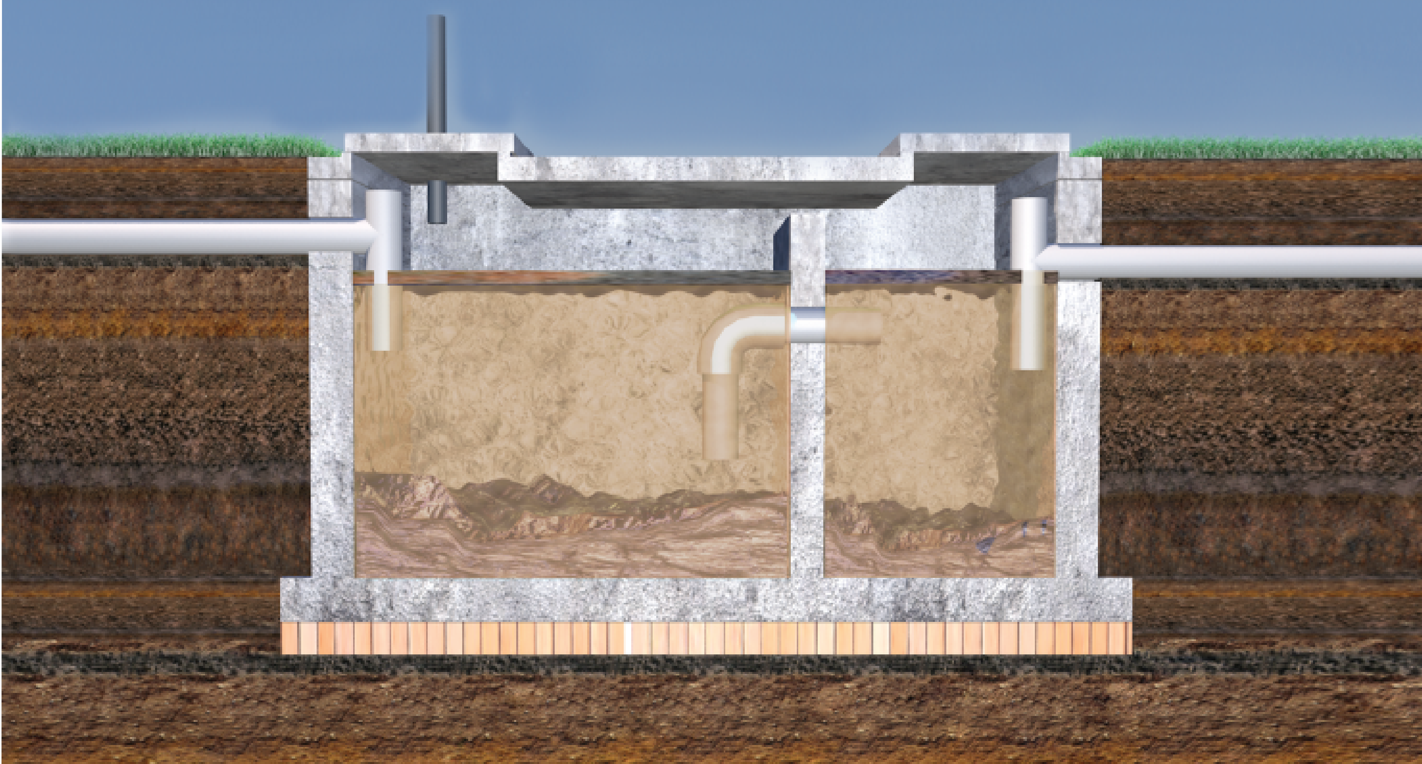
SEPTIC TANK

DESIGN MANUAL



Mahalaxmi Municipality
Lalitpur

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Septic Tank Design Manual

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Established in 1990, Environment and Public Health Organization (ENPHO) is a service oriented, scientific, national, non-governmental organization which is constantly striving towards sustainable community development by developing, demonstrating and disseminating eco - friendly technologies and approaches on water, sanitation and hygiene.

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Author: Mr. Rajendra Shrestha (Program Director, ENPHO)

Front Cover: Drawing of Septic Tank

DISCLAIMER

The author has put his best effort to provide detail and accurate information in the manual. However, if any inaccuracy is found, it is to be considered as inadvertently committed.

The views expressed in this publication do not necessarily represent the views and policies of ENPHO.

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Message

Mahalaxmi Municipality, with the support of the Bill and Melinda Gates Foundation and in partnership with Kathmandu Valley Water Supply Management Board, Environment and Public Health Organization, and other relevant stakeholders is implementing FSM ISO Standard in the Municipality. Amid this initiative, I am extremely delighted to share this indispensable handbook "Septic Tank Design Manual" and express my special gratitude to Environment and Public Health Organization (ENPHO) for its generous support in developing this manual.

Safely managed on-site sanitation system is inevitable to protect environment and attain healthy lives. This begins with safe containment. The construction of standard septic tanks is now mandatory in all new house design permits in Mahalaxmi Municipality. Also, the Municipality is further campaigning to raise awareness on importance of proper and standard septic tank including its implications on water sources and human health. In this context, I am so pleased that the manual has been developed and going to be published to provide a stepwise process for designing a standard septic tank. I strongly believe that this manual will adequately support designers, engineers and municipal planners as well as other sanitation professionals in providing know-how on design, construction, operation and maintenance of the septic tank. I equally look forward to its wider dissemination not only in Mahalaxmi Municipality but in every Municipality of Nepal.

Last but not least, on behalf of Mahalaxmi Municipality, I would like to express my sincere gratitude to the Bill and Melinda Gates Foundation, Municipal Association of Nepal and Kathmandu Valley Water Supply Management Board for their valuable support in producing this manual.

Mr. Rameshor Shrestha
Mayor
Mahalaxmi Municipality

Foreword

Municipal Association of Nepal (MuAN) has been active for the last 27 years as the only representative body of the existing six metropolitan, 11 sub-metropolitan and 276 municipalities of Nepal. The Association's main scope of services are to conduct policy debates, lobbying and advocacy, provide technical assistance, intergovernmental coordination, conduct research studies, and to capacitate municipalities to deliver accountable, transparent, and sustainable services and facilities to citizens in return for taxes paid by them.

With the declaration of Nepal as an "Open Defecation Free Nation" on September 29, 2019 as an important achievement of the sanitation sector, the entire nation has now marched to achieve the goal of Total Sanitation. In this context, the role of MuAN will be more indispensable and active at this crucial time. As specified by the association's strategic plan, the association will establish good communication mechanism among its member municipalities, develop capacity, provide technical assistance, and establish coordination among governments at all tiers by formulating necessary policies and guidelines.

In order to achieve the goal of Total Sanitation and Sustainable Development of Nepal, MuAN, in technical cooperation with the Environment and Public Health Organization (ENPHO), has implemented the "Municipalities Network Policy Advocacy on Sanitation in South Asia" Project. Accordingly, to address the main and primary issues of Faecal sludge management, a "Septic Tank Design Manual" has been published. The publication of this manual will address all the technical difficulties such as confusion on scientific design of septic tank thereby differentiating it from a conventional holding tank, lack of complete awareness and right knowledge on septic tanks among the community people and municipalities staffs, and lack of uniformity and ease in monitoring of septic tanks of newly constructed buildings in the municipalities. We believe that the faecal sludge management will prove to be a milestone for achieving the goal of Total Sanitation.

In the coming days, rigorous orientation on this manual and septic tank will be taken forward through the Nine Provincial Municipal Learning Centers (PMLCs) in all the seven provinces to the people's representatives, chief administrative officers and technical staff. We would like to thank all those who contributed in the creation and publication of this manual.

Kalanidhi Devkota

Executive Director
Municipal Association of Nepal

Foreword

Nepal has started different initiatives in the areas of sanitation and progressing well under provincial and local government. Post declaration of Open Defecation Free (ODF) country last year, the challenge is to sustain ODF by maintaining the status of districts and villages which were declared ODF and provision of appropriate Faecal Sludge Management (FSM). In the course of ODF declaration the number of septic tanks and pits have been increased exponentially so does the obligation to provide adequate, safe, affordable and manageable entire value chain (Emptying, transferring, treating and safe disposal) of FSM. This will contribute to the national commitment to achieve the Sustainable Development Goal 6.2.

Though septic tank is integral part of safe on -site sanitation, the importance of "proper septic tank" has yet to be realized by community, planner, engineers and policy makers. Study conducted by ENPHO shows that more than 95 percent of containments, called septic tanks, have not been properly constructed. In fact, it is technically a reformed pit that is large in size, rectangular and which has no provision for a baffle wall and soak pit. In addition, the tank is constructed with unsealed wall and open bottom to allow leaching of liquid directly into the ground.

I am pleased to announce that Environment and Public Health Organization (ENPHO) has developed the Septic Tank Design Manual to address the dearth of ready to use guide while designing a standard septic tank. This manual aims to provide a stepwise process for designing septic tank and practical guidance on construction, operation and maintenance. Chapter proceeds with the introduction of septic tank followed by rationale, analysis, site selection design of septic tank, operation including maintenance of Septic tank. Each and every steps have been described in a simple language with illustration where ever possible. In order to make it relatable at the actual construction sight, few examples of the calculation (for the prescribed parameters) are also included.

The manual is particularly intended to be used by planners, municipal engineers, building inspectors and technicians as a quick reference to understand the basic principles of how a septic system functions and its operation and maintenance. Taking respective responsibilities within their abilities will ultimately help in improving sanitation and protecting our health and environment.

I hope that this manual will be very useful in implementation of sanitation related programmes, particularly in construction of septic tanks for varied topography of Nepal for diffident socio - economic groups.

ENPHO is very grateful to the Bill and Melinda Gates Foundation, Municipal Association of Nepal, Mahalaxmi Municipality and Kathmandu Valley Water Supply Management Board and highly acknowledge their support in bringing out this publication.

Thank you!

Bhawana Sharma
Executive Director
ENPHO

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Context

A pre-dominantly rural country until 2011, Nepal is now one of Asia's fastest urbanizing countries. Following the promulgation of new Constitution in 2015 to restructure the country into a federal republic, Nepal has been administratively divided into 6 metropolitan cities, 11 sub-metropolitans and 276 municipalities. As a result, the population living in these Municipalities is estimated to have increased to 60%[1], up from 17% in 2011. Thus, water resource and environment is continuously degrading in terms of quality due to haphazard and rapid urbanization in Nepal.

Though there ae several advancements from government and non- government sector to improve the problem from the grassroots due to the lack of adequate and proper regulation, infrastructure, technology and management, still increasing volume of wastewater and solid waste is being discharged and dumped into the open land and water sources unsafely. These unsafe disposal is one of the ambiguities to maintain our country as the Open Defecation Free (ODF) country and affecting the national commitment to meet Sustainable Development Goal 6, adversely.

Rapid growth in urban population need to synchronize with the effective sanitation solution for faecal sludge management. Properly managed sanitation services to the wider population maximizes the positive health outcomes, secure environment, and economic opportunities.

Purpose of Manual

The purpose of the Design Manual is to provide a stepwise process for designing septic tank and practical knowhow on construction, operation, and maintenance. The intended users of this manual are designers/engineers and municipal planners.

Wastewater Management

Although sewered sanitation (SS) system is adopted in urban cities and non-sewered sanitation system (NSS) is feasible for peri-urban and rural areas respectively, NSS is common practice in both urban and rural settlements in the context of Nepal. In NSS system, wastewater is stored in a containment, which is emptied and transported via vehicle to the treatment site prior to disposal or reuse. Whereas, in SS systems, the wastewater generated is transported by means of sewer pipeline and treated at the place, far from point of generation particularly at low land of catchment area. Stand- alone system is difficult to apply for cities of any developing countries because of the mixed sanitation system of SS and NSS due to feasibility and demand.

Wastewater management is more than transportation and treatment. It includes the entire stages of sanitation service chain. Hardware intervention is not just sufficient; however,

[1] *Economic Survey, Ministry of Finance (2018)*

software interventions are equally essential to protect environment and public health. Policy and legislation should be developed and enforced to discourage people minimize from their level to generate wastewater. In addition, municipality should inform adequately to city dwellers about types of wastewater, risk associated with wastewater. At the same time there should be established technically robust in a place which needs to be socially and culturally accepted and at the same time financially affordable with the use of environmentally safe, locally contextual techniques and technologies. Entire efforts should be linked with

Series of associated software activities such as awareness generation and capacity building. In summary, wastewater management required a package of both software and hardware actions moving simultaneously for optimal effect.

A study conducted by ENPHO shows that only 7 per cent of the wastewater collected from sewered system is safely disposed after the treatment whereas 93 per cent of wastewater is discharged directly into the river without any treatment. Faecal sludge generated from NSS systems, which needs regular desludging, is disposed haphazardly into water bodies or open spaces or forest due to lack of treatment facilities.

Ultimately, in either cases of faecal sludge discharge or disposal is jeopardizing the environment impacting the human health adversely. It is evident that, there is no significant difference between 'open defecation' and 'open discharge or open disposal'. The only difference is the terminology and technique. Hence, sanitation is not just about provision of a toilet it is about to manage entire value chain and finally dispose the faecal sludge properly so that here will be no damage to environment and eventually to the human health.

Types of Wastewater

Wastewater is used water from domestic, industrial, commercial or agricultural activities, surface runoff etc. The characteristics of wastewater vary according to the sources of generation, storage technologies, and duration. Depending upon its characteristic, wastewater can be classified as follows:

Black Water:

Domestic wastewater generated from toilet is termed as black water. It contains high volume of biological contamination. It may be combined with grey water as well.

Grey Water:

Domestic wastewater generated from other than toilet is called grey water. It must not contain black water. However, it may contain solid waste. The biological contamination of grey water is far lesser contaminated in comparison to black water.

Faecal Sludge:

Blackwater stored in any types of pit is defined as faecal sludge. It may contain greywater and other solid waste as well.

Septage:

Faecal sludge stored in septic tank is called septage. Thus, septage can be termed faecal sludge but faecal sludge cannot be defined as septage.

Yellow Water:

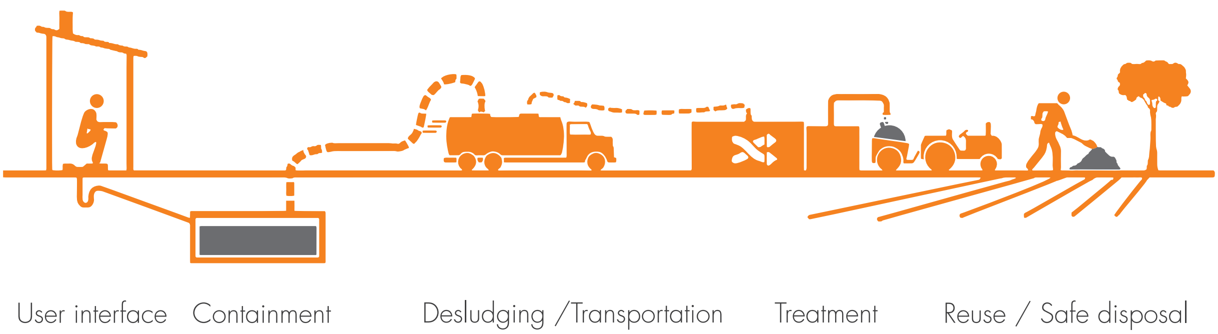
This is urine-contaminated wastewater without contamination of either black water or greywater.

Faecal Sludge Management in Nepal

Over the past decade, toilet construction has increased substantially in Nepal and finally the country has been declared as open defecation free (ODF). The Multiple Indicator Cluster Survey (MICS), 2014 report indicates about 94 percent people rely on NSS systems in the country. Only 6.1 percent population use SS and 2 percent of people residing in urban areas other than Kathmandu valley and 2.2 percent of rural population areas have access to SS. The remaining has NSS such as pit latrines, biogas digester, septic tank etc. As a result, tons of faecal sludge (FS) emptied every day, is haphazardly disposed into the environment without any treatment, hampering the national declaration of ODF status of our country. Thus, NSS is crucial for improvement of sanitation situation in the country.

Faecal Sludge Management (FSM) is a crucial and is in urgent need for safe and sustainable management of Faecal sludge. FSM includes the entire sanitation value chain starting from a proper collection of faecal sludge to its safe disposal and/or reuse.

Figure 1 Sanitation Value Chain



Rationale for Septic Tank

Septic tank is the major on-site technology adopted at household and institutional level. Local government is gradually making mandatory to install septic tank especially where there is no provision of sewer network. Though it is mandatory, a study conducted by ENPHO depicts the different angle; more than 50 percent household expressed that they have a septic tank , however during the observation 90-95 percent are simply a rectangular tank without partition, water sealing, outlet and unnecessarily big in size. This makes clear that significant number of owner do not have proper understanding about the septic tank.

Improper design and construction of septic tank is not just because of owners' misunderstanding but also there is a huge knowledge gap with the city officials and designers. Leave aside the public, even the professionals are not much aware about rationality, technicality and the maintenance of the septic tank.

In conclusion, the containment particularly septic tank is not being installed properly despite NSS is the widely practiced sanitation option in the country.

Septic Tank

Septic tank is one of the simplest form of on-site treatment technologies, which allows to undergo anaerobic digestion of organic materials of wastewater coming into the system. Effluent from septic tank is infiltrated into ground using soak pit/leach field or is sent to sewer line for further treatment. A properly designed, constructed and operated septic tank can treat wastewater to produce an effluent suitable for discharging without violating environmental health. Septic tank can be built using brick, concrete or stone. These days readymade/precast septic tank made up of fiberglass, plastic, cement concrete is also available in the market.

Key Features of Septic Tank

A septic tank should have following three key characteristics:

- It should be watertight
- It should consist of at least two chambers separated by a baffle wall
- It should be assembled with soak pit or provided with outlet

Working Principle of Septic Tank

Septic tank is a primary treatment unit, which is installed as a stand-alone structure to treat household wastewater and is prior to the secondary treatment then it passes out to sewage.

During the storage, the heavy solids settle down at the bottom of the tank and the lighter solids float above liquid. During the storage period, anaerobic digestion takes place inside it and biodegradable solids are converted into sludge and gases. In this way, significant amount of pollution is reduced and deposited in the form of sludge. Liquid part is then conveyed to soak pit or sewerage network or secondary treatment plant.

The removal efficiency of septic tank depends, mainly, upon the hydraulic retention time and temperature. Normally, septic tank removes 30 – 50 per cent of BOD (Biological Oxygen Demand) and 40 – 60 per cent of TSS (Total Suspended Solids).

Key Components of a Septic Tank

A septic tank consists of seven main components:

- Inlet
- Outlet
- Manhole
- Liquid retention tank
- Baffle wall
- Soak pit
- Vent pipe

The soak pit is also an integral part of the standard septic tank though is a separate structure. It will be discussed in chapter 7.

Inlet Chamber

Inlet is simply a chamber with cover, which allows wastewater in. Generally, it is located at center along the breadth of septic tank and it should be at the level of 100 -150 mm above the outlet level in order to avoid clogging the diameter of the Inlet should not be less than 100 mm. It consists of down pipe inside the septic tank. Figure1 illustrates the detail structure.

Outlet Chamber

Outlet is similar to inlet chamber, which is provided at the end of the septic tank. Generally, it also is located at center along the breadth of septic tank. The level of outlet chamber should be minimum 1.2 m from bottom of septic tank. Normally the diameter of the Inlet should not be less than the inlet pipe. A down pipe is also provided at starting point of outlet inside the septic tank.

Manhole

Manhole is provided for easy access during desludging and to inspect inside the septic tank. Manhole should be well covered and the weight of the lid should be lighter enough to be opened easily. At the same time, it should be strong enough to bear a weight of an adult person.

Hydraulic Retention Tank

This is a major component of septic tank. A baffle wall separates Hydraulic Retention Tank (HRT) into two compartments. LRTs collect and store sewage till the hydraulic retention time. During the storage of sewage, heavy particles settle down and anaerobic digestion of organic part takes place inside the liquid retention tank. The collected sewage stores in three layers, namely sludge, liquid and scum.

Sludge Layer:
Heavy solids (heavier than water) settle down at the bottom of the septic tank and forms a layer. Over the time, the biodegradable solids accumulated at bottom undergoes into anaerobic digestion. Sludge is generated during digestion and deposits at bottom and forms a sludge layer.

Scum Layer:
The light-weight solids (lighter than water) such as grease, oils, soap films and other solid waste float above the liquid and forms a layer which is called scum layer.

Liquid Layer:
The layer in between the sludge layer and scum layer is termed as liquid layer. It holds liquid portion of sewage, which contains microscopic biodegradable and non-biodegradable solids suspended in the liquid. Anaerobic digestion process takes place in this layer as well. During the process, biodegradable suspended solids are digested and settle down at bottom. Thus, treated/clearer liquid is conveyed to the soak pit or sewerage network.

Baffle Wall

Baffle wall is a component that divides liquid retention tank into two compartments. It is provided at the 2/3rd of length from inlet side. Series of holes are provided in this wall and size of holes is minimum dimension of 100 cm diameter or square. Generally, the holes are provided at the height above the half of the liquid depth.

Vent Pipe

Anaerobic digestion process produces poisonous, inflammable, and foul gases. A vent pipe inserted in the septic tank allows safe exit to gases. Vent pipe also prevents smell entering to the toilet via conveyance system. The vent pipe should be erected with the minimum height greater than an average height of a person.

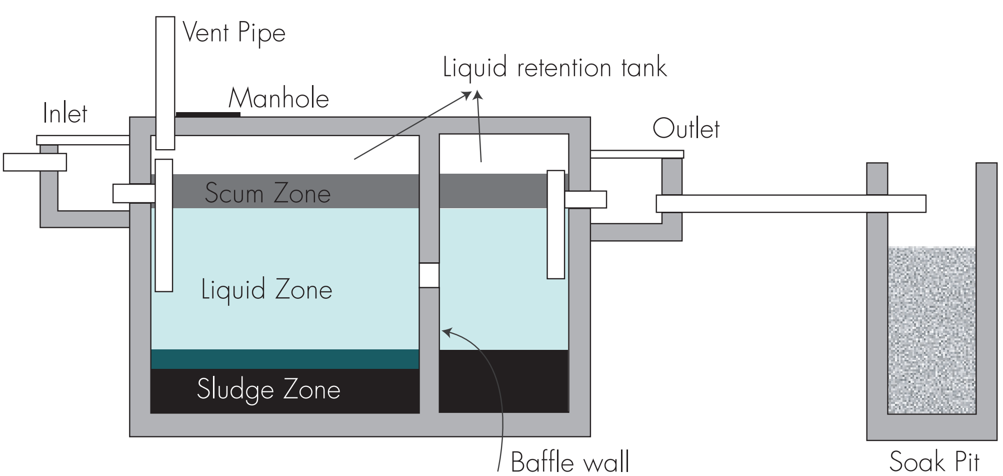


Figure 2: Key components of septic tank and various zones

Advantages and Limitations

Though there are several on-site sanitation technologies, septic tank is commonly used because of its several advantages compared to other on-site technologies. However, it has few limitations as well. Some of the most common advantages and limitations are listed below:

Advantages of Septic Tank:

- Since septic tank is a water sealed treatment technology and effluent discharged out through soak pit or leach field resulting less environmental or ground water pollution;
- Though septic tank needs regular desludging but it requires less other maintenance;
- Depending upon the material used to install and usage, it lasts for more than 20 years;
- It is an excellent onsite options especially for the areas with no or/and unfeasible sewerage networks;
- Septic tank can be constructed in situ using locally available materials (brick, concrete or stone) and human resource. These days there is a provision of buying readymade (made up of concrete, plastic, and fiberglass). Comparatively readymade septic tanks are cost effective and faster to install.

Limitations of Septic Tank:

- Since a septic tank is biological treatment technology, traces of chemicals like toilet cleaner, acid can be harmful to microorganisms (which helps to maintain the eco-system to treat wastewater) those cause the failure of septic tank;
- Since the septic tank is a structure with fixed capacity and piping systems, non-degradable or solid, that takes time to degrade, materials such as tampons, sanitary wipes, too much toilet paper may cause clogging of the septic tank;
- If the septic tank is not properly built, operated and maintained, it may cause bad odor, overflow, frequent clogging and untimely desludging;
- In case of flood prone or water logging area, especial attention should be paid while designing so that unwanted water does not enter from outside the tank;
- If the underground water table of the location is high, the soak pit cannot absorb the effluent.

Design of Septic Tank

Design of septic tank is a process that determines internal dimensions of septic tank based on the prescribed design parameter. The dimensions should be large enough to retain sewage produced from particular number of users for anticipated time (i.e. Hydraulic Retention Time). It should also provide sufficient opportunity to settle and float solids. Design defines the treatment efficiency of septic tank.

The objective of septic tank design is to determine the volume and hence dimension of septic tank.

Design Principles

Septic tank design principles are:

- provide sufficient hydraulic retention time to settle down the heavy solids of sewage and stabilization of liquid;
- ensure stable quiescent hydraulic conditions for efficient settling and floatation;
- provide adequate volume of septic tank for accumulation of sludge and scum for desludging period.

Design Parameters

Design parameters involves qualitative and quantitative factors that decide a design. It determines cost, size, working efficiency and risk related to the septic tank. Following are the basic design parameters of septic tank:

- Volume of wastewater
- Hydraulic retention time
- Desludging period
- Temperature

These parameters impacts design of septic tank in following ways:

- **Incoming volume of wastewater** – higher incoming volume increases size of the septic tank.
- **Hydraulic retention time** – longer retention time increases size of septic tank and treatment efficiency.
- **Temperature** – Anaerobic digestion is more effective in higher temperature. Thus, treatment efficiency of septic tank increases with rise in temperature.
- **Desludging Frequency** – Longer desludging period demands bigger size of septic tank.

Design Steps

Step 1. Determination of Wastewater Volume

Volume of wastewater can be determined using two methods i.e. theoretical calculation and actual measurement. In actual measurement, volume of wastewater is determined by measuring existing flow of wastewater at outfall. Generally, the accumulated volume of wastewater of 24 hours is considered as the total volume of wastewater production per day. In theoretical calculation, volume of wastewater is calculated based on the numbers of users (n) and specific water consumption (q).

In general, certain amount of total water consumption is considered to be converted into wastewater, which is known as conversion factor (fc). The conversion factor is expressed in percentage and the consideration may vary country to country. In Nepal, conversion factor is normally taken as 80% of total water consumption.

The volume of wastewater flow is calculated using following formula.

Volume of Wastewater = Q = n x q x fc (m^3/d) .... (i)

Step 2. Determination of Peak Flow

Flow of wastewater does not remain same all the time and is fluctuated based on the water consumption. Water consumption is generally higher in morning, midday, and evening due to various activities such use of toilet, food preparation, bathing, face washing, brushing, utensil cleaning etc. Therefore, these periods are known as peak hour (tPEAK) and the flow that takes place within this period is called peak flow (Qp). Peak flow is determined based on the volume of wastewater and duration of peak flow (tPEAK) as follows:

Peak Flow = Qp = Q/tPEAK .... (ii)

Step 3. Determination of Liquid Volume

As wastewater enters into septic tank, separation of heavier and lighter particles takes place forming sludge, scum and liquid layer. The volume required for the liquid layer can be determined using following formula:

Liquid volume (VL) = Qp x tHRT .... (iii)

Step 4. Determination of Sludge and Scum Volume

Volume of sludge and scum depends upon the number of users (n), sizing factor (fs) and sludge and scum accumulation rate (Vsa). Value for Vsa varies depending upon the type of wastewater coming into septic tank whether it is black water only or black water and grey water combined. Similarly sizing factor depends on temperature (T), desludging period (t). The sizing factor decreases with increase in desludging period and reduction in the temperature. If we look at table 1, the minimum value of the sizing factor is 1 for the desludging period 2 or more than 2 years regardless of temperature differences. The sizing factor decreases with increment of desludging period and. However, it remains unchanged for more than 6 years. (See table 1). Formula suggested by Pickford (1980) for calculation of sludge and scum volume is as follows.

Sludge and Scum Volume = Vs + Vsc = n x fs x Vsa x t .... (iv)

Table 1 Matrix to determine value of the sizing factor (fs)

Desludging period (in years)	Value of fc		
	Ambient temperature		
	>20°C	>10°C	<10°C
1	1.3	1.5	2.5
2	1.0	1.15	1.5
3	1.0	1.0	1.27
4	1.0	1.0	1.15
5	1.0	1.0	1.06
6 or more	1.0	1.0	1.0

Source: A Guide to the Development of On-site Sanitation, © WHO, 1992

Step 5. Determination of volume of septic tank

Volume of septic tank is calculated as the sum of liquid volume (VL), sludge volume (Vs) and scum volume (Vsc).

Volume of Septic Tank = V = VL + Vs + Vsc .... (v)

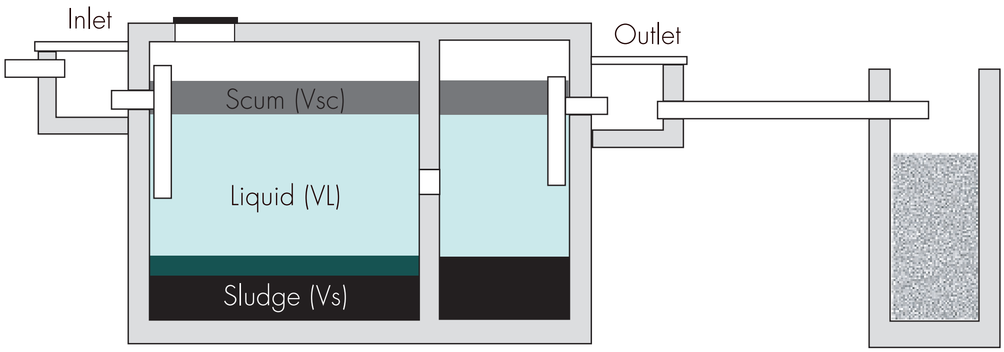


Figure 3: Volume of Septic Tank

Step 6. Sizing of Septic Tank

Sizing of septic tank is the process of determining its dimensions (length, breadth, and liquid depth). Liquid depth is generally considered between 1.2 to 2.2 m depending upon the land area and practicality. The minimum liquid depth of 1.2 is essential for anaerobic digestion process while water depth higher than 2.2 may create practical hassles during operation and maintenance. Ideally, length to breadth ratio of septic tank should be 2-4. Once we have the liquid depth and length to breadth ratio, sizing can be done using following formula.

Volume of Septic Tank = V = L x B x H... (vi)

Where, L = (2-4) B and H = 1.2 -2.2 m

Example: Design a septic tank to treat wastewater from an institute having number of users 50 for Terai region. Consider the specific water consumption is 100 lpcd and desludging period is 2 years.

Given parameter,

Number of users	n = 50
Specific water consumption	q = 100 lpcd
Average temperature (For Terai region)	T = 20°C

Chosen parameter

Hydraulic retention time	tHRT = 24 h
Peak hour	tPEAK = 12 h/d

Type of wastewater to be treated is combined.

Design Steps

Step 1: Determination of wastewater volume

Volume of Wastewater $Q = n \times q \times fc$

$Q = (50 \times 100 \times 0.8) / 1000 = 4\ m^3/d$

Step 2: Determination of Peak Flow

Peak flow $Qp = Q/tPEAK$

$Qp = 4/12 =$ **$0.33\ m^3/h$**

Step 3: Determination of Liquid Volume

Liquid volume $VL = Qp \times tHRT$

$VL = 0.33 \times 24 =$ **$8\ m^3$**

Step 4: Determination of Sludge and Scum Volume

As per the formula suggested by Pickford (1980),

Sludge and Scum Volume $Vs + Vsc = n \times fs \times Vsa \times t$

From the matrix (See table 1), fs for temperature 20°C and desludging period 2 years is 1 and Vsa = 40 litres per person per year for combined (black water and grey water) wastewater.

$Vs + Vsc = 50 \times 1 \times 40 \times 2 =$ **$4\ m^3$**

Step 5: Determination of Volume of Septic Tank

Volume of Septic Tank $V = VL + Vs + Vsc$

$V = 8 + 4 =$ **$12\ m^3$**

Step 6 Sizing of Septic Tank

Volume of Septic Tank $V = L \times B \times H$

Let's assume liquid depth septic tank = H = 2 m and ratio of Length to Breadth is 2

$12 = 2B \times B \times 2$

$B = 1.73\ m$

Take, $B = 1.75\ m$

Length of septic tank $L = 2B = 2 \times 1.75 = 3.5\ m$

Since Length of first compartment of septic tank (L1) = 2/3 of total length (L)

Length of first compartment $L1 = (2/3) \times 3.5 = 2.33\ m$

Take, $L1 = 2.3\ m$

Length of second compartment of septic tank (L2) = 1/3 of total length (L) or L - L1

Length of second compartment $L2 = 3.5 – 2.3 = 1.2\ m$

Construction of Septic Tank

Most of the septic tanks, especially in Nepal, are not being properly constructed due to its lack of technical knowledge and the not considered to have a proper septic tank is an important issue. Proper construction including site selection not only increases the work capacity of the septic tank, but it also contributes on cost effectiveness.

Site Selection

Following factors should be considered while selecting the location for septic tank:

- Groundwater flows from the higher water level to the lower water level and the groundwater circulation is according to the contour of the ground surface. Therefore, the septic tank should be located at the lower level of the water source to prevent the potential pollution chances. It is recommended to maintain adequate horizontal and vertical distances from water sources. It is better to have distances between the point of disposal and the water source should be 20 and 4 m for horizontal and vertical distances respectively;
- As septic tanks require regular desludging, it should be in an accessible location for desludging service. The most suitable place for desludging is the front yard or the side of the building;
- Water discharge from the septic tank is sent to the soak pit for infiltration into the ground. Therefore, the soil texture of the site should be permeable.

Points to Ponder during Construction

In reference to the study conducted by ENPHO showing that 95 percent of containments (people consider it as the septic tanks) have not been properly constructed. This fact provides ample evidence to have explicit planning, appropriate design and specific construction is required. Similarly community people should be aware of the importance of proper septic tank is the key factor to address the problem. The following points will help the mason and the owner in properly constructing the septic tank.

- Septic tanks must be properly sized or designed based on the number of users avoiding over size and expensive;
- Septic tank should be offset from building. If land is space is not available chambers should be accessible.
- The mason, who will build, must be well trained on septic tank construction so that the person will abide by all the required specifications
- In order to avoid confusion, mason should study the drawing of the septic tank and consult the designer and homeowner Or mason and homeowner should be oriented properly in detail before beginning construction work.

- Excavations for the septic tank must be large enough to work around the septic tank so that it becomes easy during bricklaying and shuttering for concreting. Generally, 50 cm of space should be provided around the structure;
- Compaction must be done properly;
- Minimum thickness of stone soling should be 150 mm and it should be on edge in case of brick soling;
- In the case of concrete structure, concrete with a ratio of 1: 1.5: 2 or 1: 2: 4 should be used;
- In case of brick structure, bricklaying should be ensured that each joints are filled by mortar properly and at least the inside wall should be plastered in rich mortar. However, plastering should be done from both sides when the groundwater table is high;
- A down pipe is provided from inside the septic tank with tee fittings at the inlet and outlet, which at least 39 cm below the water label.
- Clear height between liquid level and septic tank cover should be at least 30 cm
- Generally, the floor slope is not required for septic tank as the sludge is emptied by using pump. However, it is provided in a 1 to 10 slope toward the sludge outlet in case of gravity flow mechanism for desludging. And the slope should be upwards to the outlet.
- Inlet should be higher than outlet.
- Opening/Manhole of septic tank should be easy openable for inspection and desludging purpose.
- Septic tank should be provided with ventilation pipe and the height of pipe should not be lower than 2 m.
- Septic tanks must be buried. However, its cover should be at the ground level so that it does not require digging the ground to open it for inspection and desludging.
- If the septic tank is constructed 30-centimeter-deep, either the entire septic tank must be lifted or at least the manhole should be lifted.
- Wall of soak pit should be porous sufficiently or honeycomb typed and bottom of soak pit should have dry soling only;
- Full burnt brick bats are the best materials to use as filter media in soak pit. However, aggregates can also be used.

Operation and Maintenance of Septic Tank

Proper operation and maintenance of the septic tank is equally important for its efficiency. Typically, maintenance of septic tanks is not a major issue, as it requires very minimum maintenance. However, proper operation of the septic tank should be seriously taken care. The operation of the septic tank involves regular inspection of the entire technology and cleaning of the sludge. Overflow due to infiltration and clogging, leakage and falling down of down-pipes at inlet and outlet are common problems occurring in septic tanks. If the septic tank is not watertight and the inlet is below the waterlogged level, then the wastewater overflows or/and backflows into toilet due to infiltration. Likewise, solid waste in the inlet manhole, especially due to sanitary pads and condoms, also causes clogging to overflow. Construction defects are the major cause of leakage and falling of down-pipe. However, these problems can be reduced by quality control during construction and regular inspection.

Inspection of Septic Tank

The need to observe the routine inspection points / components and related facts of the septic tank is presented in the table below:

Table 2: Points and Particular of Inspection and Its Respective Time

Point/Component	What to Inspect	When to Inspect
Inlet	Clogging, connections or falling down of down-pipes and structural cracks	In every 3 months
Outlet	Clogging, connections and falling down of down-pipes and structural cracks	In every 3 months
Manhole	Misplacement and structural damage of cover	In every 3 months
Vent pipe	Pipe joints, breakage	In every 3 months
Soak pit	Chocking of effluent	In every 6 months
Sludge accumulation	Sludge depth	Before 6 months and at the end of design period

Apart from the above mentioned frequency, inspection should be done occasionally and whenever problem is noticed such as odor, overflow, waterlogging, etc.

Cleaning/Desludging of Septic Tank

Desludging is crucial activity that affects efficiency of septic tank and infiltration rate of soak pit as well. Technically, designer based on the design consideration provides desludging period. Higher the period increases, the volume of septic tank, and the annual desludging is practically annoying to owner and increases the operating cost. Therefore, desludging period is generally taken as 2-3 years.

Sludge accumulation must not exceed 1/3rd volume of septic tank. Because, sludge accumulation will be about 1/3rd of septic tank volume during the design period. However, it may vary depending upon the type of wastewater coming into it. So, it is required to inspect or check sludge depth before 6 months of design period and should be emptied if the volume of sludge is about 1/3rd of septic tank volume.

Sludge accumulation in the septic tank should be emptied timely because further accumulation of sludge beyond its designed capacity will be flushed out of it and enters into soak pit, which may create chocking of soak pit.

Major Do's and Don'ts of Septic Tank

Some important points to be considered for proper functioning of the system are listed below;

What To Do ?

- Get design of septic tank from experienced designer;
- Minimize water consumption as far as possible to control untimely filling up or overloading of septic tank;
- Protect surface rain-off entering into the system;
- Inspect and desludge regularly;
- Resolve immediately if any defect/problem experienced;
- Ensure that flow of wastewater does not exceed the capacity;
- Install water saving device or sanitary ware;
- Fix defective faucets/pipes immediately.

What Not To Do?

- Do not put/flush into solid waste like sanitary pad, condoms, garbage and food waste as it may clog the system and accumulates sludge more frequently;
- Do not connect wastewater from laundry, bathroom especially bathtub;
- Do not enter into septic tank or insert head or fire such as candle etc. into septic tank for inspection as it produces highly toxic gases from digestion process;
- Do not use highly toxic toilet cleaner and other additives excessively or toxics like paint, solvents as it can kill bacteria affecting digestion/treatment process.

Soak Pit

Structurally soak pit is a separate entity. However, it is an integral part of the standard septic as the effluent from septic is safely discharges into ground via soak pit. A soak pit is a lined, generally circular in shape, pit with cover and porous or honeycomb wall. The pit is filled with brickbats or brick ballast or stone aggregates of size 50 – 100 mm as media up to the inlet level. The unsealed surface and media facilitates to spread incoming flow into ground and provides support to protect from collapse of porous wall. The distance between soak pit and water sources should not be less than 4 m vertically and 30 m horizontally to minimize risk of biological contamination in water body.

Advantages and Limitations

Advantages:

- It is a simple technology which can be built and repaired with locally available mason and materials;
- Small land area is required;
- It is cost effective technology i.e. low investment and low operating cost;
- It recharges groundwater bodies.

Limitations:

- At least primary treatment is required to prevent clogging the filling media;
- It may affect soil negatively and might contaminate groundwater depending upon the type and concentration of inflow;
- It is not feasible for cold climate as there is chance of freezing the pores.
- It is not feasible for location having impermeable soil layer;

Site Selection for Soak Pit

Following factors should be considered during the site selection for soak pit:

- It should be at least 1 m away from the outlet of septic tank and is recommended that it should not be too far. Longer distance cost high;
- The site should be at least 4 m away vertically and 30 m horizontally from water sources like dug well, spring etc.;
- Technically sloppy, elevated terrain, sunny area is preferred for septic systems because these locations have no chance of water logging even during rain and it dries out in a short time.

Design of Soak Pit

Purpose of soak pit design is to determine the surface area of soak pit that can absorb particular volume of water coming into it. And absorption capacity of soak pit is determined also by the infiltration capacity of soil.

Design Principles

Soak pit design principles are:

- To provide sufficient surface area to percolate water coming into it;
- To ensure uniform distribution of water over the surface for efficient percolation and to avoid choking due to concentrated application;

Design Parameters

The parameters of soak pit are:

Incoming volume of water:
Higher incoming volume increases size of the surface area of soak pit.

Percolation rate:
Higher percolation rate increases faster drying up of soak pit.

Design Steps

Step 1: Determine Inflow
Volume of incoming effluent is considered as equal as the incoming volume of wastewater of septic tank.

Step 2: Determine Wall Surface Area of Soak Pit
Surface area (As) of soak pit is determined putting the value of incoming effluent volume (V) and the infiltration rate (IR) of soil in the following formula.

Surface area = As = V/IR.. (i)

Infiltration capacity is the maximum rate at which soil can absorb fluid and it depends upon factors such as grain size. It tends to decrease as the saturation level of soil increases. Infiltration capacity varies from place to place due to dissimilarities of soil. Therefore, designer should have information on infiltration capacity of site for the design of soak pit. Following values can be used if the data on infiltration capacity is not available.

Table 3: Soil infiltration rates

Soil type	Description	Infiltration rate (litres/m^2 per day)
Gravel, coarse and medium sand	Moist soil will not stick together	1,500 - 2,400
Fine and loamy sand	Moist soil sticks together but will not form a ball	720 -1,500
Sandy loam and loam	Moist soil forms a ball but still feels gritty when rubbed between fingers	480 - 720
Loam, porous silt loam	Moist soil forms a ball which easily deforms and feels smooth between fingers	240 - 480
Silty clay loam and clay loam	Moist soil forms a strong ball which smears when rubbed but does not go shiny	120 - 240
Clay	Moist soil mould like plasticine and feels very sticky when wetter	24 -120

Source: Reed and Dean, 1994

Note: For soak pits or pit latrines to function correctly the infiltration rate for clean water should be at least 120 litres/m^2/day.

Step 3 Sizing of Soak Pit

Depth and diameter of soak pit is calculated using the surface area determined above.

Surface area of soak pit = As = 2л RH .... (ii)

From the equation, either depth or radius of soak pit is assumed and dimensions of pit are calculated.

Example: Design a soak pit to dispose effluent from septic tank.

Given parameter,

Flow of effluent	n = 4 m^3/d

Chosen parameter

Infiltration capacity of site	IR = 120 ltrs/m^2 from the table 3

Step 1 Determination of flow

Volume of effluent	= V = 4 m^3/d

Step 2 Determine wall surface area of soak pit

Surface area	As = V/IR
	As = 4X1000/120 = 33.33 m^2

Step 3 Sizing of soak pit

Surface area of soak pit	As = 2л RH
	33.33 = 2 X 3.14 X R X H
Assuming, depth of pit	H = 2 m.
Therefore, Radius of pit	R = 1.9 m

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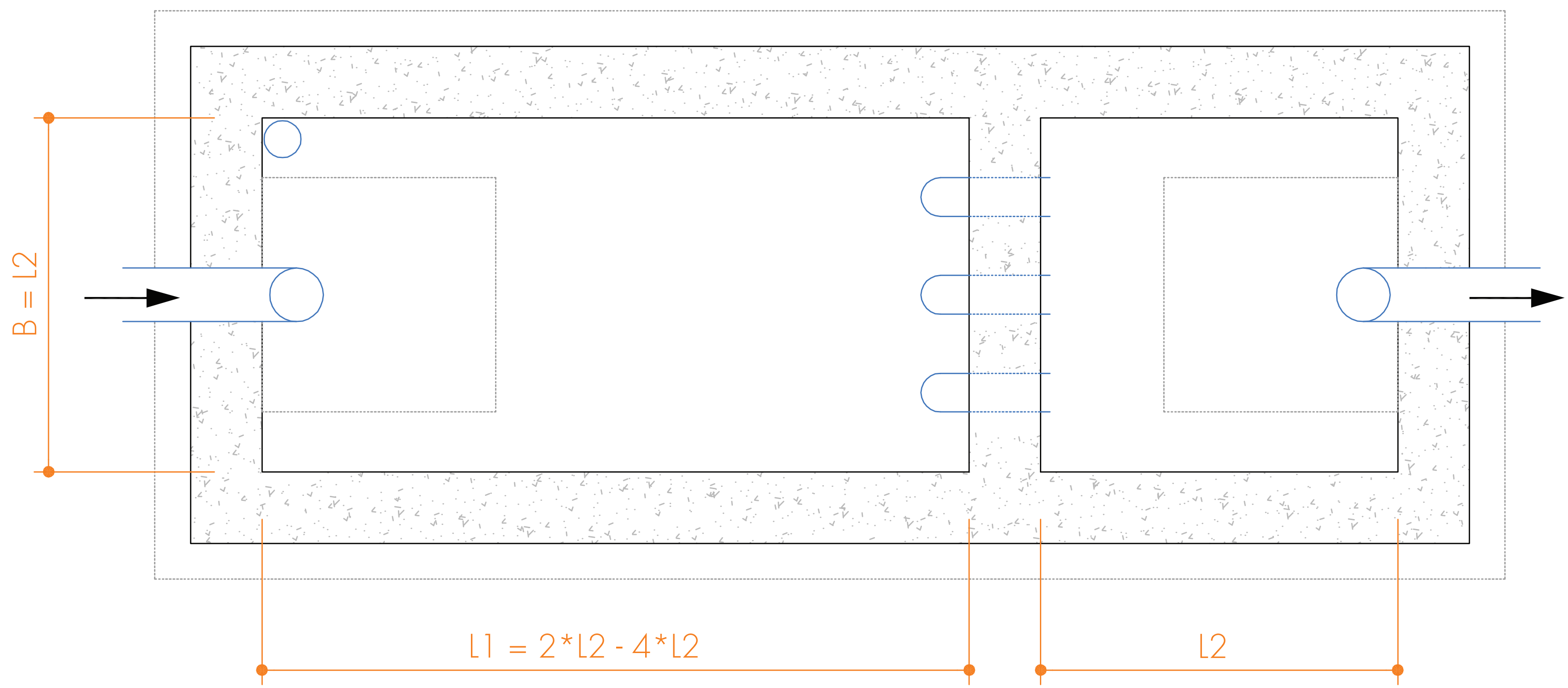
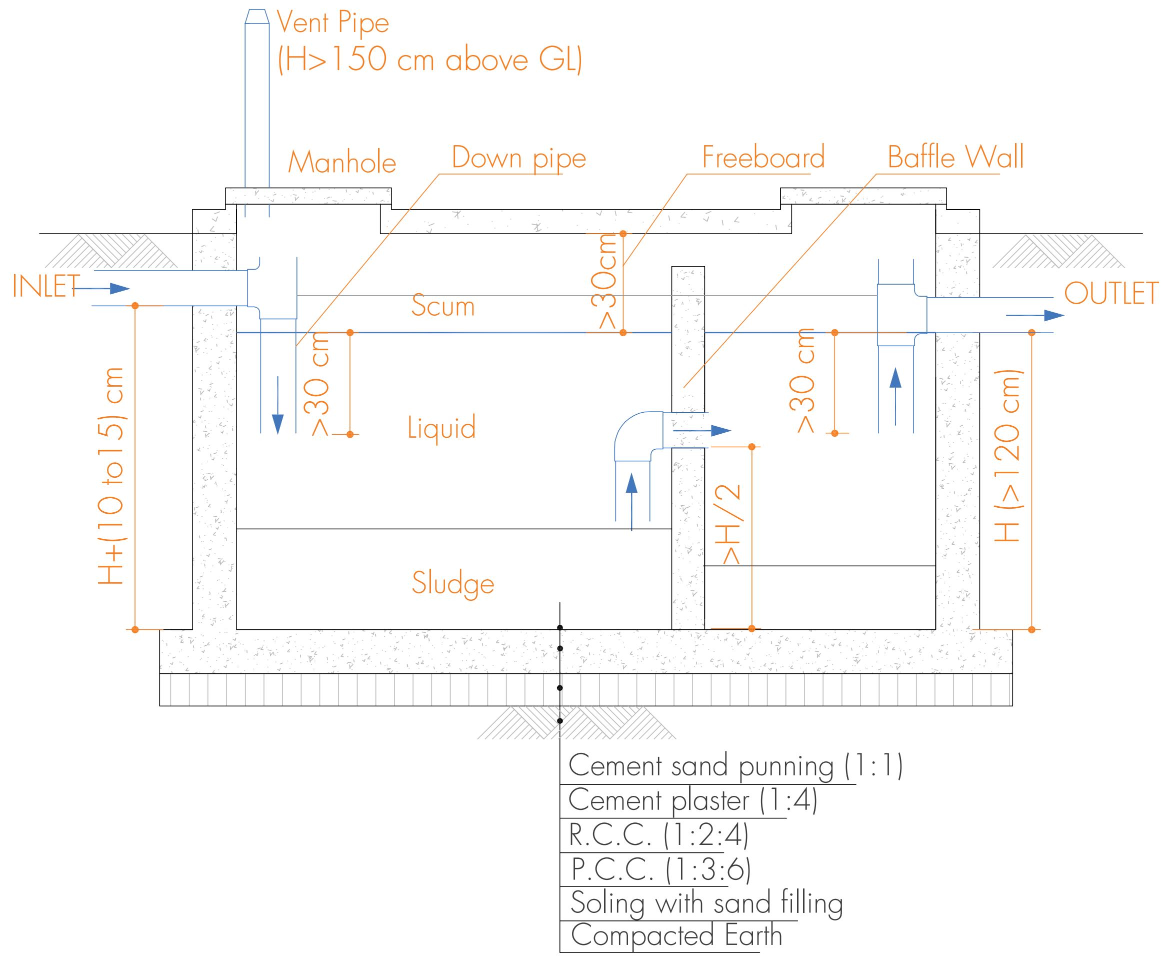
Annexes

Annex A: Typical Plan of Septic Tank



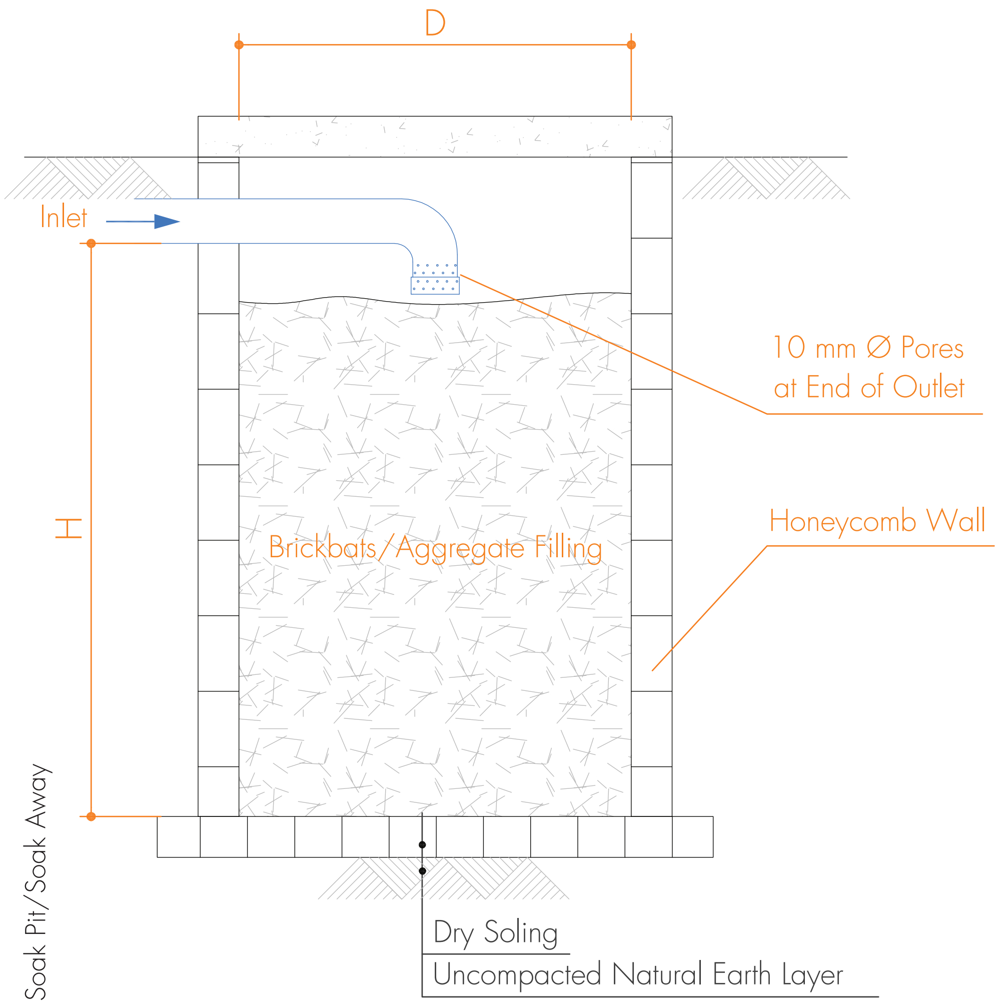
Annexes

Annex B: Typical Section of Septic Tank



Annexes

Annex C: Typical Section of Soak Pit/Soak Away



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