NVTI	Snr. Training Officer
John K. Armah	COMSANS	Contractor
Ayitey Nii Theophilus	LadMA/LekMA	Assistant Engineer
Rebecca Efua Oppong	Ghana Standards Authority	Asst. Standards Officers
Emmanuel Obeng	Ghana Standards Authority	Scientific Officer
Roland Aputiik	KKMA	Project Manager
Ebenezer Teye Korda	PCU	Assistant Engineer
Mensah Philip	Sebcom Prestige	Supervisor
Richard Ben Debrah	LadMA	Head of Works
Dieudenne Agudah	LeKMA	Service Provider
Samuel Daitey-Aquie	Acquie Co. Ltd	Managing Director

Name	Organisation	Position
Anthony Mensah	MSWR	Director EHSD
Jacob Sepenor	KKMA	MEHO
Cyril Ohene	Attachy/CNL	Civil Engineer
Mercy Mensah	GWMA	Assistant Engineer
Joseph Ampadu Boakye	Consultant	Coach
Henry Tenu	AshMA	Asst. Health Engineer
Daniel Anang Tetteh	LaNMMA	Principal Health Engineer
Stephen Akpabli	GEMA	Assistant Engineer
Kingsley Amoako-Atta	PCU	M&E Officer
Emmauel Kwaku Idun	AMA	Assistant Engineer
Dr. Peron Owusu-Awtwi	Consultant/Biofilcom	CEO
Gyabah Samuel	Samalex	CEO
Amonoo Prescott	Samalex	Engineer
Augustina Juliana Ortsin	Consultant	Coach
Catherine Ashigbi	GWMA	Household Toilet Team
Eugene Nyarko	AshMa	Assistant Engineer
Charles Asabre	GEMA	MEHO
Josephine Gawu	Okaikoi North	MEHO
Anthony K. Prosper	GAMA	NSS
Yeboah Parry	GAMA	NSS
Quarcoo Sandra	GAMA	NSS
Ray-Charles Agbekey	GAMA	NSS
Ekumah Emmanuel	GAMA	NSS
Priscilla Atram	GAMA	NSS
Yaw Adusei	LeKMA	Project Coordinator

Name	Organisation	Position
Ayodzi Fagroye	Skyfox	Programme Manager
Mathew Dapilah	Ayawaso East	MEHO

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Sanitation and Water Project.
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www.mswrpcu.com

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