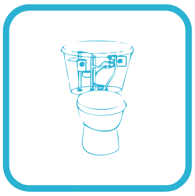

THE PHILIPPINE SUSTAINABLE SANITATION KNOWLEDGE SERIES

Guidebook for Onsite Sanitation Technologies

Department of Health

THE PHILIPPINE SUSTAINABLE SANITATION KNOWLEDGE SERIES

Guidebook for Onsite Sanitation Technologies

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The Philippine Sustainable Sanitation Knowledge Series:

- *Guidebook for a Sustainable Sanitation Baseline Study*
- *Guidebook for a Local Sustainable Sanitation Strategy*
- *Guidebook for a Local Sustainable Sanitation Promotion Program*
- *Guidebook for Community-Led Total Sanitation*
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- *The SuSEA LGU Experience: Dagupan, Guiuan, Polomolok, General Santos City, Alabel, Bauko*
- *Guidebook for a Disease Prevention and Control Program for Soil-transmitted Helminth Infections and Diarrheal Diseases*
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- *Water Pollution Prevention and Control Program: The Polomolok Experience*

For inquiries or comments, please contact the email address listed for the National Center for Disease Prevention and Control listed under this page: http://www.doh.gov.ph/contact_us.html.

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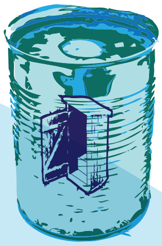

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FOREWORD

According to 2008 UN data, 2.6 billion people still do not have access to or have inadequate sanitation facilities.

Every 20 seconds, a child dies as a result of poor sanitation.[1] That's 1.5 million preventable deaths each year. In the Philippines, 23% of Filipinos or roughly 19 million still do not have access to sanitary toilets.

These realities necessitate tangible and concerted efforts that are owned by the people through the local government units (LGUs). The United Nations has already declared access to water and sanitation as a human right in its July 28, 2010 General Assembly. With the synergistic efforts of both the public and private sectors, the Philippines is also making significant gains in raising awareness and accelerating progress towards the Millennium Development Goal (MDG) on sanitation: to reduce by half the proportion of people without access to basic sanitation by 2015.

Through this Guidebook, we also emphasize that the National Government needs the support of its partners in order to achieve this goal. We need greater collaboration with our partners in the local government units. Likewise, we need to intensify our partnership with the private sector.

Attaining sustainable sanitation is a significant challenge. However, we believe that we have committed partners in the LGUs. Sustainable sanitation will happen because the LGUs are recognizing their roles and equipping themselves with the appropriate knowledge, tools, and skills.

This Guidebook is part of the national effort to bring to all Filipinos improved sanitation coverage, in this case, by laying out a diverse although by no means complete selection of onsite sanitation and other wastewater management technologies for users, builders, and decision-makers. Especially featured are simple and low-cost alternatives for households and communities with limited resources.

The contents of this Guidebook have been distilled from literature and publications here and around the world, and from experiences of workers in the Philippine sanitation sector. This Guidebook is hoped to be useful to such practitioners, but it is written particularly for those with some technical background in the subject such as sanitary inspectors and engineers.

This Guidebook is just one in a series of knowledge resource materials that we are developing towards one of our shared aspirations: ensuring health and wellness for all Filipinos through clean, safe, and life-giving water and sanitation facilities. This Guidebook is for the LGUs and the Filipino people. Use it well and then share it with other LGUs who may also find it useful in their pursuit of sustainable sanitation.

Enrique T. Ona, MD, FPCS, FACS
Secretary Of Health

[1] *Homepage of the International Year of Sanitation (http://esa.un.org/iys/health.shtml)*

The SuSEA Program

The Sustainable Sanitation in East Asia Program-Philippine Component (SuSEA) supported by the Water and Sanitation Program (WSP) of the World Bank and the Swedish International Development Cooperation Agency (SIDA), and implemented through the leadership of the Departments of Health (DOH) and Environment and Natural Resources (DENR), is geared towards increasing access by poor Filipinos, primarily low-income households, to sustainable sanitation services by addressing key demand and supply constraints. Aside from this, the program hopes to learn from local implementation of sanitation programs as basis for national policy and operational guidance.

SuSEA Philippines commenced in July 23, 2007 as a learning program to support the Government of the Philippines (GoP) update its approaches and interventions in sanitation and needs that were not present or not addressed in traditional sanitation programs that focused on two extremes: 1) toilet-bowl distribution and hygiene education and 2) centralized sewerage systems. The most important of these emerging needs are:

- Complementing interventions related to the reduction of risks of sanitation- and poverty-related diseases such as soil transmitted helminthiasis and acute gastroenteritis

- Linking sanitation interventions with environmental objectives, such as the improvement of water quality and water resources

- Sanitation in rapidly urbanizing towns and cities, including the occurrence of disease episodes that aggravate impacts of poor sanitation (such as flooding) on the economy and quality of life of city populations

- Reaching pockets of communities that comprise the remaining 20% of those without access to basic sanitation, particularly in the rural areas (among whom include indigenous peoples/cultural minorities) and urban slum communities.

SuSEA-Philippines was designed using four different models as the platform for developing specific interventions (according to themes below). The learning gained and the tools developed from these models served to assist other local governments units (LGUs), as well as informing national sanitation policy and programs for GoP-led expansion and scaling up. The four models are:

Model 1 Disease Prevention and Control – Sanitation interventions for the eradication/ reduction of disease
Model 2 Water Quality Management – Sanitation interventions for the improvement of water quality within a water quality management area
Model 3 Liveable Cities - Sanitation interventions for the improvement of quality of life in cities and low-income urban poor communities
Model 4 Sustainable Rural Livelihoods - Sanitation interventions to support sustained livelihoods in rural areas

Six sites participated in the main program sub-component of SuSEA. These are: Bauko Municipality in the Mt. Province, Dagupan City in Pangasinan Province, Guiuan Municipality in Eastern Samar Province, General Santos City and Polomolok

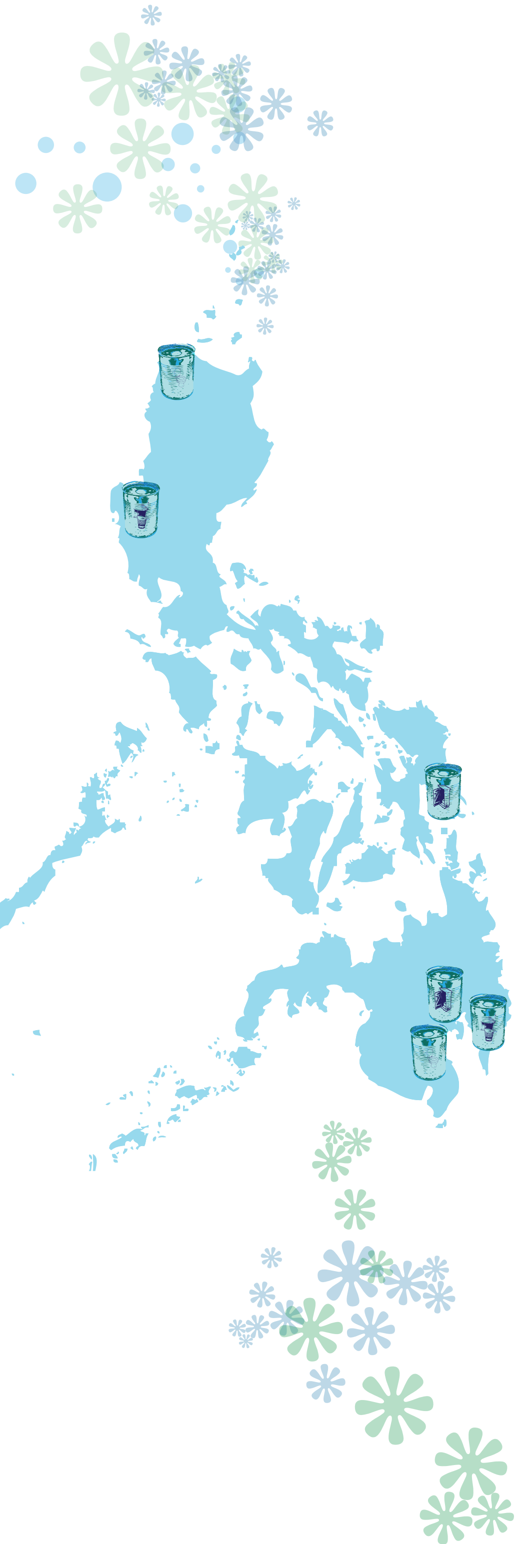
Municipality in South Cotabato, and Alabel Municipality in Sarangani Province. The desired outcome in each of the project sites varied according to the model and agreements by the Program Steering Committee and the local government.

While outcomes varied per site, each of the projects were additionally intended to provide the LGUs with a fount of information on developing and running their own sanitation programs based on the on-field experiences of the SuSEA team and their partners.

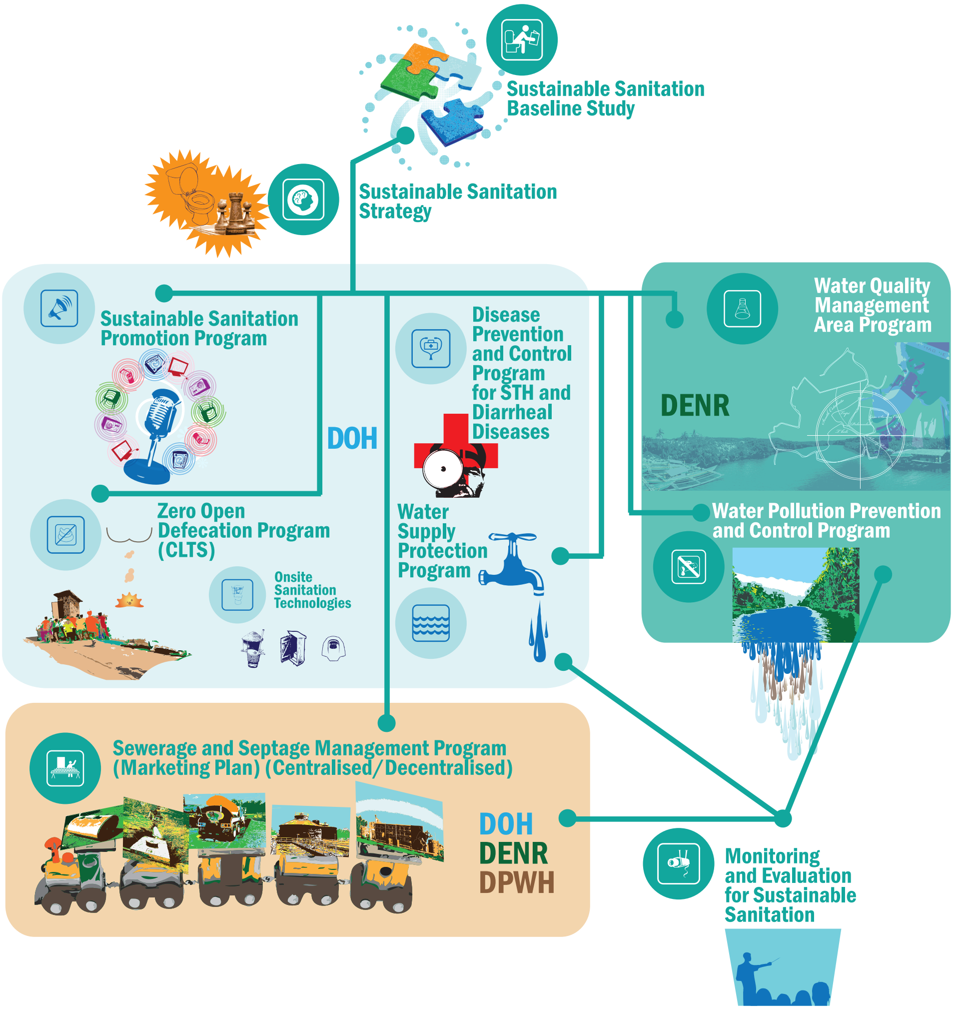
This information has been packaged for your use in a Sustainable Sanitation Knowledge Series, to which this guidebook/report belongs. The reader is encouraged to familiarize himself/herself with all the guidebooks/reports in this series beginning with the Guidebook for Conducting a Baseline Study and followed by the Guidebook for Developing a Local Sustainable Sanitation Strategy.

What guidebooks/reports you choose to utilize next will be determined by your community's particular needs and your LGU's proposed sanitation programs.

On the succeeding page, you will find an illustration of the various sustainable sanitation programs (SSPs) under the National Sustainable Sanitation Plan (NSSP). For each of these SSPs, SuSEA has also developed materials under the Philippine Sustainable Sanitation Knowledge Series, intended to guide local government units in implementing the various sanitation programs and initiatives in their own area. The information gathered in the Knowledge Series is, in turn, based on specific SuSEA projects and activities in each of the six project sites.



Sustainable Sanitation Programs



ACRONYMS AND ABBREVIATIONS[2]

BHW	*Barangay Health Worker*
BOD	*biochemical oxygen demand*
CLTS	*Community-Led Total Sanitation*
cm	*centimeter(s)*
DENR	*Department of Environment and Natural Resources*
DILG	*Department of the Interior and Local Government*
dia	*diameter*
Ecosan	*ecological sanitation*
EWB-UK	*Engineers without Borders-United Kingdom*
ft.	*foot/feet*
GI	*galvanized iron*
GTZ	*Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässerschutz (Swiss Federal Institute of Aquatic Science and Technology)*
HDPE	*high density polyethylene*
K	*potassium*
kg	*kilogram(s)*
km.	*kilometer(s)*
lcpd	*liters per capita per day*
LGU	*local government unit*
m	*meter(s)*
MEO	*Municipal Engineer's Office*
MPDO	*Municipal Planning and Development Office*
m2	*square meters*
m3	*cubic meter(s)*
mg/L	*milligram(s) per liter*
mm	*millimeter(s)*
N	*Nitrogen*
OCBW	*on center both ways*
P	*Phosphorous*
PCWS	*Philippine Center for Water and Sanitation*
PHP	*Philippine peso*
PE	*polyethylene*
PP	*polypropylene*
PVC	*polyvinyl chloride*
RHU	*Rural Health Unit*
UNICEF	*United Nations Children's Fund*
USD	*United States dollar*

[2] *Adapted from the Philippines Sanitation Sourcebook and Decision Aid (2005). World Bank, AusAID (Australian Agency for International Development), GTZ (German Technical Cooperation Agency), DOH (Department of Health), DENR (Department of Environment and Natural Resources), and LWUA (Local Water Utilities Administration). Available at http://esa.un.org/iys/docs/san_lib_docs/Philippines_sanitation.pdf.*

TABLE OF CONTENTS

I. OVERVIEW OF SANITATION

A. What is a sanitation system expected to do?

A sanitation system should be able to:

a) Contain and render sufficiently harmless human waste before releasing to the environment and

b) Prevent the sight and odor of such wastes from offending people.

B. What are the Types of Domestic Wastewater?

1. Black-water

This is human feces and any water used to flush and cleanse it with. Black-water has tens of millions to billions of microbes per milliliter and many accompanying feces-transmitted pathogens.

Depending on the amount of water flushed with it, black-water is 0.3% to 6% organic matter. When released into bodies of water, this organic matter depletes aquatic oxygen to the detriment of these environments. About a fourth of the nitrogen and potassium and half of the phosphorous excreted by a person is in his feces (nitrogen and phosphorous when released in excessive amounts to bodies of water causes algae blooms that increases water turbidity and depletes dissolved oxygen).

2. Yellow-water

This is urine and any water used to flush it with. About 75% of the nitrogen and potassium and half of the phosphorous excreted by humans is in their urine. It may initially contain urinary-tract pathogens but these usually die off within minutes of being outside the human body.

3. Grey-water

This is laundry, bath-, or sink-water. It usually has a lot less organic matter (0.00008 to 0.2%) or Biochemical Oxygen Demand (BOD) and only thousands of bacteria per milliliter. However, it often contains soaps and detergents, which can be harmful to the ecology of receiving waters. It may also contain greases and oils,

4. Storm-water

This is rain run-off from roofs, yards, and streets. Pathogen, organic matter, and mineral solids content vary largely with the condition of the catchment surface and the local air quality.

C. Strategies for Reducing the Cost and Effort of Treating Wastewater

As in other fields of waste management, reduce-reuse-recycle practices can significantly minimize waste-water generation and therefore the cost and effort of treating it.

Fixing plumbing leaks is an obvious good practice. Low-flow toilets, faucets, and showerheads as well as low water-consuming appliances reduce water consumption. In water-poor communities, showering with a dipper, reusing dish-and laundry water for the next batches, and using grey-water to flush toilets and water plants can reduce water consumption from as much as 150 liters per capita (person) per day (lcpd) to as low as 40 lcpd with no undue reduction in convenience or health benefits to the household.

Figure 1. *Above left: Toilet bowl with a built-in sink atop the cistern (from Treehugger); Above right: ferrocement cistern to store roof-water from a school under construction. Source: Philippine Center for Water and Sanitation (PCWS).*

Segregation of the different types of wastewater is, of course, essential prior to recycling them. Black-water for example is the most complicated to treat and re-use and it is easier to do this by not mixing it with the other types of wastewater.

Urine is much cleaner than black-water and can be separated at the bowl with a urine dam (see Figure 2) and piped to a waiting bucket for application to plants or, if local regulations allow, to an infiltration trench.

Grey-water is even cleaner and

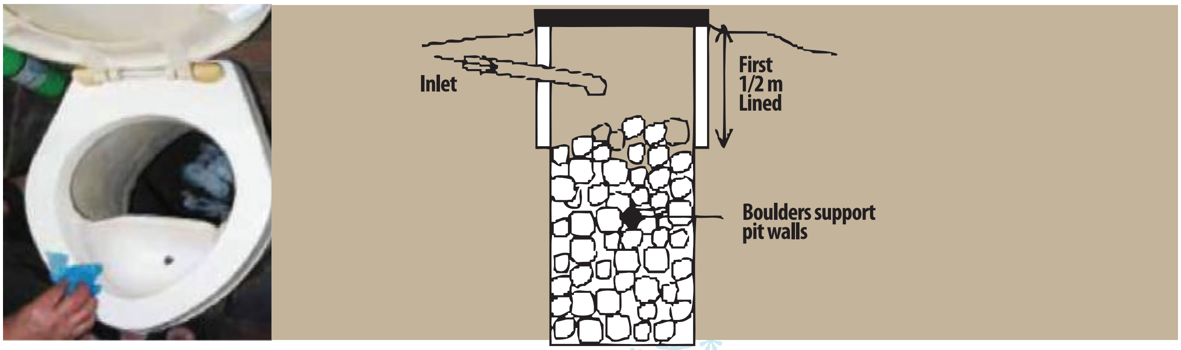


Figure 2. *Left: Dry toilet bowl with urine diversion. Source: Lipkow, Ulrike (2009). Case Study of Sustainable Sanitation Alliance Projects: Urine-diversion dehydration toilets in rural areas, Bayawan City, Philippines; Right: a soak-pit.*

needs only filtering (say through an infiltration trench then into the surrounding ground for two days) for it to be clean enough to be released to most classes of water bodies.

Storm-water is collected and minimally treated in some cities around the world before putting it to landscape uses. At the household level, it can be drained into infiltration trenches or, of course, collected in rainwater-harvesting cisterns for reuse.

D. Onsite and Offsite Sanitation Schemes

Onsite systems treat and dispose of waste right beside the household, while offsite schemes pipe it to a central treatment facility.

Onsite sanitation's advantages over offsite are:

- Onsite systems can be much less expensive to construct than offsite

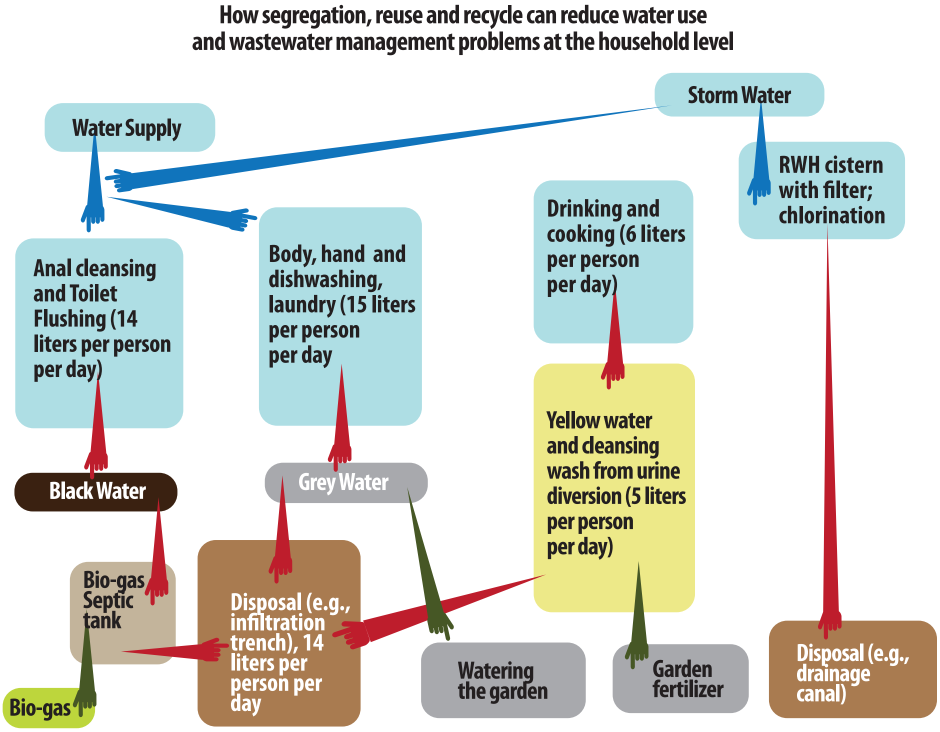


Figure 3. *How water conservation and wastewater segregation and reuse can decrease wastewater generation*

ones because there are no sewer networks, which can comprise up to 95% of construction cost.

- Another advantage of doing without sewering is that the leakages and inflows associated with such networks (which can result in sewage escaping into the ground and increased sewer flows during wet weather) is obviated.

- In communities where there are no clear routes and slopes on which to lay sewers, such as in irregularly-blocked and undulating-terrain villages opting for onsite sanitation does away with having to design complicated sewer networks and acquiring the rights-of-way.

- While sewer networks need a minimum of 20 liters of generated wastewater per person per day (and often 50 to 80 lcpd) to flow, wet onsite sanitation systems such as pour-flush toilets need only two to four lcpd to flush the bowl, and dry systems none.

- As onsite sanitation is more easily scalable to the household level, it can be implemented incrementally (i.e., house-by-house) and thus, require less initial investment requirements when the community is still sparsely populated.

- Onsite systems are also more household-centered in that responsibility because their maintenance is largely in the hands of the users.

Offsite systems, on the other hand, are:

- Usually the only choice when a community is so densely built-up that there is no space for onsite facilities, or in communities where the ground has insufficient infiltration capacity to handle onsite effluents.

- They may also be the preferred option in environmentally critical communities with strict wastewater treatment ordinances. Not only is a degree of economic scale offered by centralizing treatment facilities: centralized systems built and run with professional competence can afford better effluent quality than numerous decentralized and onsite ones.

- Lastly, unlike onsite sanitation, which disposes of liquid effluent usually by leaching it under the ground of the community, in offsite schemes it is often conducted away from the latter so the possibility of re-contaminating that community's water resources is less.[3]

Onsite or Offsite Sanitation?

ONSITE SANITATION IS BETTER FOR:

- sparsely populated communities,
- where there is not enough wastewater generated to carry the waste through sewer pipes
- where there are no clear paths and slopes on which to lay sewer pipes
- when there are inadequate resources for constructing and sustaining offsite sanitation

OFFSITE SANITATION IS PREFERRED IN:

- environmentally critical communities and sites where strict treatment of effluent is prescribed,
- where the ground has inadequate capacity to infiltrate onsite effluents, or
- where there is no space in the community itself for onsite facilities

There are communities,[4] which do not meet either of these criteria, in which case a reasoned compromise will be the best one can come up with. For example, onsite sanitation such as septic tanks with infiltration trenches can be selected but designed so that it can later be upgraded to connect to sewers.

The rest of the document will concern itself solely with onsite sanitation.

[3]Some propose that onsite facilities are the best choice when the community is still sparsely populated, but that they should be built to be upgradable to connection to offsite treatment for the time when population density is high enough to make the latter option more attractive.

[4]Environmentally critical communities are places where, due to the uniqueness or importance of the ecosystem, strict rules regarding wastewater discharges are in force.

II. ONSITE SANITATION TECHNOLOGIES

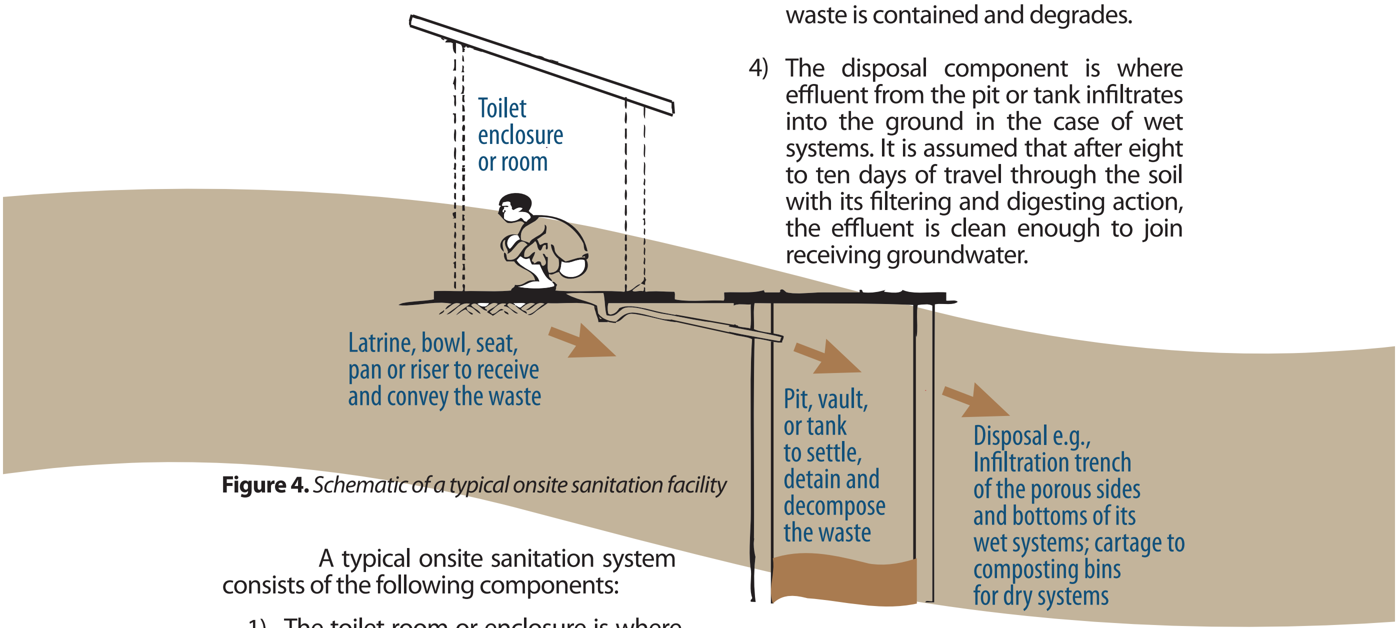


Figure 4. *Schematic of a typical onsite sanitation facility*

A typical onsite sanitation system consists of the following components:

1) The toilet room or enclosure is where the latrine or bowl is located. It provides shelter and privacy to users.

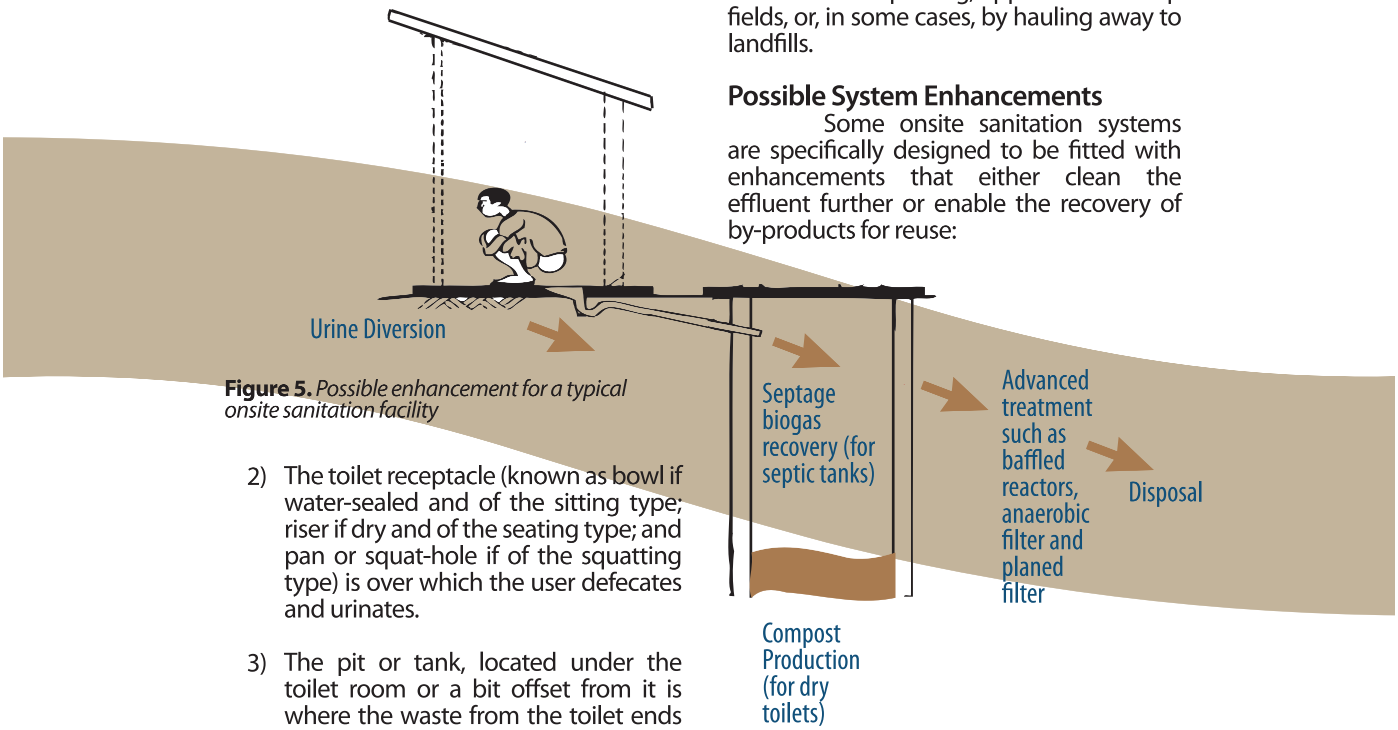


Figure 5. *Possible enhancement for a typical onsite sanitation facility*

2) The toilet receptacle (known as bowl if water-sealed and of the sitting type; riser if dry and of the seating type; and pan or squat-hole if of the squatting type) is over which the user defecates and urinates.

3) The pit or tank, located under the toilet room or a bit offset from it is where the waste from the toilet ends up. It is considered the heart of the system because it is here where the waste is contained and degrades.

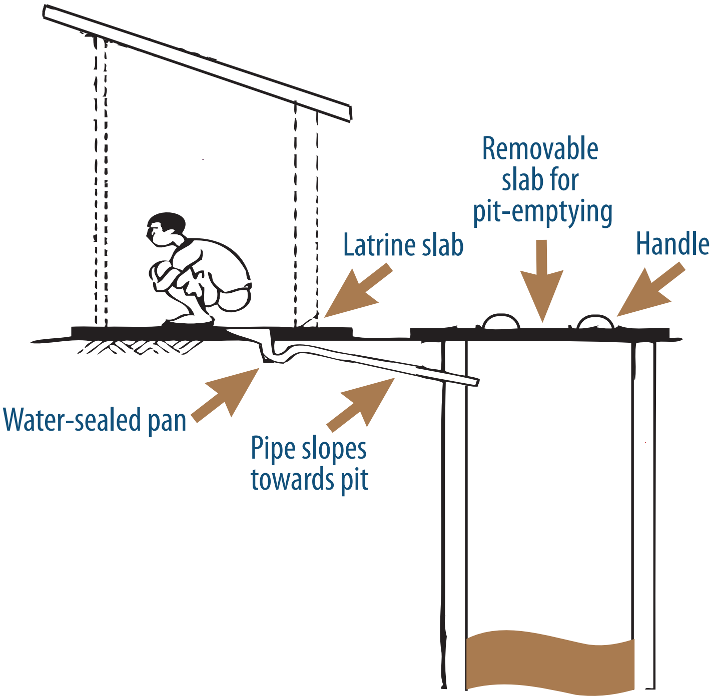
4) The disposal component is where effluent from the pit or tank infiltrates into the ground in the case of wet systems. It is assumed that after eight to ten days of travel through the soil with its filtering and digesting action, the effluent is clean enough to join receiving groundwater.

In the case of dry systems, disposal is by cartage of the reduced waste to bins for further composting, application to crop fields, or, in some cases, by hauling away to landfills.

Possible System Enhancements

Some onsite sanitation systems are specifically designed to be fitted with enhancements that either clean the effluent further or enable the recovery of by-products for reuse:

Water-Based vs. Dry Sanitation:



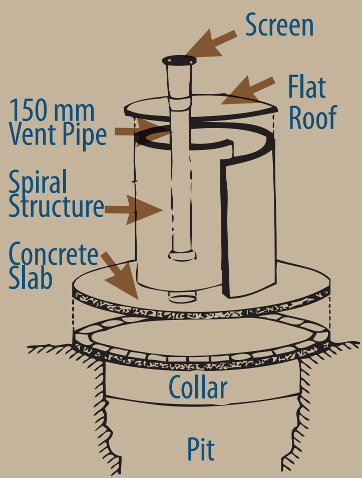


Figure 6. *Above left: an example of wet sanitation, a leach pit toilet with a water-sealed pan. Source: Harvey et. al. (2002); Above right: an example of dry sanitation, a Ventilated Improved Pit Toilet or VIP Toilet. Source: Basic Sanitation and Human Excreta Disposal in Latrines. German Technical Cooperation Agency (GTZ).*

Wet or Dry Sanitation?

Wet sanitation, especially water -sealed toilets control odor better and are much simpler to operate. People previously exposed to its use often prefer it to dry sanitation.

Dry sanitation is the alternative if the community cannot source the two to four liter flushing water needed per person per day for wet sanitation. A few people also value the more hygienized waste products that can be obtained from dry sanitation schemes.

In water-based toilets (Figure 6, above left), water is used to flush the waste and propel it through the system. In dry toilets (Figure 6, above right), the feces drops into dry receptacles or pits, where it composts and dries up and is later removed for disposal or reuse. Both technology approaches have their advantages. Many see water-based sanitation to be more convenient to use and better in odor control. On the other hand, dry sanitation is more environmentally friendly because there is no need to flush, so black-water generation is eliminated or vastly reduced. Also, with no water mixed with the feces, there is much less opportunity for pathogens to breed and, thereby, evolve into more virulent strains.

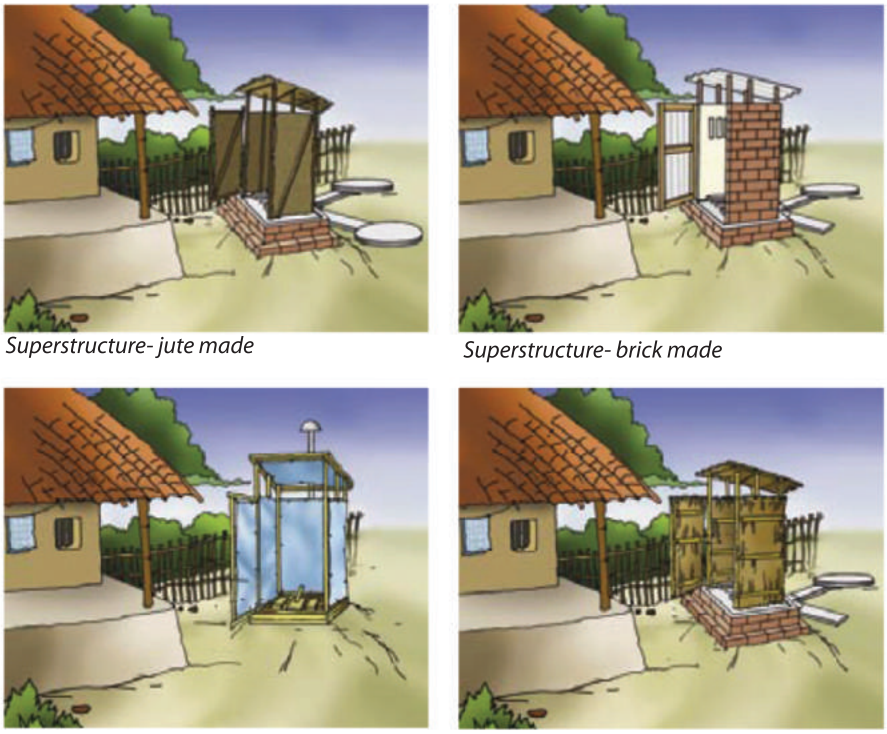
B. The User Interface: Toilet Rooms

Toilet rooms can be indoors or separate from the house (e.g., outhouses).[5] They can be placed above the vault or

[5]*The latter is a preference in many cultures and rural communities.*

offset from it. Their construction can be simple or elaborate depending on what users can afford or what local building materials are available (Figure 7).

In the Philippines, one toilet room to each household is prescribed. In schools, gender-separate facilities are recommended with at least one receptacle (urinal or bowl) per 50 pupils of each sex. In emergency situations, one toilet per fifty people is considered a good ratio. A toilet's ventilation, lighting, and other aspects of aesthetics and convenience are important in attracting the patronage of users previously accustomed to defecating outdoors.



Superstructure- jute made

Superstructure- brick made

Superstructure- plastic made

Superstructure- wood made

Figure 7. *Outhouses of various construction materials. Source: Rajiv Gandhi National Drinking Water Mission (2008). Technology Options for Household Sanitation, Indian Ministry of Rural Development and the United Nations Children's Fund.*

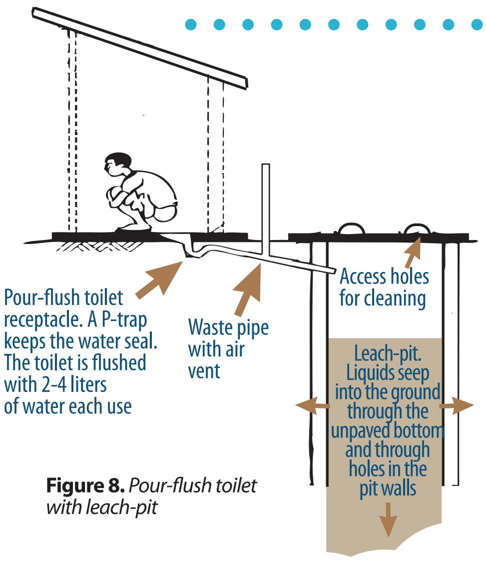


Figure 8. *Pour-flush toilet with leach-pit*

C. Wet Systems

1. The Pour-flush toilet with Leach-Pit

This toilet is flushed by two to four liters of water after every use. The flushed waste ends up in the pit where liquids leach out into the ground while solids are detained and decompose. Gases escape through the screened air vent (the vent also helps keep the needed amount of flushing water small).

Toilet receptacles can be either of the sitting or squatting type.

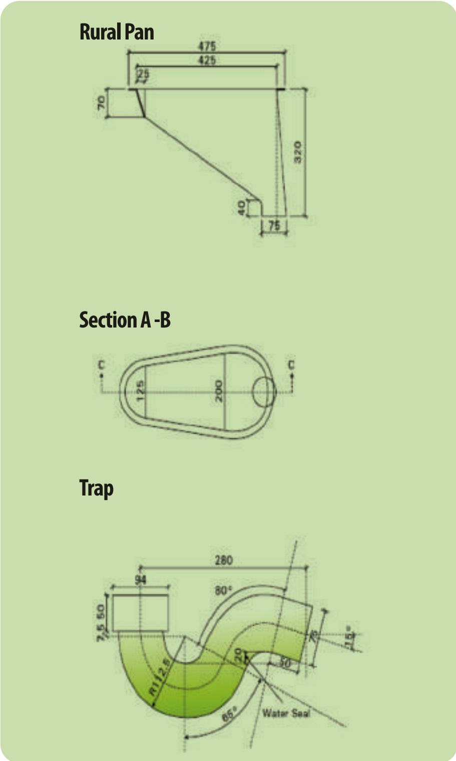


Figure 9. *Left: dimensions of a pour-flush squatting pan; Above right: a sitting pour-flush bowl.*

a. The Pour-flush Toilet Receptacle

Commercially available sitting toilet bowls in the Philippines are usually made of ceramic. Plastic pans are rarer and are mostly used in large government toilet-provision programs. Pans and bowls can also be field-fabricated from concrete using molds.

Toilet receptacles are usually installed in a corner of the toilet room to save on space, but far enough from the walls so users' bodies do not touch them while in position.

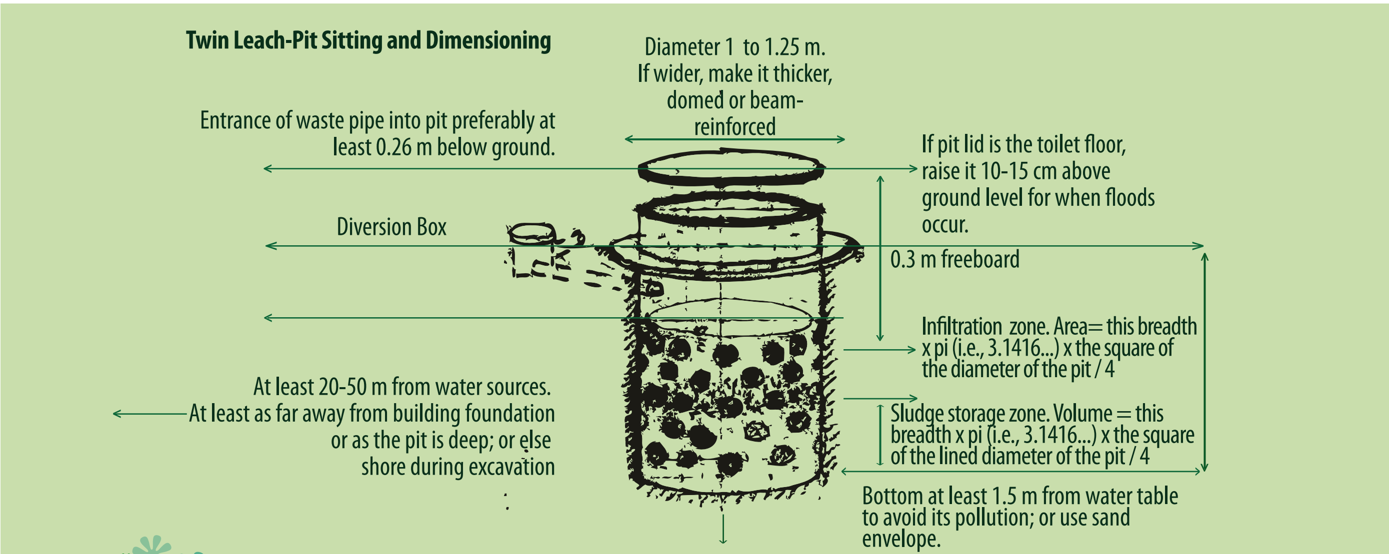


Figure 10. *Siting and design of a leach-pit. A leach-pit serving a household of five has an area footprint of at least 1 meter in diameter.*

b. The Leach Pit[6]

A leach-pit serving a household of five has an area footprint of at least 1 meter in diameter.

Leach-pits can be shared by more than one toilet as long as they are within 8 meters away.

Leach-pits almost always need to be lined except when dug in solid rock. Linings can be of rip-rap, cinderblock (hollow blocks) or ferrocement.

Leach-pit Designs:

The simplest and most common design is a single leach-pit. This design, however, means that every time the pit fills up, the toilet is out of commission while the pit is being desludged.

In areas where this periodic effort is considered too much of a bother, double leach pits[7] can be an option. When the first pit is filled-up, the toilet waste is directed into the second.

While the second pit is in use, the contents of the first have time to dewater and compost. And when the second pit is full, the first pit is emptied and put back in use.

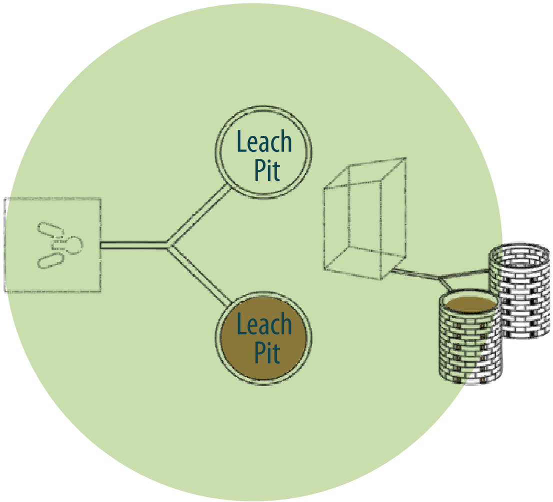


Figure 11. *Double leach-pit. Source: Tilley, Elizabeth. Fundamentals of Sanitation in Developing Countries. Sandec/Swiss Federal Institute of Aquatic Science and Technology (EAWAG).*

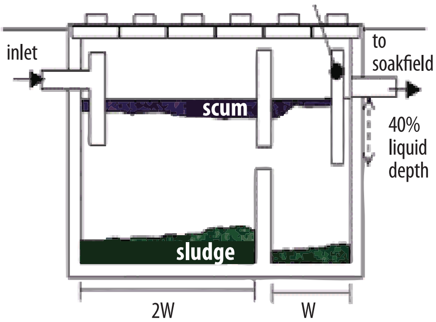
2. The Pour-flush Toilet with Septic Tank and Infiltration Trench

a. The Septic Tank

Unlike leach-pits, septic tanks have sealed bottoms and sides and are, therefore, watertight. Solids settle out, get digested anaerobically (in the absence of air) by microbial action, and accumulate as sludge and scum. Liquids are clarified and exit the tank to be disposed off onsite via infiltration trenches or (less commonly) evapo-transpiration mounds, or are sewered away.

Septic tanks may have more than one chamber[8] and may be shared with other pour-flush-toilets within 8 meters of the tank.

Typical installations reduce BOD by 30-65%, suspended solids by 80-85%, and coliform count by 1 to 4 orders of magnitude through settling and anaerobic digestion.



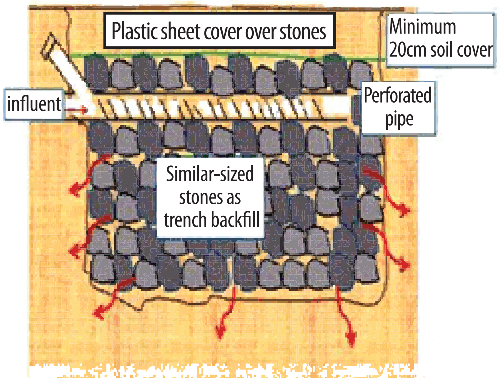


Figure 12. *Above left: a septic tank; Above right: an infiltration trench*

Septic tanks can be made of poured concrete, cinder blocks, or ferrocement. Factory-made high-density polyethylene (HDPE) plastic and fiberglass versions are also available in some countries.[9]

[6] *Reportedly not considered improved sanitation by the Philippine Sanitary Inspector's Manual. Instead, either a dry toilet or a septic tank is recommended for onsite-sanitation.*

[7] *Twin leach-pits are a rarity in the Philippines. The tropical climate facilitates a more complete and rapid decomposition of the waste resulting in slow sludge accumulation rates. Many pits take decades to fill up, if ever. Another reason for the slow rate of sludge build-up is that in most rural toilets, bathroom sullage and the mud tracked in by bathroom users do not enter the pit but instead are allowed to soak into the ground outside in swales. Only black-water enters the pit.*

[8] *The Philippine Sanitary Inspector's Manual reportedly recommends at least 3 in-series chambers for a septic tank.*

[9] *These tanks have to be filled with water first; before the excavation they are backfilled.*

Septic tanks are designed to detain wastewater from a few hours to a few months.

Settlers detain wastewater by 2 to 12 hours, usually as the first stage of a larger treatment facility.

Interceptor tanks' hydraulic detention periods range from 12 to 24 hours, enough to settle out solids that may block the larger sewer networks they feed to.

Regular septic tanks detain wastewater from 1 to 4 days, enough time to clear them up for infiltration into the soil through infiltration trenches.

Digesters are detained concentrated wastewater such as food processing and livestock waste for 4 to 60 days or more for BOD reduction or biogas production.

b. The Infiltration Trench

Infiltration trenches dispose of the settled wastewater from septic tanks by infiltration into the ground through their sides and bottoms.

The leached wastewater is assumed cleansed by 8 to 10 days travel through the soil.

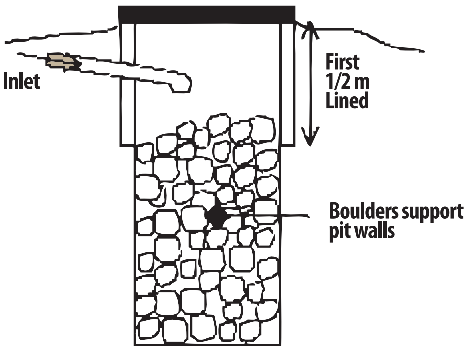


Figure 13. *A soak-pit*

Sullage may also be disposed of through infiltration trenches and similar facilities such as soak-pits.

Where regulations allow, infiltration trenches and soak-pits are a simple low-cost means of disposing domestic settled wastewater and even yellow water onsite. They can be scaled down to serve a single sink and their 'footprint' can be small enough to fit in the odd spaces of congested neighborhoods.

3. Other Examples of Wet Toilet Systems.

Chamber-pots with Cartage

Figure 14. *Chamber-pot with cartage*

Although not considered improved sanitation by health authorities, chamber-pots periodically emptied into communal leach-pits or septic tanks are a significant improvement over open defecation and may be considered in emergency situations.

It may also be of use as a toilet training intervention, not only for children but for entire communities.

C. Dry Systems:

1.Receptacles for Dry Toilets

Figure 15. *A lidded sitting receptacle for a composting toilet. In front of it is an anal-washing bidet (left) and a plastic jug funnel urinal. Behind is an ash pail and a trash can for used toilet paper. The bulge at the front of the toilet bowl houses the urine diversion dam. Source: DILG-GTZ Water and Sanitation Program.*

Figure 16. *A squat-hole in the lid of a pit. Source: Morgan, Peter (2007). Toilets That Make Compost: Low-cost, Sanitary Toilets That Produce Valuable Compost for Crops in an African Context. Aquamor, Zimbabwe, http://www.ecosanres.org/pdf_files/ToiletsThatMakeCompost.pdf.*

Figure 17. *Indian-made plastic squatting pan. The foreground compartment is for receiving urine, the lidded middle for dropping the feces through to a bucket underneath, and the basin behind is for capturing the anal-cleansing water.*

Figure 18. *A field-made dry seat riser fitted with urine diversion. Source: Morgan, Peter (2007). Toilets That Make Compost: Low-cost, Sanitary Toilets That Produce Valuable Compost for Crops in an African Context. Aquamor, Zimbabwe.*

Like pour-flush toilets, dry toilet receptacles can be either of the sitting or squatting type.

In the Philippines, factory-made dry toilet receptacles are just beginning to be made so many dry toilet builders have to still make do with fabricating them in the field.

As with pour-flush toilets, dry receptacles are usually installed in a corner of the toilet room to save on space, but far enough from the walls so users' bodies do not touch them while in position.

2. The Pit Toilet

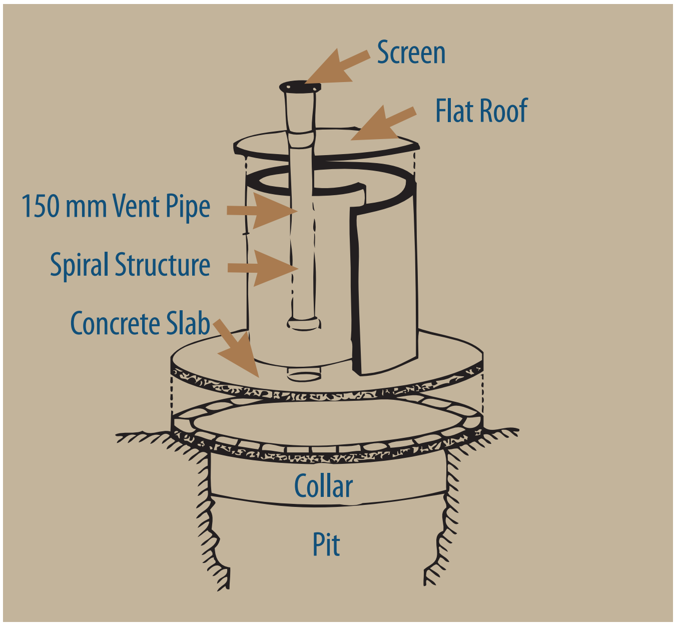


Figure 19. *Ventilated Improved Pit (VIP) ferrocement toilet. The spiral walls afford some privacy to users even without a door. The entrance faces the prevailing wind to enhance ventilation, and a big air vent conducts pit odors away from the room. Source: Basic Sanitation and Human Excreta Disposal in Latrines. GTZ.*

Pits are holes dug in the ground to receive fecal waste from toilets. Inside them, solids decompose and liquids soak into the surrounding soil.

In the Arbor Loo pit toilet design (Figure 20), the toilet is transferred to a new pit when the old one is full. A tree can be planted on the latter to take advantage of the compost left in it:

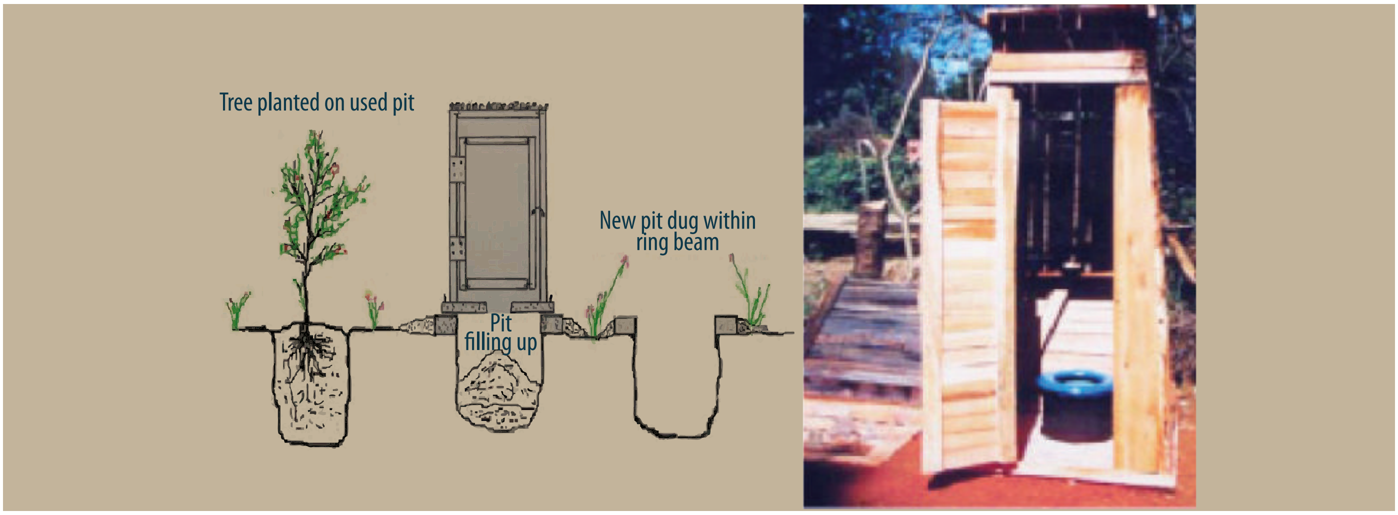


Figure 20. *The Arbor Loo (Africa). Source: Morgan, Peter (2007). Toilets That Make Compost: Low-cost, Sanitary Toilets That Produce Valuable Compost for Crops in an African Context. Aquamor, Zimbabwe.*

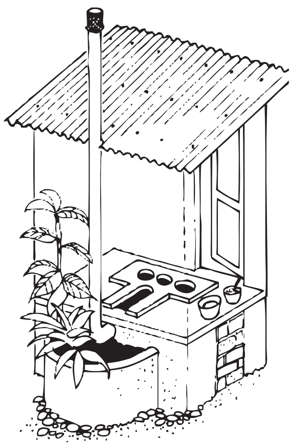


Figure 21. *The Kerala (India) double vault composting toilet. The user squats over one of the outside holes of the three. The middle hole catches the urine and empties into the elongated pan, which also serves as the anal-washing bidet. The liquid waste from it discharges into the plant bed behind the toilet. Source: Ecological Sanitation (2004; Revised and Enlarged Edition) Editors and co-authors: Uno Winblad, Mayling Simpson-Hébert. Co-authors 2004 revised edition: Paul Calvert, Peter Morgan, Arno Rosemarin, Ron Sawyer, Jun Xiao. Stockholm Environment Institute (SEI).*

3. Examples of Other Dry Toilet Systems:

a.Vault-Composting Toilets

Vault-composting toilets have permanent vaults that store and compost the feces. They are usually elevated above the ground to facilitate periodic emptying of the vaults.

In single-vault versions, the vault is emptied when full and the contents taken to an outside composting bin for further composting and hygienization.

In double-vault versions, each vault is used in turn with the 'resting time' of a vault also enabling the composting of its contents.

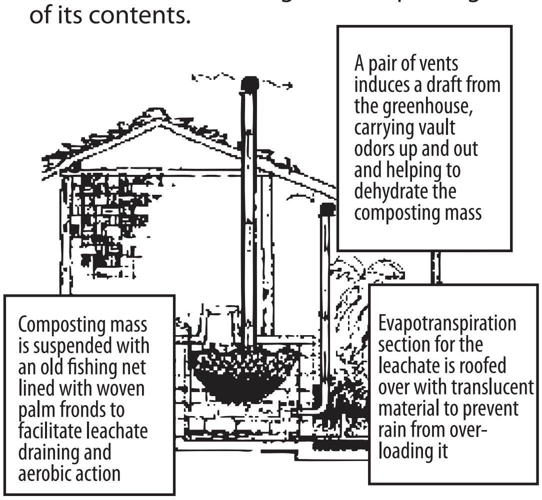


Figure 22. *The CCD composting toilet with attached evapo-transpiration bed in a greenhouse. This system allows mixing of the urine with the feces. Apparently, good draft-inducing venting and suspending the composting mass with a net are very efficient in reducing its volume. Despite the small effective volume of the vault, it took two years for user families in Yap (Micronesia) to fill the net. Source: Ecological Sanitation (2004; Revised and Enlarged Edition). SEI.*

b. Other Examples of Dry Systems:

Bucket Toilet With Cartage

Figure 23. *German-made plastic bucket toilet set. One pail serves as the feces receptacle inside the seat riser, the other as an ash bucket. Source: Lipkow, Ulrike (2009) Case study of Sustainable Sanitation Alliance Projects: Urine-diversion dehydration toilets in rural areas, Bayawan City, Philippines.*

Bucket toilets and other cartage systems are not considered improved sanitation by many health authorities. However, they are much better than open defecation, and are more immediately implementable in emergency situations such as disasters. In some instances they may also be useful in weaning away communities from open defecation.

III. A GUIDE TO ONSITE SANITATION TECHNOLOGY SELECTION

Several criteria may be considered when evaluating sanitation options for the purpose of selecting the most appropriate sanitation technologies for a given situation:

Criteria	Specifics
Socio-cultural Acceptability	E.g., social preferences regarding dry and wet sanitation, individual or communal toilet rooms, indoor or outhouse toilets, sitting or squatting latrines, ground-level vs. raised latrines, water or dry materials for anal cleansing, social attitudes to toilet maintenance tasks, social attitudes to reusing of sanitation end-products, acceptability of in-ground waste disposal, acceptability to local sanitation regulations, adaptability to people frequently moving from one place to another (portability). Performance of the technology in the area as proven by any such existing sanitation facilities.
Applicability to Site Physical Condition	E.g., areal (space) requirements, minimum distances from water sources and bodies of water, availability of water to pour-flush, soil infiltration capacity, applicability to challenging environments if required (shallow water table, flooding, unstable or rocky ground, houses on water, or floating houses which applies mainly to pits, vaults, and disposal components).
Upgradability if required Scalability	Upgradability to more-improved sanitation or to sewered sanitation (applies mainly to below-ground components). Applicability to single-household or shared use if required (applies only to below-ground components).
Availability of Resources for Construction and Sustainability	Local availability of required materials, manpower, and equipment for construction, operation, and maintenance.
Affordability	Construction (and labor and material components required), operation and maintenance costs and household willingness to pay for them. Value, if any given, to sanitation end products, environmental benefits, and economic improvements arising from improved sanitation (applies mainly to enhancements to the basic system).

It is entirely possible that this selection process will yield not one best technology but several alternatives, with each stakeholder preferring one over the others. For example, richer households may prefer the more expensive but more convenient alternatives. Poorer families may opt for lower-cost but preferably upgradable options. Health and governance authorities may prefer the higher-end technology options, but then again may opt for technologies that are more affordable to the community. Donors may also want technologies that offer the best bang for their buck but may be willing to invest more in enhancements that offer extra environmental and economic benefits to the community.

Example of a Toilet Selection Process:

A 6-member family is going to build a household latrine. They would prefer a wet facility like many other families have in their neighborhood (having at least 15 liters per day per person of water supply). They would also like a sitting toilet and are used to cleaning themselves after toilet use with water.

They would like an outhouse toilet as they say they have no room in the house for an indoor toilet. However, their yard is wide, having at least a 3-meter x 10-meter open area at the back. The nearest water source or body of water from this prospective site is 30 meters away, and the water table is 6 meters below the ground surface.

The soil at the lot is clay loam, with a proven infiltration capacity of at least 130 liters per person per day (the expected infiltration load is 7 liters of black-water per person per day; only black-water will enter the vault). The site suffers no flooding.

Common construction materials (for a building with concrete, wood, and thatch) and technologies are locally available.

The family is willing to spend PHP3,000 in materials and provide the manpower in building the toilet themselves.

While use of waste such as animal manure for agriculture is accepted in the community, they have little experience in the use of biogas from human waste or human urine as crop fertilizer. Nevertheless, the family is willing to try these enhancements for their toilet if it does not exceed their materials budget.

a) Vault Selection: This is usually done first as the vault or pit is the heart of the system. In this example, there is a short-list of two options:

RATING TWO WET VAULT OPTIONS

Criterion	**User/ Community/ Site Requirement / Preference**	**1.2 m Dia Ferrocement Leach-pit (see Annex C for details)**	**1.2 m Dia Ferrocement Septic Tank (see Annex D for details) and Infiltration Trench (see Annex E)**
Socio-cultural Acceptability			
Anal-cleansing and flushing water requirement per person per day	Not more than 6 liters	2-4 liters	2-4 liters
Method of effluent disposal	Ground	Ground through infiltration trench	Ground through pit sides and bottom
Scalability	Not required	For individual household, or shared if size is increased	For individual household, or shared if size is increased
In-door or outhouse	Outhouse	Either	Either
Compliance with local sanitation regulations	Community: preferably yes. Authorities: leach-pits not considered improved sanitation.	No	Compliant

RATING TWO WET VAULT OPTIONS			
Criterion	**User/ Community/ Site Requirement / Preference**	**1.2 m Dia Ferrocement Leach-pit (see Annex C for details)**	**1.2 m Dia Ferrocement Septic Tank (see Annex D for details) and Infiltration Trench (see Annex E)**
Portability	No requirement	No	No
Existence of similar vaults in use in the community	Required	Yes	Yes
Applicability to Site Physical Conditions			
Footprint	Not more than 3 m x 10 m	Yes. 1.2 m x 1.2m area to build the facility on; 2.4 m x 2.4 m needed during construction	Yes. At least 1.2 m x 0.2 m area to build the facility on.
Excavations can be sited at least as far from nearby building foundations as the facility is deep?	Required	Yes	Yes
Can in-ground disposal component be at least 20 m from water sources and bodies of water?	Required	Yes	Yes. Infiltration trench can be sited 20m from water sources
In-ground disposal component at least 1.6 m above the water table?	Preferred	Yes. Pit can be dug shallow to satisfy this condition	Yes. Infiltration trench can be dug shallowly to satisfy this condition
Can the in-ground disposal component be built with sufficient infiltration area?	(7 lpcd x 6 persons/130 lpd infiltration capacity = 0.32 m^2 infiltration area)	Yes	Yes
Adaptability to challenging environment (shallow water table, flooding, unstable or rocky ground, houses on water, floating houses).	Not challenging - environment community	Can be adapted to but will be more expensive to build in most challenging environments, except on water more than 1 m deep	Can be adapted to but will be more expensive to build in most challenging environments, except on water more than 1 m deep
Upgradability	Preferred	Can be upgraded to connect to sewers; or to septic tank but with difficulty	Can be upgraded to connect to sewers

RATING TWO WET VAULT OPTIONS			
Criterion	**User/ Community/ Site Requirement / Preference**	**1.2 m Dia Ferrocement Leach-pit (see Annex C for details)**	**1.2 m Dia Ferrocement Septic Tank (see Annex D for details) and Infiltration Trench (see Annex E)**
Availability of Resources for Construction and Sustainability			
Materials	Materials are locally available for concrete, wood, thatch constructions	Concrete	Concrete
Local availability of manpower and skills	Masonry, welding, concrete, woodwork skills locally available	Masonry. Some training on ferrocement needed	Masonry. Some training on ferrocement needed
Special Equipment Needed	Any special equipment should be locally available or can be fabricated using local facilities	Reusable mold-set which can be made with welding facilities required	Reusable mold-set which can be made with welding facilities required
Affordability			
Cost of construction materials (PHP)	Maximum PHP3,000, including toilet super-structure and receptacle	1,792	2,273
Cost of construction labor (PHP)	User to provide labor	2,000	2,088
Total construction cost (PHP)		3,792	4,240
Annual depreciation (PHP)		152	177
Annual maintenance (PHP)		152	169
Total of annualized costs (PHP)		303	346

From the above, it can be seen that while the leach-pit option is slightly lower in cost, its drawback is that local authorities do not consider it improved sanitation (see blue-marked cell in the table). So the preferred choice in this case is the ferrocement septic tank.

b) Toilet Superstructure Selection - the superstructure is, cost-wise, the next major component of the toilet, so it is usually selected next. In this example, there are two outhouses shortlisted and they are rated on the oppsite page:

RATING TWO OUTHOUSE OPTIONS			
Criterion	**User/ Community/ Site Requirement / Preference**	**Outhouse of Native Materials With Rebar Framing (see Annex A for details)**	**Small Ferrocement Outhouse** **(see Annex A for details).**
Socio-cultural Acceptability			
Adaptability to household or communal use	Household use	Either	Either
Adaptability to indoor or outhouse use	Outhouse	Either	Either
Indoor or outhouse	Outhouse	Either	Either
Portability	Not required	Can be moved to another site	Can be moved to another site with some difficulty
Existence of similar structures in use in the community	Not required	No	No
Applicability to Site Physical Conditions			
Footprint	Not larger than 3 m x 10 m	Can be built directly over vault	Can be built directly over vault
Applicability to Challenging Environments	Not challenging - environment community	Can be adapted to but will be more expensive to build in most challenging environments except where it has to be built on water more than 1 m deep	Can be adapted to but will be more expensive to build in most challenging environments except where it has to be built on water more than 1 m deep
Upgradability	Preferred	Can be replaced	Can be replaced
Availability of Resources for Construction and Sustainability			
Materials	Materials are locally available for concrete, steel, wood, thatch constructions	Concrete, steel, thatch	Concrete, steel wires
Local availability of manpower and skills	Masonry, welding, concrete, woodwork, thatching skills locally available	Masonry, welding, thatching skills needed.	Masonry. Some training on ferrocement needed

RATING TWO OUTHOUSE OPTIONS			
Criterion	**User/ Community/ Site Requirement / Preference**	**Outhouse of Native Materials With Rebar Framing (see Annex A for details)**	**Small Ferrocement Outhouse (see Annex A for details)**
Special Equipment Needed	Any special equipment should be locally available or can be fabricated using local facilities	None	Reusable mold-set which can be made with welding facilities required
Affordability			
Cost of construction materials	Maximum PHP3,000, including vault and receptacle	1,013	664
Cost of construction labor	User to provide labor	519	800
Total construction cost (PHP)		1,532	1,464
Annual depreciation		102	59
Annual maintenance (PHP)		61	59
Total of annualized costs (PHP)		163	118

From the above, it can be seen that while the total construction cost for each option is about the same, the ferrocement outhouse requires significantly less materials, so it the more economical choice. However, the user family may find the native materials outhouse sufficiently more aesthetic and may be willing to spend extra for this option.

c) Toilet Receptacle Selection - two makes of sitting-type pour-flush receptacles are then rated as follows:

RATING TWO SITTING-TYPE POUR FLUSH RECEPTACLE OPTIONS			
Criterion	**User/ Community/ Site Requirement / Preference**	**Factory-made ceramic pour-flush bowl (see Annex B)**	**Field-fabricated concrete pour-flush bowl (see Annex B)**
Socio-cultural Acceptability			
Anal-cleansing and flushing water requirement per person per day	Not more than 6 liters	2-4 liters	2-4 liters
Adaptability to sitting or squatting position	Sitting	Sitting	Sitting
Portability	Not required	Can be transferred to another site	Can be transferred to another site
Existence of similar structures in use in the community	Not required	Yes	Yes

RATING TWO SITTING-TYPE POUR FLUSH RECEPTACLE OPTIONS			
Criterion	**User/ Community/ Site Requirement / Preference**	**Factory-made ceramic pour-flush bowl (see Annex B)**	**Field-fabricated concrete pour-flush bowl (see Annex B)**
Applicability to Site Physical Conditions			
Adaptability to challenging environment (shallow water table, flooding, unstable or rocky ground, houses on water, floating houses).	Not challenging-environment community	Can be adapted to but will be more expensive to build in most challenging environments.	Can be adapted to but will be more expensive to build in most challenging environments.
Upgradability	Preferred	Can be replaced	Can be replaced
Availability of Resources for Construction and Sustainability			
Materials	Materials are locally available for concrete, steel, wood constructions. Factory-made pour-flush bowl available	Factory-made pour-flush bowl should be available	Materials to make concrete should be available
Local availability of manpower and skills	Masonry skills locally available	Masonry skills needed.	Masonry skills needed.
Special Equipment Needed	Any special equipment should be locally available or can be fabricated using local facilities. Reusable mold set available at the local health office.	None	Reusable mold-set needed

RATING TWO SITTING-TYPE POUR FLUSH RECEPTACLE OPTIONS			
Criterion	**User/ Community/ Site Requirement / Preference**	**Factory-made ceramic pour-flush bowl (see Annex B)**	**Field-fabricated concrete pour-flush bowl (see Annex B)**
Affordability			
Cost of construction materials	Maximum PHP3000, including vault and receptacle	550	150
Cost of construction labor	User to provide labor		100
Total construction cost (PHP)		550	250
Annual depreciation (25 years life)		22	10
Annual maintenance (PHP)			
Total of annualized costs (PHP)		22	10

While the ceramic bowl may be more expensive than the field-fabricated bowl, at this point the prospective user family, especially the women members, may opt for it over the field-fabricated concrete one because of aesthetic reasons.

d) Enhancements - two possible enhancements (of which either, both or none can be opted for) is then rated as follows:

RATING TWO POSSIBLE ENHANCEMENTS			
Criterion	**User/ Community/ Site Requirement / Preference**	**Urine Diversion (see Annex B for details)**	**PVC Tarp Biogas Harvesting Attachment (see Annex C for details).**
Socio-cultural Acceptability			
Use of sanitation products acceptable to the community	No experience yet but willing to try them out		
Adaptability to vault option used:			
Dry toilet		Yes	No
Leach-pit		Yes	No
Septic tank		Yes	Yes
Applicability to Site Physical Conditions			
Can be retro-fitted to existing facility?	Preferred		
Dry toilet		Yes, if toilet receptacle is of the bowl or pan type	No
Leach-pit			No
Septic tank			Yes

RATING TWO POSSIBLE ENHANCEMENTS			
Criterion	**User/ Community/ Site Requirement / Preference**	**Urine Diversion (see Annex B for details)**	**PVC Tarp Biogas Harvesting Attachment** **(see Annex C for details).**
Availability of Resources for Construction and Sustainability			
Materials	Materials are locally available: PE and PVC pipe and fittings, nylon wire, aluminum pipe, rubber sheet, plastic container, concrete	PE pipe and PVC fittings, rubber sheet, concrete, plastic container	PE pipe and PVC fittings, aluminum pipe, nylon wire.
Local availability of manpower and skills	Masonry, welding, concrete, woodwork, thatching, pipe-fitting skills locally available	Pipe-fitting skills needed.	Pipe-fitting skills needed.
Special Equipment Needed	Any special equipment should be locally available or can be fabricated using local facilities	Glass drill needed	
Affordability			
Cost of construction materials	Maximum PHP3,000, including toilet superstructure, vault and receptacle	319	606
Cost of construction labor	User to provide labor	150	182
Total construction cost (PHP)		409	788
Annual depreciation		19	46
Annual maintenance (PHP)		19	32
Total of annualized costs (PHP)		37	78

RATING TWO POSSIBLE ENHANCEMENTS			
Criterion	**User/ Community/ Site Requirement / Preference**	**Urine Diversion (see Annex B for details)**	**PVC Tarp Biogas Harvesting Attachment (see Annex C for details).**
Value of Recovered Products per Year (PHP)		493 (fertilizer value of urine)	1,800 (Cooking gas value of biogas)

Both enhancements give good returns for the investments they require.

Checking the total materials cost of the previously selected components:

Toilet Component	Material Cost (PHP)
1.2 m Dia Ferrocement Septic Tank and Infiltration trench	2,273
Small Ferrocement Outhouse	664
Factory-made ceramic pour-flush bowl	550
Urine Diversion	319
PVC Tarp Biogas Harvesting Attachment	606
TOTAL	**4,412**

It can be seen that the total material cost is above the budget limit set by the user family. The family then has several options:

a. Find supplementary financing to cover the cost;

b. Drop some enhancements such as the urine diversion and biogas attachments from the selection;

c. Select instead the cheaper options; or

d. Any combination of the above.

ANNEXES

Annex A. Toilet Superstructures:

1. Dimensioning:

Floor dimensions can be as little as 0.8 meters x 1.1 meters but 0.8 meters x 1.2 meters is the minimum recommended.[10]

Toilet floors are usually elevated above the ground level by at least 0.1-0.15 meters to afford some protection from floods.

2. Construction Materials

Floors can be of earth, gravel, concrete,[11] wood, or tiled.

A toilet room may sit directly on top of its vault or be offset from it.

Walls may be constructed of various materials. They can be as simple as curtains to create private space for an indoor toilet, bamboo, bamboo weave, wood, or as permanent as concrete and cinder block walling.

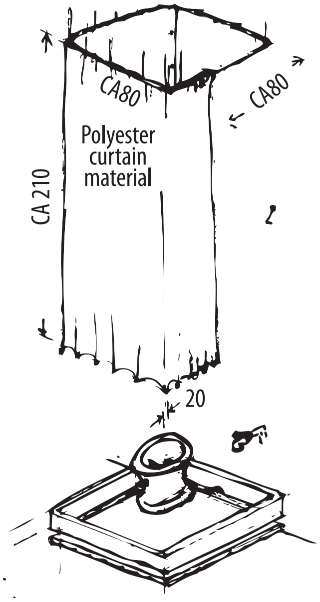
Doors for single-household toilets range from simple curtains to sliding, folding, or swinging doors of wood, plain GI sheet or vinyl,[12] secured by latches, hooks or bolt-locks.

3. Design Examples and Construction Costs

Toilet room construction costs vary widely: a simple roofless enclosure of coconut frond weave with round-poles for posts usually takes no more than three days for a rural household to gather the materials for and erect. On the other hand, a tiled concrete indoor toilet with a water closet and a sink can cost up to PHP78,000 (2010).

Below are some toilet superstructure designs and their bills of materials:

a) Curtain-Enclosed Indoor cubicle

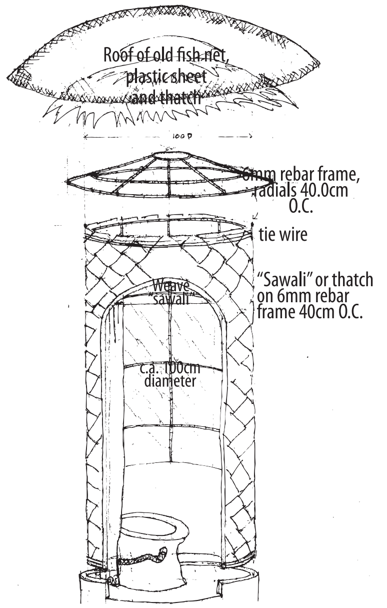


Curtain-Enclosed Indoor cubicle. Source: PCWS.

BILL OF MATERIALS						
Curtain-Enclosed Indoor Cubicle						
length of side 1, m=		1	flooring mortar mix: 1:			3
length of side 2, m=		0.8	flooring thickness,mm=			22
height, m=		2.1	Enclosure thickness, mm=			30
height to rafters, m		5	enclosure height, m			0.1
enclosure mortar mix:1:		3	flooring conc vol, m3=			0.0176
Item	Qty	Unit	Unit Cost (2009)	Cost		
Materials					417.28	
10mm rebar	1	pcs	152.7778	152.78		
#18 tie wire	0.5	kg	55	27.50		
polyester cloth	7.5	m2	17.33333	130.00		
tacks	10	sets	2	20.00		
drain	1	sets	70	70.00		
2" elbow	1	pcs	17	17.00		
2" x 3m PVC san pipe	1	pcs	80	80.00		
pvc solvent	1	can	35	35.00		
Labor	0.75	m-d	400	300.00	300.00	
TOTAL COST					717.28	
Annualized Costs:					57.38	
Depreciation (25 years)					28.69	
O&M (4% of const costs)					28.69	

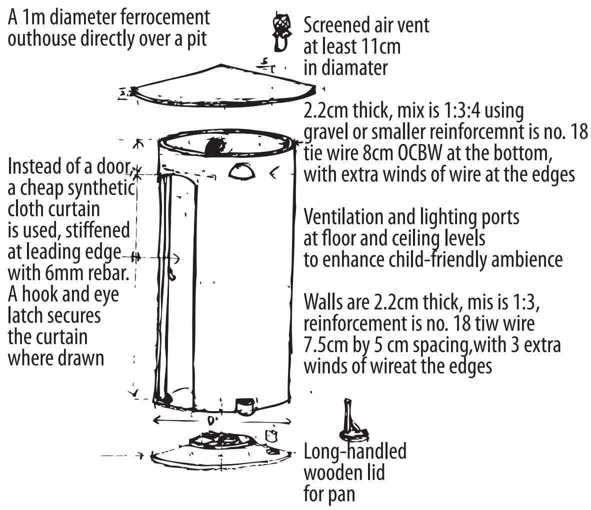
10 A fully accessorized dry toilet room with an anal-washing bidet, ash pail, and toilet paper trashcan may require at least 1 meter x 1.2 meter floor space.
11 Roughly finished to prevent slips.
12 Sliding doors can save space in a small house, as well as double-swing doors in a public restroom. Doorways are usually at least 0.7 meters in width and 2.1 meters in height.

b) Outhouse of Native Materials with Rebar Framing



Outhouse of Native Materials with Rebar Framing. Source: PCWS.

c) Small Ferrocement Outhouse



Small ferrocement outhouse. Source: PCWS.

4. Enhancements

Water and soap should always be available even in a dry toilet for hand-washing.

BILL OF MATERIALS						
Outhouse-ferrocement with squat hole						
Including floor						
Diameter, m=	1					
Height, m=	2.1					
eaves width,m=	0.1					
Item	Qty	Unit	Unit Cost (2009)	Cost		
Materials					663.97	
cement, bags	1.75		210.00	367.50		
sand, bags	5.25		10.80	56.70		
grabita, bags	1.75		13.50	23.63		
#18 tie wire	2.75	kg	55.00	151.25		
polyester cloth	2.5	m	26.00	64.90		
Labor	2	m-d	400.00	800.00	800.00	
(note: assumes use of reusable molds, workers trained in ferrocement)						
TOTAL COST					1,463.97	
Annualized Costs :					117.12	
Depreciation (25 years)					58.56	
O&M (4% of const costs)					58.56	

5. Maintenance

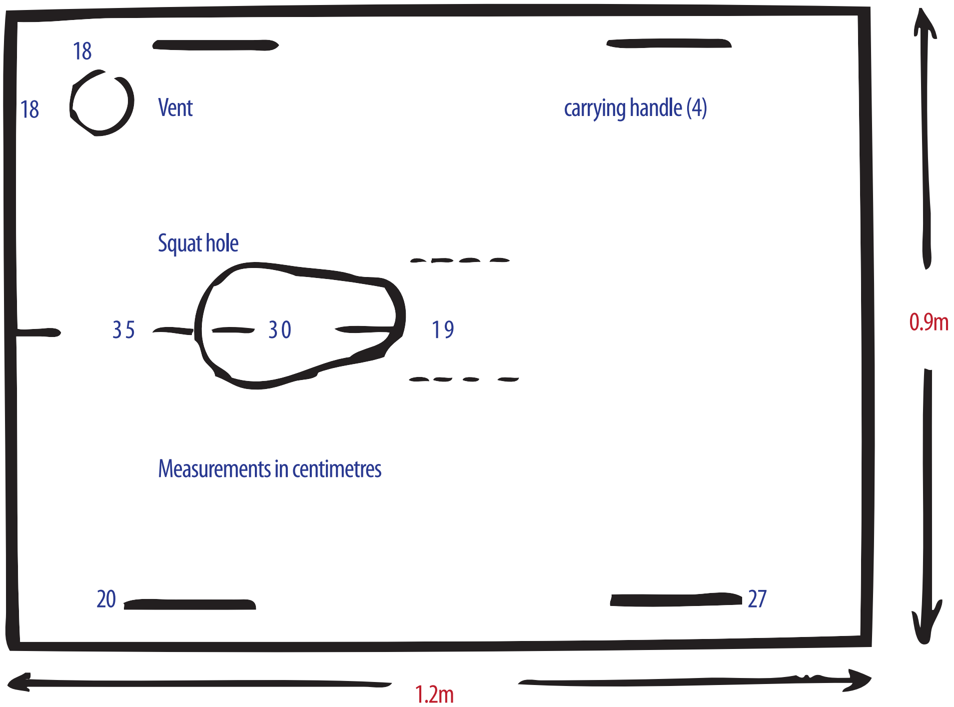
Toilet rooms are maintained like the rest of the house. Clean regularly and repair as needed. Whisk brooms, brushes, a pail, and a dipper will come in handy.

Bacterio-static chemical-based cleansing agents should be avoided. Instead, use natural cleansers such as ash, vinegar, or kalamyas juice.

Maintenance costs vary from 2 to 4% of the construction cost, although depreciation depends greatly on the materials used. Plastic sacking lasts only about six months, thatch and bamboo walls five to ten years, wood twenty to thirty years, and concrete indefinitely.

Annex B. Toilet Receptacles

1. Positioning Inside the Toilet Room



Typical dimensions of a pit toilet floor. Source: Morgan, Peter (2007). Toilets That Make Compost: Low-cost, Sanitary Toilets That Produce Valuable Compost for Crops in an African Context. Aquamor, Zimbabwe.

To save on floor space, receptacles should be sited as close as possible to one corner of the room, making sure the people will not have to touch the walls when using the toilet.

2. Toilet Receptacle Prices

In the Philippines, a factory-made ceramic bowl can cost PHP500 and up (2008); a cistern flush bowl set is priced in the region of PHP1,500 (2008).

A field-fabricated pour-flush bowl can be made using as little as a fourth of a bag of cement. Labor and materials expenses to make one bowl is about PHP250 (2009).

3. Enhancements

Pour-flush toilet receptacles can be fitted with a urine diversion dam, which is connected by hose to a collection tank or bucket.

A pour-flush bowl with urine diversion

Separating urine from black-water makes possible its use as crop fertilizer. Below is a bill of materials for a urine diversion unit that can be retro-fitted to a toilet bowl:

BILL OF MATERIALS					
Urine Collection/Infiltration Section					
Infiltration rate:					
sullage, lpd					
infiltration area					
Item	**Qty**	**Unit**	**Unit Cost**	**Cost**	
Materials					**329**
3/4 aluminum	3	cm	0.25	1	
epoxy	1	set	45	45	
1" thick					
foam rubber, 5cm x 20cm	0.01	m2	750	8	
Aluminum can for urine					
diversion	1.0	set		0	
1/2" PE pipe	2.2	m	20	44	
4-liter plas	1.0	set	45	45	
cement	0.5212717	bags	210	109	
sand	1.3031792	bags	11	14	
#18 tie wire	1.0	kg	55	53	
Labor					**150**
Construction				150	
TOTAL COST					**469.01**
Annualized Costs:					37.52
Depreciation (25 years)					18.75
O&M (4% of const costs)					18.75
Annual Benefit if Recovered Nutrients are Used:					
Annual VAlue of NPK Recovered:					
kg NPK per person per year:			2.5		
VAlue per kg of NPK, PHP (2009)			40		
Number of family members			5		
Annual Value of NPK Recovered, PHP:					492.75

Where there is piped water supply, a nozzle at the end of a length of flexible hose can be installed for anal cleansing:

An anal-washing nozzle

For odor control, lids on dry toilets are a necessity.

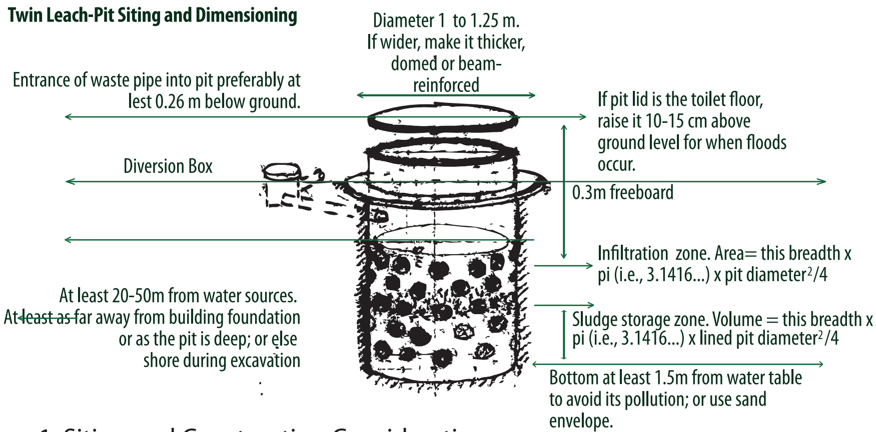
Annex C. Leach Pits

Leach-pits receive the flushings[13] from water-sealed latrines.[14] In the pit, solids decompose while liquids leach out through the bottom and openings in the wall lining.

Single leach-pits when full are taken temporarily out of service while being desludged.

In twin leach-pit toilets, when a pit is full it is rested and the influent is diverted to the second pit. By the time that pit is full, the contents of the first one would have composted more fully and the pit is then emptied and returned to service.

Wet-pits are leach-pits that are dug into the water table, and are usually larger to compensate for reduced infiltration rates in constantly wet soil.



1. Siting and Construction Considerations

Leach-pits should be sited at least 20-60 meters away from water sources such as wells, springs, and streams.

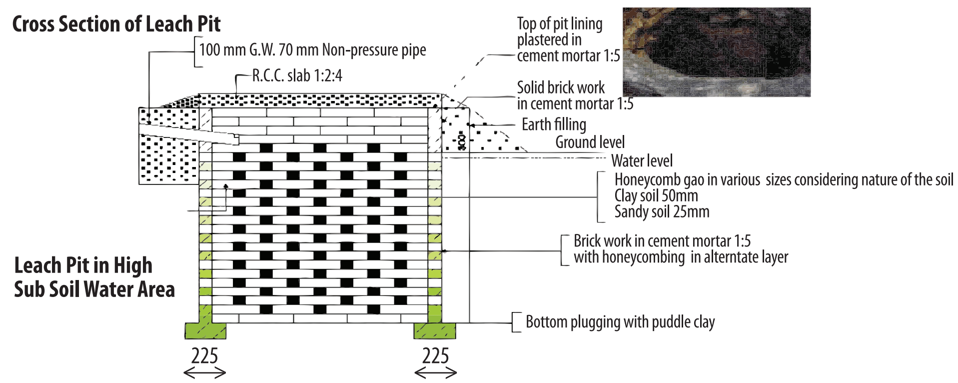
They should be no more than 8 meters away from the toilets they serve to minimize blockage of the waste pipe.

If possible, they should not be sited under vehicular traffic to minimize lid construction costs.

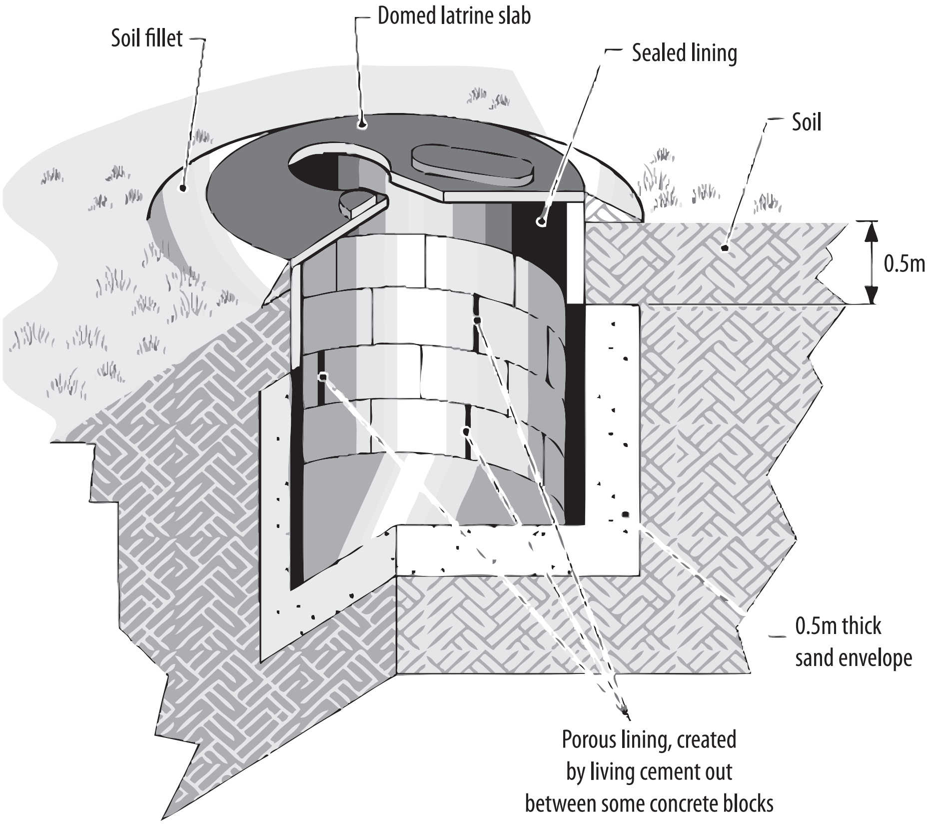
They should be dug at least as far away as they are deep from building foundations to prevent undermining the latter. If this is not possible due to lack of space, precautions to prevent the excavation from collapsing during construction must be undertaken.[15]

Excavations and the leach-pits themselves should preferably be circular for maximum structural strength.

The bottom of leach-pits should be at least 1.6 meters above the water table to minimize the possibility of polluting the latter. If the water table is too shallow, this risk can be mitigated by building a raised pit or by lining the pit bottom and sides with a 0.4 to 0.5 meters thick 'envelope' of fine sand:



13 2-3 liters of water per flush in pour-flush latrines.
14 Some sources recommend fitting the waste pipe from the latrine with a screened vent to reduce flushing water requirement.
15 E.g., dig-and-line method of excavation or excavation using the vault walls as caisson, and bracing the surrounding structures. See Annex K for more information.



A leach-pit with a sand envelope. Source: Harvey, Peter (2007). Excreta Disposal in Emergencies: A Field Manual. United Kingdom.

The waste pipe from the toilet is usually provided with an air vent, often made of plastic pipe at least 20 mm but more typically 63 mm in diameter to reduce flushing water requirements.

2. Construction Materials:

Wet conditions inside the pit will weaken bare soil walls, so leach-pits walls have to be fully lined. Wall linings can be constructed of cinder block or ferrocement. Pit lids can be made of poured reinforced concrete.

3. Pit Sizing and Dimensioning:

A pit should have
a) enough volume to store the accumulating sludge;
b) enough wetted area through which the daily liquid load can infiltrate into the soil; and
c) a freeboard of at least 0.3 meters when full.

The following table can help estimate the daily liquid load of a household leach-pit:

Black-water Generation in Pour-flush Latrines: Typical values			
Type of Liquid	**Liters used or generated per use**	**No. of times/user/day**	**Total, liters/user/day**
Fecal flushing	2	2	4
Urine flushing	2		2
Anal cleaning	2	2	4
Cleaning up after urination	0.6	6	3.6
Urine	0.2	6	1.2
Feces	0.2	2	0.4
TOTAL liters/user/day			15.2

Dividing the total daily liquid load by the appropriate value of the soil infiltration rate below, the required wetted area (the open bottom plus the wall area from it up to the water level) of the pit is computed:

Typical Long-term Soil Infiltration Rates[16]	
Type of Soil	**Infiltration rates, liters/m²/day**
Sand	50
Sandy loam, loam	30
Porous silty loams, porous silty clay loams	20
Compact silty loams; compact silty clay loams, clay	10
Anecdotal information from some school pits I in well-drained tropical humid sites indicate rates in excess of 400 liters/m2/day.	

Example: For a household of 6 members on sandy soil, the needed surface area for the infiltration zone of a pit is 15.2 liters blackwater per person per day x 6 members / 50 liters per m²per day=1.83 m².

Next, the required storage volume is computed. This is the product of the sludge accumulated per year and a suitable interval in years between desludging.

Anal Cleansing Material	Pit type (wet means dug into the water table)	Sludge Accumulation (liters per person per year)
Water	Wet	25
	Dry	30
Paper	Wet	30
	Dry	40
Anecdotal evidence suggest that long-term sludge accumulation for at least some pits in hot climates are as low as 5 liters per person per year.		

Recommended Most Economical Desludging Periods:
Where desludging costs are low and vault construction costs are high, e.g., desludged by local tradesmen or by the users themselves using manual pumps and the vault is conventional concrete built by local craftsmen: **2 to 6 years.**
Where both desludging and pit construction costs are low e.g., ferrocement-lined vaults: **6 to 14 years.**
Where both desludging and pit construction costs are high e.g., concrete-lined vaults and desludging by commercial outfits: **14 to 30 years.**
In practice, most users building on their own opt for the deepest pits that both they and ground physical situation can afford.

Example: In the previous problem, if the household will be using water for anal cleansing, the desludging interval is ten years; and the pit is 'dry,' the sludge storage volume should be: 6 persons x 30 liters sludge per person per year x 10 years desludging interval = 1800 liters or 1.8 m³.

In twin-pit toilets, the pit wall area submerged by the accumulating sludge is also considered as part of the liquid infiltration zone.

Example: In the previous problem, for a twin-pit with a pit diameter D of 1.2 meter and a wall lining thickness of 0.1 meter, the depth ds of the sludge zone is:

ds=V/(pi()D^2/4)=1.8/(pi()(1.2-2x 0.1)^2/4)=2.29 meters.

Meanwhile, the depth di of the infiltration zone for infiltration area A=1.83 m² is:

di=A/pi()/DI=1.83/pi()/1.2=0.49 meter.

the working depth of the pit is whichever is greater (in this case ds), plus a freeboard of 0.3 meter.

For a single pit the depth of the pit is the sum of the infiltration and sludge accumulation depth, plus the freeboard.

Example: In the previous problem, if the pit is a single pit the depth should instead be:

2.29 meter sludge storage zone+0.49 meter infiltration zone+0.3 m freeboard=3.17 meters.

For wet pits, the volume covered by the infiltration zone as computed above has to be multiplied by a correction factor:

TENTATIVE WET PIT VOLUME CORRECTION FACTORS[17]	
Desludging Interval, years	**Correction Factor**
2	1.96
3	1.47
4	1.12
5	0.91

The corrected infiltration zone depth is then used.

Example: If the pit in the previous problem is a wet-pit, and the desludging interval is 2 years, the new infiltration zone depth is therefore:

di=di for the single pit x 1.96 =0.49 m x 1.96=0.96 meter.

[16] *United Nations Development Programme. Interregional Project INT/81/047. Executing Agency: World Bank. The Design of Pour-Flush Latrines. D. Duncan Mara, Technology Advisory Group (TAG). A joint United Nations Development Programme and World Bank Contribution to the International Drinking Water Supply and Sanitation Decade.*

[17] *United Nations Development Programme. Interregional Project INT/81/047. Executing Agency: World Bank. The Design of Pour-Flush Latrines. D. Duncan Mara, Technology Advisory Group (TAG). A joint United Nations Development Programme and World Bank Contribution to the International Drinking Water Supply and Sanitation Decade.*

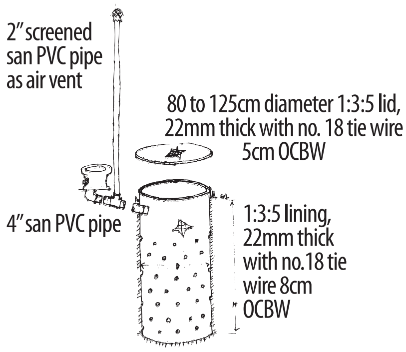
The storage volume meanwhile is: 6 persons x 30 liters sludge per person per year x 2 years desludging interval=360 liters or 0.36 m3.

The sludge storage depth then becomes: ds=V/(pi()D^2/4)=0.36/(pi()(1.2-2x 0.1)^2/4)=0.458 meter. the pit depth is now therefore: 0.458+0.96+0.3=1.718 meter.

Leach pits can be upgraded later but only with difficulty into septic tanks. They can also be shared by two or more households if built large enough and the household toilets are no more than 8 meters from the pit.

4. Design Examples and Bills of Materials

a) Ferrocement-lined Leach-pit



Ferrocement-lined leach-pit. Source: PCWS.

BILL OF MATERIALS						
Ferro-cement Single Leach Pit						
Pit Diameter, m=	1.2	elev of floor above ground, m=				0.1
Pit Depth, m=	2	doorway width, m=		0.7		
Lined Depth, m=	2	doorway height, m=		1.9		
Collar outside Diameter	1.4					
Height, m=	2.1					
platform diameter	1.2					
Item	Qty	Unit	Unit Cost (2009)	Cost		
Materials					1791.90	
cement, bags	2.5		210	525		
sand, bags	8		11	81		
grabita, bags	2		14	20		
#18 tie wire	5	kg	55	261		
polyester cloth	2	m	26	65		
4"san PVC pipe	1	pc	330	330		
4" san PVC elbow	1	pc	66	66		
2" san PVC pipe	1	pc	330	330		
4" x 2" san PVC tee	1	pc	66	66		
pvc solvent	1	small car	35	35		
3mm PE mesh	0.1	m2	125	13		
pour-flush bowl	1	pc	400			
Labor					2000.00	
Construction	3	m-d	400	1200		
excavation	2	m-d	400	800		
(note: assumes use of reusable molds, workers trained in ferrocement)						
TOTAL COST					3791.90	
Annualized Costs:					303.35	
Depreciation (25 years)					151.68	
O&M (4% of const costs)					151.68	

5. Enhancements

Leach-pits with reduced infiltration capacity can be connected to an infiltration trench to extend their serviceability.

Single leach-pits that have filled up can have another pit dug to upgrade it to a twin-pit system.

6. Maintenance

Avoid using chemical-based bactericides to clean the latrine so as not to harm the decomposing organisms in the pit. Use ash, vinegar, or kalamyas (kamias, iba) juice as cleansers.

Annex D. Septic Tanks

1. Siting and Construction Considerations

As long as the water-tightness of a septic tank and its fittings are assured, there are no restrictions to how close it can be sited to water sources. However, disposal facilities attached to it such as an infiltration trench should be at least 20 meters to 60 meters away from such water sources.

Other siting considerations are similar to those for leach-pits:

a) Septic tanks should preferablybe no more than 8 meters away from the toilets they serve to minimize blockage of the waste pipe.

b) If possible, they should not be sited under vehicular traffic to minimize lid construction costs.

c) They should be dug at least as far away as they are deep from building foundations to prevent undermining the latter. If this is not possible due to lack of space, precautions to prevent the excavation from collapsing during construction must be undertaken.[18]

d) The waste pipe from the toilet is usually provided with an air vent, often made of plastic pipe at least 20 mm but more typically 63 mm in diameter to reduce flushing water requirements.

e) If the ground in the site is too hard to dig, the tank and its sewage sources may have to be built partially raised above the ground.

2. Sizing and Dimensioning Considerations

A septic tank should be large enough to:

a) detain the wastewater for the desired hydraulic retention time,

b) store the accumulating sludge for the design desludging interval, and

c) have a freeboard of at least 0.2 - 0.3 meters.

Example: A household of 9 people consumes 80 liters per person per day (lcpd). 80% of this amount becomes wastewater, which flows into a septic tank. What should be the liquid volume of the tank?

Solution: 9 people x 0.08 m^3 LCPD x 80% x 2 days = 1.15 m^3.

Sludge accumulation rates in tropical climates vary from 0.025 to 0.04 m^3 per person per year, with the smaller figure applicable for tanks receiving only blackwater.

Example: In the previous sample problem, what should be the sludge + scum storage capacity of the septic tank? Assume a desludging interval of 10 years.

Solution: From the amount of wastewater generated, it would appear that sullage will also enter the tank. So select 0.04 m^3 per person per year as the sludge and scum accumulation rate:

9 people x 0.04 m^3 sludge + scum per person per year x 10 years = 3.6 m^3 sludge + scum storage volume.[19]

In case the computed volumes and dimensions turn out to be impracticable, re-compute using shorter but still acceptable desludging intervals.

Dimensioning a conventional two-chamber septic tank:

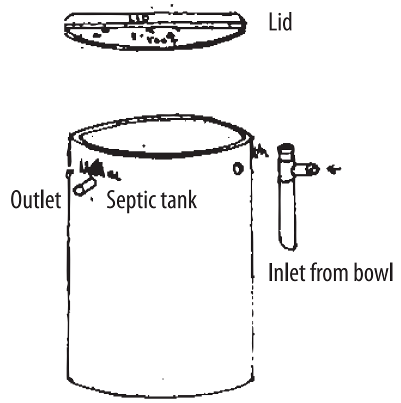
The 'classic' septic tank has two chambers, with the first longer than it is wide by a factor of 2 or more, and the second with a square plan. The depth should be at least 0.9 m but usually not more than 3 m (deeper tanks are more turbulence-prone). A minimum size of 1.5 m^3 is recommended.

[18] *E.g., dig-and-line method of excavation or excavation using the vault walls as caisson, and bracing the surrounding structures. See Annex K for more information.*

[19] *1/3 of this volume is scum.*

3. Construction Costs

For a ferrocement septic tank:



Ferrocement septic tank

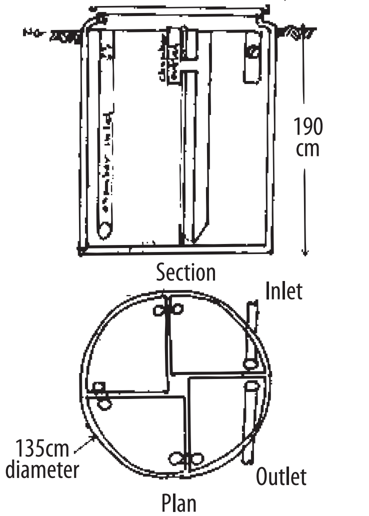
4. Maintenance

Septic tanks require desludging when their sludge storage volume is full. Leaking fittings, walls and lids should be repaired.

5. Various Septic Tank Enhancements

a) Baffled Reactor

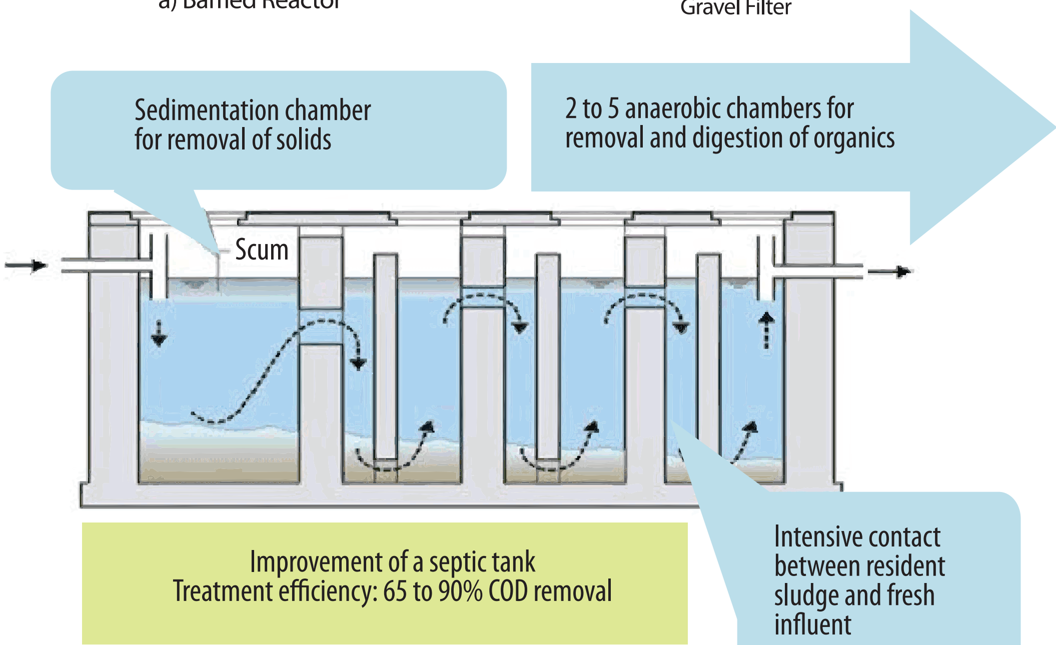
2.2M2 Baffled Reactor built in Albay Province



Ferrocement Baffled Reactor Tank. Source: PCWS.

Septic tanks with multiple baffled chambers force the sewage to flow through and mix with the sludge blanket, increasing treatment efficiency further.

b) Anaerobic Gravel Filter and Planted Gravel Filter



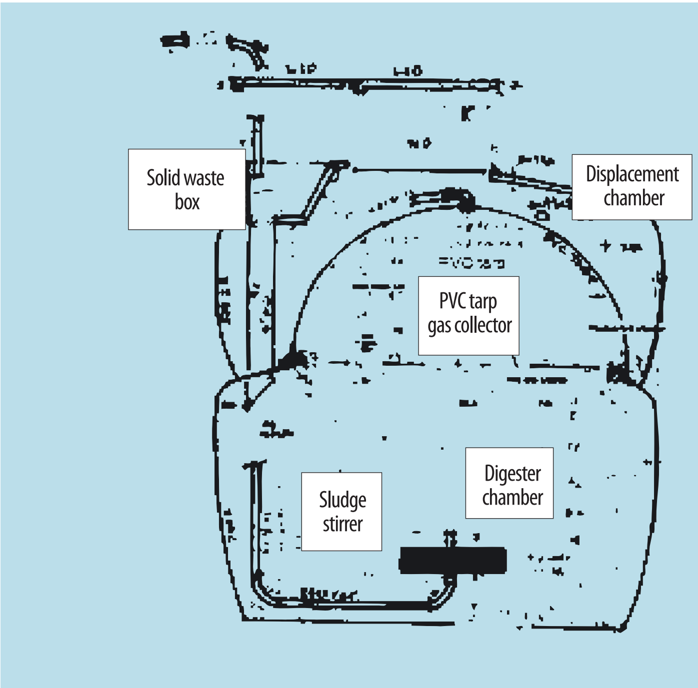
Septic Tank With Baffled Reactor. Source: Tilley, Elizabeth. Fundamentals of Sanitation in Develo-ping Countries. Sandec/EAWAG.

A ferrocement baffled reactor (background) coupled to a ferrocement anaerobic gravel filter (middle) then to a ferrocement planted gravel filter (foreground). Source: PCWS.

c) Biogas Harvesting

Biogas digesters are septic tanks designed to capture the biogas produced inside them.

A family's fecal wastes can produce enough gas for 25% of that family's cooking fuel needs. Other organic wastes such as manure and plant residues can be also be fed into a digester to increase biogas production.

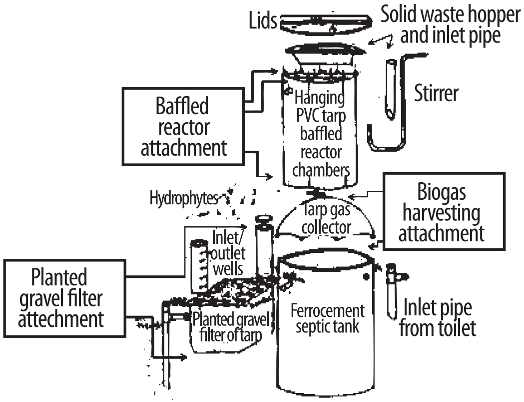


A ferrocement biogas digester. The gas is captured by a PVC tarp dome tethered to the lip of the digesting chamber. A manual stirrer speeds up gas production. Source: PCWS.

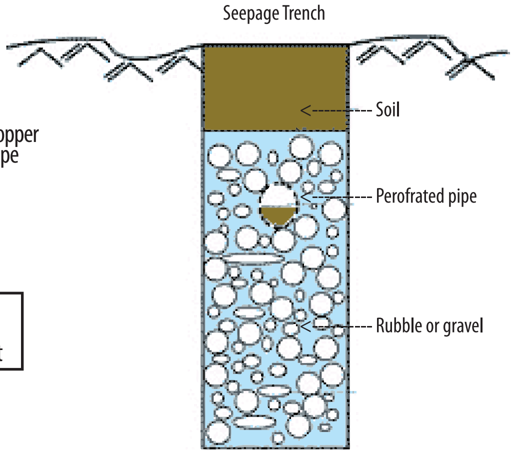
1.8 m³ x 2 m³ ferrocement digester under construction. From top left, clockwise: wire reinforcement; installing a solid waste box; the PVC tarp gas collector being tested for leaks, and the burner made from plastic faucets, aluminum pipe and an aluminum soda can. Source: PCWS.

2 m³ ferrocement biogas septic tanks cost about PHP5,000 each in labor and materials (2010). Its 4 m³ version costs about PHP7,000.

d) Bills of Materials For Some Septic Tank Enhancements:



Septic tank enhancements



Leach trench for disposal of septic tank effluent

BILL OF MATERIALS					
Biogas Harvesting Attachment					
Item	**Qty**	**Unit**	**Unit Cost (PHP, 2009)**	**Cost**	
Materials					**606**
1.8m wide PVC tarp	1.8	m	80	144	
elastomeric sealant	1	tube	45	45	
1/2" pvc male adaptor	2	pcs	13	26	
1/2" PE female adaptor	3	sets	50	150	
1/2" GI coupling	1	pcs	8	8	
1/2" plastic faucets with 1/2" nozzing	2	sets	30	60	
1/2" PE pipe	13	m	10	130	
3/4" aluminum tube	1	foot	7.5	7.5	
aluminum can	1	pcs			
some cement and sand					
6mm rebar	0.65	pcs	55	35.75	
Labor				181.875	**182**
TOTAL COST					788.13
Annualized Costs:					77.89
Depreciation (17 years)					46.36
O&M (4% of const costs)					31.53
Annual LPG value of biogas for a 5-member family:					
Savings in cooking fuel:				25%	
number of 11-kg LPG tanks used/yr:					12
price per tank:					600
Annual Value of savings:					1800

BILL OF MATERIALS					
Baffled Reactor Attachment					
No. of Chambers	6				
Length/chamber	0.4				
Width/chamber	0.4				
Height	1.4				
Item	**Qty**	**Unit**	**Unit Cost (PHP, 2009)**	**Cost**	
Materials					**1,258**
0.6mm PVC tarp	16.8	m2	72	1209.60	
PP sacking		m2	20	0.00	
2" san PVC pipe	0.5	pc	80	40.00	
2" san PVC tee	0.5	pc	17	8.50	
used synthetic f	5.8	m2	13	74.88	
Labor				399.89	**400**
TOTAL COST					1,657.99
Annualized Costs:					163.85
Depreciation (17 years)					97.53
O&M (4% of const costs)					66.32

BILL OF MATERIALS					
Planted Gravel Filter Section					
length, m=	1.2	Width of bricks,m		0.10	
width, m=	0.6	depth of bricks,mm		50.00	
height, m=	0.6				
Item	**Qty**	**Unit**	**Unit Cost**	**Cost**	
Materials					
cement, bags	0.2	bags	210	49.50	**665.34**
sand, bags	0.7	bags	11	7.64	
grabita, bags	0.7	bags	14	9.00	
aluminum can for floor drain	1.0	set		0.00	
2"san PVC pipe	0.5	pc	80	40.00	
1.8m wide pvc tarp	2.4	m	108	259.20	
2" san PVC tee	1	pc	25	25.00	
2" san PVC elbow	2.0	pc	17	34.00	
stones up to 4" dia	2.3148148	bags	11	25.00	
1/2" gravel	16.0	bags	14	216.00	
Pcs of plastic sheets					
Labor					
Construction	0.5	m-d	400	200.00	**400.00**
excavation	0.5	m-d	400	200.00	
TOTAL COST					1065.34
Annualized Costs:					105.28
Depreciation (17 years)					62.67
O&M (4% of const costs)					42.61

Annex E. Infiltration trenches and soak-pits

1. Siting and Construction Considerations

Infiltration trenches should be sited at least 20 meters away from water sources, and 3 meters away from trees.[20]

Although some references advise against its employment where the water table is less than 1.5 meters below the ground, in general, infiltration trenches are practicable where leach-pits are also known to work.

An infiltration trench usually is no deeper than 1.5 meters, the maximum practicable for a person digging with a hand hoe without actually getting into the trench itself.

Trenches should be as narrow as possible to save on backfill stones.

The length of the trench, or for a soak-pit the diameter and depth, is determined by the wall surface area required for leaching the wastewater given the infiltration capacity of the local soil:

Sample Problem: what should be the length of an infiltration trench receiving black-water from 9 persons at 10 liters per person per day? The soil at the site is loam.

Solution: assuming a 1.5 m deep trench will be dug with a soil cover of 0.2 m, the working trench depth can be 1.5 - 0.2 = 1.3 m. The required length of trench = 10 lcpd x 9 users/30 liters per m per day/2 sides per trench/1.3 m per side =^{2}1.16 m.

Infiltration trenches are very inexpensive: 2 meters of a trench 0.15 meters wide and 1.2 meters deep in soft-digging soil requires just 3 man-hours to construct, 0.3 m3 of stones (free, if locally plentiful or about PHP400-1,000 per m^3 if bought), and some plastic sheets.

BILL OF MATERIALS					
Infiltration Trench					
length, m^2	1.15				
width, m^2	0.15				
depth, m^2	1.5				
working depth	1.2				
Item	**Qty**	**Unit**	**Unit**	**Cost**	
Materials			**Cost**		
2" dia. stones	0.2	m3	700	144.90	**396.57**
Used shopping bags					
3" san PVC pipe	1.2	m	67	75.57	
9" san PVC pipe	1	pc	40	40.00	
3" san PVC plug	1.0	pc	45	45.00	
Labor					**305.66**
TOTAL COST					412.23
Annualized Costs:					40.74
Depreciation on (17 years)					24.25
O&M (4% of const costs)					16.49

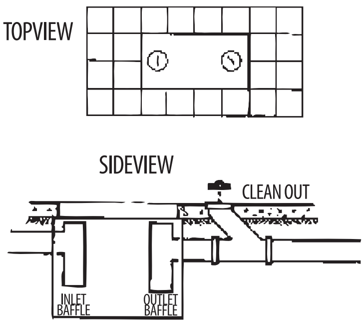
Typical Long-term Soil Infiltration Rates[21]	
Type of Soil	**Infiltration rates, liters/m^2/day**
Sand	50
Sandy loam, loam	30
Porous silty loams, porous silty clay loams	20
Compact silty loams; compact silty clay loams, clay	10

Anecdotal information from some school pits I in well-drained tropical humid sites indicate infiltration rates in excess of 400 liters/m^2/day. On the other hand, an infiltration trench in a humid tropics site with the groundwater just 0.3 m below the surface was measured to be infiltrating at least 120 L/m^2/day.

[20] To avoid damage to the trench from tree roots

[21] United Nations Development Programme. Interregional Project INT/81/047. Executing Agency: World Bank. The Design of Pour-Flush Latrines. D. Duncan Mara, Technology Advisory Group (TAG). A joint United Nations Development Programme and World Bank Contribution to the International Drinking Water Supply and Sanitation Decade.

Infiltration trenches and soak-pits are maintenance-free most of the time. One of the few things to watch out for is that the influent sullage must be mostly free of grease and grit, which can be assured if a grease trap is provided for:



A kitchen grease trap. Source: University of Leeds.

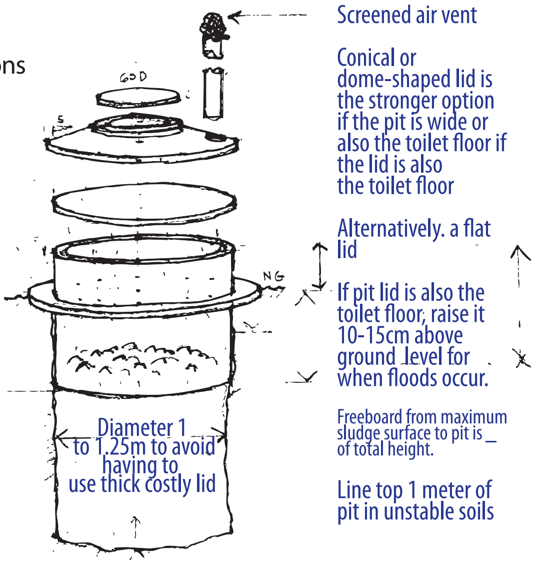
If an infiltration trench or soak-pit becomes blocked, instead of digging them up and cleaning them, it is sometimes more practicable to build another beside the old trench. The blocked unit often clears up again as the organic matter decomposes away, and it can be put back into service later.

Infiltration trenches and soak-pits are usually abandoned when a community switches to sewered connections. However, they can still do duty as storm water infiltration facilities.

Annex F. Pits

1. Siting and Construction Considerations

Pit Design and Construction Considerations



Siting and construction considerations. Source: PCWS

Pits should be sited at least twenty to sixty meters (recommended distances vary from country to country) away from potable water sources.

A pit should also be dug at least as far away as it is deep from nearby building foundations to avoid undermining the latter. If this is not possible, special precautions such as shoring, caissoning, and dig-and-line excavation methods may have to be implemented.

The top of the pit should be at least 10 cm above the ground to ensure that outside surface water does not flood the hole.

Pit wall linings can be made of cinder block or ferrocement while the pit lid can be of poured reinforced concrete.
Pits are usually circular in shape for stability. In practice, many users dig their pits as deep as local conditions and their resources allow. However, it is advisable for pits in unstable soils or more than 3 meters deep to have the upper 1 meter of their walls lined.

It is imperative to protect the local groundwater. The bottom of the pit should be above the water table by at least 2 meters.
In high water-table areas, pits may be partially raised, which also enable a higher rate of infiltration of liquids into the surrounding soil.

2. Sizing and Design Considerations

A 1-meter diameter x 3-meter-deep pit is good for 6 years' use by a 5-member family.[22]

To control odor problems, pit toilets should have the entrance door facing the wind, and a wide air vent (at least 10 cm in diameter). Receptacles should also have a lid.

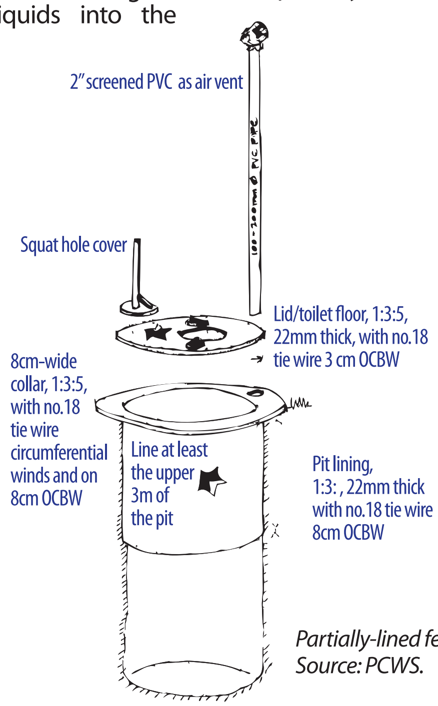
To prevent flies and other vermin from entering and escaping from the pit, the air vent should be screened and the toilet room kept dark (the flies tend to escape towards the light coming from the vent, and are trapped by the vent screen).

A manhole may be built into the lid to facilitate periodic emptying of the pit contents.

3. Construction Costs

Pit construction costs vary, from PHP650 (PHP400 for labor and PHP250 for materials) for a 1-meter-deep unlined pit with a ferrocement lid, to about PHP2,200 for a 2-meter deep pit of which the upper meter is lined with mortar.

The following is a bill of materials for a partially-lined ferrocement pit:



Partially-lined ferrocement pit. Source: PCWS.

[22] *Dry pit, to ¾ full, at 0.06m3 per person per year of sludge accumulation.*

Pit						
Pit Diameter, m=	1	elev of floor above ground, m=				0.1
Pit Depth, m=	2	doorway width, m=		0.70		
Lined Depth, m=	1	doorway height, m=		1.90		
Collar outside Diameter, m	1.4					
Height, m=	2.1					
platform diameter	1.2					
Item	Qty	Unit	Unit Cost (PHP, 2009)	Cost		
Materials					988.43	
cement, bags	1.5		210.00	315.00		
sand, bags	4		10.80	43.20		
grabita, bags	2		13.50	27.00		
#18 tie wire	3	kg	55.00	165.00		
polyester cloth	2	m	26.00	64.90		
4"san PVC pipe	3	m	110.00	330.00		
3mm PE mesh	0.1	m2	125.00	12.50		
1 x 1 x 3 wood	1	pc	10.00	10.00		
3/4 plywood	0.10	m2	208.33	20.83		
1" nails						
squat slab						
Labor					1,200.00	
Construction	2	m-d	400.00	800.00		
excavation	1	m-d	400.00	400.00		
(note: assumes use of reusable molds, workers trained in ferrocement)						
TOTAL COST					2,188.43	
Annualized Costs:					233.43	
Depreciation (15 years)					145.90	
O&M (4% of const costs)					87.54	

4. Maintenance

As in all other dry toilets, the key to odor management is to keep the feces in the pit as dry as possible. This means dry anal cleansing materials are recommended.

Pits are emptied of their contents when they are three-fourths full, or a new pit is dug instead and the toilet superstructure transferred over it.

Annex G. Composting-Toilet Vaults

The following are the advantages of composting toilets over simple pits and water-based sanitation:

a) The end-products are much more hygienic, which facilitates their economic reuse. There is more prospect of 'closing the loop'.[23]

b) Little or no water is used. There is less chance of polluting the environment and of pathogens exchanging DNA to give rise to more virulent strains.

c) They can be integrated well and creatively into landscaped yards; different configurations are possible for different situations; and

d) They are eminently suited where the water table is high as they can be built completely above-ground.

However, composting toilets require more care in use and effort in maintenance to prevent odors and assure hygienic end-products. Prospective users have to value these previously-mentioned advantages over and above this extra effort.

1. Siting and Construction Considerations

The toilet itself and its vaults should be sited preferably in a non-flooding location, or raised so that the vaults cannot be flooded. Any components that discharge effluent into the ground such as infiltration trenches for anal-washing bidets and urine disposal should be located at least 20 meters from nearby water sources.

In some communities, the practice is to site outhouse-type dry toilets at least 5 meters from the household to prevent any odors from reaching the latter.

Vault-composting toilets can be built from a wide range of construction materials. However, components in contact with the waste or the ground has to be built from corrosion resistant materials such as concrete or plastic to last for a reasonably long time.

2. Sizing and Design Considerations

Vaults are usually designed to provide 120 liters of compost storage volume per user per year:

Example: A double vault composting toilet is to be built for 9 persons. If the desired storage time in each vault is two years to produce a very hygienic compost, what should be the volume of each vault?

Solution: $V = 0.12\ m^3$/person/yr x 9 persons x 2 years = $2.16\ m^3$. The actual dimensions would depend on site limitations, but the height of the vault should be at least 0.4 meters to facilitate periodic emptying.

3. Use and Maintenance

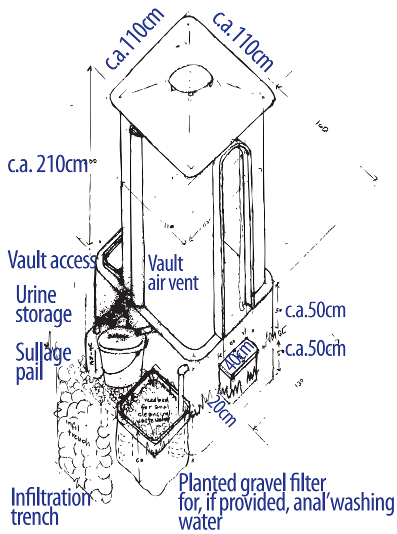
Care is taken to control the moisture of the composting waste to prevent odors and vermin breeding. Urine diversion is recommended and no anal-cleansing[24] water is permitted to join the feces:

In some designs, sand, sawdust, or ash is poured over the fresh feces. Dry bulking materials such as straw are used when available to absorb excess moisture and help the composting process along.

The vaults are also provided with wide (0.1 to 0.2 meter diameter) air vents to induce drafts that dehydrate the waste and conduct odors out.

4. Costs

Composting toilet construction costs vary with the wide range of materials and designs in existence. In China a simple indoor version costs the equivalent of PHP2,500 while the more expensive outhouses cost about PHP7,500.



Ferrocement composting toilet with vault and optional attachments for urine recovery and a planted gravel filter for treatment of anal cleansing waster. Source: PCWS.

[23]The nutrient loop, where the end-products of sanitation are returned for reuse in agriculture and food production.
[24]Anal -cleansing should be done with dry materials such as paper, or if with water a separate bidet pan is provided.

Annex G

The following is a bill of materials for a ferrocement composting toilet:

BILL OF MATERIALS									
Composting-Toilet Vault									
Vault		zocalo area		0.29		Soil-conditioning value of compost:			
Length, m=	1.6	zocalo thickness, mm=		20					
Width, m=	1.3	collar conc mix:1:		3	5	Annual Benefit if Recovered Nutrients are Used:			
Height, m+	1	cement, bags		0.042963		Annual Value of NPK Recovered:			
Zocalo width, m:	0.1	sand, bags		0.128889		kg NPK per person per year:			1.18625
		grabita, bags		0.214815		Value per kg of NPK, PHP (2009)			40
		wire spacing,m		0.05		Number of family members:			5
		wire, kg		0.174		Annual Value of NPK Recovered, PHP:			237.25
doorway width, m=		0.7							
doorway height, m=		1.9							
vault below-ground portion		0.5							
Item	Qty	Unit	Unit Cost	Cost					
Materials					1,533				
cement, bags	1.7		210	365.3896					
sand, bags	4.8		11	52					
grabita, bags	1.9		14	26					
#18 tie wire	3.7	kg	55	205					
polyester cloth		m	26	0					
4"san PVC pipe	0.8	pc	330	275					
4" san PVC coupling	1.0	pc	33	33					
2" san PVC pipe	1.0	pc	80	80					
4" x 2" san PVC tee		pc	16	0					
pvc solvent	1.0	small can	35	35					
pail	1.0		50	50					
long-handled shovel	1.0		400	400					
3mm PE mesh	0.1	m2	125	13					
ecosan seat riser w/ urine diversion		set	400	0					
Labor					885				
Construction	1.7	m-d	400	695.9802					
excavation	0.5	m-d	400	189.0909					
TOTAL COST					2,418.23				
materials					1,533				
labor					885.07				
Annualized Costs:					193.46				
Depreciation (25 years)					96.73				
O&M (4% of const costs)					96.73				

Annex H. Vault-Emptying Technologies

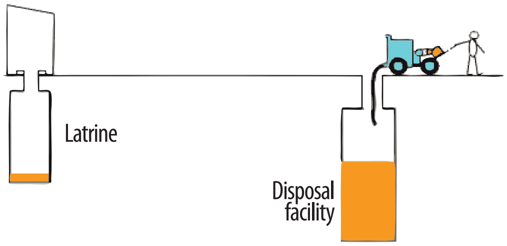
Pits and vaults have to be regularly desludged so that they retain their treatment capacity and not overflow or suffer blockage. Furthermore, the removed sludge has to be rendered safe by storage or further treatment such as composting or incineration.

Pits may emptied by pail and shovel but this is a hazardous method:

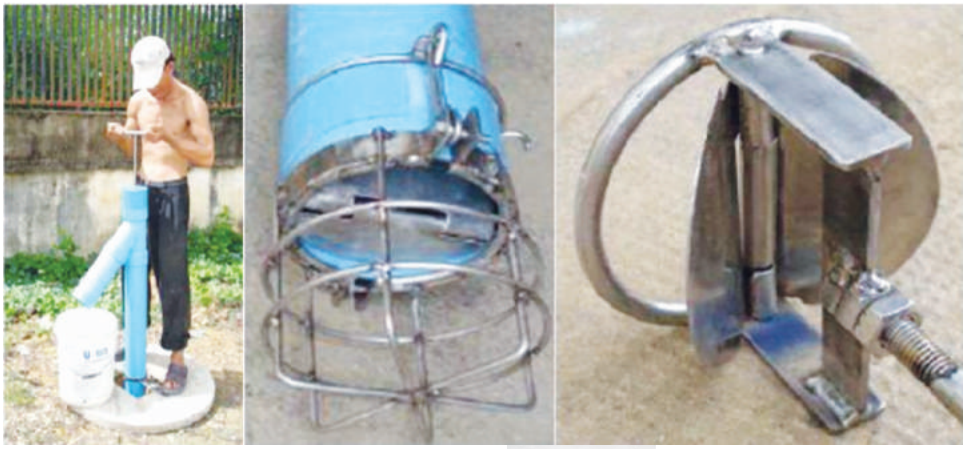
Manually emptying pits of sludge is a hazardous task. Source: Tilley, Elizabeth. Fundamentals of Sanitation in Developing Countries. Sandec/EAWAG.

Pits can also be emptied by manual pumping:

Motorized desludging equipment when available are also used to empty vaults:

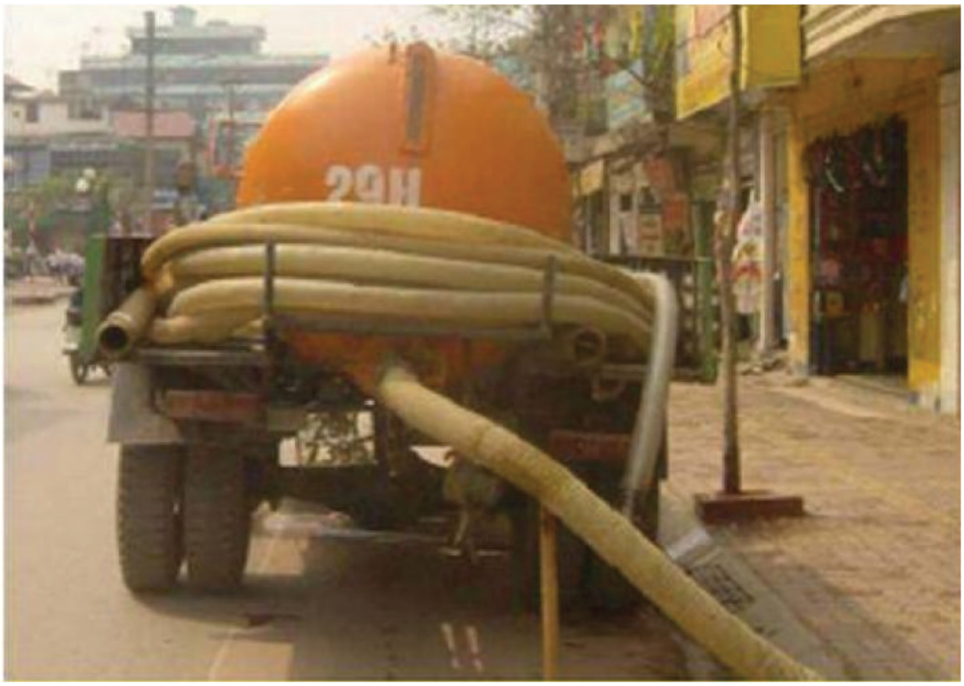


Vacu-Tug, a small walking version of vacuum trucks. This unit has an 8hp gas engine for motive power and for an air pump to evacuate the 0.5m3 tank, which sucks sludge from a pit via a flexible hose. The sludge stays out of contact with the outside air during desludging and unloading so there is less odor in manual methods. Source: Coffey International (1995).



Gulper, a manual piston pump. It costs about USD160 to fabricate. It can pump out sludge at about 3 liters per stroke. Manual pit emptying fees are about USD15 (Cambodia).
Source: The Gulper (November 2007), Ideas at Work, http://www.ideas-at-work.org/pdf/Gulper_pit_emptying_device.pdf.

Manual Desludging Handpump, similar in operation to the Gulper, was developed by the London School of Tropical Medicine and Hygiene and Oxfam in Indonesia. Source: Engineers without Borders-United Kingdom Research Conference 2009.



Vacuum truck. Commercial pit emptying outfits in the Philippines charge from USD60 to 120. Source: Tilley, Elizabeth. Fundamentals of Sanitation in Developing Countries. Sandec/EAWAG.

A comparison of the performance and cost of these equipments:

VACUUM TANKERS	
Removes waste safely for both workers and public health	Haulage distances are likely to be key in overall expenditure
It is a low odor technology	Costs too much for many SSIPs
Fastest means with which excreta can be exhausted	Access problems in many areas
Relatively fast travelling soppeds has better possibility of economical disposal of waste	Maintenance costs are also high due to imported technology
	Despite being"high technology" it does not overcome the lack of disposal site

THE VACUTUG	
Removes waste safely for both workers and public health	Slow may speeds means localized emptying point such as sewer or tank are needed
It is a low odor technology	Costs too much for many small scale independent providers
Faster to empty than either manual or manually driven mechanical systems	Is having some access problems in Kibera, Nairobi, despite its small size

MANUAL DESLUDGING HAND PUMP	
Low cost when compared to other technologies, so suitable for SSIPs	Requirement for further containerisation and safe disposal of waste
Possible to produce locally in many areas	Could still produce unpleasant odors
Facilitates access into even very densely populated areas	May be difficult to operate on thick sludge or low volume installation

MANUAL EMPTYING	
Services accessible to community	High unit cost of removal
Relatively cheap to keep latrine operational	Significant health risks to workers
Low equipment capital cost	Rarely acceptable to municipalties so not regulated
	Associated with indiscriminate dumping
	Lack of appropriate equipment means spillage regularly occurs
	Will often require slab of the latrine to be demolished to facilitate access, subsequently increasing householder cost

Source: EWB-UK Research Conference 2009

Pit emptying technology	Cost per unit of equipment	Source
Vacuum tanker	US$ 50,000 to 80,000	Kligel et al (2002)
Vacutug MK II	US$ 4,400 to 5,100*	Issias (2006); Parkinson and Quader (2008)
MAPET	US$3,000	Muller and Rijnsburger (1994)
MDHP	US$40*	Boot (2008)
Manual emptying	US$39-104 US$130	Bongi and Lorel (2005) Eales (2005)

*excludes ancillary equipment such as towing vehicles, protective gear, etc.

Source: EWB-UK Research Conference 2009

Costs:	Investment MAPET	US$3000 (1992, Tanzania).
	Capital costs Vacutug	US$5000 (1998, Nairobi).
	Operation costs MAPET	US$2.50/200 litre (1992, Tanzania).
	Operation costs Vacutug	US$3-5/500 litre (1998, Nairobi).

Advantages:	Disadvantages:
Low operation costs. Can be constructed, operated and maintained using local materials and skills. Capital costs are affordable by entrepreneurs who can develop micro-enterprises.	Solids are often not removed from pits or tanks. MAPET is not suitable if the haul distance exceeds 0.5 km. Minimizing operation costs may lead to uncontrolled disposal of sludge or urine.

Source: Tilley, Elizabeth. Fundamentals of Sanitation in Developing Countries. Sandec/EAWAG.

Septage (the sludge from the emptied pits) is usually trucked into landfills or septage management facilities where they may be further treated by composting, dewatering, or incineration. A simple alternative, where permitted, is to dig a hole beside the pit being emptied and put the septage there. Buried, it will de-water and turn into compost and be safe for use six months to two years later.

Annex I. The SuSEA Sanitation Program: Observations and Recommendations for 5 Program Communities

(by Jose Carmelo M. Gendrano[25], April-May 2010)

In April and May of 2010, the author visited five SUSEA program communities. The trip was made to validate the applicability and relevance of the Guidebook for Onsite Sanitation Technologies to these communities (Guiuan, Eastern Samar; Polomolok, South Cotabato; General Santos City; and Dagupan City).

(An earlier such trip was made to the town of Bauko, Mountain Province while the manual was being made. A separate report on this field visit has been submitted).

During the trip, observations of local sanitation situations and facilities were done, interviews of users and program implementers were made, and sanitation coverage records perused. In particular, the following facilities, most of whom were in use but a few still in construction were visited:

a) Public toilets and receiving vaults and treatment facilities;

b) Household dry and water-flushed toilets and attached pits and septic tanks;

c) Toilet superstructures of various construction and in various urban and rural settings;

d) Toilets built in difficult terrain;

e) Structures for receiving livestock wastes; and

f) A proposed site for a community-level treatment facility.

Technology Improvabilities Observed:

All in all, the technologies as evidenced in the visited facilities were, with a few and mainly minor exceptions, found apparently applicable to the local contexts.

The more common (but by no means widespread) omissions observed in the field were:

a) In Guiuan: not leaving leach holes in the cinder-block lining of leach pits (which can predispose to blockage of the leaching bottom, resulting in over-flowing pits);

b) In Guiuan, Alabel, and Polomolok: not providing air vents for the waste pipe from the toilet bowls (which tends to result in more quantities of water needed to flush them);

c) In all communities: there were unscreened air vents (which can allow vermin to come in and out, and air vents venting well below people height (which means vault odors can offend people);

d) In Polomolok: not lining pits in unstable soils (more tendency for the pits to collapse).

A collapsed pit in Koronadal, Polomolok

Above left: a septic tank with a hole-less leach pit as a second chamber; Above right: a pour-flush toilet with no air vent, resulting in large quantities of flushing water required. Both are in Guiuan.

25 Research Officer, Philippine Center for Water and Sanitation.

The first three cases can be retro-remedied (for a) an infiltration trench which will provide more leaching surface can be built beside and connected to overflowing pits; for b) a pipe (1/2" to 2" diameter) can be retrofitted to the waste pipe; for c) fit mosquito netting or similar-sized metal mesh over the vent exhausts, and fit extensions to the air vents).

These improvabilities were suggested to the municipality in a post-field meeting, using posters as visual aids.

The design details for all these are contained in the manual:

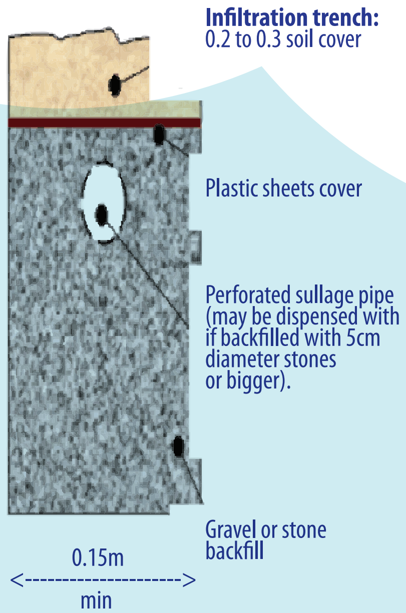
Other relevant excerpts from the manual: "Some sources recommend fitting the waste pipe from the latrine with a screened vent to reduce flushing water requirement. The pit is constantly wet, so any unlined portion of its walls would be more unstable."

For d) the only remedy is to build another lined pit if and when the unlined one collapses.

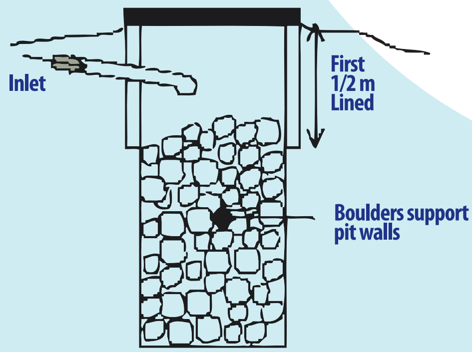
In connection with this, it is recommended that if there are any materials subsidies available for a toilet construction program, permanent construction materials (concrete and reinforcement) for the pit and its cover should be first priority for it.

A few other improvabilities in some sanitation facilities observed are worth mentioning:

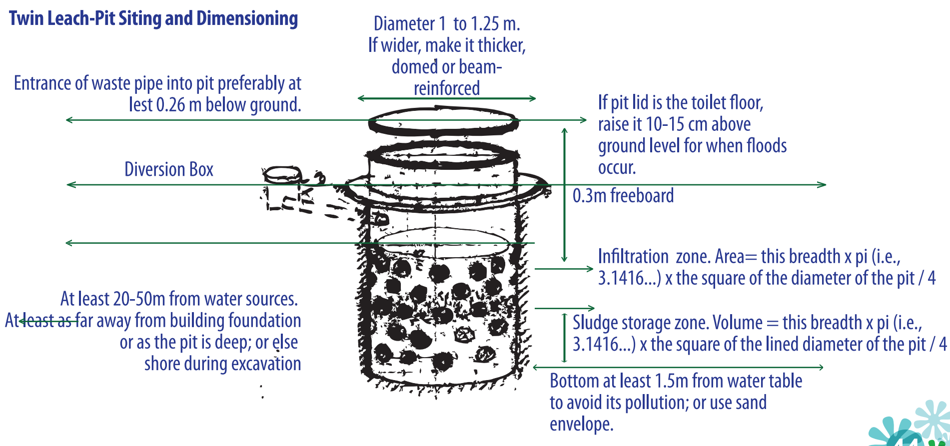
a) In Bungtod, Guiuan: a public toilet under construction with a multiple-chamber septic tank had some bowls discharging into one chamber, and some emptying into others.



Cross section of an infiltration trench



A soak-pit

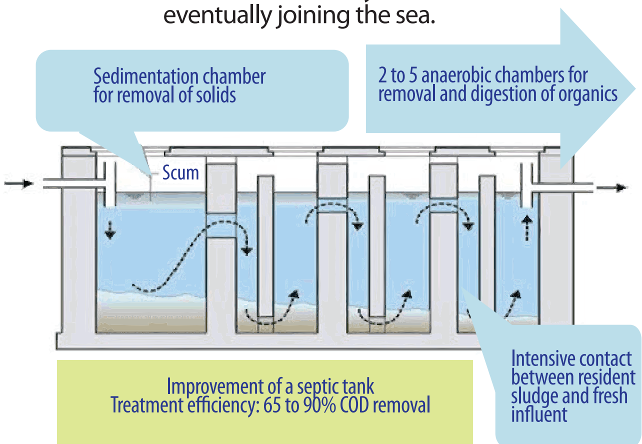


Twin Leach-pit dimensioning. Source: The manual, as adapted from PCWS.

Public toilet under construction in Bungtod

It was suggested to the implementing village officials that all the bowls be piped to empty into the first chamber and that the chambers connected to each others in series to take advantage of the cumulative treatment effect of the said facilities.

It was also suggested to the Guiuan Rural Health Unit (RHU) that since the public toilet, while adjacent to the beach is on foreshore land, an infiltration trench be dug ashore and the septic tank effluent be piped to it so that it can be cleansed further by soil infiltration before eventually joining the sea.

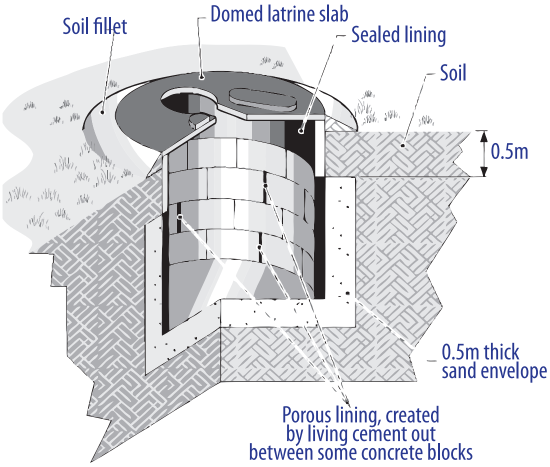


Baffled Reactor. Source: Tilley, Elizabeth. Fundamentals of Sanitation in Developing Countries. Sandec/EAWAG; as found in the manual, showing series configuration in a multi-chamber septic tank.

b) In Barangay 3, Guiuan: leach-pits with the open bottoms set in and leaching into the seabed in this foreshore community have been built.

It was suggested to the RHU that such pits can be improved so that the effluent reaching the seawater is much cleaner. This can be done by two methods: 1) by putting in a 50-cm thick layer of fine sand at the pit bottom (i.e., a sand envelope); or 2) by connecting it to an infiltration trench that will be built under the seabed adjacent to the pit.

Of course, building leach-pits on foreshore land is environmentally unsound, and this advice was given as a mitigation measure only.



A pit with a sand envelope. Source: Harvey, Peter (2007). Excreta Disposal in Emergencies: A Field Manual. United Kingdom.

In Dagupan City: not enough leaching surface for some public toilets, leading to over-flowing septic tanks in some sites (most of these facilities have since been remedied by adding a leaching tank).

This public toilet septic tank in Bonuan Gueset, Dagupan appears to be of novel design, consisting of a settler chamber and a leaching one. The innovation is that the leaching chamber reportedly has two plastic 200-liter drums, which could be serving as baffled reactor compartments. In operation, however, the septic tank overflowed, perhaps due to insufficient leaching surface area in the leaching chamber (the tank was estimated to be receiving at least 500 liters of black-water and sand tracked in by users daily). Subsequently another chamber for leaching was added to remedy the situation.

c) In Dagupan City: the bathroom floor sullage in some beach-side public toilets were routed via the same waste pipes as the toilet bowls (possibly causing blockage of these pipes and filling up the septic tanks fast (the facilities have to be desludged every two years instead of four to six).

It was suggested to the City Health Office (CHO) that the problem is probably due to sand tracked in by bathers and blocking the pipes.

To alleviate this, it was recommended that a) a clean-out be installed in every waste pipe; and/or b) a separate and shallower grit tank be built and the bathroom sullage be routed to it. This tank has to be emptied more frequently but in a simpler and less expensive manner than by vacuum truck (i.e., by shovel).

Technology Innovations Observed:

1. Toilet Superstructure

Various makes of toilet superstructures were encountered. Aside from the conventional cinder block-walled, concrete-floored, and GI sheet-roofed constructions, other designs were executed by the communities, depending on availability of funds, local abundance of materials and prevalence of construction skills:

Above left to right: Hardwood out-lumber toilet floor, PP sacks as enclosure, and a half-walled indoor toilet, all in Guiuan

Above left to right: Toilet half-walled with cinder block then finished with scrap plywood, GI sheet and PP sacking; foreshore toilet walled with 'sawali' bamboo weave; toilet with PP sacking, all in Guiuan.

Above left to right: Toilet walled with bamboo split, another walled with 'salsag' crushed bamboo on a round-pole frame, and another walled with PP sacking, all in Polomolok.

Above left to right: Outhouse walled with scrap plywood and out-lumber and roofed with palm thatch, another roofed with split bamboo 'tiles,' another roofed with 'salsag' tiles, all in Alabel.

Above left to right: Gravel as toilet flooring, detail of 'salsag' on toilet wall and door, all in Alabel

Above left to right: Detail of bamboo clips for 'salsag' walls, an outhouse roofed with 'salsag tiles, all in Alabel

Many of the toilets were outhouses.

Dagupan City opted for building public toilets in sanitation-deficient communities. The Guiuan municipal engineering office also built one in an urban community.

Bonuan Gueset, an urbanizing seaside village in Dagupan

Four-bowl public toilet in Bonuan Gueset

Two-bowl public toilet, one of several in Bonuan Gueset. The photo on the right shows its septic tank. One of these toilets was built very near the beach shore and was destroyed by waves during a cyclone.

Six-bowl public toilet in at the beach in Pugaru Island ,Dagupan

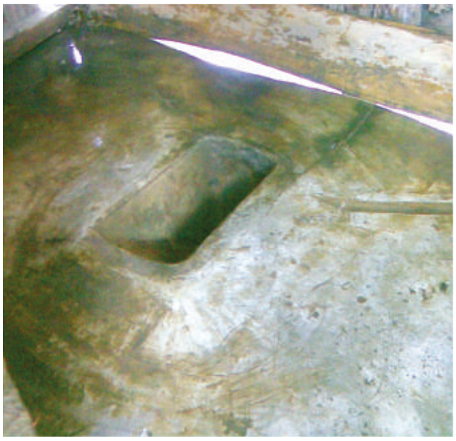
The Dagupan toilets (the Guiuan public toilet was not visited) were spacious and highly finished: the facilities in Pugaru had heavy-duty GI roofing on lumber roofing frames, foil-backed foam insulation for the roof, paint and ceramic tile-finished cinder-block walls, were elevated above the ground with a short flight of stairs, and had ceramic-tiled floors, perhaps to keep to the LGU standard of architecture.

2. Bowls and receptacles

All kinds of bowls and receptacles were also encountered. Aside from the conventional pour-flush porcelain bowl, much preferred when funds for it are available, there were:

A field-cast concrete toilet bowl on dirt flooring in Polomolok. While the design is pour-flush, it was emplaced so that there is never a water seal, and the waste is carried out of the bowl with the momentum of the flush.

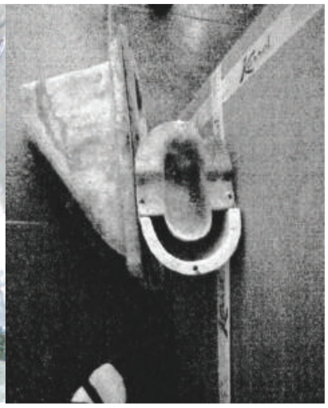
An old DOH pour-flush plastic 'rural pan,' in a toilet in Alabel



A field-cast squatting receptacle for a dry toilet in Alabel

The center plank of this toilet floor covers the squat-hole in Alabel

In this Alabel toilet, a coconut shell covers the squat-hole



Gooseneck pan mold set in Guiuan RHU

Different kinds of molds were found to be have been used in field-casting the concrete toilet bowls, ranging from a plastic jerry can to purpose-built mold sets, such as one for making gooseneck pans at the Guiuan RHU. It was suggested to the latter that the 'rural pan' design is more water-efficient than the gooseneck pan, and it would be worthwhile for it to acquire a mold-set for the same in future toilet programs.

Some pits such as this unfinished toilet in Polomolok are unlined, which, in unstable and always-wet soils, make for a shorter pit life.

3. Vaults and Pits

The most common vault type used was the leach-pit, although septic tanks were also built:

Above leftmost and center: irregularly-shaped communal septic tanks in Barangay 8, Guiuan. The reason for the irregular shapes is that large immovable boulders underlie the community and one cannot just dig near his house and be sure of not encountering them before the hole is deep or large enough. The solution adopted by the Barangay LGU was to dig several communal tanks and sewer the waste from the households to them. However, where they dug for the tanks they also encountered large boulders and had to build around them. Above rightmost: a regular communal cinder block-lined septic tank in the same barangay with the second chamber as a leaching one.

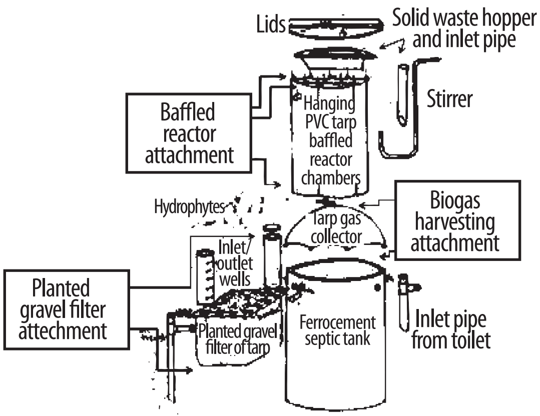
Some pits were lined with concrete culverts and one reportedly with rubber tires.

Other Sanitation Technologies Local Implementers Expressed Interest in:

Aside from the aforementioned technical suggestions to improve facilities given by the author to the local agencies and communities visited, interest was also expressed by the latter in other sanitation technologies:

1. Communal septic tanks for cartage-The Guiuan RHU head wants to try using communal septic tanks to receive chamber-pot cartage from sanitation-less households. She sees potential use for it in communities where there is lack of space for individual household vaults and where CLTS programs have not gained purchase, as in the densely built-up fishermen's beach-side communities of Sullangan. In these areas, a communal cartage septic tank may be an immediately doable solution in that it can wean beach-defecation households to a more sanitary way of disposing wastes (which is a step up the sanitation ladder).

2. A barangay health worker (BHW) in General Santos City expressed interest in introducing biogas septic tank technology to piggery owners in Fatima Silway as a way of reducing pollution in Silway river and Sarangani Bay, and alleviating odor pollution in that urban community.



Similar biogas septic tank with hanging baffled reactor, planted filter, and infiltration trench. Source: Guidebook for Onsite Sanitation Technologies.

Technology Tasks Recommendations by the author for the SUSEA Program, based on findings during the trip:

1. Dissemination of the Guidebook for Onsite Sanitation Technologies and Other Technology Materials in the Field

The first part of the Guidebook for Onsite Sanitation Technologies) has been presented to the Dagupan CHO staff and they found it to be relevant, useful and containing fresh knowledge.[26]

It is preferable that the Guidebook be available online, as it is by no means a finished piece of work. New ideas and experiences will be coming in all the time that will supplement and update the knowledge in it.

2. Provide Demonstration Sanitation Facilities at the Community Level, Especially for Technologies That are New

People learn best if they have actual full-scale copies to refer to. These can be built (but not used so people can peer inside) beside barangay health centers. Cut-away sections, labels, and indicated dimensions will help make the designs and how to construct them more comprehensible.

Building the demo facilities with local participation can also be learning exercises by themselves.

3. Try Out Ferrocement[27] as Construction Method and Other More Affordable

a) At present the construction costs obtained in the five SUSEA communities range from[28] PHP5,500 to PHP33,000 per bowl. Ferrocement can save on construction costs by 60% to 80% and can be done using everyday masonry and carpentry tools. It lends itself well to mass production if reusable molds, which often can be fabricated at the community level, are used. However, at present, it is a relatively unknown technique in the Philippines. Some hands-on training is needed, and demonstration facilities need to be built.

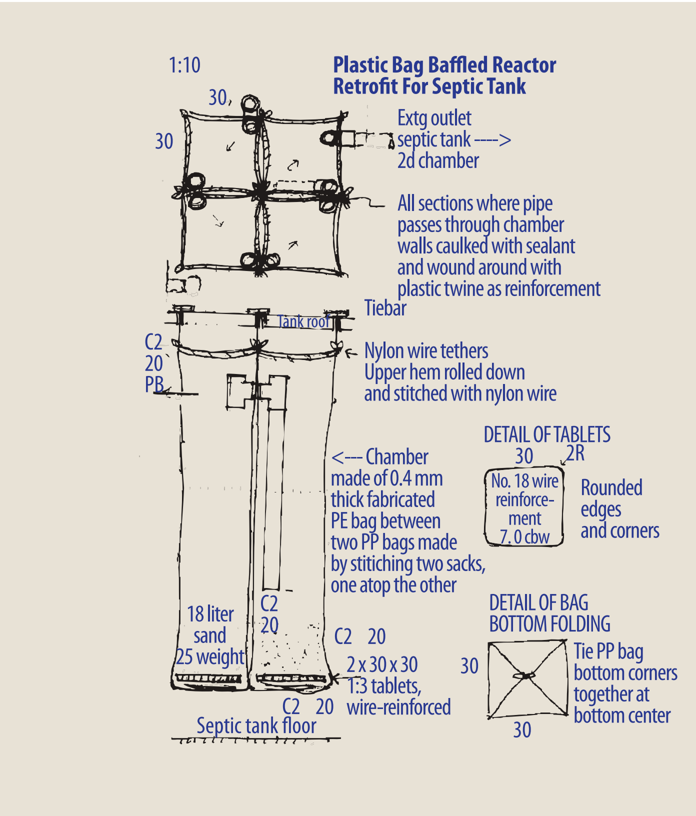
b) Use of non-conventional materials can also reduce costs significantly. routed to it. This tank has to be emptied more frequently but in a simpler and less

[26] The presentation took about half a day because time taken up by questions and answers, so there was no opportunity to present the second, or technology selection process part.
[27] Ferrocement is a concrete construction technique using mortar and thin reinforcing materials such as wires. These enable thin sections to be made, reducing materials costs. Use of reusable molds also reduces labor costs.
[28] Construction costs for pour-flush toilets per bowl range from PHP5,500 for a cinder block-lined leach-pit with concrete floor and curtained enclosure to PHP10,000 for a cinder-block walled outhouse to PHP 19,000 for a government-built, GI roofed, cement board-walled, floor-tiled public toilet to PHP33,000 for one with peaked heavy-duty GI roof and tiled walls.

expensive manner than by vacuum truck (i.e., by shovel).

For example, In General Santos City, a city ordinance will soon require septic tanks to have four or five chambers. However, the present construction cost of conventional household septic tanks ranges from PHP20,000 to 70,000 which is unaffordable to many of the city's 50,000 households.

Fortunately, there is a less costly way to increase the number of chambers inside an existing tank: chambers can be prefabricated out of plastic sheet material (a technique proven in the hatchery industry, where PVC tarp is used to line leaking tanks and ponds), connected together in series with inlet and outlet fittings, folded, and inserted into an existing septic tank. Once inside it can unfolded and hung so it can function as a baffled reactor. Installation is low-cost (say PHP2,000 to 3,000 for a household tank), fast, and minimally invasive:



Construction drawing of a plastic-bag baffled reactor retrofit for septic tanks. Source: PCWS.

A pilot installation is now operating in a PCWS staff's household septic tank:

This four-chamber plastic bag baffled reactor, made of one layer of PE sheet bagging and two of woven polypropylene sacking, is installed in the second chamber of this conventional household septic tank. Turbidity of the wastewater appears to have been reduced by 60% after four hours passage through this installation.

Given the potential value of this and other low-cost technologies, it is recommended that SuSEA conduct testing trials on them (say, try out this baffled reactor retrofit in a General Santos City Hall septic tank).

c) Try out Manual Desludging Equipment such as the Gulper, at least in SuSEA urban communities.

The Gulper, a manual desludging pump.

Manual desludging pumps offer a low-cost and, therefore, more immediately doable interim solution to the problem of filled-up septic tanks than vacuum trucks. A Gulper can be locally fabricated for less than PHP8,000 (2010). Accessories such as septage holding and dewatering bags, return flow piping, and anti-odor shrouds and vents can also be fabricated.

Gulper septage can either be disposed of onsite in a prepared hole, or trucked to an available septage facility.

A Tentative Appraisal of SuSEA Community-Led Total Sanitation (CLTS) Processes and Results

The author's visit to the communities afforded him the opportunity to observe the different approaches to sanitation (various levels and forms of implementation, incentives and subsidy; various technologies and scale of facilities) as applied by various local government agencies (RHU, MPDO, MEO) to different types of communities (rural, urban, lumad, fishing communities) with varying degrees of success.

1. Range of implementing government agencies - In all municipalities but Polomolok (where the MPDO or Municipal Planning and Development Office was the lead agency), the RHU took the lead, with at least some support from the municipal engineering office. This was perhaps because it is this agency that has people stationed down to the barangay level (BHWs and sanitary inspectors or SIs).

In Dagupan, a special projects engineering unit under the mayor's office undertook the infrastructure aspect.

In Guiuan, in villages where there was no active participation by the barangay leadership, CLTS did not gain headway. On the other hand, in Lumad areas such as Polomolok and Alabel, where local tribe/clan leaders were active, the communities there generally had better than average success than elsewhere in terms of the time rate at which sanitation coverage was increased.

2. Types of Communities Where CLTS was Most and Least Successful

Lumad communities exhibited the highest rates of sanitation coverage increase, 149% per year[29] on the average. They were followed by rural communities (19%), urban communities (13%), and lastly, by fishing communities (0).

That the lumads did exceedingly well was all the more surprising since their CLTS program involved no direct subsidies from the government.

Possible reasons for the good results for the lumads are:

a) More cohesive tribal social structure in which the authority of leaders are more respected, so once the leaders 'buy' into the program, the group follows suit.

b) The higher unemployment and under-employment rates in lumad communities means more time for the people to gather construction materials and build their toilets.

c) The level of poverty in those communities mean expectations of what their toilets should look like are simpler, so they just went ahead and built toilets no matter how austerely these looked.

d) Lumads are, in the main, shy and reticent people, and are less prone than the more politically sophisticated lowlanders to think of the CLTS program as an opportunity to bargain for subsidies and concessions from the authorities.

To be sure, as has been reported before, prior events as well as good practices of the implementers contributed to the success:

a) Prior to the program in Alabel, a typhoid outbreak swept some communities, heightening awareness in the area about good sanitation

b) The program implementors entered and stayed in the communities during the toilets construction, bringing along digging and construction hand tools to lend to the toilet-building households.

c) And as a reward, participating families were given sleeping nets chemically treated to kill mosquitoes.

[29] *This means a community with 0% sanitation coverage attains 100% coverage in 100/149, or 0.67 years.*

Of the lowland communities, the rural ones performed better than the urban ones. This could, again, be due to urban people being more individualistic and less influenced by authority than rural people.

The case of Fatima Silway in General Santos, an urban poor community which reported a sanitation coverage increase rate (20% on a per year basis during the program period) equaling the rural average, deserves mention because of a possible dynamic that may be contributory to this success:

Fatima Silway in General Santos City. The road and the houses to the left of it are already on the flood terrace of the river. The dike on the right is to protect the rest of the city from river flooding.

Above: Sullangan village in Guiuan, where CLTS on the fishing communities along the beach have not been successful. While congested, there is ample space for toilets and communal septic tanks that can receive cartage from the houses. The RHU chief broached this idea to the residents, but this was not enthusiastically received. The residents claimed it will be difficult to secure permission from the owner of the lots they are occupying.

The residents are informal settlers and some have actually encroached into the flood terraces of Silway River. Building toilets can, therefore, be regarded as an investment towards strengthening their claim on the lots they have settled on.

As for the fishing communities, possible explanations for the lack of success of CLTS in them are:

a) The tendency for fishermen to seasonally move from one place to another (to follow the fish) can deter them from building toilets and other permanent home improvements

b) They also usually just rent their dwelling lots (although the Badjaos residing in their resettlement in General Santos City have a more secure tenure on their home lots).

c) Many fishermen by the nature of their occupation are accustomed to defecation on the beach or the water, may see no harm in this practice and may even argue that feces can be food for fish.

Above: Badjao Ville in General Santos City, a densely built-up resettlement for Badjao fishermen and families.

Above left: Water supply in the village is from a few wells, such as this off-shore flowing borehole. Above right: The ground is rocky, a fact cited by residents as contributing to the difficulty of digging toilet vaults. However, a raised vault can be built under the floor of this house.

An eight-bowl public toilet was built for the community by a civic organization, but this was neglected and eventually vandalized. Above leftmost: a mosque, on the left foreground was built near the toilet. Above center: the public toilet's aboveground septic tank. Above rightmost: a graveyard was also built around the toilet.

3. A Note on Direct Materials Subsidies

The fact that the most successful CLTS communities had no benefit of direct subsidies while those toilets with totally subsidized construction (e.g., public toilets) had some facilities unserviceable[30] suggests that there are more important factors[31] for CLTS than subsidies.

The role of government subsidies however cannot be dismissed outright. For the communities in Guiuan where there was partial subsidy, participating households in four villages put up anywhere from 40% to 80% of the total cost of the toilets in the form of labor and the balance of the materials. It would appear that for at least a section of the sanitation-less, subsidies can be a 'tipping factor' that can motivate them to build toilets of their own.

Sometimes these toilets go above and beyond the basics, being roomier and made of more permanent materials than are absolutely required.

Partial materials subsidies can also help the income-poor build more permanent toilet facilities. For example, with a little more than one bag of concrete, three kilos of tie wire, and a piece of rebar, lumads can build a more permanent ferrocement-lined pit and concrete floor rather than the unlined pits with round-pole cover and dirt floors they have at present.

[30] *In the public toilets built by SuSEA municipalities about a third of the bowls have not been operational. This compares unfavorably with the reported survivability of household user-built toilets, in which only about three of the hundreds built under the CLTS program was reported out of service.*
[31] *E.g., Exclusivity of use and ease of access, sense of exclusive ownership, community motivation, and participation in the program.*

Annex J. Building Tanks with Ferrocement

Ferrocement is a reinforced concrete construction technique that is eminently suited for making vaults and water-tight tanks inexpensively. It differs from poured reinforced concrete in that it uses mainly sand as the aggregate and small-diameter but closely-spaced steel reinforcement such as wires and meshes instead of rebar. This enables the walls to be thinner, saving on materials. Also, because of the close spacing between the reinforcement, crack resistance is enhanced.

Using reusable molds also enables the construction of round tanks, further increasing strength without increasing materials expense.

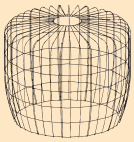
The following describes the construction of a ferrocement water tank using a reusable one-sided mold set. This method has also proven to be suitable in making ferrocement septic tanks, dry toilet vaults, and baffled reactor and gravel filter tanks.

Making a 5000-Liter Tank : A Typical Ferrocement Construction

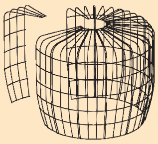
Drawing the rebar patterns

Cutting the rebars for the molds

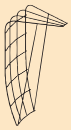
1. Making the reusable mold:



Welding the rebars together to form the mold.

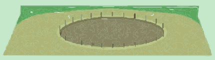


Cutting the mold into panels.



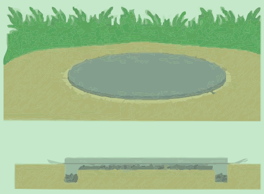
Cladding the panels with wiremesh.

2. Making the Tank: Making the tank base



a. The ground is leveled and staked.

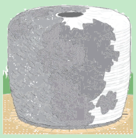
b. Plain GI strips and rebar ring comprise the base mold; a base course of gravel is laid.



c. A reinforcing grid of tie wire is laid; concrete is troweled in.

Constructing the tank:

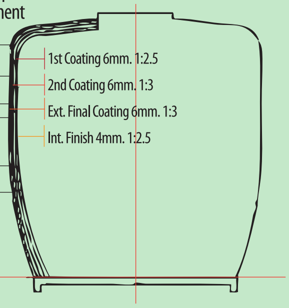
Winding some wire around the tank to hold the paper.



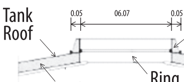
One or two mortar coats.

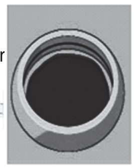
Wire positions and spacings.

Elevation (cm)	#18 Wire Spacing (mm) Piped System	#18 Wire Spacing (mm) Rain Catchment
9 additional wire wrappings	17	20
20	34	40
10	10	20
36	20	40
20	6	11
63	11	23



Lip construction details:

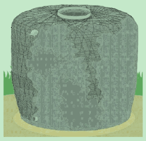


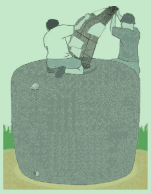


Lip mold set atop tank.

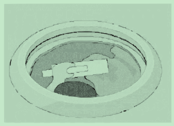
Lip mold details.

Finishing the tank exterior with more mortar:



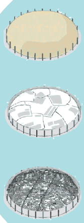


Finishing the interior: De-molding the following morning.

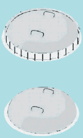


Interior finish of mortar then a final flooring layer.

3. Making the manhole lid:



a) Shape earth; stake; line with newspapers; place lid mold and reinforcement.



Emplace mortar; demold.

A finished tank, painted and decorated.

Annex K. Possible Engineering Solutions for Building Sanitation in Challenging-Environment Communities

(Compiled by Jose Carmelo M. Gendrano, August 2010, Philippines)

Many communities in Southeast Asia, especially peri-urban ones, are in locations where building sanitation facilities for them is an engineering challenge.

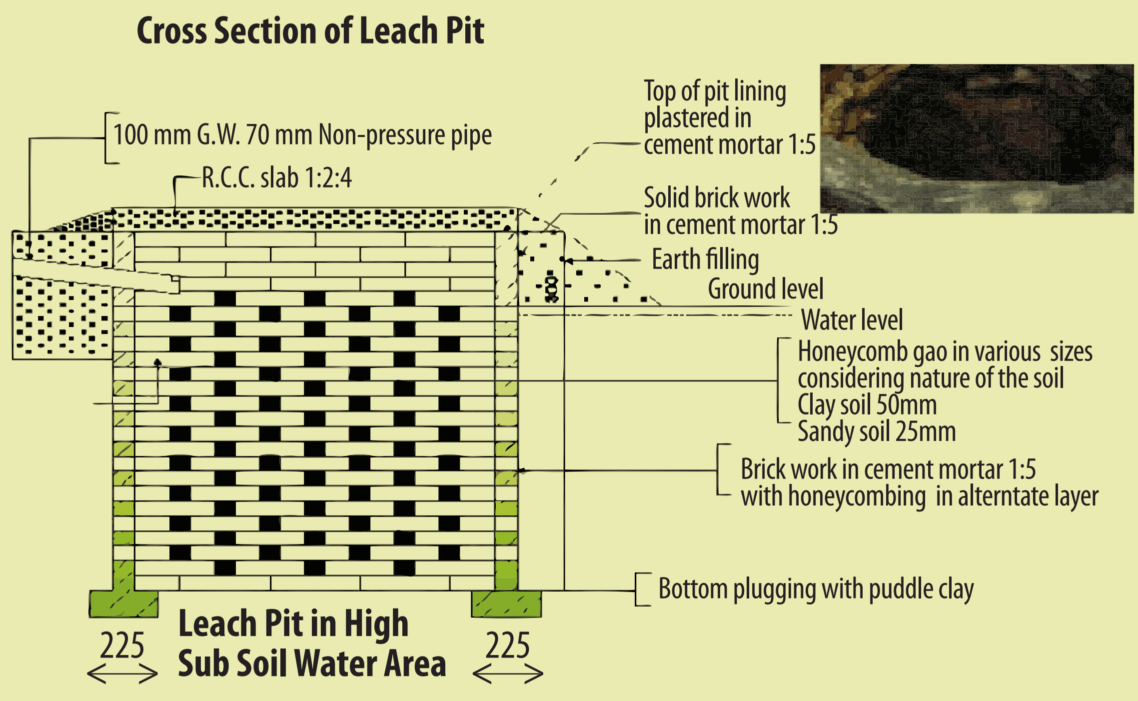
These sites may be rocky or on unstable or soft ground. Or else the water table may be high, or the site may be occasionally or regularly flooded. In some communities the houses are on stilts over water, or else the people live in houses on rafts that may be floating part of the year and grounded during the other part. In some communities, the people live in houseboats that ply the harbors and the coasts. Or else a community may be so congested that there is little space available for toilets.

In many instances, the difficulty of devising sanitation for such situations are the main reason given by their residents and local authorities for them not having proper toilets. However, as the following will show, there are engineering solutions at hand that will enable such communities to have proper sanitation facilities.

Below are some of these situations and their suggested engineering solutions:

A. Rocky-Ground Communities

In some communities, the ground may be underlain with stones or immove-



A raised leach-pit that may be built either in high-groundwater or low-permeability ground.

able boulders, or may be solid rock. This increases the difficulty of excavation work for toilet superstructures, pipe-lines, vaults, and infiltration trenches. Also, solid rock often has less infiltration capacity than soils, which is an important consideration when designing infiltration trenches.

Suggested possible solutions for this are:

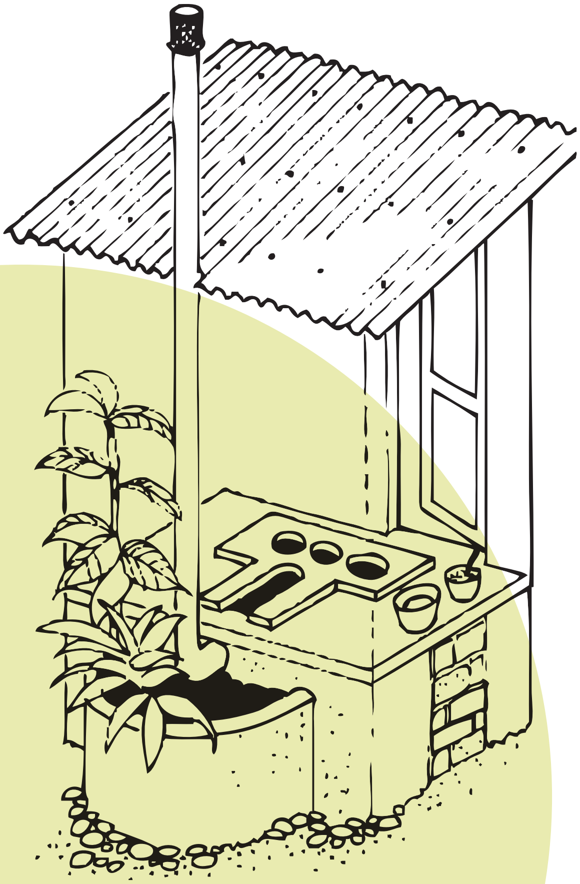
1. Accept that excavation effort will be greater (digging on solid rock increases excavation effort by up to a factor of four or more over digging on soil) and build the facilities conventionally anyway.

   The builders have to also take into consideration the probable low infiltration capacity of solid rock and make the surface areas of their pits and infiltration trenches accordingly larger.

   The construction team, which often includes user households, should also have the needed rock-digging equipment.

2. If the prime consideration is to avoid the difficulty of digging in the hard ground, build the vaults above-ground or sunk just to the level of any easily-dug upper layer.

An above-ground dry toilet may also be considered a sanitation technology option for hard-to-dig-on ground.

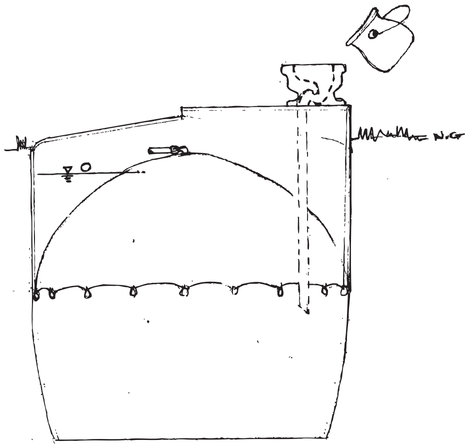


The Kerala (India) double vault composting toilet. The user squats over one of the outside holes of the three. The middle hole catches the urine and empties into the elongated pan, which also serves as the anal-washing bidet. The liquid waste from it discharges into the evapo-transpiration bed behind the toilet. Source: Ecological Sanitation (2004; Revised and Enlarged Edition). SEI.

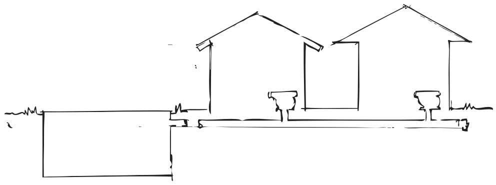
A possible downside of raised vaults is that the toilet room will also have to be raised, which usually entail additional construction costs.

Another downside is that if the toilet is an elevated outhouse, users may object to being exposed to view from neighbors and streets whenever they climb up and down it.

3. Cartage or sewerage to a communal vault facility in an easy-to-dig-on site in or adjacent to the community may be considered if it is less expensive to dig one communal vault and lay the sewer pipes than build individual household pits or vaults.[33]



A communal septic tank receiving cartage. In this instance, the tank also harvests bio-gas



Shared wastewater facility serving adjacent community

Cartage, while not acceptable to the WHO and the Philippine government as improved sanitation, is a step up from open defecation and may be the only immediate option if all other alternatives are even less attractive.

4. Public toilets built on more suitable ground inside or adjacent to the community.

If suitable sites for onsite sanitation facilities are possible in a few sites in or near the community that are not rocky, shared toilets may be built in these sites.

A public toilet in Pugaru, Dagupan City Philippines

A downside of public toilets in some cultures such as in many parts of the Philippines is that they are less preferred than private toilets due to the value attached to privacy and exclusivity of use afforded by the latter.

B. Communities on Crumbly Ground

In many communities such as in some beachside villages, the ground may be so loose as to pose difficulty in keeping excavation walls stable.

Suggested solutions for this situation include:

1. Design vaults and pits to be as shallow as possible. The downside of this is that the facilities will have a larger ecological footprint.

2. Making circular rather than rectangular excavations, which are weaker against collapse, when digging holes for pits and vaults.

3. Shoring excavation walls during digging and construction.

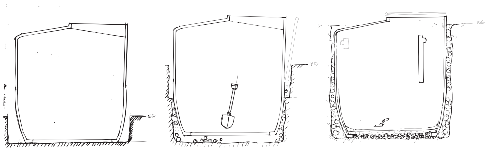
4. Shoring structures adjacent or near to excavations, especially those whose foundations are as near to the edge of the hole as the hole is deep, or nearer.

Some construction methods that may be used on crumbly ground are:

1. Using the caisson method in sinking vaults and pits:

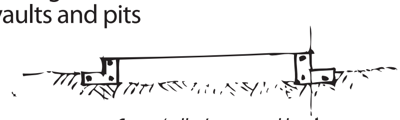
[33] *This solution (individual household toilets sewered to communal septic tanks) was adopted by Barangay 8 in Guiuan, Eastern Samar, where much of the ground is underlain by immoveable boulders and households could not just dig beside their toilets for their pits.*

vaults and pits:

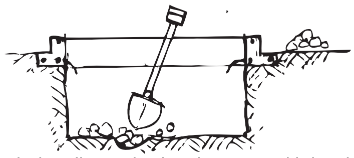


Above leftmost: Build the tank on a shallow hole atop its intended location. Leave the base blank except for the ring-like 'toe'. Above center: lower the tank to the required elevation by deepening and widening the hole, thus undermining it. Above rightmost: Finish the tank. Construct the base, overlapping the toe (in this case, the tank is first underlain by its compacted gravel base course, reinforcement grid, and at least two sealing mortar layers. This point is also a good time to finish the tank inside, if needed, and punch the holes for the fittings.

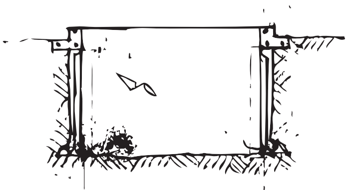
2. Dig-and-line method of constructing vaults and pits



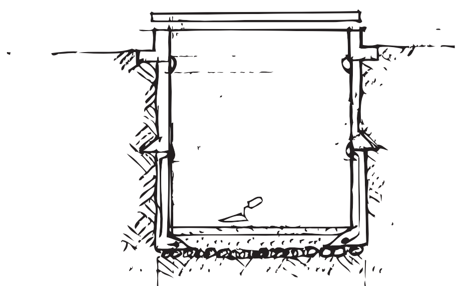
Cast a 'collar' at ground level.



Dig inside the collar to a level as deep as possible but shallow enough so that the walls will not start crumbling



Line the inside of the walls with mortar, using the earth face as form; also put in the reinforcement. Notch the bottom of the wall and put in a 'toe'.



When the wall has set, continue digging and repeat construction of wall sections until the design bottom elevation of the vault is reached. Put in a final, inward toe and after half a day of setting the base can be sealed if called for in the design as in the caisson method.

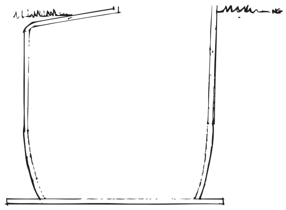
C. Soft Ground

This may occur in swampy, sandy, or soft clay areas, and may predispose to shifting and subsidence of structures after construction due to the soil bearing strength being inadequate to support them.

Inspect existing structures in the area and talk to residents to determine whether subsidence is a problem.

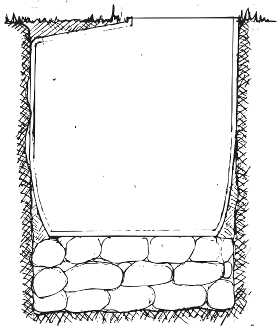
If so, possible solutions to this are:

1. Make the base and footings of pit linings and septic tanks wider to spread the load over a larger soil area (consult local engineering lore and references for information on how much to widen such footings).



Above: A vault with an oversized base so that its weight can be supported by the soil. This feature can also be used as a collar to prevent vaults from floating up if the groundwater suddenly rises.

2. When building septic tanks, lay a thick compacted layer of boulders at the bottom of the excavation on which to build the base. As a rule of thumb, a 60-cm thick layer of boulders compacted into the bottom of the hole can support the weight of a septic tank filled with 160 cm of water.

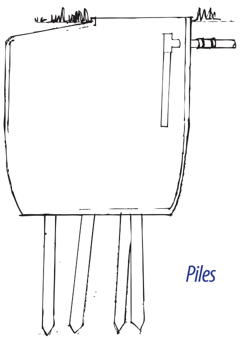


3. In extreme cases, it may be necessary to drive piles into the bottom of the hole to support the weight of the structures. Consult local lore and engineering texts to

determine the number, length, and diameter of the piles to drive.

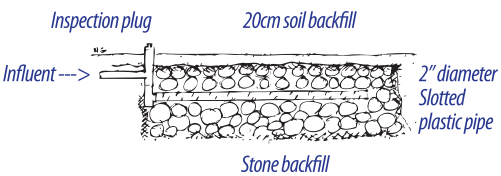
4. Another possible problem when building on soft soil is differential subsidence, e.g., when tanks and attached sewer pipelines subside to different elevations. This imposes loads on the weaker structures (in this case the pipes), which may cause leakage and breakage.

A solution to this, if the pipelines are not pressure ones, is to connect the pipes at the point where they join the tank with flexible pipe material, e.g., rubber or PVC tarp.



Above: A vault supported by piles. The inlet pipe has a flexible sleeve to allow for some differential settling between pipes and vault.

5. Some soft soils such as some mucks and peats can choke infiltration trenches by creeping into the voids between the backfill stones. This may be mitigated by lining the trenches first with mosquito netting or some other suitable geo-textile:



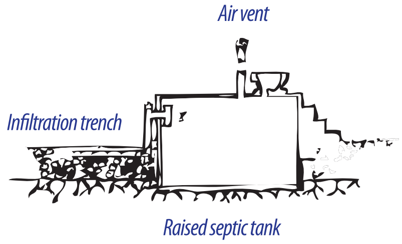
Above: Infiltration trench lined with mosquito netting in creep-prone soil.

D. High Water Table (Less than one Meter Below the Surface)

Excavation and construction of sanitation facilities are naturally more difficult in high-groundwater communities than in areas where the water table is low. Likewise, the capacity for infiltration of wastewater in to the ground from pits and infiltration trenches are reduced when the groundwater is high.

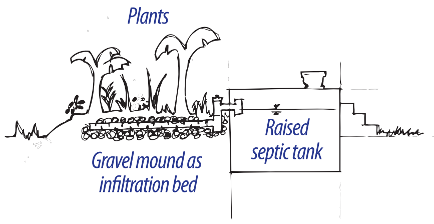
Possible solutions are:

1. Build the pits or tanks partly raised to avoid excavating below the water table. For leach-pits, this has the added advantage of a bigger available head for the leachate to help it infiltrate into the water-logged ground (see A.2 above).



Above: A raised septic tank paired with an infiltration trench.

2. In lieu of infiltration trenches, raised evapo-transpiration mounds may be considered. These mounds are raised platforms of earth covering a layer of gravel into which the effluent pipe from the septic tank can be discharged. Plants growing on the mound help evaporate the wastewater while the rest percolates into the ground.



Above: A raised septic tank paired with an evapo-transpiration mound.

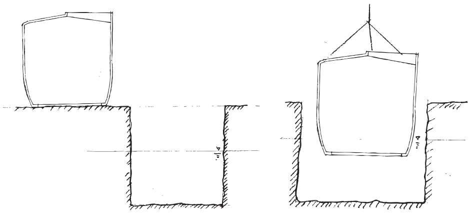
3. Design infiltration trenches to be deeper or longer in consideration of the ground's reduced infiltration capacity (trenches can be dug into the water table with a long-handled hoe).

4. If the decision is to dig the pit or trench flush with the ground anyway, the following excavation and construction techniques

may be useful:

a. Bailing while excavating (manual diggers can dig up to waist deep in standing water).

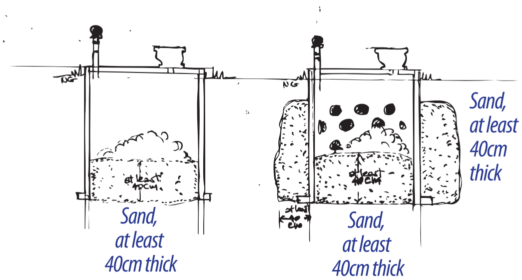
b. Building the tank beside the excavation and then lowering it into the hole



c. Building the walls of the tank aboveground over the hole site, then digging the hole from inside and under it (dig-and-line, see Section B).

d. If the tank or pit lining is to be made of concrete hollow blocks, these can be laid underwater with care.

5. If the primary consideration is to avoid polluting the shallow groundwater, a sand envelop[34] may be laid under and around the leach-pit:



Leach-pits provisioned with sand envelopes.
Left: bottom-only leaching pit.
Right: Side-leaching pit.

E. Occasionally-Flooding Ground

Flush-with the ground sanitation facilities such as pits and septic tanks often overflow and stop working whenever the ground is flooded. Also, septic tanks are prone to floating during floods if they are buoyant and not adequately anchored to the ground.

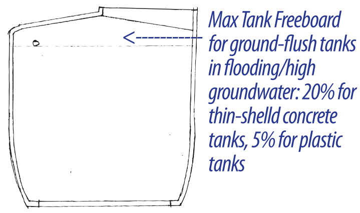
Engineering options for these situations are:

1. If the flooding frequency is low (say once a year on the average) and flooding duration is short (say a few days), and if there are no other acceptable alternatives, a decision can be made to build conventional sanitation facilities, accepting that they will fail every once in a while.

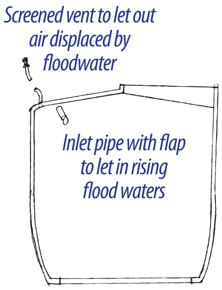
2. Building the facilities partly raised above the floodwater level (see Section A).

3. Providing septic tanks with oversize bases (see Section C). This will resist any uplift due to hydrostatic pressure from the floodwaters.

4. Limiting freeboard or air volume inside tanks to 20% for thin-shelled concrete tanks and even less for plastic tanks; ballasting existing tanks with rocks or sand.



5. Providing septic tanks with a flooding valve and a lid air vent. The valve will let in floodwaters to equalize inside and outside pressure, while the air vent will let out the displaced air.



Above: Tank with flooding valve to guard against floating up during periods of flooding or sudden rises in groundwater.

34 A sand envelope is a layer of sand at least 40 cm thick around and under pits that is supposed to filter leachate and render it clean enough to join the groundwater. In its absence, there should be a distance of at least 2.2 meters between the bottom of the pit and the surface of the groundwater to assure the same effect.

F. Houses on Stilts over Water

Above: Shanties lining an estero or tidal canal a few meters from a downtown street in Manila.

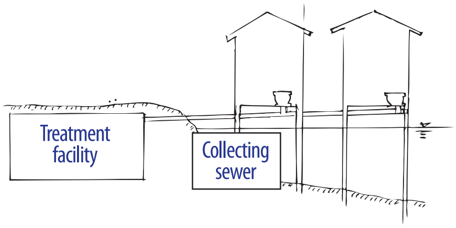
In Southeast Asia, 'water villages' which are clusters of houses on stilts or plinths built over tidal flats, lake- and seashores, stream banks, mangroves, swamps, and other foreshore land are common.

The advantages of building on such land are many. Ambient temperatures are cooler; disposal of wastes is convenient; and access to water for some household and economic purposes is good. For fishermen this may mean living closer to their work, and for the landless urban poor this may be the only place where they can put up a dwelling.

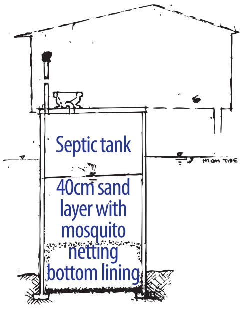
However, land use, safety and environmental regulations restrict building on such places in many countries. The following engineering solutions are, therefore, on the premise that these regulations may not be violated.

That said, here are some possible engineering solutions:

1. Sewer toilet wastes from individual houses to common treatment facilities ashore (see Section A).

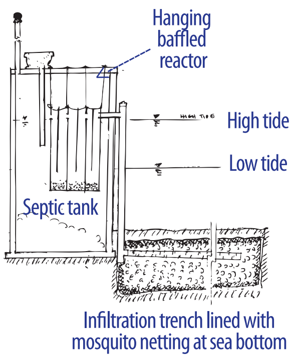


2. Individual or shared raised leach-pits with sand envelopes. The sand will reduce the organic and pathogen load of the leachate before it reaches the surrounding waters.



Proposed modification for Guiuan (Eastern Samar) foreshore household toilets

3. Individual or shared raised leach-pits or septic tanks with baffled reactor, anaerobic filter, and/ or underwater infiltration trench. These will produce a higher quality effluent.

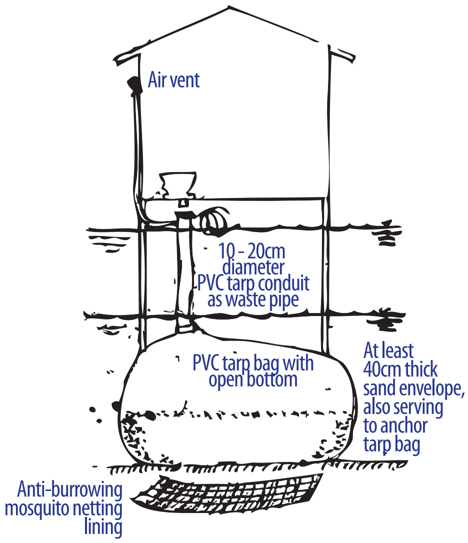


Concept for cleaner-effluent septic tank in foreshore environments

When the facility is in a waterway where currents can at times be strong, provision should be made to make the facilities withstand such currents. Also, it should be ascertained beforehand that building such facilities will not unduly constrict the flow of the water.

Floating septic tanks have been designed and tried over the years, and recently, tanks made of flexible plastic sheeting have been tested. These tanks usually comprise sinkers and floaters to maintain their shape. The weakness of floating tanks is their susceptibility to being tossed about and smashed against other objects in the water by strong currents and waves. This is especially true for tanks installed for fish-pen stilt-houses located in open water where storm surge-induced currents are particularly strong during cyclones.

A proposed design improvement for such tanks is this anchored leach-pit concept:



This leach-pit will be made of PVC tarpaulin anchored by the weight of its own sand-envelope at its bottom (which is open except for a layer of mosquito-netting to allow leaching). The tarp will be totally enclosed save for a flexible conduit made of the same material to connect it to the pour-flush toilet bowl. This connection will be easily detachable so that before the expected strong currents occur it can be cast off and allowed to flutter about. After the water calms it can be reeled back in and reattached.

The tarp can be protected from ultraviolet ray embrittlement with a sacrificial cloth or black polyethylene sheet shroud.

During the storm, the body of the tank will deflate as currents try to push against it, and this will further reduce its 'sail' area, making it more resistant to being moved about. Some of its contents will however be spilled, and this is the penalty of the design. This 'failure' is not expected to happen more than once or twice a year in even the most typhoon-prone places in the Philippines.

G. Floating Houses

There are two kinds of such houses: 1) tethered houses[35] that are anchored in one place and depending on the height of the water, either floats or is grounded on the waterway bottom; and 2) houseboats, which usually moves from place to place.

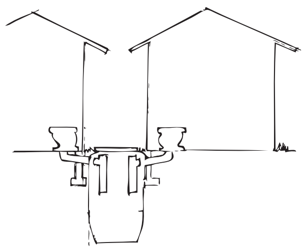
Floating houses are an especially difficult proposition to fit with sanitation, as they are made with moving from place to place in mind. This eliminates permanent sanitation options in most situations.

The most practical sanitation option is bucket toilets coupled with on-shore communal cartage disposal facilities (see Section A).

H. Congested Communities

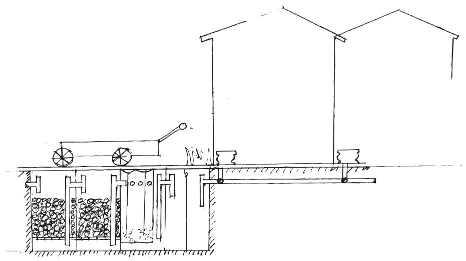
Limited space and the difficulty of excavation so close to houses are the main problems in constructing onsite sanitation facilities in congested communities. Possible engineering solutions to these are:

1. If households have no space in their lots to site their pits and septic tanks in, adjacent alleys and open public places at least 1.2 m in width are possible sites for flush-on-the-ground wastewater facilities. Economies of scale are often possible when these facilities are shared with adjacent households.



Shared septic tank sited in the space between adjacent houses

[35] *Such as the houses in some Lumad communities in Agusan del Sur*



It is often possible to site wastewater treatment facilities under alleys even in congested communities.

2. Designing and building tanks and pits should be done carefully:

a. Brace any structures whose foundations are as close to the proposed hole as the hole is deep before excavation.

b. Avoid digging below the foundation of nearby structures.

c. Dig-and-line is usually the safest way of building vaults and tanks beside structures (see Section B).

d. It is usually safer to excavate, emplace, then backfill around a chamber before starting on the next chamber as the hole at any one time is smaller and, therefore, less prone to collapse.

3. It may also be possible to build pits and tanks under the ground floor of existing houses. However, many cultures in Southeast Asia prefer pits and septic tanks to be outside of the house.

I. Possible Septage Management Techniques in Communities That Cannot Be Reached by Vacuum Trucks

In many congested communities, desludging of pits and septic tanks by vacuum trucks is not an option as alleys are too narrow to be negotiated by the latter. This is aside from their fees being often prohibitive.

However, affordable onsite septage management options may be resorted to:

1. Septage minimization: as soil and sand tracked in by users can add up to a significant amount of septage over time when

1. Septage minimization: as soil and sand tracked in by users can add up to a significant amount of septage over time when bathroom sullage is directed to a septic tank, this sullage may instead be passed first through a smaller, shallow interceptor tank. This silts up fast but can be desludged by shovel safely and the sediment disposed of in a garden.

2. Desludging by Sludge Handpumps and Onsite Composting: several makes of low-cost sludge handpumps have proven reliable in Southeast Asian countries. The sludge can be put into buckets or sacks and carted off to be placed in landfills. An easier option where possible is to dig a hole beside the septic tank being desludged and put the septage there to be dewatered and composted naturally over time. When the desludging is done, the hole is filled in with soil. Shrouds can be installed during desludging for odor control.

The process of determining the best sanitation technology options for a given community situation may be summarized as follows:

1. Short-list all technologically applicable options.

2. Shorten the list further by discarding obviously unaffordable and culturally unacceptable options. Check that the remainder is doable with the resources, skills, and equipment that the community has or can easily have access to.

3. Compare the remaining options to each other on the basis of costs and, if possible, benefits. Try to quantify all of these considerations so that they can be more easily compared to each other. Rank the options as to preference.

4. Present findings to the stakeholders (e.g., the community and assisting agencies). Walk them through the process and the results so that they can make their own decisions.

It is entirely possible that a community may adopt more than one of the solutions mentioned above because the situation for each household may differ.

Technology fixes alone may not be enough to bring sanitation to communities in challenging environments. By definition, challenging environments are where people marginalized by other issues such as poverty, land tenure problems, and social up-rootedness are driven to settle, and these issues may take more precedence over their lives than sanitation. The real challenge, therefore, is making them aware that sanitation is essential, that there are sanitation solutions even for challenging situations, and that they can do something to bring it about, despite their difficult circumstances.

DEFINITION OF TERMS[36]

Aerobic - condition characterized by the presence of free oxygen. (Water Environment Federation)

Anaerobic - condition characterized by the absence of free oxygen. (Water Environment Federation)

Anaerobic digestion - involves the decomposition of organic and inorganic matter in the absence of molecular oxygen. (Metcalf & Eddy)

Bacteria - microbes that decompose and stabilize organic matter in wastewater. (Water Environment Federation)

Biochemical Oxygen Demand - quantity of oxygen that will be required to biologically stabilize the organic matter present. (Metcalf & Eddy)

Biodegradable - used to describe organic matter that can undergo biological decomposition. (Water Environment Federation)

Biodigester - tank used for aerobic or anaerobic digestion of sludge.

Bucket latrine - a type of toilet wherein the feces with or without separation of urine are collected in a pail or bucket.

Burial - a system of disposal for small volumes of feces, sludge or other solid wastes by digging a pit and covering it with earth.

Collection System - system of conduits, generally underground pipes, that receives and conveys sanitary wastewater and/or stormwater. (Water Environment Federation)

Compost - the product of the thermophilic biological oxidation of sludge or other materials.

Composting - stabilization process relying on the aerobic decomposition of organic matter in sludge by bacteria and fungi. (Water Environment Federation)

Contamination - the introduction into water of micro-organisms, chemicals, wastes, or wastewater in a concentration that makes the water unfit for its intended use.

Desludging - removal of sludge or settled solid matter from treatment tanks such as septic/Imhoff tank, aquaprivy, interceptor tank or sedimentation tanks.

Digestion - See anaerobic digestion.

Disposal - discharge, deposit, injection, dumping, spilling, leaking, or placing of any liquid or solid waste on land or water so that it may enter the environment.

Dissolved Oxygen - the oxygen dissolved in a liquid. (Water Environment Federation)

Domestic wastewater - wastewater derived principally from dwellings, business buildings, institutions, and the like. It may or may not contain groundwater, surface water, or stormwater.

Domestic sewage - waste and wastewater from humans or household operations.

Drying - the process of hygienization of wastes (sludge, feces or urine) by subjecting it to the heat of the sun.

Ecological sanitation - sanitation whose design builds on the concept of protecting ecosystems, and which excreta as a valuable resource to be recycled. (Sanitation and Hygiene Promotion)

Effluent - wastewater or other liquid, partially or completely treated or in its natural state, flowing out of a reservoir, basin, treatment plant, or industrial treatment plant, or part thereof.

Excreta - feces and urine. (Sanitation and Hygiene Promotion)

Fats - triglyceride esters of fatty acids. (Water Environment Federation)

Feces - excrement of humans and animals. (Water Environment Federation)

Gas - of the three states of matter, the state having no fixed shape or volume and capable of expanding indefinitely. (Water Environment Federation)

Grit removal - a preliminary wastewater treatment process to remove grit from

[36] *Adapted from the Philippines Sanitation Sourcebook and Decision Aid*

organic solids. (Water Environment Federation)

Groundwater - water found below ground level in the sub-soil. (Sanitation and Hygiene Promotion); subsurface water found in porous rock strata and soil. (Water Environment Federation).

Groundwater table - the level at which the subsoil is saturated. (Sanitation and Hygiene Promotion)

Inorganic matter - substances of mineral origin, not containing carbon, and not subject to decay. (Water Environment Federation).

Landfill - a land disposal site that employs an engineering method of solid waste disposal to minimize environmental hazards and protect the quality of surface and subsurface waters. (Water Environment Federation)

Micro-organisms - very small organisms, either plant or animal, invisible or barely visible to the naked eye. Examples are algae, bacteria, fungi, protozoa, and viruses.

Nitrogen (N) - an essential nutrient that is often present in wastewater as ammonia, nitrate, nitrite, and organic nitrogen. The concentrations of each form and the sum (total nitrogen) are expressed as milligrams per liter (mg/L) elemental nitrogen. Also present in some groundwater as nitrate and in some polluted groundwater in other forms.

Nutrient - any substance that is assimilated by organisms to promote or facilitate their growth. (Water Environment Federation).

Offsite sanitation - system of sanitation where excreta are removed from the plot occupied by the dwelling and its immediate surroundings. (Sanitation and Hygiene Promotion).

Onsite sanitation - system of sanitation where the means of collection, storage and treatment are contained within the plot occupied by the dwelling and its immediate surroundings. (Sanitation and Hygiene Promotion)

Organic matter - solids derived from both animal and plant kingdoms and the activities of man as related to the synthesis of organic compounds.

Pathogen highly infectious, disease-producing microbes commonly found in wastewater. (Water Environment Federation).

Permeability - the property of a material that permits appreciable movement of water through it when it is saturated; the movement is actuated by hydrostatic pressure of the magnitude normally encountered in natural subsurface water.

Phosphorus - a nutrient that is essential element of all life forms. (Water Environment Federation).

Pit latrine - latrine with a pit for collection and decomposition of excreta and from which liquid infiltrates into the surrounding soil. (Sanitation and Hygiene Promotion).

Pour-flush latrine - latrine that depends for its operation of small quantities of water, poured from a container by hand, to flush away faeces from the point of defecation (Sanitation and Hygiene Promotion).

Recycle - to return water after some type of treatment for further use; generally implies a closed system.

Retention time - the length of time that water or wastewater will be retained in a unit treatment process or facility. (Water Environment Federation).

Sanitation - interventions (usually construction of facilities such as latrines) that improve the management of excreta. (Sanitation and Hygiene Promotion). The WHO Study Group in 1986 defines sanitation as "the means of collecting and disposing of excreta and community liquid wastes in a hygienic way so as not to endanger the health of individuals and the community as a whole."

Sedimentation - removal of settleable suspended solids from water or wastewater by gravity in a quiescent basin or clarifier. (Water Environment Federation).
Septage - sludge produced in individual onsite wastewater-disposal systems, principally septic tanks and cesspools. (Metcalf & Eddy).

Septic tank - a tank or container, normally with one inlet and one outlet, that retains sewage and reduces its strength by settlement and anaerobic digestion. (Sanitation and Hygiene Promotion)

Sewer - a pipe or other conduit that carries wastewater from more than one property. (Sanitation and Hygiene Promotion)

Sewage - see Wastewater. (Water Environment Federation).

Sewage sludge - a solid, semi-solid or liquid residue generated during the treatment of domestic sewage in treatment works. Sewage sludge includes, but is not limited to domestic septage, scum or solids removed in primary, secondary, or advanced wastewater treatment processes.

Sewerage - the entire system of wastewater collection, treatment, and disposal. (Water Environment Federation).

Sludge - accumulated and concentrated solids generated within the wastewater treatment process that have not undergone stabilization. (Water Environment Federation) 106.

Sullage - dirty water that has been used for washing, cooking, washing clothes, pots, pans, etc.) (Sanitation and Hygiene Promotion) see Greywater. (Water Environment Federation).

Turbidity - suspended matter in water or wastewater that scatters or otherwise interferes with the passage of light through the water. (Water Environment Federation).

Wastewater - liquid or waterborne wastes polluted or fouled from households or commercial or industrial operations, along with any surface water, stormwater, or groundwater infiltration. (Water Environment Federation).