CMS WATER & SANITATION FOR ALL

Methodological Guides

n°4

How to select appropriate technical solutions for sanitation

pS-Eau

PDM

contents

WATER AND SANITATION FOR ALL

Methodological Guide n°4

How to select appropriate technical solutions for sanitation

Concerted Municipal Strategies (CMS), a program coordinated by the Municipal Development Partnership (MDP) and programme Solidarité Eau (pS-Eau)

• Authors:

. Jacques Monvois, GRET

. Julien Gabert, GRET

. Clément Frenoux, GRET

. Marie Guillaume, GRET

• Contributors:

. Denis Désille, pS-Eau

. Christophe Le Jallé, pS-Eau

• This publication has been prepared with the financial support of the AFD and the European Commission's ACP-EU Water Facility.

Graphic design and page layout: Solange Münzer

Translation: Nicola Brodrick

In this guide

▶

List of Figures

List of Tables

NOTE TO THE READER

There are a wide range of technologies available for managing domestic wastewater and excreta. In addition, designing a sanitation chain means using a series of complementary components, the organization and combination of which will vary according to the physical context, user demand and the level of treatment required, etc. As a result, you are advised that the technical solutions presented in this guide are not exhaustive.

Furthermore, the authors have, in places, chosen to simplify the way in which certain technical options, their means of application or their efficiency are presented. This decision was motivated by a desire to provide a clear approach to a relatively complex subject. However, these simplifications in no way affect the recommendations and approaches contained within this publication.

In conclusion, it is important to bear in mind that this guide does not constitute a technical reference (it is neither precise nor comprehensive enough for this) but is instead a methodological guide where the objectives are to:

– promote an approach to sanitation that takes into consideration the entire chain;

– present the main categories of possible technical options;

– provide assistance in selecting technologies that are adapted to the specific context of a local authority.

To supplement the contents of this guide, at the end of this publication, as well as at the end of each technical factsheet, you will find a detailed bibliography which will enable you to further develop your knowledge of sanitation technologies.

The technical sanitation terminology used in this guide and marked with an asterisk (*) are defined in the technical glossary in Annex 3. In particular, this glossary contains the definitions of the different types of water to be treated as part of the sanitation process (greywater, blackwater, sludge, effluent, etc.).

The sign ❗ draws the reader’s attention to certain information.

The sign ◎ indicates the possible courses of action available to the reader at the end of a step.

Introduction

What are the objectives of this guide?

For the local decision-maker, selecting an appropriate sanitation solution that is adapted to the context of his local environment is complex. Wastewater and excreta management is linked to many different domains (technical, sociological, political, land use, financial, etc.) and depends on numerous criteria (topography, geology, urban population density, user demand, water consumption, etc.).

Given this context, the aim of this guide is to assist local decision-makers and technicians in the choice of sanitation technologies best suited to their local authority in sub-Saharan Africa. This guide is particularly aimed at local authorities, national and decentralized technical departments, local stakeholders (NGOs, engineering firms), as well as development partners. It provides a progressive methodology that is adapted to this wide audience.

This guide focuses on the process to be followed when selecting a sanitation technology. Therefore, it is not, strictly speaking, a technical guide. Although adapted technical solutions are provided in the technical factsheets (Part 2), this guide does not detail how to implement these but rather redirects you to the appropriate technical publication. The design, sizing and construction of sanitation facilities can, in some cases, be carried out based on these technical documents (as mentioned in the corresponding technical factsheets) or can be conducted by a specialized engineering firm. In addition, the costs of the technologies presented in this publication are based on different field experiences (sometimes from outside sub-Saharan Africa) and so are purely indicative.

The technologies presented in this guide can be broken down into three categories: technologies to provide households with access to sanitation at home, technologies for evacuating wastewater off-site, outside the residential area, and technologies for the final treatment of wastewater.

Lastly, this guide deals with sanitation issues for the whole town, not only for a particular area. The suggested planning process aims to provide an overall vision of sanitation at town level to ensure that the technologies proposed are coherent and adapted to the different contexts and constraints of the town.

In order to simply and effectively arrive at a final, relevant decision, this guide is broken down into two parts:

1. Part 1, choosing technical solutions, a three-step process is a step-by-step guide that will provide you with a better understanding of local, sanitation-related issues and constraints and assist you in selecting the most viable technical solution.

2. Part 2, technical factsheets gives the technical characteristics and operating principles of each technology and highlights their pros and cons.

What type of sanitation is being discussed and how is it dealt with?

Sanitation: the management of wastewater and excreta

Sanitation, as considered within this guide, concerns only the management of wastewater* and excreta*. It does not deal with either the management of solid waste or stormwater.

DEFINITIONS

The term wastewater refers to all water used for domestic activities: greywater (water used for washing up, cooking, laundry and bathing) + blackwater (excreta mixed with flush water – for flush toilets – and water and materials used for anal cleansing – such as toilet paper, for instance).

The term excreta refers to all urine and excrement (also known as feces).

What are the different sanitation chains used?

The different types of sanitation technologies, which can evolve over time, use either improved on-site systems, or small-piped or conventional sewerage systems. The sanitation system is selected by considering the demand from the population, the requirements imposed by the natural environment, the local context, the population density and local practices. Given these considerations, the different sanitation chains* are defined in Table 1.
At local authority level, it is important to consider these different systems (on-site sanitation, small-piped and conventional sewerage systems) as being complementary to each other: several sanitation chains can coexist within the same area. In practice, this is very common and is even to be encouraged. The urban development of a commune (local authority) is never uniform. Different contexts can exist side by side; each with its own particularities and requiring its own type of sanitation chain.
It is necessary to consider this concept of complementary systems when defining the overall strategy at municipality level. This guide (and Steps 1 and 2 of the planning process, in particular) will enable you to identify the chain(s) best suited to your particular town.

TABLE 1. The different sanitation chains

CHAIN	DESCRIPTION	PROS	CONS
On-site sanitation	These are technologies that enable wastewater storage within a plot (e.g. simple latrines). Storage can be combined with pretreatment (such as a septic tank). These installations often require periodic emptying and transportation of the resulting sludge to suitable disposal and treatment plants.	- Low investment costs; - Can be constructed and repaired using locally available materials; - Techniques can be mastered locally (they don't require great technical expertise); - Not necessary to have a constant water source.	- Costs of emptying; health risks linked to sludge if this is not sanitized; - Risk of underground pollution.
Small-piped sewerage system	These are technologies, such as simplified sewerage systems used by multiple plots that collect wastewater and excreta produced at neighborhood level or from several houses. The wastewater thus collected can either be treated on-site or be directly transported to a treatment plant.	- Medium-level operation and maintenance costs; - Very convenient; - Extension possible should the population evolve; - Permanent evacuation of pollution far from the population's place of residence.	- Design and construction requires expert intervention; - Qualified labor required for care and maintenance.
Conventional sewerage system	These are sewerage systems to which households are directly connected. These systems transport wastewater and excreta to treatment plants which reduce the pollution content of effluent* prior to this being discharged into the environment.	- Highly convenient; - Long lifespan of the system; - Permanent evacuation of pollution far from the population's place of residence; - Adapted for areas of high population density and where large volumes of wastewater are produced.	- Very high investment costs; - Design and construction requires high-level expert intervention; - Qualified labor required for care and maintenance.

FIGURE 1. The three segments of the sanitation chain

SEGMENTS	SEGMENT-RELATED OBJECTIVES AND METHODS	TECHNICAL SOLUTIONS TARGETED BY THIS SEGMENT
Segment 1 Access / Collection	**Objective**: to improve the sanitary conditions in people's homes. **Methods**: removal of wastewater and excreta from households' dwellings.	This segment groups together those technologies with which the user has direct contact. These technologies enable wastewater and excreta to be collected, temporarily stored and, if appropriate, to be partially treated: latrines, septic tanks, soakaways, etc.
↓		
Segment 2 Evacuation / Transport	**Objective**: to ensure the health and hygiene of the neighborhood. **Methods**: evacuation of wastewater and excreta from the neighborhood.	This segment includes all those technologies that transport wastewater and excreta away from the user's home to discharge and final treatment sites: vacuum trucks, sewerage systems, etc.
↓		
Segment 3 Disposal and Treatment	**Objective**: to reduce pollution. **Methods**: physico-chemical and / or biological treatment of effluent (followed by utilization, if appropriate).	This segment brings together those technologies used to dispose of wastewater, excreta and sludge, used for treatment to reduce the pollution load and, if appropriate, utilization of the end-product.

The three successive segments of a sanitation chain

Regardless of the sanitation chain under consideration, the management of wastewater and excreta can generally be divided into three segments*, as shown in Figure 1. Breaking down sanitation into successive segments in this way enables us to better understand this complex field. Indeed, each segment has different, yet complementary, objectives and sets out a specific approach for meeting these.

❗ It is vital that there is coherence between these three successive segments (and so between the different technologies used); to ensure this coherence is in place for a given area and for each of the segments, it is necessary to choose technologies from the same sanitation chain (on-site, small-piped or conventional sewerage system).

Within each segment, there are specific technologies available that enable the required objectives to be met. It is these technologies that are the focus of this guide. Upon completion of Step 3 of the planning process, you will be in a position to select the appropriate technologies to be put in place.

! This guide provides an approach to local sanitation based on the whole chain, from beginning to end, to ensure that equal consideration is given to the collection of wastewater and excreta, its evacuation and its treatment. Indeed, addressing only one particular segment just transfers the problem elsewhere. For example, households equipped with toilets in an area where there are no pit emptying or treatment services are likely to empty their full pits into the street: thereby transferring the problem from the private home into the public domain.

Specific technical solutions for each chain and for each segment

Sanitation technologies are very diverse and vary according to both the sanitation chain used and to the segment within this chain. This 'chain'/'segment' double entry is summarized in a non-exhaustive manner in Table 2 and Figure 2.

This guide will provide you with an understanding of the main sanitation technologies available, as well as their pros and cons, and thereby enable you to choose the most viable technical solution

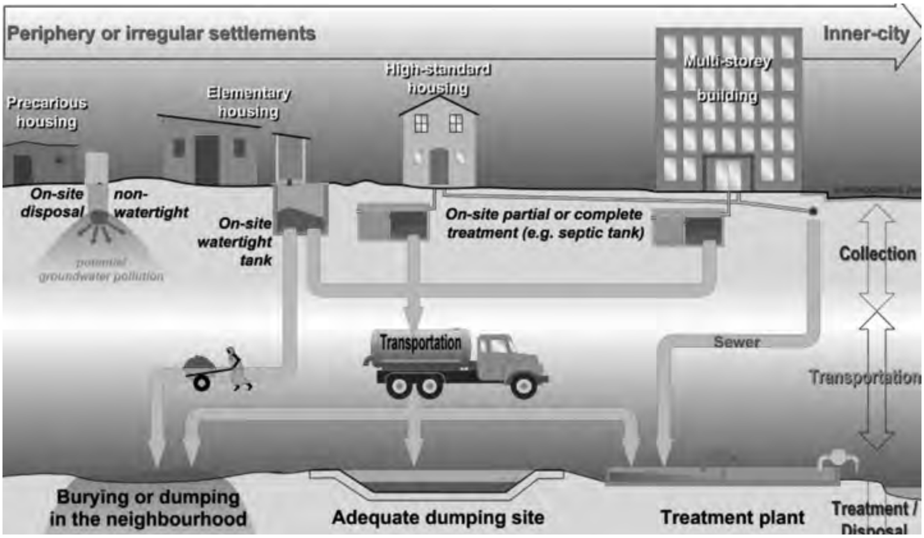
TABLE 2. Some examples of technologies in relation to the chain used and segment considered

		CHAIN		
		ON-SITE SANITATION	SMALL-PIPED SEWERAGE SYSTEM	CONVENTIONAL SEWERAGE SYSTEM
SEGMENT	Access to sanitation, collection (Segment 1)	Simple toilet [1], VIP latrine [2], soakaway, septic tank, infiltration trenches, flush toilet	Cistern flush or pour flush toilet, septic tank, grease trap	Cistern flush toilet
	Evacuation, transport (Segment 2)	Manual pit emptying, vacuum truck	Small-piped system (simplified or settled sewerage system)	Conventional evacuation system
	Disposal and treatment (Segment 3)	Sludge treatment plant	Intensive or extensive, decentralized treatment plant	Intensive or extensive, centralized treatment plant

1 These are simple non-ventilated pit toilets. The term 'simple toilet' is also regularly used throughout this guide as a straightforward means of describing this technology.

2 These are Ventilated Improved Pit (VIP) toilets.

FIGURE 2. The different sanitation segments and chains used for the management of domestic wastewater & excreta



Source: Hydroconseil

for each segment of the chain selected. Examples of some of the technologies are provided in Figure 3.

Constructing a sanitation chain for wastewater and excreta

In order to provide a complete solution to sanitation issues in your area, we strongly recommend you put in place a system to jointly manage both wastewater and excreta.

This is the approach selected for this guide and it is possible to proceed in one of two distinct ways:

– - either combine a technological solution for collecting excreta only (simple toilets, VIP, urine diverting dry toilets (UDDT), flush toilets) *with a technology that collects wastewater only (soakaway, infiltration trenches, settled sewerage system)*;

– or opt for a technological solution that collects and treats all wastewater and excreta (septic tank, conventional sewerage system).

It is important to always find a solution to sanitation issues in their entirety and, therefore, to propose technical solutions to households that consider both excreta and wastewater.

Excreta collection facilities (toilets) should only normally be used for blackwater*. It is therefore necessary to plan specific facilities for the collection of greywater*, prior to it reaching a soakaway, pit or sewerage system. There are simple and low cost facilities available that should be offered to households:

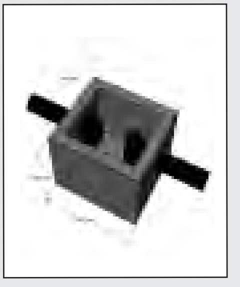
FIGURE 3. Examples of sanitation technologies for each segment of the chain

Access Segment

1. Simple pit latrine

2. Micro-septic tank

3. Sink



4. Sewerage system junction chamber

Evacuation Segment

5. Tank-cart

6. Vacuum truck

7. Settled sewerage system

Disposal/Treatment Segment

8. Sludge disposal site

9. Waste stabilization pond

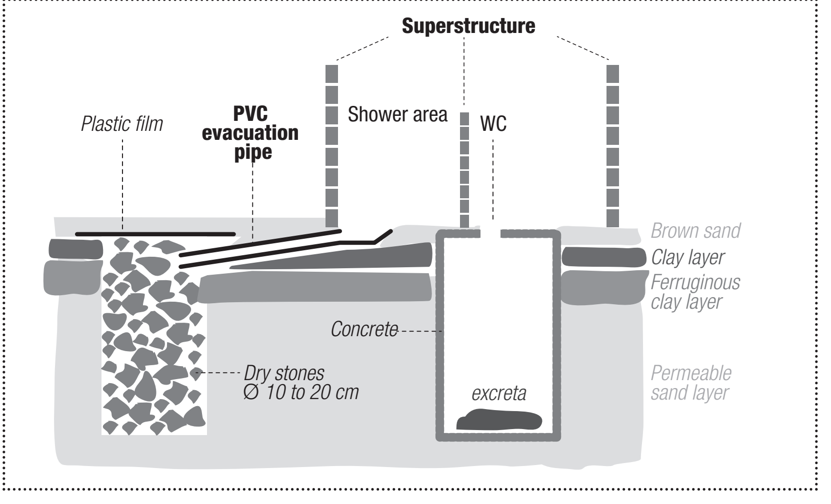
10. DEWATS intensive decentralized treatment plant

Photos: NGO RAIL Niger, Gret Pacepac, Eawag, pS-Eau.

BOX 1

The latrine-soakway approach developed by NGO RAIL-Niger

In order to prevent fecal hazards (diarrhea, cholera, etc.), as well as wastewater flowing into the streets (contamination and pollution risks), the Réseau d'Appui aux Initiatives Locales (NGO RAIL-Niger) has proposed a 'latrine-soakaway' approach. This system is made up of a defecation area that uses a Sanplat slab with a simple pit (for the collection and storage of excreta) and a shower area with a soakaway to aid the infiltration of wastewater (from bathing, washing up and laundry) into the ground.The aim of this approach is to offer robust latrines at a low cost and thus affordable to the majority of Niger's households, which is why a simple pit (as opposed to a double pit or septic tank) was the preferred technical option. This choice does, however, have one disadvantage in that it involves regular pit emptying, which has to be carried out by a professional.



• **shower**: a shower area means that a person can wash in private; the water used runs out into a soakaway, pit or sewerage system (via a grease trap, if necessary). An example of this is the 'latrine – soakaway' approach described in Box 1;

• **sink:** a sink is practical for washing up and directs the washing up and cooking water into a soakaway, pit or sewerage system (via a grease trap, if necessary);

• **grease trap:** situated before a soakaway, pit or sewerage system, a grease trap helps remove grease from wastewater (in particular from washing up water) and so protects against blockages further along the system.

These technologies are presented in the corresponding technical factsheets (see factsheets A10, A11, A12).

The methodology used in this guide: a three-step process

Having looked at the brief technical introductions to sanitation above, it is now time to consider the fundamental question: 'How can I find relevant solutions to the sanitation issues that exist throughout my town?'

This guide sets out a three-step methodology that will enable you to progress towards the final selection of one or more appropriate sanitation technologies.

The steps involved are as follows:

• **Step 1**: Characterize the town with regard to sanitation at neighborhood level and, more generally, at town level. This step enables identification of users' habits, as well as of any constraints linked to particular neighborhoods, so that homogeneous areas[3] can be established for sanitation within the town.

• **Step 2**: Identify the appropriate sanitation chain(s). This step determines the type of sanitation chain to be selected for the different homogeneous areas identified in Step 1. In practice, it is often necessary to make use of several complementary chains within the same town. To carry out this step, you will use a series of specific selection criteria, such as: population density, topography, water consumption, etc.

• **Step 3**: Select appropriate sanitation technologies. In each area identified, and for each segment of the chain selected, select the technological solution that is best adapted to the physical, urban and socio-economic context by comparing the different technologies that are locally feasible.

Upon completion of the three steps in Part 1 of this guide, you will have selected technologies that are appropriate for the different contexts of your town and which are feasible locally. To further support and organize your planning, two additional aids are provided:

– a table for you to complete is provided in Annex 2 that summarizes the technical choices made throughout the planning process;

– 29 technical options are described in Part 2 of this guide in the form of technical factsheet summaries (see introduction p. 63). The factsheets list the prerequisites necessary for the implementation of each technical solution, as well as the advantages, disadvantages and technical characteristics in terms both of construction and operation.

FIGURE 4. The three steps of the planning process

3 Here, areas are homogeneous in terms of physical, urban and socio-economic context. For further information, see Step 1 of the planning process.


NE PAS
VERSER
D'EAU USEE
AVEC DES
SALETES

PART 1

Selecting the technical solutions

A three-step process

STEP 1. Characterizing the town with regard to sanitation

To carry out this step, the reader can refer to the 'Concerted Municipal Strategy' approach described in the CMS n°1 methodological guide: 'How to develop a concerted municipal strategy for water and sanitation in large towns in Africa'.

Step 1 involves a two-stage process:

- a first 'sub-step' (**characterize the town in its entirety**) provides an understanding of the sanitation situation at overall town level and enables you to anticipate any urban development that may take place over the next 10 to 20 years;

- this is then followed by a more refined analysis (**characterize the neighborhoods to identify homogeneous areas**) to identify areas that are homogeneous in terms of physical, urban and socio-economic context. An appropriate sanitation technology that is adapted to the context will then be implemented in each area.

Characterize the town in its entirety

The aim of characterizing the town is twofold: on the one hand, it provides direction to ensure there is overall coherence in the different technological solutions implemented locally; and, on the other hand, it ensures that the town's future development is taken into account.

Overall coherence in sanitation

Although different technologies can be implemented in different areas of the town based on their contexts, it is nonetheless important to bear in mind that sanitation needs to remain coherent at town level, as certain aspects need to be considered on this scale. It is not possible to only consider the evacuation and treatment of wastewater and excreta at 'micro' level (house, neighborhood); they also need to be examined at 'macro' level (on a town scale) to ensure that the solutions selected take account of the fact that different areas are technically compatible.

It may be necessary to evacuate sludge from several different areas of the town, for example. If a vacuum truck is used, then it needs to be able to meet the various requirements of these areas. In the same way, the location and construction of any wastewater and excreta treatment plant need to be considered on a town scale: wastewater and excreta from different areas will often all be delivered (either through a sewerage system or by vacuum truck) to a single treatment plant[4].

Although we are now going to deal with finding technological solutions adapted to different 'micro' contexts, it is always important to remem-

[4] The construction of small decentralized treatment units is possible and even recommended when the town is very spread out, for example (to limit the cost of evacuating wastewater and excreta).

ber that sanitation is a service that needs to be considered at town level. We will return to this need for overall coherence in the sanitation service during the final summary.

Development of the town and its sanitation technologies

The town's development over the next 10 to 20 years has a bearing now on the type of sanitation technologies to be put in place, particularly in terms of:

• technology selection. In a developing town, certain neighborhoods are likely to undergo rapid development meaning that, in several years, those sanitation solutions that are perfectly adequate today will need to be upgraded;

• the size of facilities. The design of facilities for shared use (shared toilet blocks, small–piped sewerage systems, conventional systems, treatment plants) should allow for population growth within the town and for anticipated developments in the population's habits (water consumption, etc.). These shared facilities needs to be sized to meet short and medium-term needs (5 to 10 years);

• the location of sanitation facilities. It is important to take urban development into account when deciding on the location of technological solutions, particularly with regard to wastewater treatment plants. This precaution will, for example, help prevent against the construction of a treatment plant in an area that is currently situated outside the town but that may, in the future, be required to accommodate residential areas

Furthermore, the development of the town and, in particular, improvements in the inhabitants' standard of living means that the technical solutions used for sanitation will also develop over time (notably in terms of the level of comfort and user-friendliness sought by households).

BOX 2

An example of the development in sanitation technologies

There are examples (such as in Dakar, Senegal) where (long-standing) existing on-site sanitation facilities in a densely populated urban area have been connected to a newly installed sewerage system. This has enabled wastewater and excreta to be continuously evacuated and has enabled cleanup of the ground, which had become saturated.

Future changes within the town should be analyzed by examining how factors that can impact on sanitation may evolve, in particular:

1. Population growth. How will the population of the town develop? How will population density evolve in the different areas of the town? What will be the impact on the space available in homes and public places?

2. Geographical growth. In which direction(s) will the town develop?

3. Evolution of water consumption. What will any increase in water consumption look like (in relation to how the systems for accessing drinking water – network, standpipes, etc. – develop, as well as any improvements in standards of living)?

The answers to these questions can be summarized in writing, for reference. They should be borne in mind when selecting the sanitation chains in Step 2.

Characterize the neighborhoods to identify homogeneous areas

There are numerous technological sanitation solutions available and each is appropriate for a specific context: from a physical perspective (topology, geology, etc.); urban perspective (density of population and habitat); and socio-economic perspective (the local population's habits and beliefs with regard to water and sanitation, ability to pay, technical skills available, etc.), as illustrated in Box 3.

In order to select the most appropriate technical solution for a given context, we need to be able to characterize each neighborhood. To do this, we use a set of ten criteria. These criteria, presented in Table 3, are divided into three categories: physical criteria, urban criteria and socio-economic criteria.

The information required for these criteria can be collected from the specialized technical departments (decentralized or municipal) and from field studies (visits, household surveys, etc.).

Each 'administrative area' of the commune needs to be characterized. It is however likely that, in the course of this activity (with the aid of Table 3), you will come across disparities in some areas (neighborhoods) for some of the criteria being considered. Should this be the case, it is possible to divide each of these neighborhoods into different areas again and undertake the analysis once more for each new area. For instance, a neighborhood may be located on land that is partly flat and partly sloped: it will therefore be necessary to divide this neighborhood into two areas (one flat, the other sloped) as topography affects the choice of technical solution.

It is now possible to characterize the neighborhoods in your town, based on the questions in Table 3, with a view to defining the different homogeneous areas using 'sanitation criteria'. These areas can then be transferred to the first column of the table in Annex 2.

BOX 3

Example of a technology appropriate for a specific context

Simple pit latrines (technical factsheet A01) are toilets that consist of a defecation slab (such as Sanplat) placed over a pit, the sides of which are usually concrete-lined, and water infiltrates the soil through the pit-base. These toilets are suitable for areas where the soil is not rocky and is permeable (to allow water to infiltrate), where the groundwater table is of a sufficient depth (to prevent pollution) and where there is enough space (2m²) available for its construction.

This toilet is perhaps the least expensive facility for the collection of excreta: it is therefore particularly attractive to households. This technology is not, however, suitable for use in areas where there is impermeable soil, for example.

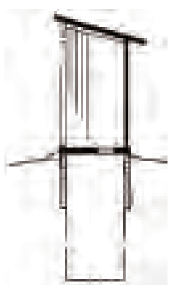


Diagram: Franceys R. et al., 1995
Photo: Julien Gabert

TABLE 3. Criteria for selecting sanitation chains: what questions need to be answered and why?

Critères		Questions	Answers	Why are these questions relevant?
PHYSICAL	Soil type	Does the soil enable the absorption of wastewater and excreta in the area of intervention?	☐ YES ☐ NO	The infiltration of water into the soil: (i) prevents the presence of stagnant water, (ii) dries out and compacts the sludge and (iii) enables partial treatment of the wastewater (any infiltrated bacteria will die due to lack of nutrients). This soil infiltration process is used by wastewater and excreta collection technologies (simple latrines) and by treatment technologies (sludge drying beds).
		Is the soil rocky?	☐ YES ☐ NO	A rocky layer near the surface makes digging difficult for constructing pits (toilets) or burying pipes (sewerage systems).
	Groundwater table	Is there a groundwater table near the surface? At what depth?	☐ YES ☐ NO Depth: .... meters	Wastewater that infiltrates the soil or comes from leakages can constitute a pollution risk for the groundwater table. A groundwater table is not compatible with technologies that use infiltration of water into the soil or where there is a risk of leakage if this table is situated less than 3 meters away from the point of infiltration (e.g. the bottom of a pit). The intervention of a (hydro-) geologist may be required to establish if there is a risk of groundwater table contamination.
	Topography	Is the gradient sufficient to enable the gravitational flow of effluent?	☐ YES: > 1% (1m/100m) ☐ NO: < 1%	The flow of wastewater through the sewerage system is caused by the force of gravity. These piped systems therefore need to have enough gradient to enable a natural flow; this is difficult to implement where the ground is flat (due to the additional digging work that this would entail).

▸ Criteria for selecting sanitation chains: what questions need to be answered and why?

	Criteria	Questions	Answers	Why are these questions relevant?
URBAN	**Population density** A	What is the population density?	☐ Low: <16,000 inhab./km² ☐ High: >16,000 inhab./km²	Sewerage system technologies are not adapted to low population densities (as they become too expensive). Conversely, on-site sanitation technologies can pose a problem in areas of high population density (saturation of the soil with pathogenic bacteria* and environmental pollution).
	Available surface area A	Does the population have sufficient surface area in their homes (in the house or yard) to install a system that provides access to sanitation?	☐ Small: < 2 m² ☐ Average: > 2 m² and < 20 m² ☐ Large : > 20 m²	On-site technologies providing access to sanitation (and to settled sewerage systems) sometimes require a large surface area; this makes them incompatible with densely populated urban areas.
	Land status	Is this a planned or unplanned settlement?	☐ Planned ☐ Unplanned	For unplanned settlements the authorities and inhabitants generally prefer not to invest in infrastructure that could later be destroyed should the settlement be subsequently developed.
SOCIO-ECONOMIC	**Water consumption** A	What is the level of household water consumption?	☐ Low: < 30 l/d/inhab. ☐ Average: > 30 l/d/inhab. and < 50 l/d/inhab. ☐ High: > 50 l/d/inhab.)	A high level of water consumed by households means a high level of wastewater is produced. Large quantities of wastewater are a problem for on-site sanitation systems as this entails regular pit emptying (and so an additional cost). In contrast, a sewerage system cannot function without minimum volumes of wastewater: where volumes are too low, there is a risk of clogging*.

A It is important to bear in mind that these criteria will evolve over the next 10 to 20 years. This development must be taken into account now when selecting the sanitation chains and technologies.

B See the pS-Eau methodological guide on 'How to finance sanitation in sub-Saharan Africa'.

C See CMS methodological guide n°3 on 'How to analyze the demand of current and future users for water and sanitation services in towns and cities in Africa'.

▸ Criteria for selecting sanitation chains: what questions need to be answered and why?

	Criteria	Questions	Answers	Why are these questions relevant?
Socio-economic	**Local investment capacity**	What level of investment can be mobilized?	◻ Low: < 200 €/ household ◻ Average: > 200 and < 500 €/ household ◻ High: > 500 €/ household	Investment (and operating) costs vary widely depending on the system selected. On a simplified level, investment costs for on-site sanitation are low; investment costs for small-piped sewerage systems are medium and those for conventional sewerage systems are high. To answer this question, it is therefore necessary to answer the following sub-questions: - Who will pay the investment and operating costs[B]? Households, the local authority, the state, international aid, etc.? - What funds are available at institutional level (local authorities, state, etc.) for financing the investment and operation of the planned technology? - What is the demand for sanitation?[C] Are the households willing and able to pay the investment and operating costs? What funds do households have available for financing the investment and operation of the planned technology? These questions arise from an analysis of the demand for sanitation.
	Local technical skills	What level of local technical skills is available for building the infrastructure? For operating the facilities?	◻ Low ◻ High	The design and construction of certain sanitation infrastructure (sewerage systems, intensive treatment plants) require the services of engineering firms and specialized, competent and experienced enterprises. Other structures (latrines, tanks for sludge removal) can be built by a local craftsman (mason). The same is true for the care and maintenance of sanitation facilities: if high level skills are required, it is necessary to call upon technically qualified resources. If these resources are not available locally, then the technical solution is perhaps not appropriate for the area and technical solutions that are simpler to use should be investigated.
	Local financial management skills	What level of local financial management skills is available?	◻Low ◻ High	The care and maintenance of sanitation facilities may require financial management skills that are not always available locally.

STEP 2. Determining a sanitation chain for each area identified

For each of the areas identified (and which have been listed in the table in Annex 2), it is possible to select a sanitation chain based on an initial simplified approach, as presented in Figure 5. This simplified approach makes use of a limited number of the criteria for which information was collected during Step 1 and which need to be satisfied to validate the selection of a given chain.

We therefore proceed by elimination. For instance, if there is low water consumption in a given area, a conventional sewerage system sanitation chain will not be possible. In the same way, if there is dense housing and so no space to build a pit for a household latrine, then on-site sanitation will not be appropriate.

It may however be the case that based on this simplified approach shown in Figure 5, several sanitation chains are possible for the same area. This type of situation is not unusual. To deal with such a situation, a second qualitative approach is proposed in Table 4. This table describes the pros and cons of each sanitation chain based on indicators previously identified at Step 1. From this table you can make a choice which, at this stage in the planning process, does not have to be definitive: if, at Step 3, it transpires that this choice is not the most appropriate, it is always possible to go back and explore a different sanitation chain for this area.

Note: the criteria in Table 4 exclude certain sanitation chains. For example, low local investment capacity excludes the conventional sewerage system sanitation chain as it requires high levels of investment. These qualifying criteria are marked with <u>an underscore</u>.

Upon completion of this second step, you will be able to select the sanitation chain that is best suited to each area identified in your town and to note all these choices in the table in Annex 2.

FIGURE 5. Simplified diagram for the selection of sanitation chains

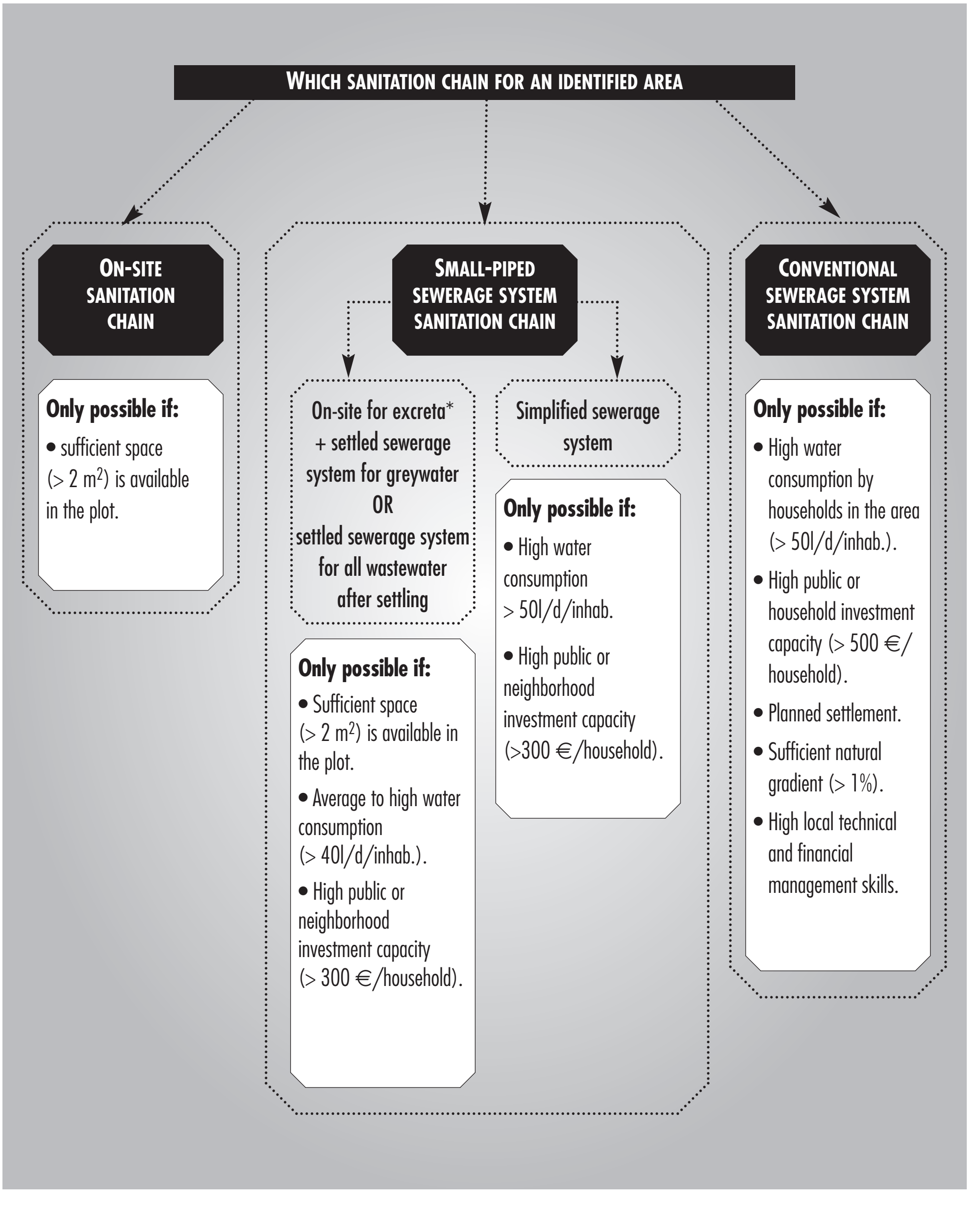


TABLE 4. Table for the precise selection of sanitation chains

				Pros and Cons
Criteria		**Questions**	**Responses**	**On-site sanitation chain**
PHYSICAL	Soil type	Does the soil enable the absorption of wastewater and excreta in the area of intervention?	☐ YES ☐ NO	Certain technologies used in this chain (simple latrines, VIP), which are also the least costly, require permeable soil as they work through the partial infiltration of blackwater into the soil. Where the soil is impermeable, other 'on-site' technologies can be put in place (septic tanks, urine diverting dry toilets).
		Is the soil rocky?	☐ YES ☐ NO	All technologies used with this sanitation chain require digging work. If the soil is rocky, then this will increase the cost of construction. In this case it will be necessary to raise the pit, ensuring that its volume is as small as possible (micro-septic tank) to reduce costs. This constraint means using technical solutions that require little water (urine diverting dry toilets, etc.) to ensure that the emptying frequency remains acceptable.
	Groundwater table	Is there a groundwater table near the surface? At what depth?	☐ YES ☐ NO Depth: ...... meters	For technical solutions used in this chain that require infiltration, there is an increased risk of contamination if the groundwater table is high, particularly if it is less than 3 meters from the base of the pit. Where there is a recognized risk of contamination due to proximity to the groundwater table, it will be necessary to use watertight pits or to study the possibility of using the small-piped or conventional sewerage system sanitation chains.
	Topography	Is the gradient sufficient to enable the gravitational flow of effluent?	☐ YES: > 1 % (1m/100m) ☐ NO: < 1 %	A very steep gradient can pose problems for vacuum trucks. Where this is the case, preference should be given to an on-site sanitation chain using simple toilets or to small-piped or conventional sewerage system sanitation chains.

TABLE 4.

Pros and Cons		
Small-piped sewerage system sanitation chain	**Conventional sewerage system sanitation chain**	
The 'simplified sewerage system' technical solution does not work on the principle of infiltration into the soil and so places no demands on the soil's absorption capacity. The same is true for technologies such as septic tanks or urine diverting dry toilets, which can be used for 'shared toilet blocks', or for the 'on-site for excreta + settled sewerage system for greywater' option. However, for these last two options, some technologies used in on-site sanitation can be selected, such as simple latrines or VIP, for instance. These technologies work on the basis of effluent being infiltrated into the soil and so require permeable ground.	The conventional sewerage system sanitation chain does not require any infiltration into the soil. It is therefore an option regardless of the soil's absorption capacity.	PHYSICAL
If the soil is rocky, then digging costs can be considerable, if not prohibitive, for the small-piped sewerage system solution, as this must all be buried underground. The pros and cons for the on-site facilities within this chain (latrines, septic tanks, etc.) are the same as for the on-site sanitation chain.	If there is rocky soil, the cost of digging for this chain will be very high, making it a considerable financial undertaking.	
The small-piped sewerage system technical solution, if well-built, should theoretically guard against any contamination of the water table, even where this is high. It is necessary to ensure that the work is carried out in line with best practice to reduce the risk of leaks once the system is operational. The pros and cons for the on-site facilities within this chain (latrines, septic tanks, etc.) are the same as those in the on-site sanitation chain.	In theory, the conventional sewerage system sanitation chain should guard against any contamination of the water table, even where this is high. To further prevent the risk of contamination, construction work needs to be carried out in line with best practice and the system must be regularly maintained.	
The small-piped sewerage systems used in this chain require sufficient gradient (> 1%) for the flow of effluent. If this condition is not met, digging down into the ground is an option, but it is often very expensive. Preference should therefore be given i) either to an on-site chain, ii) or to a settled sewerage system for greywater only (due to its low viscosity, greywater can flow down shallow slopes), combined with an on-site sanitation facility for excreta.	The conventional sewerage system sanitation chain requires sufficient gradient (> 1%) for the flow of effluent. If this condition is not met, preference should be given to either further digging, which will be very costly, or to the small-piped sewerage or on-site sanitation chain.	

▸ **TABLE 4.** Table for the precise selection of sanitation chains

	Criteria	Questions	Answers	Pros and cons: On-site sanitation chain
Urban	Population density	What is the population density?	☐ Low: <16,000 inhab./km^2 ☐ High: >16,000 inhab./km^2	Technologies used in on-site sanitation chains are particularly suited to areas of low population density.
	Available surface area	Does the population have sufficient surface area in their homes (in the house or yard) to install sanitation infrastructure?	☐ Small: < 2 m^2 ☐ Average: > 2 m^2 and < 20 m^2 ☐ Large: > 20 m ^{2}	The surface area required varies depending on the technology used within this chain: 2m^2 for simple latrines, VIP, 5m^2 for septic tanks, 20m^2 for infiltration trenches.
	Land status	Is this a planned or unplanned settlement?	☐ Planned ☐ Unplanned	This chain can be developed in unplanned settlements and where residents do not possess title deeds. However, should the area be subsequently developed, some households risk expulsion and so will lose their sanitation facilities at the same time.
Socio-economic	Water consumption	What is the level of household water consumption?	☐ Low: < 30 l/d/inhab.) ☐ Average: > 30 l/d/inhab. and < 50 l/d/inhab. ☐ High: > 50 l/d/inhab.	This chain, through its wide-range of technical solutions, can be adapted to different levels of water consumption.
	Local investment capacity	What level of investment can be mobilized?	☐ Lows: < 200 € /household ☐ Average: > 200 to < 500 € ☐ High: > 500 €	Low to average investment is required for the on-site sanitation chain, depending on the technical options selected.
	Local technical management skills	What level of local technical skills is available for building the infrastructure? For operating the facilities?	☐ Low ☐ High	Low level skills are usually sufficient for the technologies used in this chain. Prior training is, however, sometimes required.
	Local financial management skills	What level of local financial management skills is available?	☐ Low ☐ High	Low level financial management skills are usually sufficient for the technologies within this chain and these can usually be mobilized locally.

TABLE 4.

PROS AND CONS		
SMALL-PIPED SEWERAGE SYSTEM SANITATION CHAIN	**CONVENTIONAL SEWERAGE SYSTEM SANITATION CHAIN**	
Conventional and small-piped sewerage sanitation chains are to be implemented in areas of high population density. Using these two chains in sparsely populated areas involves very high investment costs (in total and per user) that are difficult to withstand and also means users need to discharge large volumes of wastewater (to guarantee effective sludge removal from the system and to prevent clogging), which rarely happens in sparsely populated areas.		**URBAN**
Small-piped sewerage systems do not require a lot of space in the home.	The conventional sewerage system sanitation chain does not take up any significant surface area in the home.	**URBAN**
This chain can be developed in unplanned settlements and where residents do not possess title deeds. However, should the area be subsequently developed, some households risk expulsion and so will lose their sanitation facilities at the same time.	Given the collective dimension and investment required to develop this chain, it needs to be located in planned settlements where the land status is clearly defined.	**URBAN**
• For a small-piped greywater and blackwater (simplified) sewerage system, average to high consumption is required to prevent the risk of clogging. • For a small-piped (settled) sewerage system carrying greywater only, low consumption will suffice.	High household water consumption is crucial for ensuring the sewerage system functions correctly.	**SOCIO-ECONOMIC**
Medium to high investment is required for the small-piped sewerage system sanitation chain, depending on the technical options selected.	High levels of investment are required for the conventional sewerage system sanitation chain.	**SOCIO-ECONOMIC**
High level skills are usually required for small-piped sewerage systems. The skills required for the on-site facilities within this chain (latrines, septic tanks, etc.), are the same as those in the on-site sanitation chain.	High level skills are required for the technologies used within this chain.	**SOCIO-ECONOMIC**

STEP 3. Selecting appropriate technological solutions

We have previously carried out a characterization of the town in order to identify homogeneous areas with regard to sanitation (Step 1), as well as identified the sanitation chain that corresponds to each of these areas (Step 2). In Step 3 we will identify the technologies available for each area, segment by segment.

The selection criteria

Each technical solution has its own characteristics, as well as its own pros and cons. For any given area, the selection process consists of assessing the extent to which the characteristics of a technical solution fit the context and constraints of the area under consideration. Lastly, it is necessary to establish whether or not a technical solution is feasible for a given area.

A technological solution is feasible if it meets local demand; if the financial resources are available for its construction; and if the technical and management skills exist to ensure its operation. The approach used in this guide consists of helping you assess the feasibility of the different technical sanitation solutions by providing a series of feasibility criteria for each one.

More specifically, the feasibility of each technical solution will be assessed in this guide on the basis of ten criteria:

1. The criterion of acceptance by households and by local sanitation professionals.
2. The criterion of lifespan of the infrastructure.
3. The criterion of the efficiency of the service put in place.
4. The criterion of investment and operating cost.
5. The criterion of design, construction and care and maintenance (C&M).
6. The criterion of accessibility.
7. The criterion of range.
8. The criterion of electrical energy.
9. The criterion of required surface area.
10. The criterion of water requirements.

THE 'ACCEPTANCE' CRITERION

In this guide, the acceptance of a technology, by households and local sanitation sector professionals, is qualified on two levels:

• high: acceptance: households or professionals have no particular issue with this technology and use it without difficulty;

• low: acceptance: some aspects of this technology (dealing with excreta, smells, etc. – please refer to the technical factsheets for more information) can discourage households or professionals and they are sometimes reticent to take ownership of and use this technology.

The assessment levels that feature in this guide for the different technical options are purely indicative and based on field experience and observations. It is possible, however, to validate these assessments by conducting surveys with both households and sector professionals in the area under consideration (for further details on this subject, please see the CMS n°3: 'How to analyze the demand of current and future users for water and sanitation services in towns and cities in Africa').

BOX 4

Examples of households' expectations and demands

It is often the case that households are only prepared to buy a latrine if this is robust, simple to use and doesn't require frequent emptying.

On a different note, some people are not prepared to handle excreta (for cultural or religious reasons) and so will not want to use toilets that require regular emptying by the user (as is the case with a urine diverting dry toilet, for instance).

THE 'LIFESPAN' CRITERION

TABLE 5. Lifespan of sanitation technologies

TYPE OF FACILITY	LIFESPAN (YEARS)
Traditional latrine	5 – 10
Wet or dry latrine, more advanced than traditional latrines	10 – 20
Sludge removal equipment, other than vacuum trucks (cart and tank)	2– 10
Vacuum truck	10 – 20
Equipment made from PVC	10 – 25
Equipment made from reinforced concrete	25 – 50

The lifespan of technologies is an important criterion: in principle, it would seem to make sense to opt for facilities with the longest possible lifespan. However, some technical solutions with a long lifespan can have investment or operating costs that are beyond the means of users, service professionals or local authorities. For some areas, it is therefore possible to opt for technical solutions with a short lifespan but that have the advantage of being accessible to users, for example, and in line with their demands. The lifespan ranges used in this guide are provided in the table above.

THE 'EFFICIENCY' CRITERION

The efficiency required of a technology depends on the segment under consideration:
– the efficiency of a technology used to collect wastewater and excreta (Access segment) is defined by its ease of use and maintenance and by its capacity for pretreating effluent;

– the efficiency of a technology used to evacuate wastewater and excreta (Evacuation segment) is defined by its capacity to minimize all contact between operator and excreta, by the speed of evacuation, by its capacity to evacuate all sludge (solid and liquid) and by its capacity to transport this to a suitable treatment plant;

– the efficiency of a technology used for treatment (Disposal/Treatment segment) is defined by the level of treatment the effluent has received upon leaving the plant.

In this guide, the required efficiency will be broken down qualitatively for each technical solution into two levels: low or high.

THE 'INVESTMENT AND OPERATING COST' CRITERION

The investment cost criterion is used to assess the financial effort required to develop a sanitation service. The operating cost criterion assesses the recurring costs that need to be met, preferably at local level, to ensure the service functions correctly.

These two criteria are quantified in this guide in the form of cost[5] brackets per user: investment costs are expressed as euro[6]/equipment (or euro/household) and operating costs as euro/equipment/year (or as euro/household/ year).

To assess the capacity to finance investment and recover operating costs, the following questions will need to be answered:

– who will pay the investment and operating costs[7] ? Will this be the households, local authorities, the state, an international donation, etc.?

– what funds are available at institutional level (local authorities, state, etc.) for financing the investment and operation of the planned approach?

– do households have the willingness and ability to pay investment and operating costs? What funds are available at household level for financing the investment and operation of the planned approach? These questions form part of the sanitation demand assessment[8].

Based on the answers to these questions, and after referring to the investment and operating cost brackets, you will be able to determine the feasibility of a technical solution within a given area.

THE 'DESIGN, CONSTRUCTION, AND CARE AND MAINTENANCE (C&M)' CRITERION

This criterion refers to the local technical skills available for the design, construction and operation of the infrastructure, as well as to the skills required to ensure facilities are kept in good working order. In this guide, this criterion is broken down into two levels, low or high:

5 The costs given in this guide result from case studies of different sub-Saharan African countries (but also from Latin America and Asia, taking into account the different pricing levels for raw materials and labor). Given the disparity in the cost of technological solutions in the different countries (and even within the same country), the costs are given in indicative brackets to facilitate selection. These costs should, however, be treated with caution and used for comparison only in order to choose between several technologies. For further information on actual implementation costs, please refer to the technical factsheets and associated bibliography to establish a precise quote for your town.

6 Prices in this guide are given in euro. For reference: 1 euro = 655.957 CFA Francs.

7 Please see the guide: 'How to finance sanitation in sub-Saharan Africa'.

8 Please see the CMS 3 methodological guide: "How to analyze the demand of current and future users for water and sanitation services in towns and cities in Africa".

• If the skill level required is high, it is necessary to:

– call upon the services of a specialized engineering firm and/or enterprise with proven experience in the design and construction of sanitation infrastructure. These engineering firms and enterprises are usually found in large towns (regional or national capitals);
– employ qualified staff to undertake care and maintenance. If this staff is not available locally, the technological solution is perhaps not appropriate for the town and it will therefore be necessary to investigate other technical solutions that are easier to use.

• If the skill level required is low:

– as far as the design and construction of the infrastructure is concerned, the system can be built by an enterprise with few or no specific sanitation skills, by a local craftsman (mason), for instance;
– care and maintenance activities can be carried out by staff with few or no specific skills, for example a local artisan (informal pit emptier), usually after having received some prior training.

To assess whether or not a technical solution is feasible in a given area from a design and construction perspective, it is necessary to compare the level of complexity (high or low) with the local capacities available. In other words, the questions that need to be asked are: who will design and build the system? Will this be the households, a local craftsman, a technical engineering firm, a private company, a technical department from the local authority? Do they have the skills required to carry out the studies and the work? If not, which organizations or people do have the skills locally, in the region or nationally?
To assess the feasibility of a technical solution in a given area from a care and maintenance perspective, again it is necessary to compare the level of complexity (high or low) with the local capacities available. The questions here that need to be answered are: who will manage the system once it is operational? Will this be the households, a local craftsman, a private company, a technical department from the local authority? Do they have the skills required?

These two concepts – design and construction and care and maintenance – have been grouped together into a single criterion as they are closely linked: a facility of complex design and construction will require care and maintenance that is also complex, and vice versa.

The 'accessibility' criterion

This criterion refers to whether or not vacuum trucks (or tank-carts) can access latrines pits (if, for instance, the area studied is in a densely populated neighborhood with alleyways that are narrow or unsuitable for vehicles, pit emptying using a vacuum truck will not be possible so a more suitable, smaller system will have to be identified). This criterion only concerns the Evacuation segment for on-site sanitation.

The 'range' criterion

This criterion relates to the distance between the pits being emptied and the disposal or treatment site: if the disposal site is a long way from the area studied (> 5 km), a system that uses animal-drawn tank-carts will not be suitable and a truck would need to be used. Alternatively, it is possible to introduce a hybrid solution (with an intermediate discharge station where the sludge can be transferred from the tank-cart into a vacuum truck to then be transported to the final treatment site). This criterion only concerns the Evacuation segment for on-site sanitation.

THE 'ELECTRICAL ENERGY' CRITERION

This criterion refers to the energy (where relevant) required to operate sanitation facilities. This criterion only concerns the Disposal/Treatment segment for the treatment of effluent.

THE 'REQUIRED SURFACE AREA' CRITERION

The required surface area criterion relates to the amount of land required for the sanitation facilities. Within the framework of these feasibility criteria, this criterion is only used for the Disposal/Treatment segment. There are two distinct levels of surface area requirement: large or limited.

THE 'WATER REQUIREMENTS' CRITERION

Some technical sanitation options work by discharging greywater (this is particularly the case of cistern flush toilets and sewerage systems) and so therefore consume high volumes of water, here referred to as water requirements. In this guide, two levels of water requirements are used: low or high.

Selecting technical solutions for each chain and segment

Now that you are familiar with the selection criteria, it is time to move from theory to practice. This chapter is divided into three sections that correspond to each of the three chains:

- choosing technical solutions for the on-site sanitation chain;
- choosing technical solutions for the small-piped sewerage system sanitation chain;
- choosing technical solutions for the conventional sewerage system sanitation chain.

Each of these sections deals with the three segments of the chain (access, evacuation and disposal/treatment). In this chapter, you will therefore need to refer to the section that corresponds to the chain you selected in Step 2.

The on-site sanitation chain

The technical solutions possible for the three segments of the on-site sanitation chain are as follows:

• **access segment:** simple pit toilets, soakaway, flush toilets, septic tank, etc.;

• **evacuation segment:** pit emptying service;

• **disposal/treatment segment:** sludge treatment systems (drying, composting, anaerobic reactors (anaerobic biogas reactor, upflow anaerobic sludge blanket reactors – UASB), etc.).

All these technologies will now be compared using the feasibility criteria defined above in order to choose the solution that is most appropriate for the area being considered.

Access segment of on-site sanitation: the collection of wastewater and excreta

To choose a wastewater and excreta collection technology for the Access segment of on-site sanitation, an initial step involves identifying whether the target area is able to accept technical solutions that work on the principle of raw effluent infiltration (latrines, soakaways, etc.), or, conversely, technical solutions that prevent any infiltration of raw effluent (watertight pits, etc.), or that permit the infiltration of pretreated effluent (septic tanks combined with infiltration trenches, etc.). In order to make this initial distinction, there are two criteria to consider:

• **the permeability of the soil.** Permeable soil allows wastewater to infiltrate and to be gradually treated as it passes through the soil. In contrast, impermeable soil does not enable infiltration and can instead lead to the wastewater re-emerging and stagnating on the surface;

• **the proximity of the groundwater table.** A groundwater table that is located close to the surface will be at high risk of contamination should technologies be used that involve the infiltration of grey and blackwater. To avoid all contamination, either the groundwater table must be situated more than 3 meters below the base of 'infiltrating systems' or watertight structures should be used.

These two criteria give rise to three different scenarios:

– *there is permeable soil and a low groundwater table.* Infiltration techniques are perfectly suited to this situation: wastewater can infiltrate the soil; there will have been sufficient infiltration time to ensure that this wastewater no longer poses a contamination risk when it eventually reaches the groundwater table;

– *there is a high groundwater table.* A high groundwater table, combined with permeable soil, presents a high contamination risk should it come into contact with wastewater. In this situation, watertight structures should therefore be used. Where there is a high groundwater table and impermeable soil, there is no contamination risk due to the impermeability of the soil; at the same time, however, any attempt to use wastewater infiltration techniques will be in vain (see the following point);

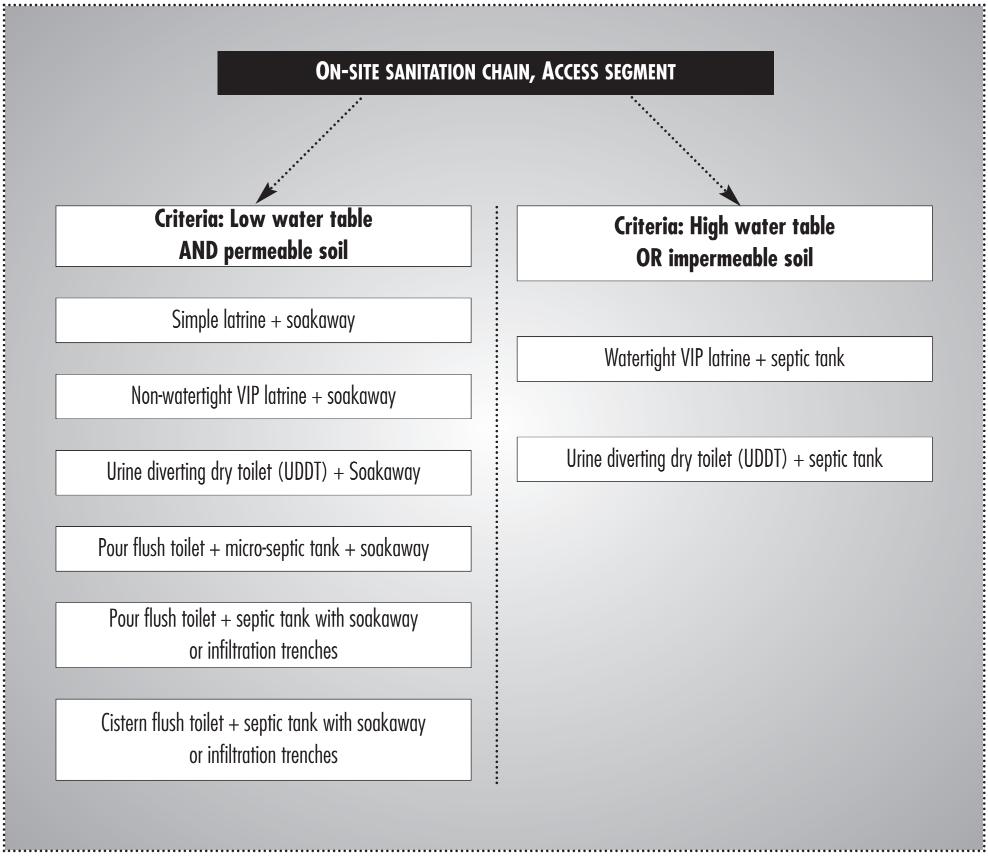
– *there is impermeable soil.* Impermeable soil will prevent all infiltration, regardless of the type of groundwater table (high or low). Such a scenario means using facilities providing access to sanitation that don't require the infiltration of effluent into the soil.

These three scenarios (which can be condensed into two categories: 'permeable soil and a low water table' or 'a high water table or impermeable soil') are shown in Figure 6, along with the different appropriate technological solutions.

Once you have identified the category that corresponds to the area studied – 'permeable soil and a low water table' or 'a high water table or impermeable soil' – you are able to select the most appropriate technical solution with the aid of decision tables 6 and 7.

❗ The technical solutions provided consider both blackwater and greywater, as previously recommended in this guide.

FIGURE 6. The different technologies available for the Access segment of on-site sanitation



❗ How to use decision tables 6 and 7

(Simple) example 1

The example used here is of an area where there is 'permeable soil and a low water table', and where the household demand assessment reveals a preference for a technology capable of lasting 10 years, with an investment cost no greater than 150 euro and low maintenance costs. With the aid of Table 6 we can establish that:

– the lifespan criterion immediately rules out the 'simple toilet + soakaway' option;

– based on the investment cost criterion, only the 'non-watertight VIP toilet + soakaway' and the 'pour flush toilet + micro-septic tank + soakaway' options would potentially cost less than 150 euro (and have a lifespan of at least 10 years);

– based on the operating cost criterion, only one option then remains: 'non-watertight VIP toilet + soakaway'.

Possible technologies	Acceptance	Lifespan (years)	Efficiency	Investment costs €/equipment	Operating cost € /equipment	Design construction and C&M
Simple toilet + soakaway	High	5-10	Low [a]	70-160	10-30	Low
Non-watertight VIP toilet + soakaway	High	10-20	High [b]	130-360	10-30	Low
Urine diverting dry toilet + soakaway	Low	10-20	High [b]	230-460	10-30	High
Pour flush toilet + micro-septic tank + soakaway	High	10-20	High [b]	130-460	20-40	High
Pour flush toilet + septic tank with soakaway or infiltration trenches	High	10-20	High [b]	500-800	20-40	High
Cistern flush toilet + septic tank with soakaway or infiltration trenches	High	10-20	High [b]	600-800	20-40	High

(More complex) example 2

Now let us consider an area where there is 'permeable soil and a low water table', where the household demand assessment reveals a preference for a technology capable of lasting 20 years, with an investment cost of no higher than 100 euro. Using Table 6, we can see that there is no technology that fulfils all of these requirements. However the 'simple pit toilet + soakaway' (with a lifespan of less than 10 years) and the 'VIP toilet + soakaway' (that costs over 100 euro) are the options that best match local demand. In this case, it is possible to offer both these technologies to households who will, themselves, select the level of service they desire. Work can be carried out on the technical design to ensure these technologies are better able to meet users' expectations.

FIRST SCENARIO

If the area being considered has 'permeable soil and a low water table', the most appropriate technology can be selected using Table 6.

TABLE 6. Decision table for selecting technologies in the Access segment of on-site sanitation, for an area with 'permeable soil **AND** a low water table'

POSSIBLE TECHNOLOGIES	ACCEPTANCE	LIFESPAN (YEARS)	EFFICIENCY	INVESTMENT COST (€/EQUIPMENT)	OPERATING COST (€/EQUIPMENT/YEAR)	DESIGN, CONSTRUCTION AND C&M
Simple toilet + soakaway	High	5-10	Low [A]	70-160	10-30	Low
Non-watertight VIP toilet + soakaway	High	10-20	High [B]	130-360	10-30	Low
Urine diverting dry toilet + soakaway	Low	10-20	High [B]	230-460	10-30	High
Pour flush toilet + micro-septic tank + soakaway	High	10-20	High [B]	130-460	20-40	High
Pour flush toilet + septic tank with soakaway or infiltration trenches	High	10-20	High [B]	500-800	20-40	High
Cistern flush toilet + septic tank with soakaway or infiltration trenches	High	10-20	High [B]	600-800	20-40	High

[A] Low efficiency means that there is a risk of smells and flies, and wastewater and excreta are not treated.

[B] High efficiency means that there are no smells or flies and wastewater and excreta is pretreated.

SECOND SCENARIO

If the area being considered has 'a high water table **OR** impermeable soil', the most appropriate technology can be selected using Table 7.

TABLE 7. Decision table for selecting technologies in the Access segment of on-site sanitation, for an area with 'a high water table **OR** impermeable soil'

POSSIBLE TECHNOLOGIES	ACCEPTANCE	LIFESPAN (YEARS)	EFFICIENCY	INVESTMENT COST (€/EQUIPMENT)	OPERATING COST (€/EQUIPMENT/YEAR)	DESIGN, CONSTRUCTION AND C&M
Watertight VIP toilet + septic tank	High	10-20	High [B]	300-800	10-30	Low
Urine diverting dry toilet + septic tank	Low	10-20	High [B]	400-900	10-30	High

BOX 5

Shared toilet blocks

The shared toilet block option is particularly appropriate (and necessary) for certain public areas, particularly in schools, healthcare centers, market places and disadvantaged neighborhoods . Although several technical options are possible for this type of facility, in addition to connection to a sewerage system, the option selected for this guide is that of a single or VIP latrine, combined with a septic tank (please see technical factsheet A13).[9]

◎ At this stage, you have selected the appropriate technology (or technologies) for the Access segment. The technology selected should be noted in the table in Annex 2. We will now turn our attention to the next segment: the evacuation of wastewater and excreta.

Evacuation segment of on-site sanitation: the evacuation of wastewater and excreta

Within the on-site sanitation chain, the evacuation of wastewater and excreta involves emptying the pits of the latrines constructed in the area. When used regularly by the inhabitants of a house, the pit in which the wastewater and excreta is collected gradually fills up (even where there is partial infiltration of wastewater into the soil) and so must be emptied on a regular basis (usually every 2 to 5 years). This pit emptying should ideally be carried out in a hygienic manner by well-equipped professionals (using an emptying system, gloves, protective overalls, etc.) who can then transport the sludge to a treatment site. This thereby prevents households from emptying the pits themselves either onto their plot or into the street (as this practice poses health risks).

FIGURE 7. The different technologies available for the Evacuation segment of on-site sanitation

ON-SITE SANITATION CHAIN, EVACUATION SEGMENT

Manual pit emptying	**Mechanical pit emptying**
Shovel + cart or barrow [10]	Motorized pump + tank-cart
Bucket + tank-cart	Vacuum truck
Handpump + tank-cart	

[10] This technical option is recommended for dry pit latrines. As it requires simple equipment and has no particular technical limitations, although mentioned, it will not be further developed within this guide.

[9] Please refer to the CMS methodological guide n°5: 'How to manage public toilets and showers'.

It is therefore necessary to put a pit emptying service in place that is both technically appropriate and affordable to users.
There are two types of pit emptying: manual emptying (using a bucket or handpump) and mechanical pit emptying (using a motorized pump or vacuum truck).

To select a pit emptying technology, the acceptance criterion disappears from the decision table (as used for the Access segment) to be replaced by the accessibility and range criteria (both defined at the start of this chapter). The most appropriate pit emptying technology can be identified with the aid of Table 8.

How to use decision table 8 for a complex situation

Here, the example is of a complex situation where the household demand assessment and consultation with local stakeholders has established a preference for an efficient and quick technology, but where the operating cost does not exceed 100 euro/year for the service operator. The town hall can invest no more than 1,500 euro in equipment. With the aid of Table 8, we can see that 'vacuum truck' technology is efficient, but not financially viable (neither in terms of investment nor operation). In such a situation, we would need to investigate more appropriate technologies in terms of cost and required efficiency (such as 'motorized pump + tank-cart' or 'mechanical pump + tank-cart') and consult once more with local stakeholders and households to discuss the possibility of implementing a more suitable technology.

TABLE 8. Decision table for selecting technologies in the Evacuation segment of on-site sanitation

	Possible technologies	Acceptance	Range	Lifespan (years)	Efficiency	Investment cost (€/equipment)	Operating cost (€/equipment /year)	Design, construction and C&M
Manual emptying	Bucket + tank-cart	Alleyways	< 5 km	2-10	Low [A]	300-1,000	50-150	Low
	Handpump + tank-cart	Alleyways	< 5 km	2-10	High [B]	400-1,000	50-150	High
Mechanical emptying	Motorized pump + tank-cart	Alleyways	< 5 km	2-10	High [B]	1,000-2,000	150-1,000	Low
	Vacuum truck	Alleys, etc. suitable for vehicles	> 5 km	10-20	High [B]	10,000 – 50,000	1,000 – 10,000	High

[A] Low efficiency means that evacuation is not very hygienic (manual emptying by bucket).

[B] High efficiency means wastewater and excreta is evacuated quickly. It is to be noted that removing the solid sludge component that remains at the bottom of the pit is always difficult regardless of the pit emptying technique used. As a result, this part often has to be completed manually.

◎ Once the relevant technology (or technologies) has been selected for the Evacuation segment, this needs to be noted in the table in Annex 2. We will now move on to look at the sludge treatment segment.

Disposal/Treatment segment of on-site sanitation: sludge treatment

There is a wide range of technologies available for sludge treatment; the level of treatment achieved by these technologies depends on a number of different factors, such as the composition of the effluent or the quality of management of the facilities, etc.

It is often best to consider the technologies included in the Disposal/Treatment segment as a series of complementary components, the organization and combination of which vary according to the level of treatment desired or required. Lastly, the requirements in terms of treatment (and so the quality of the end product that will be discharged into the environment as the output of this segment) also vary, due in particular to national and local legislation.

In light of these reasons, you are advised that the technical solutions presented in this chapter are not exhaustive: they are, however, options that have been used successfully in many different locations and are thus considered relevant and so recommended by the authors.

For further information on other possible technical solutions, we invite you to consult the available literature, in particular the 'Compendium of Sanitation Systems and Technologies', published by EAWAG/SANDEC.

STEP 1: TREATING SLUDGE

Within the on-site sanitation chain, the effluent to be treated corresponds to the sludge collected as a result of manual or mechanical pit emptying. As this sludge contains a significant amount of blackwater, there are often high levels of solid matter present. As a result, the first level of treatment aims to extract this solid waste by reducing its pollution load (it then becomes known as treated sludge). There are two possible categories of treatment available for extracting solid matter from effluent collected through manual or mechanical pit emptying:

- **extensive treatment,** which includes those facilities using processes that require large surface areas and that have a large footprint (solar drying beds combined with composting, or planted drying beds). These facilities are relatively inexpensive; however they may be difficult to construct if there is insufficient space available or if the cost of land is high.
- **intensive treatment**, which includes those facilities that use processes requiring small volumes and that have a small footprint (anaerobic biogas reactor and UASB reactor). These facilities, whilst being relatively compact, have fairly high investment costs.

Regardless of the type of treatment selected, the treated sludge that results is considered to be sanitized (provided that the level of treatment is satisfactory and meets current environmental standards). It can then:

– *be disposed of by burying* it underground. This option enables further stabilization of the sludge and the elimination of any residual pathogenic bacteria.

– *or be utilized,* notably as a form of soil enrichment for agricultural purposes. This option can be of interest due to the nutritional value of the treated sludge. Great care does need to be taken, however: in the case of partial treatment, treated sludge that contains residual pathogenic bacteria can have a harmful effect on agricultural products (the risk of helminth egg contamination, in particular).

STEP 2: TREATING THE EFFLUENT THAT RESULTS FROM THE TREATMENT OF SLUDGE

All sludge treatment produces not only treated sludge, but also residual water. This effluent often needs to undergo secondary treatment.

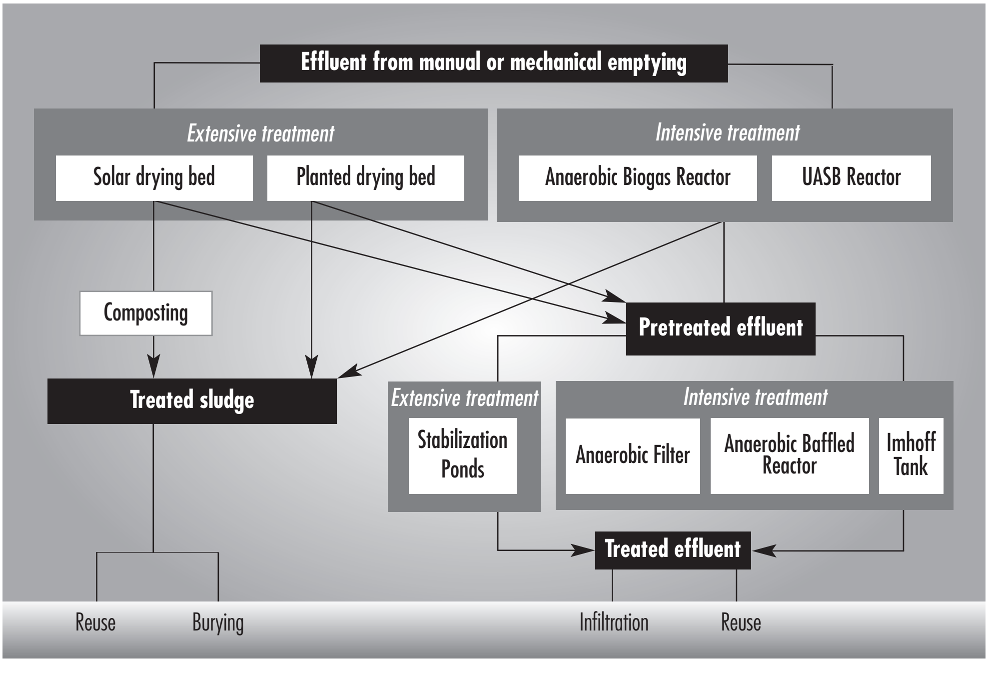
The additional treatment of residual effluent can be either a necessary or optional step, depending on the environmental standards in force and on the level of treatment required.

However, complete treatment – of sludge and of the effluent resulting from the treatment of this sludge – is always recommended in order to protect the environment and to satisfy public health requirements.

As for sludge treatment, it is possible to treat residual liquid effluent in one of two ways:

- **extensive treatment** through use of a waste stabilization pond;
- **intensive treatment** using an anaerobic baffled reactor, an anaerobic filter or an Imhoff tank.

FIGURE 8. The different technologies available for the Disposal/Treatment segment of on-site sanitation



Regardless of the treatment method selected, once treated the residual effluent can be:

• infiltrated into the soil. This option enables treatment to continue using the purification capacities of the soil. Nonetheless, care must be taken with regards to the water source: where there is a high groundwater table, any effluent that infiltrates the soil needs to have undergone sufficient levels of treatment to ensure there is no risk of contamination;

• utilized, notably for agricultural irrigation or it can be fed into aquaculture ponds (in particular, for fish farming). Great care needs to be taken if using this option: in the case of partial treatment, any treated effluent that contains residual pathogenic bacteria can have a harmful effect on agricultural and aquacultural products.

Technology selection criteria

In order to select a technology for treating the sludge collected from on-site sanitation, the accessibility and range criteria used in the Evacuation segment decision table are replaced by the **energy and required surface area** criteria (both of which are defined at the beginning of this chapter). Prior to choosing a technology with the help of Table 9, there are three factors to be considered that require particular attention:

1. What is the level of treatment obtained at the end of the Access segment? Depending on the technologies selected for the Access segment of this sanitation chain, the effluent may have already undergone some level of treatment. For instance, septic tanks and grease traps in place earlier in the chain will have already treated part of the wastewater and excreta, reducing the amount of pollutants. In some cases, it is possible for wastewater and excreta to undergo full treatment during the Access segment, where there is a properly used double VIP[11] latrine, for example. Your choice of treatment technology will therefore partly depend on the level of any pretreatment that may have taken place during the preceding segments, as well as on the level of treatment that the effluent needs to have undergone by the time it leaves the treatment plant (in accordance with local and national regulations and depending on its subsequent use)[12].

2. What is the most appropriate level of treatment? In addition to the technologies available in the Access segment that offer 'full' treatment on-site (on the plot), via systems such as double VIP latrines or septic tanks, there are two possible levels of treatment:

• *treatment at neighborhood level:* when you want to reduce the distance required for the transportation of wastewater and excreta (by vacuum truck), treatment can be carried out at neighborhood level (called 'decentralized' treatment) if there is the necessary space available. Intermediate discharge stations (for tank-carts or small trucks) are particularly suitable for towns that are spread out over a large area;

• *treatment in a centralized site* outside the town, often at some distance away. In a large town (of over one million inhabitants), one discharge or treatment site will not suffice. It will therefore be necessary to plan for the construction of several discharge sites, located in different parts of the

[11] See technical factsheet A02.

[12] Sludge treatment usually consists of a succession of several technologies to treat sludge and effluent. The way in which these technologies should complement each other is indicated in the technical factsheets but expertise is usually required to implement this effectively.

TABLE 9. Decision table for selecting technologies in the Disposal/Treatment segment of on-site sanitation

Possible techniques	Electrical energy	Required surface area	Efficiency	Investment cost (€/equipment)	Operating cost (€/ equipment/year)	Design, construction and C&M
For sludge treatment…						
Solar drying bed	No	Large [A-B]	Low [C]	20-50	2-4	Low
Planted drying bed	No	Large [A-B]	High [D]	25-60	2-4	High
Composting	No	Large [A]	High [D]	Average [F]	2-4 [G]	Low
UASB Reactor	Yes	Limited	High [D]	200-1,000	5-50 [G]	High
Anaerobic Biogas Reactor	No	Limited	High [D]	200-600	5-10 [G]	High
For the treatment of pretreated effluent…						
Anaerobic Filter	No	Limited	High [D]	150-400	2-4	High
Anaerobic Baffled Reactor	No	Limited	High [D]	150-400	2-4	High
Imhoff Tank	No	Limited	High [D]	150-400	2-4	High
Planted or unplanted pond	No	Large [A]	High [D]	15-100	5-50	Low

[A] For technologies that require a large surface area, it will be necessary to consider both the cost of land and the availability of sufficient space for construction.

[B] There is a risk of uncovered drying beds overflowing during periods of localized heavy rain, this would render treatment inefficient.

[C] Low efficiency corresponds to a reduced level of treatment: solar drying beds are used to dry out the sludge.

[D] High efficiency corresponds to a high level of treatment (to a 50 to 90% reduction in BOD*).

[E] Very low efficiency corresponds to no formal treatment (in practice, water infiltration and sludge drying takes place, but in unsanitized conditions). The sludge used for agricultural slurry spreading normally requires additional prior treatment.

[F] The investment cost for a composting center depends on several factors (technology, land prices, etc.).

[G] These technologies can be revenue-generating (compost, biogas). As this revenue is usually only marginal in comparison to operating costs (except for anaerobic biogas reactors which can provide substantial energy savings), it has not been taken into account here.

town. In the town of Ouagadougou (Burkina Faso), for example, the National Office for Water and Sanitation (ONEA: Office National pour l'Eau et l'Assainissement) established a number of discharge sites around the town to ensure that the vacuum trucks were able to use them without difficulty. As a result, the trucks now have less distance to travel.

3. Where is the treatment facility located? The choice of location of a treatment site within the neighborhood or outside the town has a large impact on the Evacuation segment as it determines the distance between the sites from which wastewater and excreta are to be evacuated (plots or neighborhoods, which are geographically fixed) and the treatment plant. The location of the treatment site therefore has a particular impact on the investment and operating costs of the Evacuation segment (notably in terms of the distance to be covered by pit emptiers).

Bearing in mind these three points, you are now in a position to select the technical solutions that are most appropriate for a given area using Table 9.

There is always an appropriate technical solution!

Example of a (presumed) bottleneck in the technology selection process

In certain 'difficult' contexts, it can sometimes seem as though none of the technical solutions for sanitation are possible (due to the qualifying criteria of the area). Should you find yourself in this situation, please rest assured: there is always a solution. It is possible to investigate ways of 'by-passing' the problematic qualifying criteria, often by working on the technological design. Let us take as an example a poor area with narrow access roads, situated in the middle of a large town. You have logically opted for the on-site sanitation chain, but there is an issue with sludge removal. At first glance it would appear that there is no technological option available: vacuum trucks are unable to access the area (the alleyways are unsuitable for vehicles) and tank-carts are unable to reach the treatment site (as it is 30km away). In fact, it is possible to construct an intermediate discharge station for the tank-carts, nearer the area concerned, from which the sludge can be transported to the treatment plant either by vacuum truck or via the sewerage system.

In a 'complicated' situation, it is important to bear in mind that it is often possible to use several chains within the same area. It may be the case that a different sanitation chain (that you initially discounted) ultimately proves to be the most appropriate. You can then return (to Step 2) and investigate the possibility of another sanitation chain for this area.

At this stage, you have now selected the appropriate technology (or technologies) for the entire on-site sanitation chain in the area studied. These technologies now need to be noted in the table in Annex 2. It is now time to move on to establish the appropriate sanitation chain for a different area.

Once all the areas of the town have been studied, please turn to the final chapter in this part of the guide, entitled 'Summary of technological choices'.

The small-piped sewerage system sanitation chain

Small-piped sewerage systems aim to provide alternative technical solutions to those used for on-site sanitation (such as a latrine or septic tank located on the household's plot) on the one hand, and to conventional sewerage systems, on the other. They have been developed in response to the wide range of different situations that can be encountered on a local level.

It is often necessary to use small-piped sewerage systems in areas where the population density is too high for on-site sanitation (lack of space in homes, saturation of the surrounding soil from the infiltration of wastewater, etc.), or in situations where the local population and public authorities don't have the means to invest in the construction and management of a conventional sewerage system.

Access and Evacuation segments of small-piped sewerage systems: the collection and evacuation of wastewater and excreta

The small-piped sewerage system sanitation chain includes the technical option of a sewerage system constructed using small-diameter pipes, which can be of two different types:

- **a settled system** only discharges greywater and/or excreta that have undergone pretreatment (such as in a septic tank) at household level, which means that most of the solid waste is retained. This type of system is designed to evacuate liquid effluent only and can handle only very low volumes of solid waste;
- **a simplified system** evacuates wastewater (greywater and excreta from flush toilets, sinks and showers) at neighborhood level, regardless of the amount of solid matter it contains. It therefore requires no pretreatment at household level.

In addition, regardless of the type of small-piped sewerage system considered (settled or simplified), to function properly it requires sufficient quantities of greywater to ensure the effluent flows through the pipes under the force of gravity.

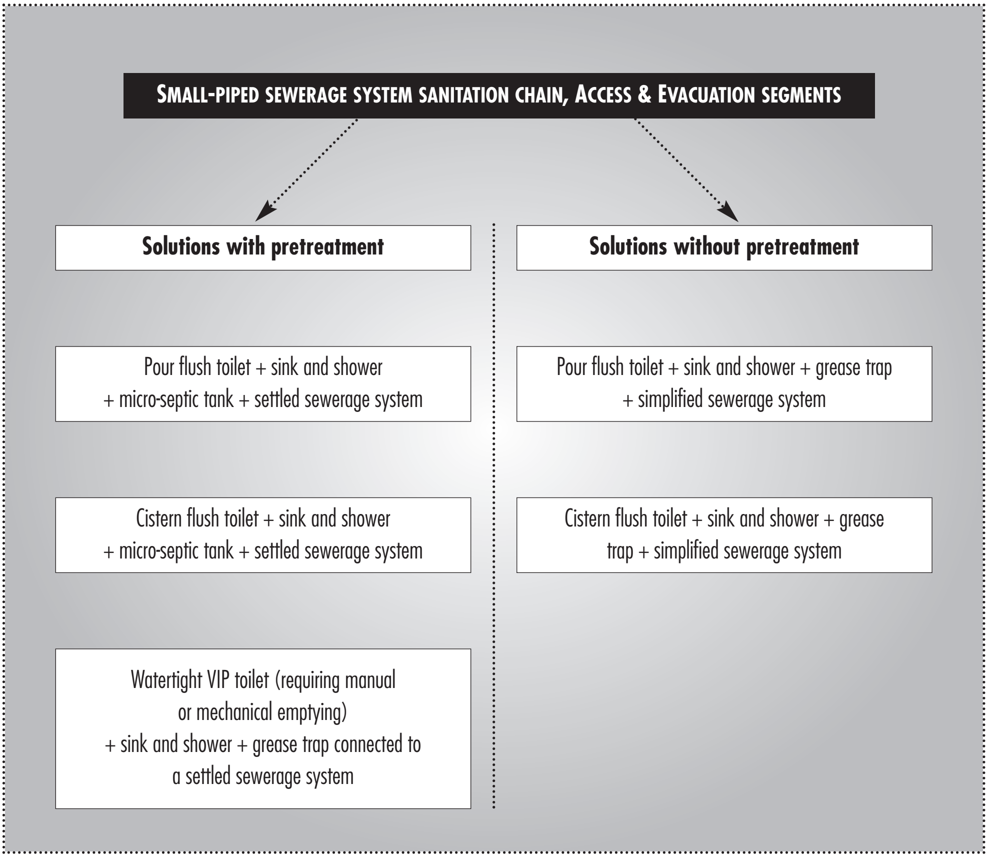
As a result, investigating technological choices within the small-piped sewerage system sanitation chain means considering both the Access segment (collection of wastewater) and the Evacuation segment (evacuation of wastewater) together.

! How a household being connected to the drinking water network impacts on the choice of toilet

A household not connected to the drinking water network (by an individual household connection) should preferably be connected to the sewerage system through means of a pour flush toilet (which only uses 3 - 4L of water per flush).

A household that is connected to the drinking water network can be connected by a cistern flush toilet (that uses 20L of water per flush).

FIGURE 9. The different technologies available for the Access and Evacuation segments of the small-piped sewerage system sanitation chain



◎ It is now possible to select the most appropriate technologies for the collection and evacuation of wastewater with the aid of Table 10.

You have now selected the appropriate technology (or technologies) for the Access and Evacuation segments of the small-piped sewerage system sanitation chain for the area being studied. These technologies should now be noted in the table in Annex 2. It is then possible to move onto the Disposal/Treatment segment.

TABLE 10. Decision table for selecting technologies in the Access and Evacuation segments of small-piped sewerage systems

Type of solution	Possible technologies	Water requirements	Required surface area	Efficiency	Investment cost (€/household)	Operating cost (€/household /year)	Design, construction and C&M
Solutions with pretreatment	Watertight VIP toilet + sink and shower + grease trap connected to a settled system	Average	High	Low [A]	350-800 [C]	20-50 [C]	High
	Pour flush toilet + sink and shower + micro-septic tank + settled system	Average	High	High [B]	350-900 [C]	30-60 [C]	High
	Cistern flush toilet + sink and shower + micro-septic tank + settled system	Average	High	High [B]	400-1,000 [C]	30-60 [C]	High
Solutions without pre-treatment	Pour flush toilet + sink and shower + grease trap + simplified system	High	Low	High [B]	300-600 [C]	20-50 [C]	High
	Cistern flush toilet + sink and shower + grease trap + simplified system	High	Low	High [B]	350-700 [C]	20-50 [C]	High

[A] Low efficiency means that there is a risk of flies and smells, and no treatment of excreta (VIP toilet).

[B] High efficiency means that there are no flies or smells, and some level of treatment of wastewater and excreta.

[C] The construction and investment costs given here pertain to the Access and Evacuation segments. They are calculated based on 250 households (small-piped system and shared toilet block), except where there is a vacuum truck (which will be used to empty more than one block) – here the costs are calculated based on 1,000 households.

Disposal/Treatment segment of small-piped sewerage systems: the treatment of wastewater and excreta

For the small-piped sewerage system sanitation chain, the Disposal/Treatment segment needs to be considered in relation to the approach selected for the Access and Evacuation segments:

• the 'Watertight VIP toilet (with manual or mechanical pit emptying) + sink and shower connected to a settled system' technical option. This option combines on-site sanitation for excreta and a settled sewerage system for greywater. In this type of scenario, the Disposal/Treatment segment needs to be able to:

– treat the sludge that results from emptying the VIP toilets. Please consult the chapter: 'Disposal/Treatment segment of on-site sanitation: sludge treatment';

– treat the greywater from the settled sewerage system. Please consult the chapter: 'Disposal/Treatment segment of conventional sewerage systems: the treatment of wastewater and excreta'.

• the settled or simplified sewerage system options. The Disposal/Treatment segment should be able to treat the wastewater from the small-piped system, using an approach similar to that of a conventional system. Please consult the chapter: 'Disposal/Treatment segment of conventional sewerage systems: the treatment of wastewater and excreta'.

The conventional sewerage system sanitation chain

For the three segments from Access to Disposal/Treatment, the conventional sewerage system sanitation chain is based on the following technologies:

• **access segment:** flush toilets (pour flush or cistern);

• **evacuation segment:** conventional sewerage system;

• **disposal/treatment segment:** intensive wastewater treatment systems (anaerobic baffled reactors or UASB reactors, anaerobic filters, Imhoff tank) or extensive treatment systems (waste stabilization ponds).

Access segment of a conventional sewerage system: the collection of wastewater and excreta

Where a conventional sewerage system is selected, this system has to be accessed by a pour or cistern flush toilet (WC). The cistern flush toilet is more user-friendly but is more expensive and uses more water.

As previously highlighted in this guide, it is recommended that solutions that provide access to sanitation systematically consider both blackwater and greywater. This means that, in addition to flush toilets, sinks and showers need to be put in place to evacuate all wastewater into the sewerage system.

All facilities that provide access to sanitation at home (flush toilets, sinks and showers) are connected to the sewerage system via a junction chamber. This junction chamber can also act as a basic settling/interceptor tank (see diagram 4 of Figure 3) to reduce the quantity of solid waste entering the sewerage system.

For the Access segment of the conventional sewerage system sanitation chain, a technological choice needs to be made between the pour flush toilet and the cistern flush toilet. This choice is directly dependent upon whether or not there is a connection to the drinking water network:

– a household that is not connected to the drinking water network (by an individual household connection) will only be able to install a pour flush toilet, as this only uses between 3 and 4 liters of water per flush;

TABLE 11. Decision table for selecting technologies in the Access segment of conventional sewerage systems

Possible technologies	Water requirements	Investment cost (€/equipment)	Operating cost (€/equipment/year)	Design, construction and C&M
Pour flush toilet	Low	50-100	5-10	Low
Cistern flush toilet	High	100-200	5-10	High

– a household that is connected to the drinking water network will be able to install a cistern flush toilet that uses 20 liters of water per flush.

It is now possible to select the most appropriate access technology using Table 11 (page 49).

◎ At this stage, you will have chosen the most appropriate technology (or technologies) for the Access segment, which you can now note in the table in Annex 2.

Evacuation segment of a conventional sewerage system: the evacuation of wastewater and excreta

For the conventional sewerage system sanitation chain, the technology used for the evacuation of wastewater is, as its name suggests, a conventional sewerage system, which is described in technical factsheet E07. As its investment and maintenance costs are very high, great consideration needs to be taken prior to selecting this option to ensure that the local authority is in a position to take on the responsibility of such an infrastructure.

Disposal/Treatment segment of conventional sewerage systems: the treatment of wastewater and excreta

There is a wide range of technologies that can be used to treat the effluent coming from sanitation facilities, the treatment levels of which depend on a large number of factors, such as the composition of the effluent and the quality of management of the facilities, etc. In addition, it is often necessary to deal with the Disposal/Treatment segment as a series of complementary components, the organization and combination of which vary according to the level of treatment desired or required. Lastly, the requirements in terms of treatment (and so the quality of the end product that will be discharged into the environment as the output of this segment) also vary, due in particular to national and local legislation.

In light of these reasons, you are advised that the technical solutions presented in this chapter are not exhaustive: they are, however, options that have been used successfully in many different locations and are thus considered relevant and so recommended by the authors.

For further information on other possible technical solutions, we invite you to consult the available literature, in particular the 'Compendium of Sanitation Systems and Technologies' published by EAWAG/SANDEC.

STEP 1: TREATING THE LIQUID EFFLUENT

Within the conventional sewerage system sanitation chain, the effluent to be treated is the liquid waste that comes out of the sewerage system and contains suspended solid matter. The first level of treatment to be applied serves to trap pathogens and suspended solids so that the pollution load of the effluent is reduced to an acceptable level (which then becomes treated effluent). There are two possible categories of treatment available[13]:

• **extensive treatment** that requires a large surface area and has a large footprint (waste stabilization ponds). Waste stabilization ponds are relatively inexpensive but constructing these can be

13 Trickling filter and activated sludge technologies, which are more costly to construct and operate and require technical expertise, may prove suitable for large urban centers but they are not dealt with directly in this guide.

difficult if there is not sufficient space available or the cost of land is high. In addition, localized heavy rain events can cause problems for extensive treatment as it can cause 'leaching*' of the stabilization ponds (heavily diluting the concentration of pollutant-degrading microorganisms) or flood the drying areas making the treatment inefficient;

• **intensive treatment** that includes facilities whose processes require low volumes and a small footprint (Imhoff tank, anaerobic baffled reactor, anaerobic filter, UASB reactor). These facilities are relatively compact but their investment costs are fairly high.

Regardless of the treatment type selected, the treated effluent that is obtained can then be:

• **infiltrated into the soil.** This option enables treatment to continue using the purification capacities of the soil. Nonetheless, care must be taken with regards to the water source: where there is a high groundwater table, any effluent that infiltrates the soil needs to have undergone sufficient levels of treatment to ensure there is no risk of contamination;

• **utilized**, notably for agricultural irrigation or it can be fed into aquaculture ponds (in particular, for fish farming). Great care needs to be taken if using this option: in the case of partial treatment, any treated effluent that contains residual pathogenic bacteria can have a harmful effect on agricultural and aquacultural products.

STEP 2: TREATING THE SLUDGE THAT RESULTS FROM THE TREATMENT OF EFFLUENT

All treatment of liquid effluent therefore produces treated effluent, but also residual sludge that often requires secondary treatment. The additional treatment of residual sludge can be either a necessary or optional step, depending on the environmental standards in force and on the level of treatment required.

However, complete treatment – of effluent and of the sludge resulting from the treatment of this effluent – is always recommended in order to protect the environment and to satisfy public health requirements.

As for the treatment of effluent, it is possible to treat residual sludge in one of two ways:

• **extensive treatment** using a solar drying bed combined with composting or planted drying bed;

• **intensive treatment** using a biogas reactor.

Regardless of the treatment type selected, once treated the residual sludge can:

– **be disposed** of by burying it underground. This option enables further stabilization of the sludge and the elimination of any residual pathogenic bacteria;

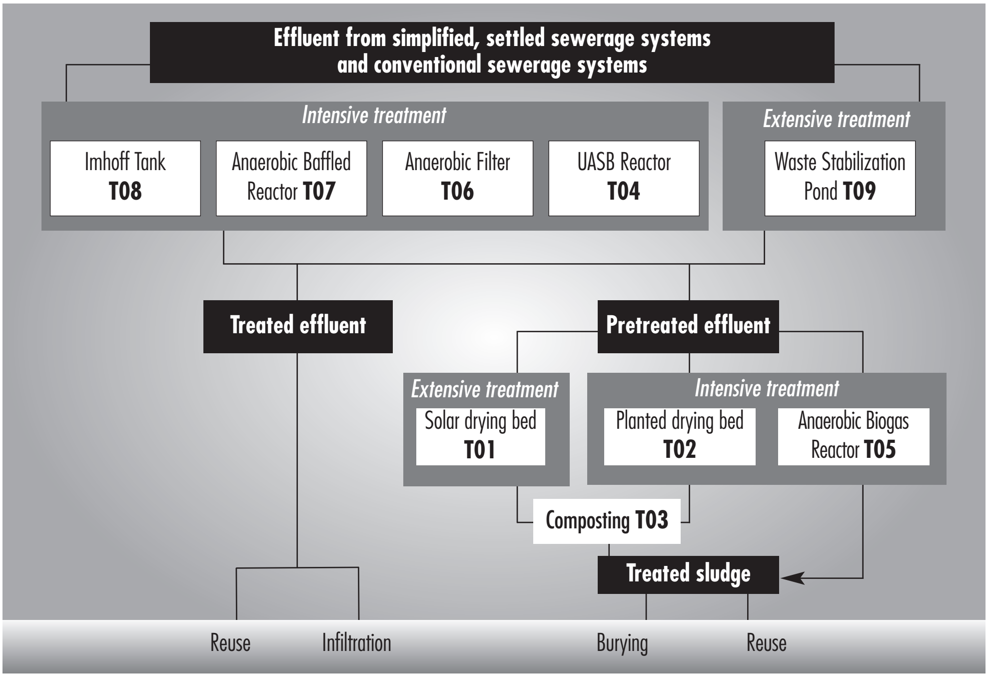
– **or be utilized**, notably as a form of soil enrichment for agricultural purposes. This option can be of interest due to the nutritional value of the treated sludge. Great care does need to be taken, however: in the case of partial treatment, the treated sludge that contains residual pathogenic bacteria can have a harmful effect on agricultural products (the risk of helminth egg contamination, in particular).

For the Disposal/Treatment segment, it is important to bear in mind that this relates to the final treatment of wastewater and excreta prior to this being discharged or reused. Depending on the technologies used in the Access segment, the effluent may have already undergone a certain level of treatment. For instance, the septic tanks and grease traps in place earlier in the chain will have already treated part of the wastewater and excreta, reducing the amount of pollutants. In some cases, it is possible for wastewater and excreta to have undergone full treatment during the Access segment, where there is a properly used double VIP toilet in place, for example. The choice of treatment technology is therefore partially dependent upon the level of any pretreatment that has already taken place in the previous segments.

This choice is also dependent upon the level of treatment that needs to have been applied to the water leaving the treatment plant (based on local and national regulations and on its subsequent use). The water discharged from the treatment plant can be utilized once it has undergone sufficient treatment. It can also be used for irrigation or for aquaculture; as these are both revenue-generating activities they can be required to take on part of the treatment plant's operating costs[14].

It is now possible to select the most appropriate treatment technology with the aid of Table 12.

FIGURE 10. The different technologies available for the Disposal/Treatment segment of conventional sewerage systems



[14] These revenue-generating activities are not able to take on all the operating costs of a treatment plant, but usually (although not always) a small part of these costs.

TABLE 12. Decision table for selecting technologies in the Disposal/Treatment segment of conventional sewerage systems or small-piped sewerage systems

Possible techniques	Electrical energy	Required surface area	Efficiency	Investment costs (€/household)	Investment costs (€/ household /year)	Design, construction and C&M
For the treatment of effluent…						
Anaerobic Filter	No	Limited	High [B]	150-400	2-4	High
Anaerobic Baffled Reactor	No	Limited	High [B]	150-400	2-4	High
Imhoff Tank	No	Limited	High [B]	150-400	2-4	High
UASB Reactor	Yes	Limited	High [B]	200-1,000	5-50	High
Planted or Unplanted Stabilization Ponds	No	Large [A]	High [B]	15-100	5-50	Low
For the treatment of pretreated sludge…						
Solar drying bed	No	Large [A]	Low [C]	20-50	2-4	Low
Planted drying bed	No	Large [A]	High [B]	25-60	2-4	High
Composting	No	Large [A]	High [B]	Average [D]	2-4 [E]	Low
Anaerobic Biogas Reactor	No	Limited	High [B]	200-600	5-10 [E]	High

A Where a large surface area is required, it is necessary to consider (i) the space available for construction, (ii) the cost of land and (iii) any risk of leaching* from the waste stabilization pond or flooding of drying beds during periods of localized heavy rain.

B High efficiency corresponds to a high level of treatment (to a 50 to 90% reduction in BOD).

C Low efficiency corresponds to a reduced level of treatment: solar drying beds are used to dry out the sludge.

D The investment cost of a composting center depends on several factors (technology, land prices, etc.).

E These technologies can be revenue-generating (compost, biogas). As this revenue is usually only marginal in comparison to operating costs (except for anaerobic biogas reactors which can provide substantial energy savings), it has not been taken into account here.

◎ You have now selected the relevant technology (or technologies) for the whole conventional sewerage system sanitation chain of the area studied. This choice should now be noted in the table in Annex 2. You can now move on to study the sanitation chain for a different area.

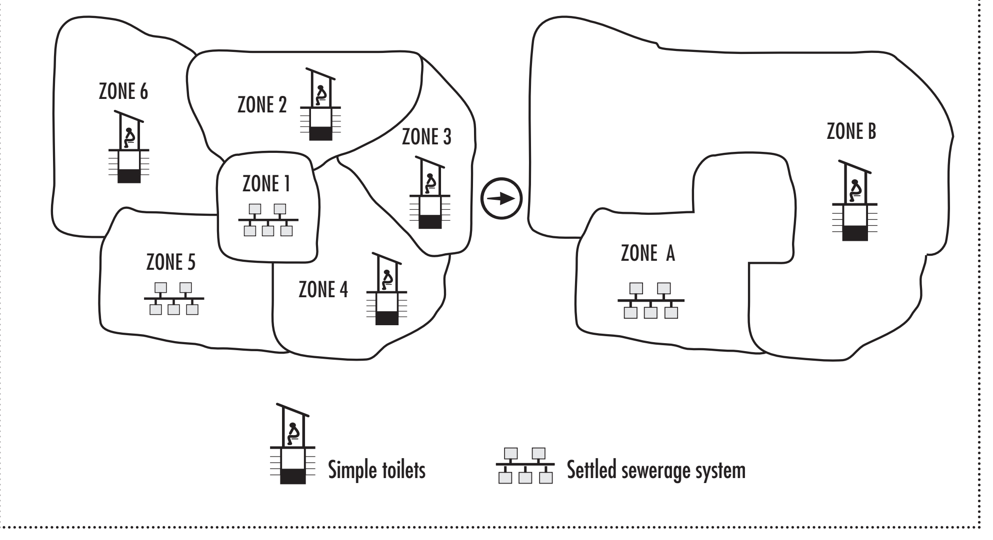
Summary of technological choices

By the end of the process, chain by chain, segment by segment, the choices you have made should be summarized in the table in Annex 2. It is possible to confirm each of these choices using the additional information provided in the technical factsheets in Part 2.

Coherence in technological choices at town level

As mentioned at the beginning of the planning process (Step 1), it is useful at this point to gain some perspective on the choices made for the different individual areas by looking at the town as a whole. This will ensure there is overall coherence in terms of the sanitation technologies selected. In order to do this, it is possible to work from a town map or to create a schematic diagram, as shown in Figure 11.

FIGURE 11. Coherence in the sanitation technologies selected within a town



Ensuring that there is coherence at town level essentially consists of reviewing and validating the choices made within each area, particularly where the technology selected impacts on an area wider than that in which it is located. This therefore mainly concerns the Evacuation and Disposal/Treatment segments and consists of identifying if it is possible to merge (or consolidate) areas using similar sanitation solutions (even if the initial characterization of these areas produced different results). This makes it possible to go beyond the boundaries of one particular area to offer the same technology to the inhabitants of neighboring areas (which can lead to economies of scale), for instance.

In Figure 11, for example, the appropriate solution for both zone 1 and its neighboring zone, 5, is the construction of a settled sewerage system. As such, it would be useful to consolidate these two areas and build a settled sewerage system that covers both neighborhoods. This example highlights why it is useful to validate the technical solutions of the Evacuation segment at town level. Coherence between neighborhoods is even more important for the Disposal/Treatment segment. It is not possible to equip each area with its own wastewater and excreta treatment plant. It is usually more appropriate to construct a limited number of treatment plants in carefully considered locations[15] (please see the box pertaining to the location of treatment sites on page 40) to treat the wastewater and excreta from several areas for which similar treatment systems have been identified.

It is therefore necessary to conduct a review of the Evacuation and Disposal/Treatment segments to produce a complete sanitation service at town level that is based on the whole chain, 'access – evacuation – treatment'. When undertaking this task, it is also important to consider urban development and population growth, as covered during Step 1. The development of the town and its inhabitants (standard of living, level of comfort/user-friendliness required) will have a particular impact on the sizing and location of facilities, as well as on the future upgrading of those sanitation systems selected (from on-site sanitation in the short-term to conventional or small-piped sewerage systems in the longer term). As part of this technology upgrading process, it is possible to find sewerage systems and on-site sanitation temporarily coexisting in the same area (in a neighborhood where households are initially equipped with on-site sanitation facilities and are then progressively connected to a newly installed sewerage system, for example).

◎ Upon completion of this planning process for selecting sanitation technologies, you will have made the relevant choice as to the appropriate technologies to be put in place and where these are to be located, both within the different areas and within the town as a whole.

15 Consolidating a town's wastewater treatment into one site will reduce the cost of treatment (through economies of scale). Nevertheless, there are decentralized wastewater treatment solutions available that can reduce the distance required for evacuation of the wastewater (and thereby the cost of the sewerage system or emptying services). These involve placing small plants in different areas of the town.

Realizing the selected sanitation technologies

For the actual implementation of technical solutions, you can refer to the specialized technical publications provided in the bibliographies of the technical factsheets. From these you can establish (or have a specialist establish, if they are highly technical) plans and estimated costs for designing and constructing the sanitation facilities.

! Reminder: when designing these technical solutions, it is important to consider the management systems that will be put in place to operate these facilities in the long-term. Putting in place an infrastructure or a sanitation service does not solely involve looking at the technological aspects. It is also important to consider the financial aspects[16]; the management of the service or the infrastructure[17]; how the stakeholders are organized[18]; communication and awareness-raising. You will have been made aware of these different aspects when reading this guide. We would also encourage you to consult other specialized publications that deal with these issues.

Figure 12, on pages 58 and 59, provides a synthesis of the different technological solutions available for on-site sanitation, small-piped and conventional sewerage systems. The information in bold after each technology – **A04** or **T07** – refers to the number of the relevant factsheet, which can be found in Part 2 of this guide.

16 For further information on these aspects, please see pS-Eau's guide: How to finance sanitation in sub-Saharan Africa.

17 For further understanding of the knowledge and skills required to manage a sanitation service, please see the CMS program's 'Professional and competency framework for water supply and sanitation'.

18 To learn more about managing the consultation process for (improving) water supply and sanitation services, please refer to the CMS program's methodological guide n°1 'How to develop a concerted municipal strategy for water and sanitation in large towns in Africa'.

FIGURE 12. Synthesis of the different technological solutions available for on-site sanitation, small-piped and conventional sewerage systems

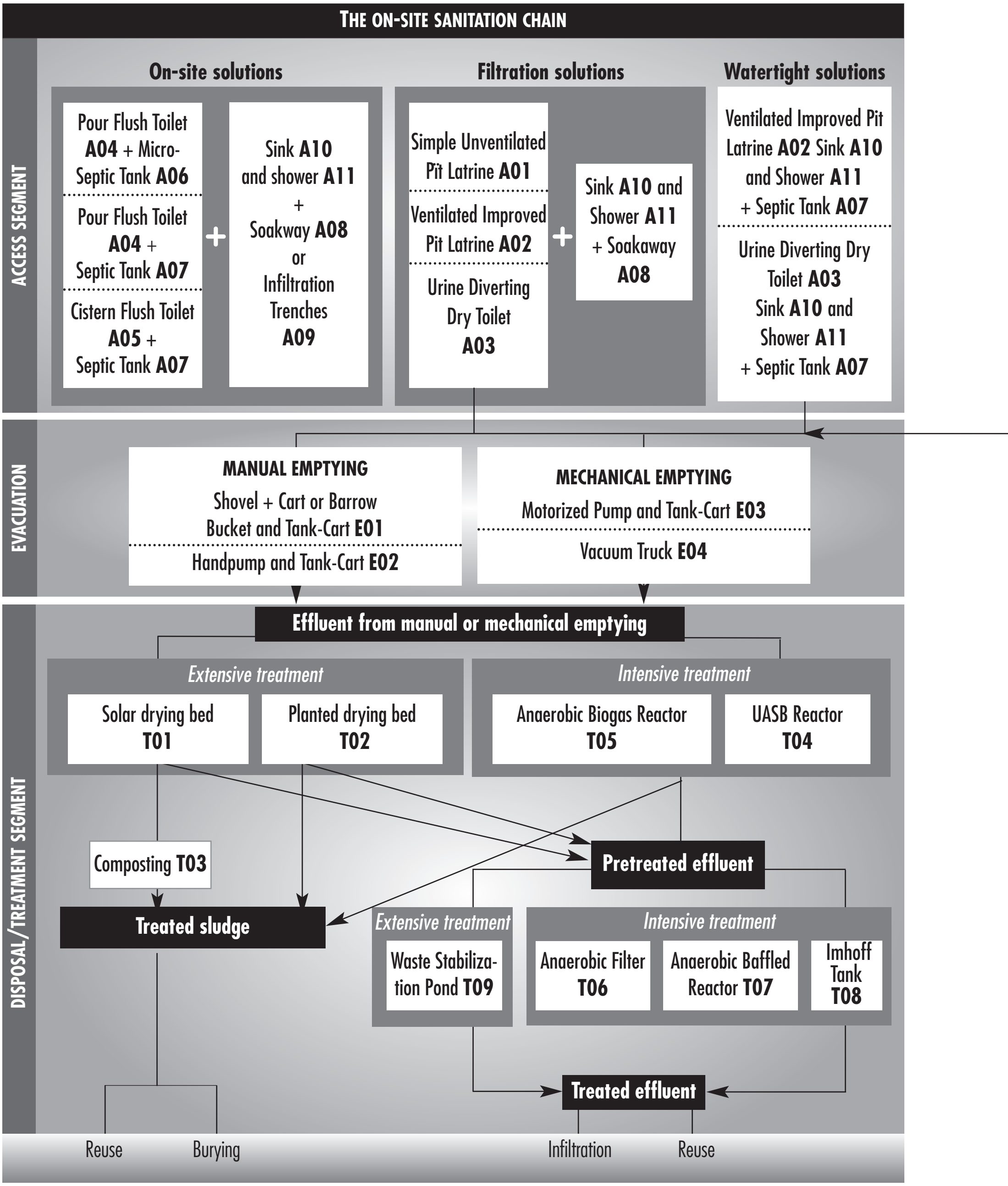
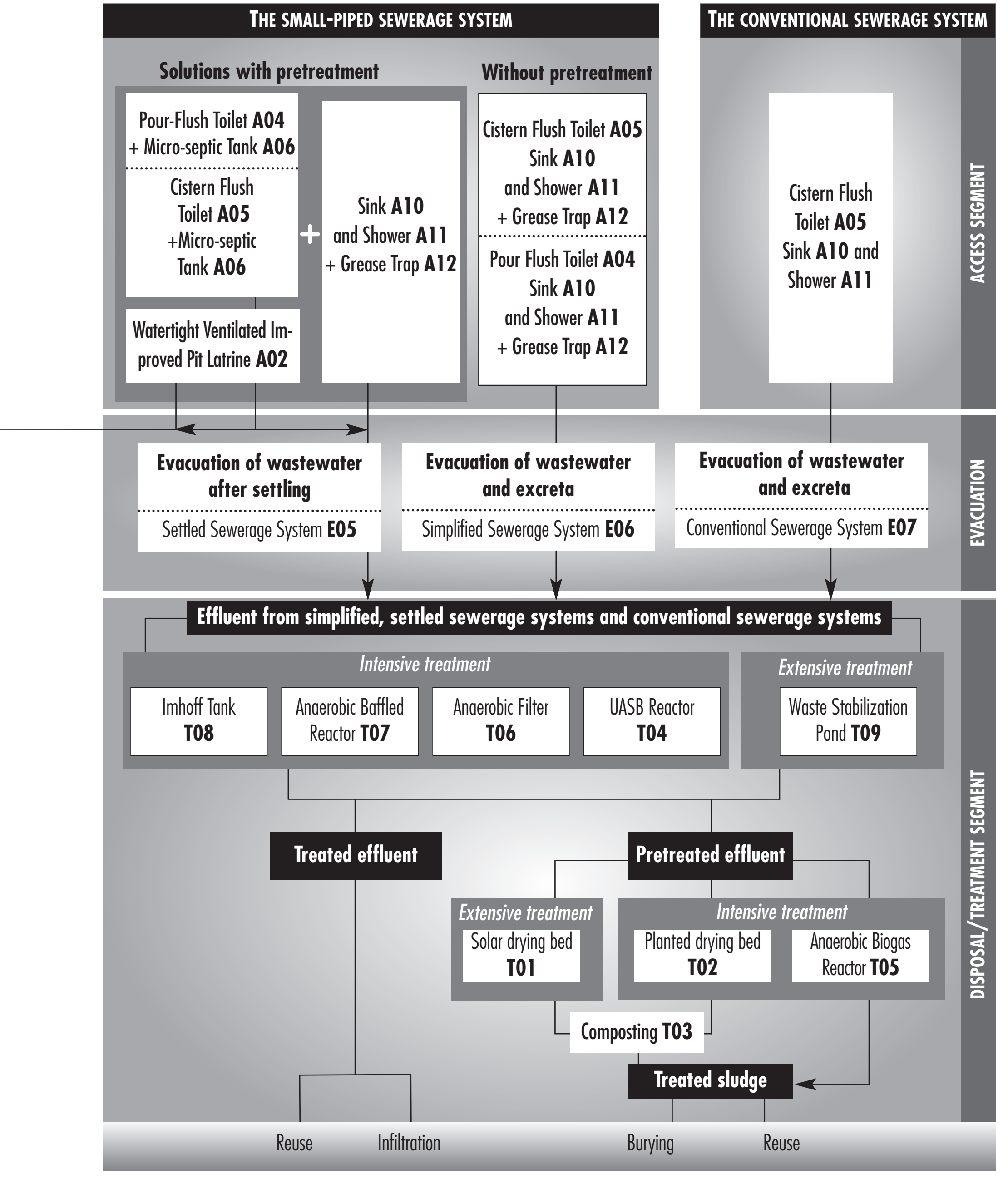


FIGURE 12.


THE SMALL-PIPED SEWERAGE SYSTEM
THE CONVENTIONAL SEWERAGE SYSTEM
Solutions with pretreatment
Without pretreatment
Pour-Flush Toilet A04 + Micro-septic Tank A06
Cistern Flush Toilet A05 +Micro-septic Tank A06
+
Sink A10 and Shower A11 + Grease Trap A12
Watertight Ventilated Improved Pit Latrine A02
Cistern Flush Toilet A05 Sink A10 and Shower A11 + Grease Trap A12
Pour Flush Toilet A04 Sink A10 and Shower A11 + Grease Trap A12
Cistern Flush Toilet A05 Sink A10 and Shower A11
ACCESS SEGMENT
Evacuation of wastewater after settling
Settled Sewerage System E05
Evacuation of wastewater and excreta
Simplified Sewerage System E06
Evacuation of wastewater and excreta
Conventional Sewerage System E07
EVACUATION
Effluent from simplified, settled sewerage systems and conventional sewerage systems
Intensive treatment
Imhoff Tank T08
Anaerobic Baffled Reactor T07
Anaerobic Filter T06
UASB Reactor T04
Extensive treatment
Waste Stabilization Pond T09
Treated effluent
Pretreated effluent
Extensive treatment
Solar drying bed T01
Intensive treatment
Planted drying bed T02
Anaerobic Biogas Reactor T05
Composting T03
Treated sludge
Reuse
Infiltration
Burying
Reuse
DISPOSAL/TREATMENT SEGMENT

PART 2

Technical Factsheets

What is a technical factsheet?

This second part of the guide provides details of all the technical solutions used for sanitation that are mentioned in this publication. There is a technical factsheet that corresponds to each technical solution. The technical factsheets are grouped according to the three segments of the sanitation chain: **Access (A), Evacuation (E)** and **Treatment (T)**.

For each segment there is an introduction page that provides a reminder of the main characteristics and objectives of the segment concerned. It also lists the different technical solutions for which there is a factsheet.

! The factsheets are indexed with a letter to identify the segment to which it belongs (A, E or T) and a number.

Each technical factsheet is broken down into 7 parts:

- **the prerequisites** required for putting the technology in place;
- **the general characteristics** that refer back to the feasibility criteria (lifespan, efficiency, investment costs, operating costs, skills required for the design, skills required for operation), accompanied by a brief description of the advantages, disadvantages and limitations of the technology;
- the main issues relating **to design and construction**;
- **care and maintenance** requirements;
- **variations and upgrades** (where appropriate);
- **further information**. For some particularly relevant technical facilities, this paragraph gives precise bibliographical references (page numbers) to: additional technical descriptions of the facilities, the design and sizing of facilities and maintenance of facilities.

Access to sanitation segment

What is it?

Access to sanitation is the first segment in the sanitation chain. Access corresponds to the interface between users and wastewater. It makes it possible to collect greywater and excreta with reduced human contact and thus contributes to reducing the health risks for users. Access technologies are often made up of several components, such as a toilet plus pit, for example.

Several technological components sometimes have to be combined in order to ensure improved access to sanitation. Notably, to ensure effective management of blackwater and greywater, a toilet of whatever type needs to be combined with a shower and sink.

What are the objectives of this segment?

The objectives of the access to sanitation segment are:

- to minimize contact between humans and wastewater and excreta;
- to ensure people live in hygienic conditions;
- to minimize the transmission of pathogenic bacteria.

List of technical factsheets for the access to sanitation segment

Chain	Technologies	
On-site sanitation	**On-site solutions**	• Pour-flush toilet (A04) + micro-septic tank (A06) + sink (A10) and shower (A11) + soakaway (A08) or infiltration trenches (A09) • Pour-flush toilet (A04) + septic tank (A07) + sink (A10) and shower (A11) soakaway (A08) or infiltration trenches (A09) • Cistern flush toilet (A05) + septic tank (A07) + sink (A10) and shower (A11) soakaway (A08) or infiltration trenches (A09)
	Filtration solutions	• Simple pit latrine (A01) + sink (A10) and shower (A11) + soakaway (A08) • Non-watertight VIP latrine (A02) + sink (A10) and shower (A11) + soakaway (A08) • Urine diverting dry toilet (A03) + sink (A10) and shower (A11) + soakaway (A08)
	Watertight solutions	• Watertight VIP latrine (A02) + sink (A10) and shower (A11) + septic tank (A07) • Urine diverting dry toilet (A03) + sink (A10) and shower (A11) + septic tank (A07) • Shared toilet block (A13)
Small-piped sewerage system	**Solutions with pretreatment**	• Pour-flush toilet (A04) + micro-septic tank (A06) + sink (A10) and shower (A11) • Cistern flush toilet (A05) + micro-septic tank (A06) + sink (A10) and shower (A11) • Watertight VIP toilet (A02) + sink (A10) and shower (A11) + grease trap (A12)
	Solutions without pretreatment	• Cistern flush toilet (A05) + sink (A10) and shower (A11) + grease trap (A12) • Pour-flush toilet (A04) + sink (A10) and shower (A11) + grease trap (A12)
Conventional sewerage system		• Cistern flush toilet (A05) + sink (A10) and shower (A11)

Simple Unventilated Pit Latrine

A simple pit toilet is the simplest type of latrine technology. It enables the collection of excreta but has the disadvantage of giving off smells and attracting flies.

A simple toilet is used to collect excreta, not greywater. It is therefore recommended that a soakaway (see factsheet A08) is constructed as a complement to the simple latrine to dispose of the greywater.

A simple toilet needs to be emptied regularly and the sludge that is extracted needs to be treated.

PREREQUISITES

YES	NO	
☐	☐	The groundwater table is at a suitable depth (> 3 m from the bottom of the planned pit).
☐	☐	There is a non-rocky layer several meters deep and water is able to infiltrate the soil.
☐	☐	The nearest water source is over 30 meters away.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	5-10 years
Efficiency	Low (smells and flies present)
Investment costs	40-100 euro for a simple pit toilet
Operating costs	5-15 euro/year for maintenance and regular emptying of a dry toilet
Design	Low-level skills (can be constructed by a local craftsman)
Operation	Low-level skills (for maintenance and pit emptying)

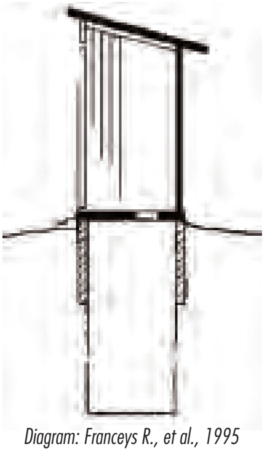


Diagram: Franceys R., et al., 1995

Photo: Julien Gabert

Design and construction

A simple unventilated pit toilet consists of a pit for the collection of excreta covered by a defecation slab (e.g. SANPLAT).

The main design criterion is the pit volume, which should be in proportion to the number of people using the latrine in order to reduce the emptying frequency. The construction of a simple pit toilet does not require high level skills, but it is necessary to provide the mason with training to ensure that the infrastructure is constructed in line with best practice (fabricating the defecation slab, sizing and constructing the pit).

Care and maintenance

• *Main operating activities:* Regular cleaning of the latrine by the users, emptying once the pit is almost full (when the level of excreta is 50cm below the defecation hole).

• *Main equipment and human resources required:* The latrine should be cleaned with disinfectant, emptying should preferably be carried out by a professional.

ADVANTAGES

- Can be constructed and repaired locally.
- Low investment and operating costs.
- Not necessary to have a constant source of water.

DISADVANTAGES

- Presence of flies and smells.
- Not very user-friendly.
- Requires regular transportation of effluent to a centralized treatment area.

LIMITATIONS

- Large quantities of water should not be poured down the toilet (from the shower, etc.). Water can, however, be used for anal cleansing.
- The latrine should not be located in an area prone to flooding as the pit is liable to overflow, rendering it temporarily unusable.

FURTHER INFORMATION

Ref. 1: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO (technical description: pp.48-54 and 61-62; design and sizing: pp.136-139).

Ref. 2: Pickford John, 1995, *Low-cost sanitation, A survey of practical experience.*

Ref. 3: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies*, EAWAG (technical description: pp.53-54).

Ref. 4: Diop O., 2008, *Catalogue des dispositifs d'assainissement autonome*, GRET, p.56.

Ventilated Improved Pit Latrine (VIP)

The VIP latrine is more user-friendly than a simple toilet: the ventilation pipe serves to reduce the presence of flies and smells.

A VIP toilet is used to collect excreta, not greywater. It is therefore recommended that a soakaway (see factsheet A08) is constructed as a complement to the VIP latrine to dispose of the greywater. The VIP toilet can be watertight (if the groundwater table is high) or enable filtration into the soil (where there is a low water table and permeable soil).

A VIP toilet needs to be emptied regularly and the sludge that is extracted needs to be treated.

PREREQUISITES

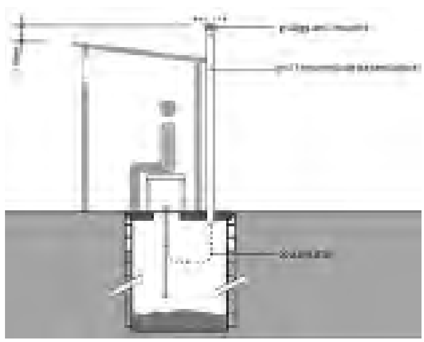
YES	NO	
☐	☐	The buildings around the latrine are not very high.
☐	☐	There is a low groundwater table.
☐	☐	There is a non-rocky layer several meters deep and water is able to infiltrate the soil.
☐	☐	The nearest water source is over 30 meters away.

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (no smells or flies)
Investment costs	100-300 euro for a simple VIP toilet
Operating costs	5-15 euro/year for the maintenance and regular emptying of a single VIP latrine
Design	Low-level skills (can be constructed by a local craftsman)
Operation	Low-level skills (for maintenance and pit emptying)

Photo: GRET Méddea



Single VIP latrine (diagram: Tilley E., et al., 2008)

Design and construction

A single VIP toilet consists of a pit for the collection of excreta covered by a defecation slab (e.g. SANPLAT) and equipped with a ventilation pipe that reaches 30cm above the toilet superstructure. There is a screen at the top of this ventilation pipe to prevent flies entering the pit.
The main design criterion is the pit volume, which should be in proportion to the number of people using the latrine in order to reduce the emptying frequency. The construction of a VIP toilet does not require high level skills, but it is necessary to provide the mason with training to ensure that the infrastructure is constructed in line with best practice (fabricating the defecation slab, sizing and constructing the pit).

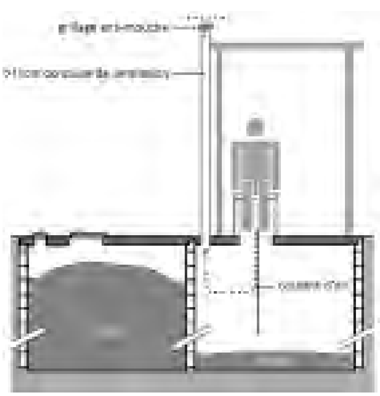
Care and maintenance

• *Main operating activities:* regular cleaning of the latrine by the users, emptying once the pit is almost full (when the level of excreta is 50cm below the defecation hole).

• *Main equipment and human resources required:* the latrine should be cleaned with disinfectant, emptying should preferably be carried out by a professional.

Variations and upgrades

A single VIP latrine can be upgraded by adding an extra pit. The two pits are used alternately: when the second pit is in use, the sludge contained in the first pit (which is full) dries out and, after a few months, can be emptied manually without risk.



Double VIP latrine (diagram: Tilley E., & al., 2008)

ADVANTAGES

- Can be constructed and repaired locally.
- Low investment and operating costs.
- Reduction of flies and smells.
- Not necessary to have a constant source of water.

DISADVANTAGES

- Requires regular pit emptying.
- Requires sludge treatment.

LIMITATIONS

- The latrine should not be located in an area prone to flooding as the pit is liable to overflow, rendering it temporarily unusable.

FURTHER INFORMATION

Ref. 1: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO (technical description: pp.48-54 and 123-130; design and sizing: pp.136-139).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies*, EAWAG (technical description: pp.53-54).

Ref. 3: Diop O., 2008, *Catalogue des dispositifs d'assainissement autonome*, GRET.

Urine Diverting Dry Toilet (UDDT)

A urine diverting dry toilet separates the urine and feces meaning that these two products can be more easily used in agriculture. These toilets are generally constructed with two pits for storing feces: once the first pit is full, the feces is able to dry out in the time it takes to fill the second pit, thereby rendering manual emptying easier.

A urine diverting dry toilet is used to collect excreta, not greywater. It is therefore recommended that a soakaway (see factsheet A08) is constructed at the same time as the UDDT to dispose of the greywater.

A urine diverting dry toilet needs to be emptied regularly. Where the toilet is equipped with two drying pits, the sludge extracted is sanitized and requires no further treatment.

PREREQUISITES

There are no particular prerequisites required for the area of intervention.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (no smells or flies; treatment of excreta)
Investment costs	200-400 euro for a urine diverting dry toilet
Operating costs	5-15 euro/year for the maintenance and regular emptying of a UDDT
Design	High-level skills (training required for its construction)
Operation	Low-level skills (for maintenance and emptying)

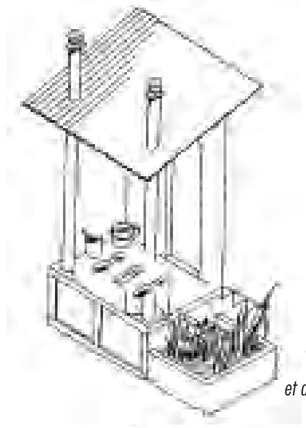
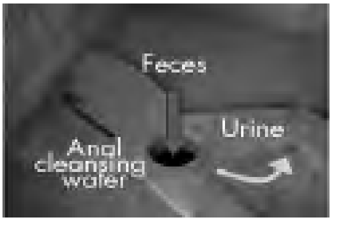


Diagram: Esrey S. et al., 1998



Photos:PPT CREPA presentations, 2008

Design and construction

• A urine diverting dry toilet consists of two chambers for the collection of feces covered by a defecation slab. Each chamber has a ventilation pipe and a metal door to facilitate emptying. The slab above each chamber contains a defecation hole that separates the urine; the hole for the urine is connected to a pipe that drains into the urine collection area.

• *The main design criterion* is the pit volume, which should be in proportion to the number of people using the latrine in order to reduce the emptying frequency and to ensure sufficient drying time for the feces in the unused pit. In addition, medium to high level skills are required for the construction of a UDDT, with prior training given to the mason to ensure the infrastructure is built in line with best practice.

Care and maintenance

• *Main operating activities:* cleaning and maintenance of the latrine by users, regular manual emptying by the users (of the urine collection areas and of the dry sludge in the unused pit chamber).

• *Main equipment and human resources required:* the latrine must be cleaned with disinfectant; a shovel and bucket are required for pit emptying.

FURTHER INFORMATION

Ref. 1: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies*, EAWAG (technical description: pp.63-64).

Ref. 2: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO (technical description: pp.79-82; design and sizing: pp.143-145).

Ref. 3: Esrey S., et al., 1998, *Assainissement écologique*, Sida.

Ref. 4: WSP, 2005, *A review of EcoSan experience in Eastern and Southern Africa*, Water and Sanitation Program Africa.

ADVANTAGES

- Can be constructed and repaired locally.
- Low operating costs.
- Not necessary to have a constant source of water.
- The sludge extracted from the pit is sanitized.
- No flies or smells.

DISADVANTAGES

- Medium to high investment costs.
- Manual removal of urine and feces must be carried out regularly.
- Not easy to use (particularly for children) and can be culturally difficult to accept.

LIMITATIONS

- This is a dry toilet technology. The feces storage area must not be used for liquids, not even urine. Users need to be made aware of how to use this technology for it to be accepted. Where water is used for anal cleansing, there needs to be some way of collecting this water; this can then be used nearby for watering plants.
- These urine diverting dry toilets require regular manual emptying by the users which involves handling urine and feces (sanitized). This needs acceptance by users, who should be trained to undertake this maintenance task.
- The latrine should be located near to crop fields or gardens so that the sanitized urine and feces can be used in agriculture.

Pour Flush Toilet

A pour flush toilet provides improved user-friendliness as there is a water seal to prevent flies and smells.

A pour flush toilet needs to be connected to:

- either a pit (ventilated pit, septic tank) that requires regular emptying and additional sludge treatment;
- or a sewerage system, via a junction chamber that needs regular cleaning out.

PREREQUISITES

YES	NO	
☐	☐	There is a low groundwater table (for a non-watertight pit).
☐	☐	There is a non-rocky layer several meters deep.
☐	☐	The nearest water source is over 30 meters away (for a non-watertight pit).
☐	☐	There is enough water available (2.5L is required per flush, equating to typical water consumption of at least 30L/person/day).

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (no smells or flies)
Investment costs	50-100 euro for a pour flush toilet
Operating costs	5-10 euro/year for the maintenance of a pour flush toilet
Design	Low-level skills (can be constructed by a local craftsman)
Operation	Low-level skills (for maintenance and emptying)

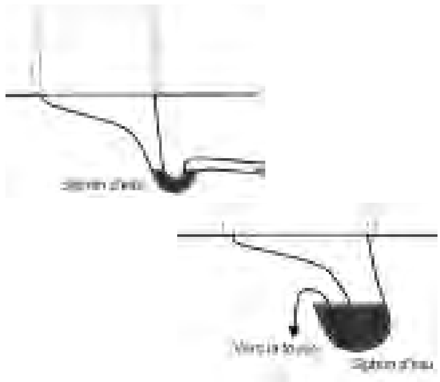


Diagram: from Parry-Jones S., 2005

Photo: Gret PacepaS

Design and construction

• A pour flush toilet consists of a defecation slab or squatting pan with a water seal. The pour flush toilet can be connected to a simple pit (A01), a ventilated pit (A02), a micro-septic tank (A06), septic tank (A07) or to a sewerage system (E05, E06, E07).

• The main design criterion is the pit volume (where appropriate), which should be in proportion to the number of people using the toilet in order to reduce the emptying frequency. High level skills are not required for the construction of a pour flush toilet, but the mason should receive prior training in order to ensure the infrastructure is built in line with best practice (fabrication of the defecation slab, sizing and construction of the pit).

Care and maintenance

• *Main operating activities:* cleaning and maintenance of the toilet by the users, regular pit emptying.

• *Main equipment and human resources required:* the toilet must be cleaned with disinfectant; pit emptying should preferably be carried out by a professional.

Variations and upgrades

The pour flush toilet can be upgraded by adding a junction chamber under the defecation slab to direct blackwater into the pit. This means the pit can be built next to the slab instead of underneath, so the slab doesn't have to be removed each time the pit is emptied (see the Gret PacepaC photo on the previous page, bottom right, with a partially buried pit).

Photo: Gret PacepaS

ADVANTAGES

• Can be constructed and repaired locally.
• Low investment costs.
• No flies or smells.

DISADVANTAGES

• Requires a constant source of water.
• Requires regular emptying if connected to a pit.
• High investment and operating costs for a watertight pit.
• Sludge requires secondary treatment.
• Health risks due to the presence of unsanitized sludge

LIMITATIONS

• This technology is not designed for greywater: large quantities of water should not be poured down the toilet (from the shower, etc.). Only water used for flushing and anal cleansing (where appropriate) should be poured down the toilet.

• The toilet should not be located in an area prone to flooding as the pit is liable to overflow, rendering it temporarily unusable.

FURTHER INFORMATION

Ref. 1: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO (technical description: pp.54-61).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies*, EAWAG, (technical description: pp.43-44 and 61-62).

Cistern Flush Toilet

The cistern flush toilet provides improved user-friendliness through use of a water seal that eliminates flies and smells. The flush water comes from tank (cistern) and so requires a constant source of water. It is more convenient to use than a pour flush toilet as it is not necessary to fill a bucket with water for flushing, but simply to pull the chain or lever.
A cistern flush toilet should be connected to:
- either a pit (ventilated pit, septic tank) that requires regular emptying and treatment of the extracted sludge;
- or to a sewerage system, via junction chamber that requires regular cleaning out.

PREREQUISITES

YES	NO	
☐	☐	There is a low groundwater table (for a non-watertight pit).
☐	☐	There is a non-rocky layer several meters deep.
☐	☐	The nearest water source is over 30 meters away (for a non-watertight pit).
☐	☐	There is a constant supply of water to the toilets.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (no smells or flies)
Investment costs	100-200 euro for a cistern flush toilet
Operating costs	5-10 euro/year for the maintenance and regular emptying
Design	High-level skills (a knowledge of plumbing is required to install the cistern)
Operation	Low-level skills (for maintenance and emptying)

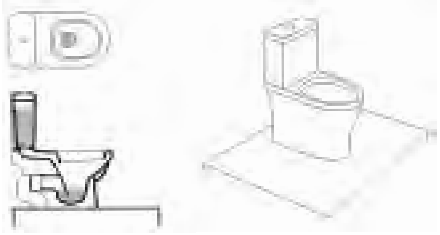


Diagram: Tilley E., et al., 2008

Design and construction

• A cistern flush toilet consists of a squatting pan or seat, with a water seal and with a water tank above it. The cistern flush toilet can be connected to a micro-septic tank (A06), septic tank (A07) or a sewerage system (E05, E06, E07).

• The main design criterion is the pit volume (where appropriate), which should be in proportion to the number of people using the toilet in order to reduce the emptying frequency. The construction of a cistern flush toilet requires medium to high level skills combined with knowledge of plumbing and masonry.

Care and maintenance

• *Main operating activities:* cleaning and maintenance of the toilet by the users, regular emptying of the pit or junction chamber.

• *Main equipment and human resources required:* the toilet must be cleaned with disinfectant; pit emptying should be carried out by a professional.

Photo: Gret Méddea, 2010

ADVANTAGES

• Can be constructed and repaired locally.
• Very user-friendly.
• No flies or smells.

DISADVANTAGES

• Requires a constant source of water.
• Requires regular emptying if connected to a pit.
• High investment and operating costs for a watertight pit.
• Sludge requires secondary treatment.
• Health risks due to the presence of unsanitized sludge.

LIMITATIONS

• This technology is not designed for greywater: large quantities of water should not be poured down the toilet (from the shower, etc.). Only water used for flushing and anal cleansing (where appropriate) should be poured down the toilet.
• The toilet should not be located in an area prone to flooding as the pit is liable to overflow, rendering it temporarily unusable.

FURTHER INFORMATION

Ref. 1: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO, (technical description: pp.54-61).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologiesEAWAG* (technical description: pp.45-46).

Micro-Septic Tank

Septic tanks store and pretreat wastewater through settling and anaerobic processes. A septic tank consists of at least two chambers. A micro-septic tank is designed for blackwater only and has a minimal investment cost.

The septic tank provides partial treatment: a large amount of pathogens remain. The effluent that is removed therefore needs to undergo further treatment (usually through infiltration or in a centralized treatment plant). A micro-septic tank needs to be emptied once every one to two years to remove the accumulated thick sludge. This sludge is then transported to a treatment site (e.g. solar or planted drying bed). The emptying frequency can be reduced by increasing the size of the tank (by adding chambers).

PREREQUISITES

YES	NO	
☐	☐	There is a system in place for the subsequent treatment or evacuation of effluent from the septic tank (soakaway or infiltration trenches, sewerage system).
☐	☐	There is sufficient water available (water consumption of at least 30L/person/day).
☐	☐	There is a pit emptying service available locally (or such a service can be set up).

! If you answered ‘no’ to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (no flies or smells; partial treatment of blackwater)
Investment costs	100-400 euro for a micro-septic tank
Operating costs	5-15 euro/year for the maintenance and regular emptying of a micro-septic tank
Design	High-level skills (for the design, sizing and construction)
Operation	Low-level skills (for maintenance and emptying)

Design and construction

- A micro-septic tank consists of (1) T-shaped inlet pipe carrying the blackwater into the tank, (2) a first chamber: the sludge settles at the bottom and grease and oils form a scum on the surface, (3) a ventilation pipe in the first chamber to eliminate gases created by anaerobic bacteria, (4) a wall or baffle between the 2 chambers with an opening half-way up (or a T-shaped pipe), (5) a second chamber into which any solids remaining in the liquid can settle out, (6) a T-shaped outlet pipe leading to an infiltration or sewerage system.
- The main design criterion is the sizing of the tank and different chambers, which should be proportional to the volumes of blackwater discharged in order to ensure optimal treatment. The construction of a septic tank requires high-level skills and knowledge.

Care and maintenance

• *Main operating activities:* filling the micro-septic tank with water before using for the first time and after each time it is emptied; emptying once the first chamber is between half and two-thirds full of solid sludge.

• *Main equipment and human resources required:* emptying should preferably be carried out by a professional.

Variations and upgrades

The micro-septic tank should be connected to a subsequent treatment system. In ascending order of treatment efficiency (and cost), the tank can be connected to: a soakaway (A06), infiltration trenches (A09) or to a sewerage system (E05, E06, E07) that leads to a treatment plant.

Diagram: Gret PacepaC

ADVANTAGES

- Can be constructed and repaired locally.
- Low investment and operating costs.
- No flies or smells.
- Ensures partial treatment of blackwater.
- Very user-friendly.

DISADVANTAGES

- Requires constant source of water.
- Requires frequent emptying.
- Effluent and sludge require secondary treatment.
- Risk of pollution of the groundwater table.

LIMITATIONS

- This technology should not be located in an area prone to flooding as the micro-septic tank is liable to overflow, rendering it temporarily unusable.

FURTHER INFORMATION

Ref. 1: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO (technical description: pp.63-73; design and sizing: pp.139-142).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies*, EAWAG (technical description: pp.67-68).

Ref. 3: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.69-72; design and sizing: pp.127-129).

Septic Tank

Septic tanks are designed to collect both blackwater and greywater. They store and pretreat wastewater (excreta and greywater) using settling and anaerobic processes*.
The septic tank provides partial treatment: a large amount of pathogens remain. The effluent that is removed therefore needs to undergo further treatment (usually through infiltration or in a centralized treatment plant). A septic tank should be emptied every two to five years to remove the accumulated thick sludge. This sludge then has to be transported to a treatment site (e.g. solar or planted drying bed).

PREREQUISITES

YES	NO	
☐	☐	There is a system in place for the subsequent treatment or evacuation of effluent from the septic tank (soakaway or infiltration trenches, sewerage system).
☐	☐	There is sufficient water available (water consumption of at least 30L/person/day).
☐	☐	There is a pit emptying service available locally (or such a service can be set up).
☐	☐	There is sufficient space available for the construction of a septic tank (minimum of $5m^2$).

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (no flies or smells; partial treatment of wastewater and excreta)
Investment costs	500-800 euro for a septic tank
Operating costs	5-10 euro/year for the maintenance and regular emptying of a septic tank
Design	High-level skills (for the design, sizing and construction)
Operation	Low level skills (for maintenance and emptying)

Design and construction

- A septic tank consists of (1) a pipe that carries wastewater into the pit, (2) a first chamber (2/3 of the total volume): the sludge settles at the bottom and grease and oils form a scum on the surface, (3) a ventilation pipe in the first chamber to eliminate gases created by anaerobic bacteria, (4) a baffle to separate the 2 chambers with an opening half-way up, (5) a second chamber into which any solids remaining in the liquid can settle out, (6) an outlet pipe leading to an infiltration or sewerage system.
- The main design criterion is the sizing of the tank and the different chambers, which should be proportional to the volumes of wastewater discharged in order to ensure optimal treatment. The construction of a septic tank requires high-level skills and specific design knowledge.

Care and maintenance

• *Main operating activities:* filling the septic tank with water before using for the first time and after each time it is emptied; emptying once the first chamber is between half and two-thirds full of solid sludge.

• *Main equipment and human resources required:* emptying should preferably be carried out by a professional.

Variations and upgrades

The septic tank should be connected to a subsequent treatment system. In ascending order of treatment efficiency (and cost), the tank can be connected to a soakaway (A08), infiltration trenches (A09) or to a sewerage system (E05, E06, E07) that leads to a treatment plant.

ADVANTAGES

• Can be constructed and repaired locally.
• Low operating costs.
• No flies or smells.
• Ensures partial treatment of wastewater and excreta.
• Very user-friendly.

DISADVANTAGES

• Requires a constant source of water.
• Requires regular emptying.
• High investment costs.
• Effluent and sludge require secondary treatment.

LIMITATIONS

• This technology should not be located in an area prone to flooding as the septic tank is liable to overflow, rendering it temporarily unusable.

FURTHER INFORMATION

Ref. 1: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO (technical description: pp.63-73; design and sizing: pp.139-142).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies*, EAWAG (technical description: pp.67-68).

Ref. 3: Morel A., Diener S., 2006, *Greywater management in low and middle-income countries*, EAWAG (technical description: pp.24-26).

Ref. 4: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.69-72; design and sizing: pp.127-129).

Ref. 5: Diop O., 2008, *Catalogue des dispositifs d'assainissement autonome*, GRET.

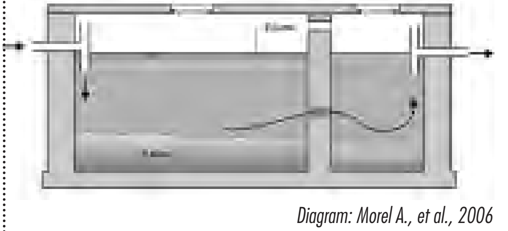


Diagram: Morel A., et al., 2006

Soakaway

A soakaway is a simple and inexpensive technology used for the collection of greywater and its infiltration into the soil. The soakaway thus prevents wastewater from running through yards and in the streets.

It is recommended to always construct a soakaway with facilities that only handle excreta (simple toilets, VIP, UDDT).

PREREQUISITES

YES NO

- ☐ ☐ There is a low groundwater table.
- ☐ ☐ There is a non-rocky layer several meters deep and water can infiltrate the soil.
- ☐ ☐ The nearest underground water source is over 30 meters away.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	Low (no treatment)
Investment costs	30-60 euro for a soakaway
Operating costs	5-10 euro/year for the maintenance of a soakaway
Design	Low-level skills (can be constructed by a local craftsman)
Operation	Low-level skills (for maintenance and emptying)

Diagram: Kopitopoulos D., 2005

Design and construction

• A soakaway consists of a pit in which the greywater is collected and from which this greywater can be directly discharged. The soakaway can also be directly connected to a shower, sink or septic tank (via a pipe).

• The main design criterion is the volume of the pit, which should be in proportion to the number of people using the soakaway and based on local water consumption levels to ensure efficient infiltration. The construction of a soakaway does not require high-level skills.

Care and maintenance

• *Main operating activities:* regular upkeep of the soakaway by users or a professional emptier to remove the build up of discharge that can clog the soakaway and restrict infiltration.

• *Main equipment and human resources required:* there is no specific equipment required.

Variations and upgrades

A soakaway can be used to receive greywater from a sink (A10) for the water used in cooking and for washing up, and from a shower (A11) for water used for bathing. A grease trap (A12) can also be installed between the sink-shower and soakaway (to protect the soakaway and reduce the risk of clogging).

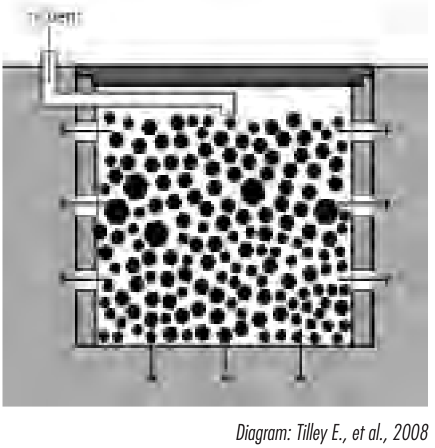


Diagram: Tilley E., et al., 2008

ADVANTAGES

• Can be constructed and repaired locally.
• Low investment and operating costs.
• Very small footprint.

DISADVANTAGES

• Risk of pollution of the groundwater table if this is too high.

LIMITATIONS

• The soakaway should not be located in an area prone to flooding as it is liable to overflow, rendering it temporarily unusable.

FURTHER INFORMATION

Ref. 1: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO (technical description: pp.75-77; design and sizing: p.143).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.137-138).

Ref. 3: Pickford John, 1995, *Low-cost sanitation, A survey of practical experience.*

Ref. 4: Kopitopoulos D., 2005, *Guide pour l'assainissement liquide des douars marocains*, ONEP/the World Bank.

Ref. 5: Morel A., Diener S., 2006, *Greywater management in low and middle-income countries*, EAWAG.

Infiltration Trenches

Infiltration trenches work on the same principle as a soakaway (factsheet A08). This system is used for greywater and blackwater that have undergone a form of pretreatment (in a septic tank). The infiltration capacity of the soil depends on its permeability (the soil's capacity to allow liquid to percolate). Gravel or sand is added to the network of trenches to maximize the soil's infiltration properties.

PREREQUISITES

YES	NO	
☐	☐	There is a low groundwater table.
☐	☐	The soil enables water to infiltrate.
☐	☐	The nearest water source is over 30 meters away.
☐	☐	There is enough space available for the construction of infiltration trenches (minimum 20m²) and this space is in the sun.

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (large infiltration area and so high level of treatment)
Investment costs	30-60 euro for infiltration trenches
Operating costs	5-15 euro/year for the maintenance of infiltration trenches
Design	High-level skills (design and laying of pipes and the different layers of gravel)
Operation	Low-level skills (no on-going maintenance) to high-level skills (if there is clogging)

Design and construction

- Infiltration trenches consist of (1) a distribution box that directs the water into the different channels (optional), (2) perforated 100mm diameter pipes buried 15cm below the surface and laid on (3) a 15cm layer of gravel (20 to 50mm diameter). Another layer of gravel is laid on top of the perforated pipes; this is then covered with (4) a layer of geotextile fabric to prevent the pipes being punctured.
- The main design criteria are the volumes of water discharged, the available surface area and the infiltration capacity of the soil. The design and construction of infiltration trenches require high-level skills.

Care and maintenance

- *Main operating activities:* there is no on-going maintenance. In the event of clogging, it will be necessary to call upon a professional to clean, repair and restore the pipes
- *Main equipment and human resources required:* there is no specific equipment required.

ADVANTAGES

- Very user-friendly.
- Low maintenance.

DISADVANTAGES

- High-level skills required for the design and construction.
- Large footprint.
- Requires parts for construction that are not always readily available in sufficient quantities.
- Risk of pollution of the groundwater table if this is too high.

LIMITATIONS

- Infiltration trenches should not be located in an area prone to flooding as they are liable to overflow, rendering them temporarily unusable.

FURTHER INFORMATION

Ref. 1: Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation*, WHO (technical description: pp.77-79).

Ref. 2: Pickford John, 1995, *Low-cost sanitation, A survey of practical experience.*

Ref. 3: Morel A., Diener S., 2006, *Greywater management in low and middle-income countries,* EAWAG.

Ref. 4: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.139-140).

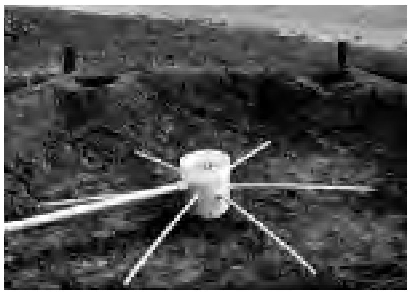


Photo: Morel A. et al., 2006

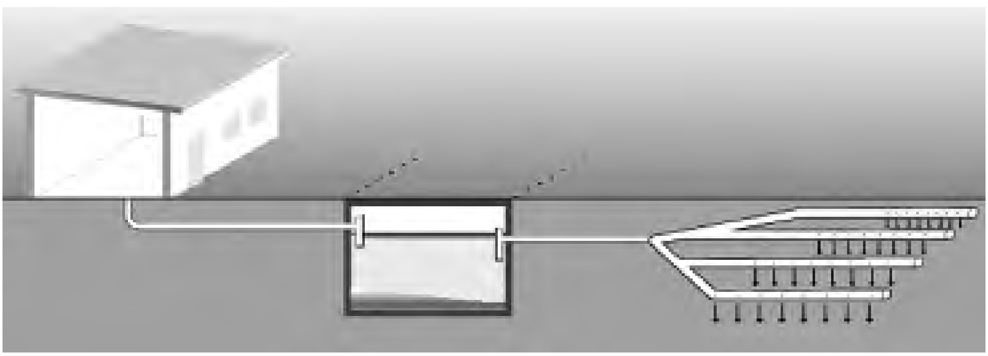


Diagram: Tilley E., et al., 2008

Sink

A sink is a simple and usually inexpensive fixture used for greywater, in particular water used for laundry, cooking and washing up. It acts as an interceptor (by retaining large solid particles).

It is purely a receptacle: it does not store or treat the greywater and so needs to be connected to either a septic tank, a soakaway or a sewerage system.

PREREQUISITES

YES	NO	
☐	☐	There is a device for collecting the greywater (septic tank, soakaway, sewerage system) to which the sink can be connected.

❗ If you answered 'no' to this question, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Investment costs	5-15 euro for a sink
Operating costs	0 euro/year for the maintenance of a sink
Design	Low-level skills (can be constructed by a local craftsman)
Operation	Low-level skills (for maintenance)

Photo: pS-Eau

Photo: Gret Mirep

Design and construction

• A sink consists of a basin (in concrete, plastic, metal or ceramic) equipped with an outlet pipe to take the water into a septic tank (A07), a soakaway (A08) or a sewerage system (E05, E06, E07). The pipe is usually equipped with a drain screen (wire mesh or grill) at the point of entry that traps large solid particles and prevents them being evacuated with the wastewater.

• The main design criterion is the volume of the sink which should be able to contain the equivalent of one or more buckets of water.

Care and maintenance

• *Main operating activities:* cleaning the sink with disinfectant, removal of the large solid particles trapped in the drain screen.

• *Main equipment and human resources required:* there is no specific equipment required.

Variations and upgrades

Cooking and washing up water is often full of oils and grease. It is therefore often advisable to connect the sink to a grease trap (A12) to protect, and reduce the maintenance of, the subsequent collection device (septic tank, soakaway or sewerage system).

Diagram: Gret Mirep

ADVANTAGES

• Can be constructed and repaired locally.

• Low investment and operating costs.

• Small footprint.

DISADVANTAGES

• There is no disadvantage or particular limitation associated with this technology.

FURTHER INFORMATION

Ref. 1: Guene, *Evaluation des aspects techniques du système d'assainissement alternatif à Rufisque*, Enda Rup.

Ref. 2: Inchauste F., 2004, *Guide technique, Système d'Assainissement par Canalisation de Petit Diamètre: Système semi-collectif*, Onas.

Ref. 3: Steiner M., 2002, *Evacuation des réseaux d'égout à faible diamètre dans des quartiers défavorisés à Bamako (Mali)*.

Shower

A shower is a simple and generally low cost facility that enables the collection of water used for bathing. It acts as an interceptor (by retaining large solid particles).

It is purely a receptacle: it cannot store or treat wastewater and so needs to be connected to either a septic tank, soakaway or to a sewerage system.

PREREQUISITES

YES NO

☐ ☐ There is a device for collecting greywater (septic tank, soakaway, sewerage system) to which the shower can be connected.

❗ If you answered 'no' to this question, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Investment costs	15-30 € for a shower (negligible)
Operating costs	0 euro/year for shower (negligible)
Design	Low-level skills (can be constructed by a local craftsman)
Operation	Low-level skills (for maintenance)

Photo: pS-Eau

Photo: Réseau Projection

Design and construction

A shower consists of a washing area (cement or ceramic surface) with a slope to draw the shower water towards a pipe that leads to either a septic tank (A07), a soakaway (A08) or a sewerage system (E05, E06, E07). The entry point of the pipe is usually equipped with a drain screen (wire mesh, grill) to prevent large solid particles from being evacuated with the wastewater.

Care and maintenance

• *Main operating activities:* cleaning the shower with disinfectant, removal of the large particles caught in the drain screen.

• *Main equipment and human resources required:* there is no specific equipment required.

ADVANTAGES

- Can be constructed and repaired locally.
- Low investment and operating costs.
- Small footprint.

DISADVANTAGES

- There is no particular disadvantage or limitation associated with this technology.

FURTHER INFORMATION

Ref. 1: Guene, *Evaluation des aspects techniques du système d'assainissement alternatif à Rufisque*, Enda Rup.

Ref. 2: Inchauste F., 2004, *Guide technique, Système d'Assainissement par Canalisation de Petit Diamètre: Système semi-collectif*, Onas.

Ref. 3: Steiner M., 2002, *Evacuation des réseaux d'égout à faible diamètre dans des quartiers défavorisés à Bamako (Mali)*.

Grease Trap

A grease trap is a wastewater pretreatment device for intercepting oils and grease (usually contained in cooking and washing up water). This device must be placed before a small-piped sewerage system. It is also recommended that a grease trap is installed before a septic tank or soakaway.

Grease is intercepted by flotation, thereby protecting the rest of the system. A grease trap is not able to store or treat wastewater and should therefore be connected to a septic tank, soakaway or sewerage system.

PREREQUISITES

YES NO

☐ ☐ There is a sink to which a grease trap can be connected.

☐ ☐ There is a means of collecting greywater (septic tank, soakaway, sewerage system) before which it is possible to connect the grease trap.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	Low (limited treatment of greywater)
Investment costs	40-80 euro for a grease trap
Operating costs	Negligible
Design	High-level skills (can be constructed by a local craftsman once he has received prior training)
Operation	Low-level skills (for maintenance)

Design and construction

- A grease trap consists of (1) an initial chamber (equipped with a T-shaped inlet pipe) in which the greywater is stabilized, (2) a second chamber that separates the grease from the water through flotation, (3) a third chamber equipped with a T-shaped outlet pipe. The three chambers are separated by baffles that are open at the base.
- The main design criterion is the quantity of water to be treated. For effective separation of grease, the retention time of wastewater in the trap should be between 15 to 30 minutes (to allow the water to cool down and stabilize sufficiently). The volume of the grease trap therefore needs to be large enough to satisfy this requirement (and not undersized).

Care and maintenance

- *Main operating activities:* regular removal of accumulated grease from the surface and solid waste from the bottom of the trap; checking the condition of the internal coating.
- *Main equipment and human resources required:* no specific equipment is required.

ADVANTAGES

- Can be constructed and repaired locally.
- No operating costs.
- Small footprint.

DISADVANTAGES

- Medium-level investment costs.
- Limited treatment.

FURTHER INFORMATION

Ref. 1: Morel A., Diener S., 2006, *Greywater management in low and middle-income countries, EAWAG* (technical description: pp.22-24).

Ref. 2: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: p.69).

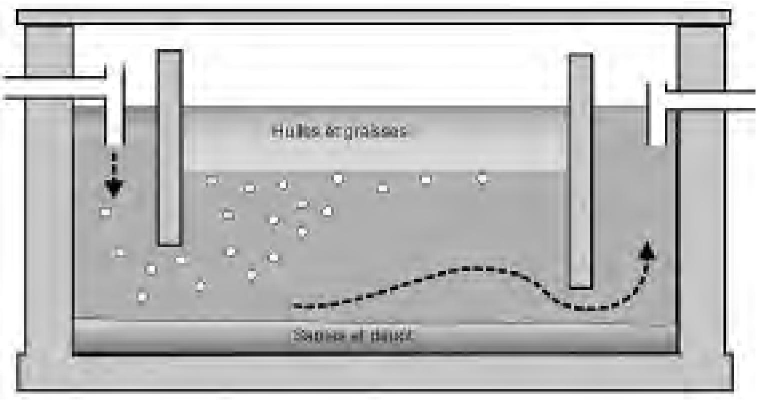


Diagram: from Morel A., 2006

Shared Toilet Block

PREREQUISITES

YES NO

- ☐ ☐ There is a sufficiently large and easily accessible space available within the neighborhood on which to construct a shared toilet block.
- ☐ ☐ It is possible to put a system in place to manage the shared toilet block[19].
- ☐ ☐ The shared toilet block can be connected to the drinking water network.
- ☐ ☐ There is a pit emptying service available locally (or such a service can be set up).
- ☐ ☐ There is a system in place for the subsequent treatment or evacuation of effluent from the septic tank (soakaway or infiltration trenches, sewerage system).

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-30 years
Efficiency	High (no flies or smells; partial treatment of wastewater)
Investment costs	50-100 euro/household for a shared toilet block
Operating costs	5-10 euro/household/year for the use of a shared toilet block
Design	High-level skills (for the design, sizing and construction)
Operation	Low-level skills (for maintenance)

[19] For further information, please see the CMS program guide: 'How to manage public toilets and showers'.

• Shared toilet blocks provide access to sanitation to people living in densely populated areas without the financial means to install private sanitation facilities. For households who have neither the space nor the financial resources to install sanitation facilities at home, they can use the shared blocks to go to the toilet, wash themselves and do their laundry.

• In general, any technical solution can be used in shared toilet blocks. Where it is not possible to connect a shared block to the sewerage system, it needs to be equipped with a septic tank in which the wastewater can be stored and pretreated using settling and anaerobic treatment processes (factsheet A07).

• The septic tank provides partial treatment: a large amount of pathogens remain. The effluent that is removed therefore needs to undergo further treatment (usually through either infiltration or in a centralized treatment plant). A septic tank should be emptied every two to five years to remove the accumulated sludge. This sludge then has to be transported to a treatment site (e.g. solar or planted drying bed).

Photo: Julien Gabert

Design and construction

• A shared toilet block consists of (1) a building that houses several toilet cubicles, showers (separate for men and women), sinks (for handwashing) and potentially a washtub (for laundry). This building also contains an area for the storage of maintenance materials and an office for the manager at the entrance. It is connected to the water network and to the electricity network, if possible. The wastewater from the toilets, showers, sinks and washtubs are evacuated through the pipes into (2) a septic tank (see factsheet A07) equipped with (3) an outlet pipe that leads to an infiltration system or sewerage system.

• The main design criterion is the sizing of the septic tank and its chambers, in proportion to the volume of wastewater discharged, so as to optimize treatment. The construction of a septic tank requires high-level skills and specific design knowledge.

Care and maintenance

• *Main operating activities:*
For the block: supervision of users (taking payment), distribution of water and soap (where necessary), frequent cleaning and maintenance of toilets and showers.
For the septic tank: filling the septic tank with water before using for the first time and after each time it is emptied; emptying once the first chamber is between half and two-thirds full of solid sludge.

• *Main equipment and human resources required:* one full-time operator for supervision and undertaking maintenance (or two if the block is open at night). Emptying should preferably be carried out by a professional.

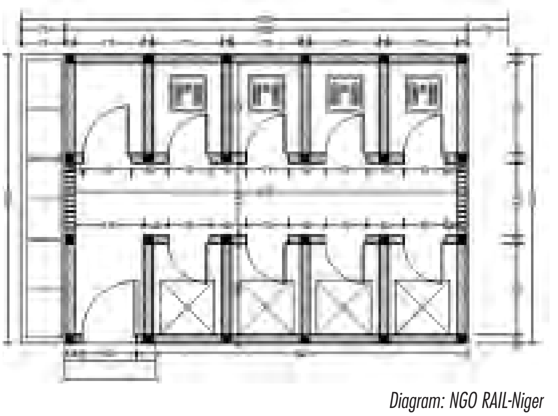


Diagram: NGO RAIL-Niger

ADVANTAGES

• Can be constructed and repaired locally.
• Low investment costs.
• No flies or smells.
• Small footprint (compared to the number of households).

DISADVANTAGES

• Requires a constant source of water.
• Partial treatment of wastewater.
• Requires sharing the toilets with other households.
• High cost of use for households (although cost is spread out over time).
• Requires regular emptying.
• Effluent and sludge requires secondary treatment.
• Risk of pollution of the groundwater table.

FURTHER INFORMATION

Ref. 1: *Nitti R., Sarkar S., 2003, Urban notes: Reaching the Poor through Sustainable Partnerships: The Slum Sanitation Program in Mumbai, India*, the World Bank.

Ref. 2: Bongi S., Morel A., 2005, Field Note: *Under¬standing Small Scale Providers of Sanitation Services: a Case Study of Kibera*, WSP.

Ref. 3: Sarkar S., Ghosh Moulik S., Sen S., 2006, *Partnering with Slum Communities for Sustainable Sanitation in Megalopolis: The Mumbai Slum Sanitation Program*, WSP.

Ref. 4: CMS n°5, How to Manage Public Toilets and Showers, MDP/pS-Eau, 2010.


42

Evacuation segment

What is it?

The evacuation of wastewater and excreta is the second segment of the sanitation chain. The Evacuation segment involves the transportation of wastewater away from households' dwellings to discharge and treatment sites.

Evacuation technologies can be divided into two categories: emptying (for the regular, ad hoc evacuation of wastewater stored in household pits/tanks) and the sewerage system (for the continuous evacuation of wastewater as it is produced).

What are the objectives of this segment?

The objectives of the evacuation of wastewater and excreta segment are:

- to take the wastewater and excreta away from the households' dwellings;
- to ensure the neighborhoods are kept clean and hygienic;
- to transport the wastewater and excreta to discharge and treatment sites.

List of technical factsheets for the evacuation segment

CHAIN	TECHNOLOGIES	
On-site sanitation	**Manual emptying**	• Bucket + Cart or barrow • Bucket + Tank-cart **E01** • Handpump + Tank-cart **E02**
	Mechanical emptying	• Motorized Pump + Tank-cart **E03** • Vacuum Truck **E04**
Small-piped sewerage system	**Evacuation of wastewater following initial evacuation**	• Settled sewerage system **E05**
	Evacuation of all wastewater	• Simplified sewerage system **E06**
Conventional sewerage system	**Evacuation of all wastewater**	• Conventional sewerage system **E07**

Bucket and Tank-Cart

The use of a bucket for emptying is not, strictly speaking, a technology. This is a method of manually emptying sludge from a pit into a tank placed on top of a cart that is then used to transport the sludge to a location outside the town. There are health risks involved in this approach for the emptier as he can come into contact with excreta. The advantage of this method is that the sludge is taken out of the neighborhood (rather than being poured into a hole in the yard or directly into the street).

In urban areas, emptying by bucket needs to be followed by a sludge treatment process, such as that provided by drying beds, UASB reactors or anaerobic biogas reactors.

PREREQUISITES

YES NO

☐ ☐ There is a sludge discharge site (treatment site or discharge station) less than 5km away from the neighborhoods from which the sludge is to be removed.

❗ If you answered 'no' to this question, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	2-10 years
Efficiency	Low (health risks for the emptier)
Investment costs	300-1,000 euro for a bucket + tank-cart
Operating costs	50-150 euro/year for a bucket + tank-cart
Design	Low-level skills (tank can be constructed by a local craftsman)
Operation	Low-level skills (for the handling and maintenance of materials)

Photos: NGO RAIL-Niger

Design and construction

• A tank-cart consists of a flatbed cart (that preferably tips from the wheel axis to facilitate sludge removal), on top of which is a watertight tank equipped with a filler cap at the top and a drain valve at the bottom.

• The main design criterion is the volume of the tank, as a suitable balance needs to be found between the number of trips to be made and the weight that an animal (donkey, ox, etc.) is able to pull.

Care and maintenance

• *Main operating activities:* cleaning out the bucket and tank-cart after use.

• *Main equipment and human resources required:* there is one operator in charge of emptying with a bucket and tank-cart. This operator needs to be provided with adequate protective clothing for emptying the pit (boots, facemask, glasses, overalls, etc.) to minimize all contact with excreta.

ADVANTAGES

- Can be constructed and repaired using locally available materials.
- Low investment and operating costs.
- No electrical energy is required.
- Provides a pit emptying service to areas not connected to a sewerage system or areas difficult for vacuum trucks to access.
- Low cost for using the service.

DISADVANTAGES

- Time-consuming: emptying is slow.
- Significant health risks for emptiers.
- Short range sludge transfer by tank-cart (sludge transport over large distances is impractical).

LIMITATIONS

- Pit emptying is often considered to be a dirty and degrading activity (smells, handling excreta). It is important to support existing emptiers or people willing to continue this activity. It is also important that the work be carried out correctly so it's reputation is enhanced.
- Demand for the emptying service should be high enough to ensure it is both financially viable and sustainable.

FURTHER INFORMATION

Ref. 1: Yoke Pean Thye., Michael R. Templeton, Mansoor Ali, *Pit latrine emptying: technologies, challenges and solutions*, EWB-UK Research Conference 2009.

Ref. 2: Klutse Amah, Ouattara Regina, Tandia Cheikh Tidiane, 2004, *Etude comparative des modes de gestion des boues de vidange en Afrique de l'Ouest, Analyse des problèmes et recommandations*, Crepa.

Handpump and Tank-Cart

A handpump (a 'gulper' or 'MAPET') can be used for emptying the pits of latrines and toilets. One end of the handpump is placed in the pit to remove the sludge, which is usually thick. The advantage of the handpump is that the emptier (who remains outside the pit) doesn't come into contact with the excreta. This type of technology is therefore safer and more hygienic than manual emptying with a bucket and shovel. The sludge is then transported in a tank placed on a cart.

In urban areas, emptying by handpump needs to be followed by a sludge treatment process, such as that provided by drying beds, UASB reactors or anaerobic biogas reactors.

PREREQUISITES

YES NO

☐ ☐ There is a sludge discharge site (treatment site or discharge station) less than 5km away from the neighborhoods from which the sludge is to be removed.

☐ ☐ The pits only contain viscous sludge (long retention time in the pit + no solids, such as garbage).

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	2-10 years
Efficiency	High (few health risks)
Investment costs	400-1,000 euro for a gulper + tank-cart
Operating costs	50-150 euro/year for a gulper + tank-cart
Design	Medium-level skills (a gulper can be purchased from a specialized dealer or be constructed by a skilled craftsman)
Operation	Low-level skills (for the handling and maintenance of materials)

Photo: Gret – PacepaC

Photo: G. Aubourg (pS-Eau)

Design and construction

• A gulper consists of a rod joined to two valves inside a PVC casing. The valve system, operated by the emptier, pumps up the sludge through the shaft; this sludge is then discharged through the V-shaped spout into a bucket (see the Gret PacepaC photo on the previous page, top right). For the tank-cart, please see factsheet E01.

• The main design criterion is the depth of the pit, as gulpers can remove sludge up to a height of 1.5m once inserted into the pit sludge.

Care and maintenance

• *Main operating activities:* cleaning of the pump after each emptying to remove any large particles that may be caught inside.

• *Main equipment and human resources required:* one operator is required for emptying using a gulper.

Variations and upgrades

One possible variation of handpump is the 'MAPET' (MAnual Pit Emptying Technology) that consists of a handpump connected to a vacuum tank. This system is more robust and more expensive (between 3,000 and 4,000 euro to buy) than the gulper.

ADVANTAGES

- Can be constructed and repaired using locally available materials.
- Low investment and operating costs.
- No electrical energy is required.
- Provides a pit emptying service to areas not connected to a sewerage system or areas difficult for vacuum trucks to access.
- Reduced health risks for operators.
- Low cost for using the service.

DISADVANTAGES

- Time-consuming: emptying is slow.
- Short range sludge transfer by tank-cart (sludge transport over large distances is impractical).

LIMITATIONS

- Pit emptying is often considered to be a dirty and degrading activity (smells, handling excreta). It is important to support existing emptiers or people willing to continue this activity.
- Demand for the emptying service should be high enough to ensure it is both financially viable and sustainable.

FURTHER INFORMATION

Ref. 1: *Ideas at Work*, The Gulper, Nov 2007 (www.ideas-at-work.org).

Ref. 2: Yoke Pean Thye., Michael R. Templeton, Mansoor Ali, *Pit latrine emptying: technologies, challenges and solutions*, EWB-UK Research Conference 2009.

Ref. 3: Maria S. Muller, Jaap Rijnsburger, MAPET, *A neighbourhood based pit emptying service with locally manufactured handpump equipment in Dar es Salaam, Tanzania*, WASTE, 1992.

Ref. 4: Klutse Amah, Ouattara Regina, Tandia Cheikh Tidiane, *Etude comparative des modes de gestion des boues de vidange en Afrique de l'Ouest, Analyse des problèmes et recommandations*, Crepa, 2004.

Motorized Pump and Tank-Cart

Using a motorized pump means that liquid sludge can be quickly and safely emptied from a pit and transferred to a tank on a cart which then transports the sludge to a location outside the town. The advantage of the motorized pump is that it reduces contact between the emptier (who remains outside the pit) and the excreta. This thereby means that there are significantly lower health risks involved compared to manual emptying with a bucket and shovel.

In urban areas, emptying by motorized pump needs to be followed by a sludge treatment process, such as that provided by drying beds, UASB reactors or anaerobic biogas reactors.

PREREQUISITES

YES	NO	
☐	☐	There is a sludge discharge site (treatment site or discharge station) less than 5km away from the neighborhoods from which the sludge is to be removed.
☐	☐	The pits only contain viscous sludge (long retention time in the pit + no solids, such as garbage).

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	2-10 years
Efficiency	High (few health risks)
Investment costs	1,000-2,000 euro for a motorized pump + tank-cart
Operating costs	150-1,000 euro/year for a motorized pump + tank-cart
Design	Low-level skills (tank can be constructed by a local craftsman and motorized pumps widely available on the market)
Operation	Low-level skills (for the handling and maintenance of materials)

Photo: NGO RAIL-Niger

Photo: pS-Eau

Design and construction

• A tank-cart consists of a flatbed cart (that preferably tips from the wheel axis to facilitate sludge removal), on top of which is a watertight tank equipped with a filler cap at the top and a drain valve at the bottom.

• The main design criterion is the volume of the tank, as a suitable balance needs to be found between the number of trips to be made and the weight that an animal (donkey, ox, etc.) is able to pull.

Care and maintenance

• *Main operating activities:* cleaning out the motorized pump and the tank-cart after use.

• *Main equipment and human resources required:* there is one operator in charge of emptying with a motorized pump and tank-cart.

Variations and upgrades

One possible variation of the motorized pump is the 'Vacutug' which consists of a vacuum pump connected to an engine (see the pS-Eau photo bottom right). This system is more robust and more expensive (between 4,000 and 5,000 euro to buy) than the motorized pump, and they are not widely available on the market.

ADVANTAGES

- Can be constructed and repaired using locally available materials.
- Medium-level investment and operating costs.
- Emptying is conducted quickly.
- Provides a pit emptying service to areas not connected to a sewerage system or areas difficult for vacuum trucks to access.
- Reduced health risk for operators.
- Low cost for using the service.

DISADVANTAGES

- Requires fuel.
- Short range sludge transfer by tank-cart (sludge transport over large distances is impractical).

LIMITATIONS

- Pit emptying is often considered to be a dirty and degrading activity (smells, handling excreta). It is important to support existing emptiers or people willing to continue this activity. It is also important that the work be carried out correctly so it's reputation is enhanced.
- Demand for the emptying service should be high enough to ensure it is both financially viable and sustainable.

FURTHER INFORMATION

Ref. 1: Yoke Pean Thye., Michael R. Templeton, Mansoor Ali, 2009, *Pit latrine emptying: technologies, challenges and solutions*, EWB-UK Research Conference 2009.

Ref. 2: Klutse Amah, Ouattara Regina, Tandia Cheikh Tidiane, 2004, *Etude comparative des modes de gestion des boues de vidange en Afrique de l'Ouest, Analyse des problèmes et recommandations*, Crepa.

Ref. 3: Bodian Ibou, 2006, *Gestion des boues dans la région de Dakar, L'exemple du Vacutug dans les villages traditionnels et dans les bidonvilles*, UN-HABITAT Vacutug Workshop.

Ref. 4: Alabaster G., 2008, *Experience of the UN-Habitat Vacutug: sustainable latrine emptying*, UN-HABITAT.

Vacuum Truck

Vacuum trucks can be used to empty toilet and latrine pits without the operators coming into contact with excreta. The sludge is usually liquid but can sometimes be quite viscous. The removed sludge then needs to be transported to a treatment site or intermediate discharge station (where the sludge is collected to reduce the number of trips required to transport it to the final treatment site, further away).

PREREQUISITES

YES	NO	
☐	☐	There are a large number of latrines that require the removal of sludge contained in the pits.
☐	☐	The pits are accessible by roads suitable for vehicles.
☐	☐	There is a sludge discharge site (treatment site or discharge station) less than 10km away from the neighborhoods from which the sludge is to be removed.
☐	☐	The pits only contain liquid sludge (water dischar ged into the pits + but not solids such as garbage).
☐	☐	The pits are sufficiently robust that they will not collapse during emptying.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years (hardy and robust system)
Efficiency	High (no health risks)
Investment costs	10,000 to 50,000 euro/truck
Operating costs	1,000 to 10,000 euro/year/truck
Design	High-level skills (purchased from a specialized dealer)
Operation	Medium-level skills (for the handling and maintenance of the truck)

ADVANTAGES

- Quick and efficient emptying.
- Reduced health risks (safest emptying system in terms of health risks).
- Able to remove large volumes.

DISADVANTAGES

- Use is restricted to those areas accessible by vehicle.
- Does not remove dry (solid) sludge.
- High investment and operating costs.
- Requires large amounts of fuel.
- High cost of using the service.

LIMITATIONS

- Where there is a risk of flooding in the vacuum truck's area of intervention, it is advisable to consider whether this is likely to be an occasional, seasonal constraint or one that is more incapacitating (long-lasting floods); in the event of the latter, it may be necessary to reconsider the vacuum truck option.
- Pit emptying is often considered to be a dirty and de-grading activity (smells, handling excreta). It is impor-tant to support existing emptiers or people willing to continue this activity.

Design and construction

• Vacuum trucks consist of a holding tank and a vacuum pumping system mounted on a truck, as well as an air and water injection system for suspending the sludge solids. They can be purchased from specialized dealers.

• The main design criteria are the size of the holding tank, which determines the sludge pumping capacity, and the suction power of the pump that determines the maximum depth from which sludge can be removed.

Care and maintenance

• *Main operating activities:* weekly service, cleaning the equipment after each emptying.

• *Main equipment and human resources required:* two operators are required for emptying using a vacuum truck.

Variations and upgrades

A vacuum truck system can be combined with a handpump or motorized pump emptying system to cover those areas that are difficult to access (where roads are unsuitable for vehicles). It is also possible to equip a 4x4 pick-up truck with a tank and a motorized pump that can access narrow roads.

Photos: pS-Eau

FURTHER INFORMATION

Ref. 1: Wegelin-Schuringa Madeleen (IRC), Coffey Manus (Manus Coffey Associates: MCA), 2003, *Small Pit Emptying Machine an Appropriate Solution in Nairobi Slum*, www.irc.nl.

Ref. 2: Yoke Pean Thye, Michael R. Templeton, Mansoor Ali, *Pit latrine emptying: technologies, challenges and solutions*, EWB-UK Research Conference 2009.

Ref. 3: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.81-82).

Ref. 4: Alabaster Graham, *Experience of the UN-Habitat Vacutug: sustainable latrine emptying*, AfricaSan Durban, 2008.

Ref. 5: Klutse Amah, Ouattara Regina, Tandia Cheikh Tidiane, 2004, *Etude comparative des modes de gestion des boues de vidange en Afrique de l'Ouest, Analyse des problèmes et recommandations*, Crepa.

Settled Sewerage System

Settled sewerage systems collect wastewater in the same way as conventional sewerage systems but are less expensive as they are not buried as deep underground and use smaller diameter pipes. The distinctive feature of these settled sewerage systems is that they only collect the greywater and a fraction of the blackwater, once this has been pretreated through settling at household level (micro-septic tank and grease trap). This is different to simplified and conventional sewerage systems that evacuate wastewater without any prior settling having taken place.

PREREQUISITES

YES	NO	
☐	☐	The population density of the area is at least 16,000 inhabitants/km².
☐	☐	Local drinking water consumption is at least 40 to 50L/person/day (this varies according to the gradient and diameter of the network).
☐	☐	There is a non-rocky layer several meters deep.
☐	☐	There is sufficient space in the plot for the pretreatment facilities (8m²/plot).
☐	☐	A management system for the settled sewerage system can be put in place.
☐	☐	A wastewater treatment system can be installed after the sewerage system.
☐	☐	There is a sufficient gradient to permit the natural flow of water (>1%).

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (water is continuously discharged far away from the housing)
Investment costs	200 to 400 euro/household
Operating costs	10 to 30 euro/household/year
Design	High-level skills (technical engineering firm)
Operation	High-level skills (people with experience of management and maintenance)

ADVANTAGES

- High level of user-friendliness.
- Possible to extend the system.
- Constant evacuation of wastewater.

DISADVANTAGES

- Expert assistance required for the design, construction and supervision of works.
- Qualified labor required for operation.
- High investment costs.

LIMITATIONS

A groundwater table that is visible on the surface or very high creates two problems: it renders construction work more complicated; the water table may be polluted by leakages from the settled sewerage system. If this factor poses too great a risk, it is perhaps advisable to select a watertight pit and emptying technology. Furthermore, groundwater from the table may infiltrate the settled sewerage system, thereby increasing the volumes to be treated at the treatment plant.

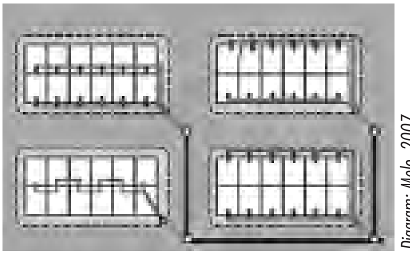


Diagram: Melo, 2007

Design and construction

• A settled sewerage system consists of:

– *At house level* (1) toilets, showers and sinks that receive wastewater and excreta (these facilities can be equipped with drain screens that remove large particles), (2) one or two grease traps to remove oils and grease, (3) a settling tank to remove the largest solids, (4) a septic tank to collect the wastewater and excreta, (5) a junction chamber to connect to the settled sewerage system.

– *In the street:* (6) 100 to 200mm diameter pipes, (7) connection points at the lowest point of the main pipe, (8) manholes providing access for maintenance, (9) in some cases, a pumping station to transport the water to the treatment site.

• The main design criteria are (1) the population to be covered, (2) the quantities of water used and its composition, (3) the quantities of wastewater actually discharged into the system, (4) the gradient, (5) the self-cleansing velocity, and (6) the location of the outlet.

Care and maintenance

• *Main operating activities:* checking the manholes of the system every 3 months (every month for those located at a change of alignment), emptying of household equipment every 3 to 6 weeks, checking the water levels of any pumping station.

• *Main equipment and human resources required:* two operators are in charge of the technical management and maintenance of the settled sewerage system, as well as the construction of private connections to the system. There is a manager who is responsible for the financial management of the sewerage system.

FURTHER INFORMATION

Ref. 1: Bakalian A., Wright A., Otis R., Netto J.A., 1994, *Simplified sewerage: design guidelines, UNDP-World Bank Water and Sanitation Program* (design and sizing: pp.6-16 and 25-28).

Ref. 2: Melo J.C., 2007, *La ciudad y el saneamiento - Sistemas condominiales: un enfoque diferente para los desagües sanitarios urbanos*, WSP.

Ref. 3: Tandia C.T., 2007, *Manuel d'entretien et de suivi des Réseaux d'Egoûts à Faible Diamètre (REFAID)*, Cas du Crepa Siège, Crepa.

Ref. 4: Mara D., Alabaster G., 2006, *A new paradigm for low-cost urban water supplies and sanitation in developing countries*, Water Policy 10, pp.119-129.

Ref. 5: Mara D., 2001, *Low-cost urban sanitation, Dept. of Civil Engineering*, University of Leeds, U.K, 233 pages.

Ref. 6: Steiner M., 2002, *Evaluation des réseaux d'égout à faible diamètre dans des quartiers défavorisés à Bamako (Mali)*, EPFL.

Ref. 7: Crepa, 2005, *Gestion des eaux usées domestiques par les réseaux d'égouts de faible diamètre* (REFAID), Projet pilote d'Hippodrome Extension Bamako-Mali, Crepa.

Photo: Gret - PacepaC

Photo: Gret - PacepaC

Simplified Sewerage System

Simplified sewerage systems collect wastewater in the same way as conventional sewerage systems but are less expensive as they are not buried as deep underground and they use smaller diameter pipes. These systems collect greywater and blackwater directly, without any pre-treatment. The water collected is then evacuated to a treatment facility.

At house level, the facilities that collect the wastewater and excreta are connected to the simplified sewerage system via a junction chamber.

PREREQUISITES

YES	NO	
☐	☐	The population density of the area is at least 16,000 inhabitants/km^2.
☐	☐	Local drinking water consumption is at least 40 to 50L/ person/day (this varies according to the gradient and diameter of the network).
☐	☐	There is a non-rocky layer several meters deep.
☐	☐	A management system for the simplified sewerage system can be put in place.
☐	☐	A wastewater treatment system can be installed after the (potential) sewerage system.
☐	☐	There is a sufficient gradient to permit the natural flow of water (>1%).

❗ If you answered ‘no’ to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	10-20 years
Efficiency	High (water is continuously discharged far away from the housing)
Investment costs	200 to 400 euro/household
Operating costs	15 to 30 euro/household/year
Design	High-level skills (technical engineering firm)
Operation	Medium-level skills (people with experience of management and maintenance)

Photos: Gret - PacepaC

Design and construction

• A simplified sewerage system consists of:

– *At house level:* (1) toilets, showers and sinks that receive wastewater and excreta, (2) potentially a pit for the collection of wastewater and excreta, (3) an individual junction chamber connecting each household to the sewerage system;

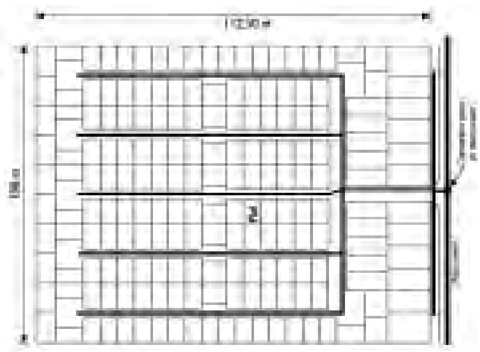
– *In the street:* (4) 100 to 200mm diameter pipes, (5) connection points at the lowest point of the main pipe, (6) manholes providing access for maintenance, (7) in some cases, one or several pumping stations with two pumps for transporting the water to the treatment site.

• The main design criteria are (1) the population to be covered, (2) the quantities of water consumed and its composition, (3) the quantities of wastewater actually discharged into the system, (4) the gradient, (5) the self-cleansing velocity, and (6) the location of the natural outlets.

Care and maintenance

• *Main operating activities:* checking the manholes of the system every 3 months (every month for those located at a change of alignment), emptying of household equipment every 3 to 6 weeks, checking the levels of water entering any pumping station.

• *Main equipment and human resources required:* two operators are in charge of the technical management and maintenance of the sewerage system, as well as the construction of private connections to the site. There is a manager who is responsible for the financial management of the system.



ADVANTAGES

• High level of user-friendliness.

• Possible to extend the system.

• Small footprint.

• Ensures constant evacuation of wastewater

DISADVANTAGES

• Expert assistance required for the design, construction and supervision of works.

• Qualified labor required for operation.

• High investment costs.

LIMITATIONS

A groundwater table that is visible on the surface or very high creates two problems: it renders construction work more complicated; the water table may be polluted by leakages from the simplified sewerage system. If this factor poses too great a risk, it is perhaps advisable to select a watertight pit and emptying technology. Furthermore, groundwater from the table may infiltrate the sewerage system, thereby increasing the volumes to be treated at the treatment plant.

FURTHER INFORMATION

Ref. 1: Bakalian A., Wright A., Otis R., Netto J.A., 1994, *Simplified sewerage: design guidelines, UNDP-World Bank Water and Sanitation Program* (design and sizing: pp.6-16 and 25-28).

Ref. 2: Mara D., 2001, *Low-cost urban sanitation, Dept. of Civil Engineering,* University of Leeds, U.K.

Ref. 3: Steiner M., 2002, *Evaluation des réseaux d'égout à faible diamètre dans des quartiers défavorisés à Bamako (Mali)*, EPFL.

Conventional Sewerage System

Conventional sewerage systems collect wastewater (i.e. greywater and blackwater) that is discharged without pretreatment. This technology is used in areas of high population density. It is a large infrastructure and so is expensive, both in terms of investment and of operation and maintenance.

A conventional sewerage system can be combined (wastewater and stormwater is carried by the same network of pipes) or separate (two specific parallel pipe networks – one for wastewater, the other for stormwater).

PREREQUISITES

YES NO

- ☐ ☐ The population density of the area is at least 16,000 inhabitants/hectare.
- ☐ ☐ The existing toilets are either cistern flush or pour flush toilets.
- ☐ ☐ Local drinking water consumption is at least 50L/person/day (this varies according to the gradient and diameter of the network).
- ☐ ☐ There is a non-rocky layer several meters deep.
- ☐ ☐ There is an outlet downstream from the potential sewerage system and a wastewater treatment system can be installed after the sewerage system.
- ☐ ☐ There is a sufficient gradient to permit the natural flow of water (>1%).

❗ If you answered ‘no’ to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	High (water is continuously discharged far away from the housing)
Investment costs	400 to 1,000 euro/household
Operating costs	20 to 50 euro/household/year
Design	High-level skills (technical engineering firm)
Operation	High-level skills (people with experience of management and maintenance)

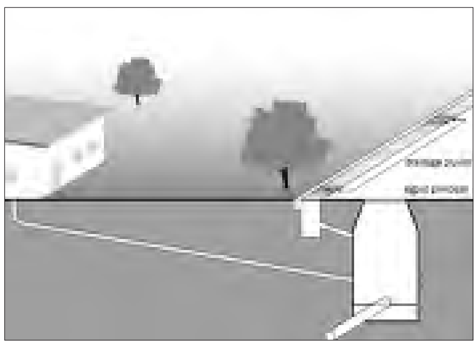


Diagram: Tilley E., et al., 2008

Design and construction

• A conventional sewerage system consists of (1) 200 to 1200mm diameter pipes, on average, buried between 1.5 and 3m underground, (2) manholes (in concrete) providing access to the sewerage system and enabling maintenance, (3) if necessary, pumping stations equipped with pumps located at low parts of the system to raise the water being transported. A combined sewerage system is also equipped with (4) drains for the collection of stormwater and (5) sewer overflows that mean that any surcharge of water can be discharged into the environment during periods of heavy rain.

• The main design criteria are (1) the population to be covered, (2) the quantities of water consumed and its composition, (3) the gradient, (4) the collection efficiency, (5) the self-cleansing velocity, (6) the location of natural outlets.

Care and maintenance

• *Main operating activities:* checking the level of water entering the pumping stations, checking the manholes every 3 months (every month for those located at a change of alignment), cleaning of the pipes for maintenance or in the event of clogging.

• *Main equipment and human resources required:* operators (the number varies depending on the population to be covered) are in charge of the technical management and maintenance of the system, as well as the installation of individual connections to the sewerage system. There is a manager who is responsible for the financial management of the system.

ADVANTAGES

• High level of user-friendliness.
• Possible to extend the sewerage system.
• Small footprint.
• Constant evacuation of wastewater.

DISADVANTAGES

• Very high investment and operating costs.
• Expert assistance required for the design, construction and supervision of works.
• Qualified labor required for operation.

LIMITATIONS

A groundwater table that is visible on the surface or very shallow creates two problems: it renders construction work more complicated; the water table may be polluted by leakages from the sewerage system. If this factor poses too great a risk, it is perhaps advisable to select a watertight pit and emptying technology. Furthermore, groundwater from the table may infiltrate the sewerage system, thereby increasing the volumes to be treated at the treatment plant.

FURTHER INFORMATION

Ref. 1: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.87-88).

Ref. 2: Satin M., Selmi B., 2006, *Guide technique de l'assainissement*, 3e édition.

Ref. 3: Valiron F., 1991, *Manuel d'assainissement pour les pays à faible revenu, Agence de coopération culturelle et technique conseil international de la langue française*, Presses universitaires de France.

Ref. 4: Colombet L., 1990, *Assainissement des agglomerations - Techniques de l'ingénieur.*

Treatment Segment

What is it?

The disposal and treatment of wastewater and excreta or the 'Disposal/Treatment segment' is the third and final segment of the sanitation chain. The 'Treatment' segment deals with the treatment of wastewater and excreta following its evacuation from households' dwellings, with a view to reducing subsequent health risks and environmental pollution.

! Several technological solutions sometimes need to be combined in order to ensure full treatment and enable the wastewater and excreta to be reused if necessary (extensive or intensive treatment + utilization). In addition, a treatment site has to be compatible with the technical solutions chosen for the Evacuation segment.

What are the objectives of this segment?

The objectives of the treatment of wastewater and excreta segment are:

- to reduce the transmission of pathogenic bacteria;
- to reduce environmental pollution.

List of technical factsheets for the treatment segment

CHAIN	TECHNOLOGIES			
	STEP 1		STEP 2	
On-site Sanitation	**Treatment of the effluent from manual and mechanical emptying**	• Solar Drying Bed **T01** + composting **T03** • Planted drying bed **T02** + composting **T03** • Anaerobic Biogas Reactor **T05** • UASB Reactor **T04**	**Treatment of residual effluent**	• Planted or Unplanted Stabilization Pond **T09** • Anaerobic Baffled Reactor **T07** • Anaerobic Filter **T06** • Imhoff Tank **T08**
Small-piped and Conventional Sewerage Systems	**Treatment of the effluent from simplified and settled sewerage systems and from conventional sewerage systems**	• Imhoff Tank **T08** • Anaerobic Baffled Reactor **T07** • Anaerobic Filter **T06** • UASB Reactor **T04** • Planted or Unplanted Drying Bed **T09**	**Treatment of residual sludge**	• Solar drying bed **T01** + composting **T03** • Planted drying bed **T02** + composting **T03** • Anaerobic Biogas Reactor **T05**

Solar drying bed

Solar drying beds treat the sludge obtained from pit emptying. This system uses a sand and gravel filter and the action of the sun's rays to dry the sludge and treat the residual water.

The sludge obtained as a result of this system needs to undergo further treatment, such as Composting (T03). The resulting effluent must also be treated by anaerobic filter (T06), by anaerobic baffled reactor (T07), Imhoff tank (T08) or through means of a waste stabilization pond (T09), for example. This system can be used on either neighborhood or town scale.

PREREQUISITES

YES NO

- ☐ ☐ The area of intervention is a small town (<50,000 inhabitants) or an urban neighborhood.
- ☐ ☐ There is a local pit emptying service.
- ☐ ☐ There is sufficient space available for creation of the treatment plant ($50m^2$/1000 inhabitants).
- ☐ ☐ The plant will be located a sufficient distance away from, and upwind of, housing areas (to avoid bad smells).
- ☐ ☐ There is a demand for the subsequent use of the sludge.
- ☐ ☐ There is an outlet after the drying bed for the evacuation of residual water

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	Low (requires subsequent treatment before use as a fertilizer)
Investment costs	20 to 50 euro/household
Operating costs	2 to 4 euro/household/year
Design	High-level skills (technical engineering firm)
Operation	Low-level skills (people with little experience)

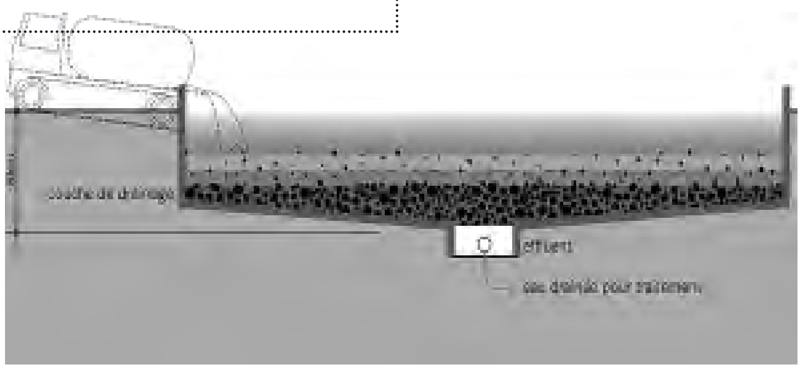


Diagram: Tilley Elisabeth, et al., 2008

Design and construction

•A solar drying bed consists of (1) a sludge discharge area, (2) a screening system for trapping large particles, (3) a filter composed of (from top to bottom) sand (10-15cm), fine gravel (70cm) and coarse gravel (25cm). The system usually contains drainage pipes that collect the water from the sludge. Free space of between 20 and 30cm is left above the filter for depositing the sludge. The main part of the treatment site can be made from compacted earth covered with a geotextile membrane or concrete to make it watertight. Two drying beds are usually required to ensure continuous sludge treatment.

• The main design criteria are (1) the quantity of sludge to be treated per year, (2) the quantity of solids contained in the sludge (for calculating the quantity of water to be removed), (3) the surface area of the drying bed, (4) recorded rainfall (which may mean a protective cover is required).

Care and maintenance

• *Main operating activities:* reapplication of fresh sludge every 10 days on average (between 7 to 14 days). After drying, the filter needs to be cleaned at the first sign of saturation, i.e. when the flow of water extracted from the sludge has slowed considerably in comparison to that seen when the filter was new. Quality controls (of leachate, sludge) should be conducted every three months. Drainage pipes needs to be checked to ensure water extracted from the sludge is being properly collected.

• *Main equipment and human resources required:* two operators are in charge of technical management of the site; a manager deals with administration; and a security guard is required to monitor the site. This system is relatively uncomplicated (less complex than a planted drying bed).

ADVANTAGES

- Can be constructed and repaired using locally available materials.
- Medium-level investment and operating costs.
- No electrical energy required.
- The solar drying bed is a system that can be developed over time (in line with the quantities of sludge to be treated).

DISADVANTAGES

- Large footprint.
- Long storage times.
- Presence of flies and smells.
- Requires expert design.
- Resulting dehydrated sludge requires secondary treatment.

LIMITATIONS

- Heavy rain will prevent the drying bed from functioning correctly (as the principle is to dry the sludge). It is therefore necessary to consider the recorded rainfall of the area. One possibility is to cover the drying bed with a transparent roof (for small treatment sites) to prevent flooding.
- For the same reason, the drying bed should be located in an area that is not prone to flooding.

FURTHER INFORMATION

Ref. 1: Montangero A., Strauss M., 2002, *Faecal sludge treatment*, IHE Delft.

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.117-118).

Ref. 3: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.107-108).

Planted drying bed

Planted drying beds treat the sludge obtained from pit emptying. This system uses a sand and gravel filter and the action of plants (macrophytes) and evapotranspiration to dry out the sludge and partially treat the residual water.

The sludge obtained as a result of this system needs to undergo further treatment that is less extensive than that required when using a solar drying bed, such as composting (T03). The resulting effluent must also be treated by anaerobic filter (T06), by anaerobic baffled reactor (T07), Imhoff tank (T08) or through means of a waste stabilization pond (T09), for example. This system can be used on either neighborhood or town scale.

PREREQUISITES

YES	NO	
☐	☐	The area of intervention is a small town (<50,000 habitants) or an urban neighborhood..
☐	☐	There is a local pit emptying service.
☐	☐	There is sufficient space available for creation of the treatment plant (50m²/1,000 inhabitants).
☐	☐	The plant will be located a sufficient distance away from, and upwind of, housing areas (to avoid bad smells).
☐	☐	There is an outlet after the drying bed for the evacuation of residual water.

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	High (good level of treatment, but final treatment required prior to using as fertilizer)
Investment costs	25-60 euro/household
Operating costs	2-4 euro/household/year
Design	High-level skills (technical engineering firm)
Operation	Low-level skills (people with little experience)

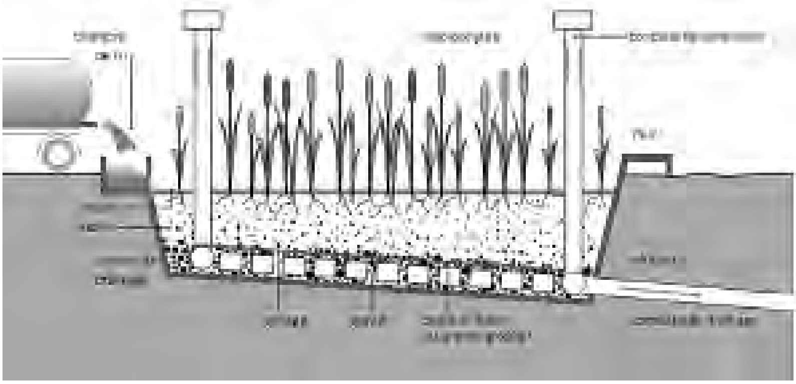


Diagram: Tilley Elisabeth, et al., 2008

Design and construction

• *A planted drying bed consists of* (1) a sludge discharge area, (2) a screening system for trapping large particles, (3) a filter composed of (from top to bottom) sand (10-15cm), fine gravel (70cm) and coarse gravel (25cm), (4) macrophytes such as reeds, cattails or rushes planted in the upper part of the filter, (5) vertical ventilation pipes providing optimum conditions for the development of the vegetation. The system usually contains drainage pipes that collect the water from the sludge. Free space of between 20 and 30cm is left above the filter for depositing the sludge.

• *The main design criteria are:* (1) the quantity of sludge to be treated per year, (2) the quantity of solids contained in the sludge (for calculating the quantity of water to be removed), (3) the surface area of the drying bed.

Care and maintenance

• *Main operating activities:* reapplication of fresh sludge once or twice a week and removal of sludge every 2 to 5 years. After drying, the filter needs to be cleaned at the first sign of saturation, i.e. when the flow of water extracted from the sludge has slowed considerably in comparison to that seen when the filter was new. Quality controls (of leachate, sludge) should be conducted every three months. Drainage pipes needs to be checked to ensure water extracted from the sludge is being properly collected.

• *Main equipment and human resources required:* two operators are in charge of technical management of the site; a manager deals with administration; and a security guard is required to monitor the site. This system is not particularly complex, but care needs to be taken to ensure that the plants are periodically thinned, which makes it more intensive than operating a solar drying bed.

FURTHER INFORMATION

Ref. 1: Montangero A., Strauss M., 2002, *Faecal sludge treatment*, IHE Delft.

Ref. 2: Philippines sanitation sourcebook and decision aid, WSP.

Ref. 3: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.85-93; design and sizing: pp.139-141).

Ref 4: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.119-120).

ADVANTAGES

- Can be constructed and repaired using locally available materials.
- Medium-level investment costs, low operating costs.
- No electrical energy required.
- This system can be developed over time (in line with the quantities of sludge to be treated).
- Better quality of sludge obtained than from a solar drying bed.

DISADVANTAGES

- Large footprint.
- Long storage times.
- Requires expert design.
- Resulting dehydrated sludge requires secondary treatment.
- Maintenance is more complex than for solar drying beds (thinning the filtering plants and planting new vegetation).

LIMITATIONS

- Heavy rain will prevent the drying bed from functioning correctly (as the principle is to dry the sludge). It is therefore necessary to consider the recorded rainfall of the area. One possibility is to cover the drying bed with a transparent roof (for small treatment sites) to prevent flooding.
- For the same reason, the drying bed should be located in an area that is not prone to flooding.

Composting

• Composting is an extensive utilization technique. This system is based on natural processes: the degradation of organics by microorganisms that destroy the pathogens contained in the sludge. The resulting compost provides nutrients to cultivated land, improves the retention properties of the soil and the storage of minerals. In contrast to chemical fertilizer, it enriches the soil.

• The sludge to be treated (which has already undergone treatment in a solar or planted drying bed) can be combined with organic matter from household waste or vegetation to optimize the composting process. There must be sufficient moisture levels to ensure decomposition in optimum conditions. Composting consists of several stages, during which different types of microorganisms break down the organic matter. The material to be composted is piled into heaps so there is little infrastructure required.

PREREQUISITES

YES	NO	
☐	☐	There is a low groundwater table.
☐	☐	There is sufficient water available in the area.
☐	☐	The composting site is located away from housing or against the wind (note: if the process is carried out correctly there should be no flies or smells).
☐	☐	There is an initial pretreatment system or one can be put in place (e.g. solar or planted drying bed).
☐	☐	There is an agricultural sector near the site interested in using the compost.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	High (possible to use treated sludge as fertilizer)
Investment costs	Medium-level cost for the construction of a composting site
Operating costs	2 to 4 euro/year/household for the operation of a composting site
Design	Low-level skills (simple construction and can be carried out locally)
Operation	Low-level skills (for pile turning, controlling moisture levels)

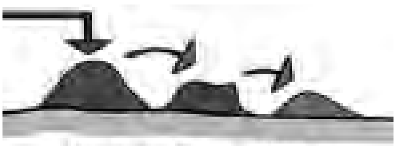


Diagram: from Strauss M., 2003

Photo: Strauss M., 2003

ADVANTAGES

- The composting platform can be constructed and repaired using locally available materials.
- Low investment and operating costs.
- Produces a natural resource that can be used as fertilizer.
- No electrical energy required.

DISADVANTAGES

- The process takes a long time to set up.
- Large footprint.
- System requires intensive monitoring.
- Flies and smells present if the process is not properly controlled.

LIMITATIONS

The use of compost from excreta and household waste can sometimes be seen as 'dirty' by households or farmers. Composting is only an option if the local population accepts the use of excreta in the cultivation of food products meant for human consumption.

Photo: Strauss M., 2003

Design and construction

- A composting platform consists of (1) a system for sieving household waste and/or grinding vegetation, (2) an area for mixing the sludge with lime or soda, (3) an area for turning the sludge piles during the composting process, (4) a system for recuperating the water that runs off the compost heaps (also called 'windrows').
- The main design criteria are the storage time, the composition of the sludge (nitrogen, carbon, and moisture), the humidity of the air, the amount of vegetable matter and/or biodegradable matter contained in household waste.

Care and maintenance

- *Main operating activities:* monitoring the temperature and moisture of the compost heaps, pile turning, taking chemical and microbiological measurements.
- *Main equipment and human resources required:* two people are in charge with operating the site; shovels or a tractor are required for pile turning.

FURTHER INFORMATION

Ref. 1: Strauss M., Drescher S., Zurbrügg C., Montangero A., Cofie O., Dreschel P., 2003, *Co-composting of faecal sludge and municipal organic waste*, IWMI, Eawag/Sandec.

Ref. 2: IWMI, Sandec, 2002, *Co-composting of faecal sludge and solid waste, Preliminary recommendations on design and operation of co-composting plants based on the Kumasi Pilot Investigation.*

Ref. 3: Aalbers H., 1999, *Resource recovery from faecal sludge using constructed wetlands, A survey of the literature*, UWEP/WASTE.

Ref. 4: NWP, ICCO, 2006, *Des solutions adaptées pour l'assainissement - Exemple de technologies innovantes à faible coût pour la collecte, le transport, le traitement et la réutilisation des produits de l'assainissement*, NWP.

Ref. 5: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.108-109).

Upflow Anaerobic Sludge Blanket Reactor

UASB Reactors are intensive wastewater treatment systems. They have only a small footprint. The wastewater to be treated circulates in the reactor, flowing upwards through suspended sludge granules. The wastewater is treated by microorganisms contained in the sludge. This technology is particularly suitable for pretreating pit sludge (which needs to be pre-diluted), but it is also possible to use this system for treating liquid effluent from sewerage systems.

This technology provides better quality effluent than a septic tank, but this effluent will need to undergo subsequent treatment (a large amount of pathogens remain) in a waste stabilization pond, for example. The biogas produced during treatment can be used as a source of energy.

PREREQUISITES

YES NO

- ☐ ☐ There is a constant source of electricity.
- ☐ ☐ There is a constant supply of water.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	High (high level of treatment of organic load)
Investment costs	200 to 1,000 euro/household for the construction of a UASB Reactor
Operating costs	5 to 50 euro/year/household for the operation of a UASB Reactor
Design	High-level skills (for the design, sizing and construction)
Operation	High-level skills (for chemical controls and monitoring)

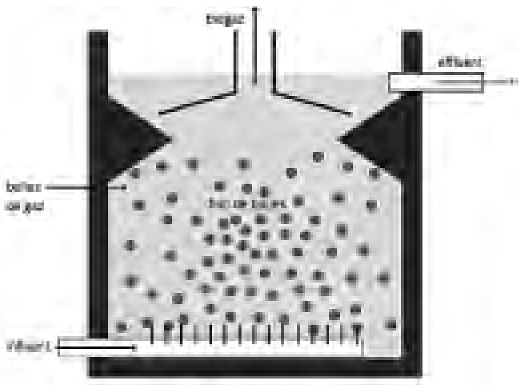


Diagram: Tilley et al., 2008

Design and construction

• A UASB Reactor consists of (1) a wastewater inlet at the base of the reactor, (2) a sludge blanket comprised of granules of between 0.5 and 2mm in diameter that contain microorganisms (the balance between the wastewater upflow rate and the sludge sedimentation rate means the granules remain suspended), (3) baffles preventing the sludge granules from reaching the biogas collection dome, (4) a dome for collecting the biogas, formed as a result of microorganisms degrading the organic matter (the gas bubbles also ensure the fluidization and mixing of the sludge), (5) an outlet pipe above the baffles for the treated water.

• The main design criteria are (1) the retention time in the reactor, (2) the flow of the wastewater to be treated and its composition, (3) the composition of the sludge treating the wastewater.

Care and maintenance

• *Main operating activities:* removing excess sludge every 2 to 3 years, monitoring the composition of the treated water and the biogas.

• *Main equipment and human resources required:* two operators are in charge of technical management of the site.

ADVANTAGES

- Small footprint.
- No mechanical equipment required.
- Infrequent sludge removal required.
- Stability of resulting sludge.
- Produces biogas.
- High reduction in organics.
- Able to withstand high organic loading rates.

DISADVANTAGES

- Smells are possible.
- Low tolerance of toxic elements.
- Long start up time.
- Difficult to maintain proper hydraulic conditions.
- Constant source of energy is required.

FURTHER INFORMATION

Ref. 1: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA, (technical description: pp.78-79).

Ref. 2: Mara D., 2003, *Domestic Wastewater treatment in Developing Countries*, Earthscan ed. (technical description and design: pp.200-206).

Ref. 3: Méndez J., Pardo L.P., Rivera M., Miranda L., Vera R., Moya L., Mairena R., 2008, *Edici n especial de saneamiento integral,* CHAC, Red de agua y saneamiento de Honduras.

Ref. 4: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.111-112).

Anaerobic Biogas Reactor

Anaerobic Biogas Reactors are used for the anaerobic treatment of fecal sludge and produce biogas, a gas that can be used to produce electricity for cooking, for example. This system produces effluent that requires secondary treatment.

PREREQUISITES

YES	NO	
☐	☐	The biogas can be reused at a distance of within 10m of the reactor.
☐	☐	There is a non-rocky layer several meters deep.
☐	☐	There is a local pit emptying service (or one can be set up).
☐	☐	There is a subsequent system in place for treating or using the resulting sludge.

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	High (high level wastewater treatment; utilization of biogas)
Investment costs	200 to 600 euro/household for the construction of an anaerobic biogas reactor
Operating costs	5 to 10 euro/year/household for the operation of an anaerobic biogas reactor. Savings then made through the utilization of biogas.
Design	High-level skills (for the design, sizing and construction)
Operation	Low-level skills (for maintenance and emptying)

ADVANTAGES

- Can be constructed and repaired using locally available materials.
- Produces energy.
- Medium investment costs, low operating costs.
- System has a long lifespan.
- Small footprint.

DISADVANTAGES

- High-level skills required for design and construction.
- Sludge and effluent require further treatment.
- Risks associated with the production of biogas.

Photo: Sasse L., 1998

Design and construction

• Anaerobic biogas reactors consist of (1) a mixing chamber into which the sludge is placed and mixed with water (the ratio of excreta to water is between 1/3 and 2), (2) a digestion chamber (equipped with a biogas outlet pipe) which receives the sludge mixed with water, (3) an expansion chamber that collects the excess sludge and/or slurry, (4) a small diameter pipe to extract the resulting effluent.

• The main design criteria are (1) the retention time in the digestion chamber, (2) the quantity of wastewater to be treated per day, (3) the composition of the blackwater and/or sludge to be treated.

Care and maintenance

• *Main operating activities:* controlling the large particles in the sludge, checking the supply of sludge, controlling the water separator, checking renewal of the water seal, checking sludge levels, regularly emptying the reactor, testing the pressure of the installations.

• *Main equipment and human resources required:* one operator is in charge of the daily technical management of the site; a second person is responsible for emptying the reactor.

Variations and upgrades

There are different types of biogas reactor that can be employed depending on the context, the means available and the sludge to be treated. Please see Reference 2, in particular.

FURTHER INFORMATION

Ref. 1: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.83-84 and 116-122; design and sizing: pp.136-139).

Ref. 2: Kossmann W., Pönitz U., 1998, B*iogas digest Volume II, Biogas – Application and product development,* ISAT, GTZ (design and sizing: pp.39-40).

Ref. 3: Koottatep S., Ompont M., Joo Hwa T., 2004, *Biogas: A GP option for community development, Asian Productivity organization*, Japan.

Réf. 4: NWP, ICCO, 2006, *Des solutions adaptées pour l'assainissement, Exemple de technologies innovantes à faible coût pour la collecte, le transport, le traitement et la réutilisation des produits de l'assainissement.*

Ref. 5: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.123-124).

Ref. 6: Marchaim U., 1994, *Les procédés de production de biogaz pour le développement de technologies durables*, FAO.

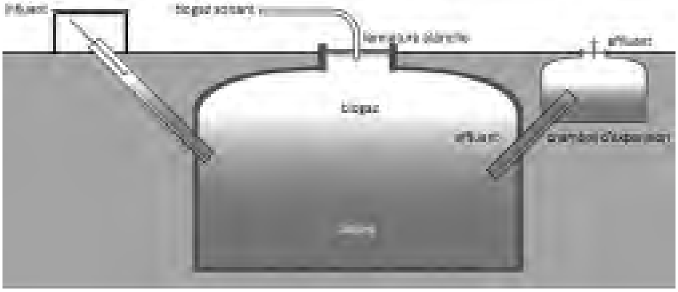


Diagram: Tilley E., et al., 2008

Anaerobic Filter

The anaerobic filter is a treatment system based on the natural degradation process of organic matter by microorganisms that form a layer on the filter (or 'biofilm'). It works by isolating the unsettleable particles and dissolved solids.

The water obtained from the anaerobic filter can be reused for irrigation (according to WHO standards, cultivated fields can be irrigated using water treated by anaerobic filter) or be infiltrated into the soil. The sludge that accumulates in the filter needs to be regularly cleaned out and treated.

PREREQUISITES

YES NO

☐ ☐ There is sufficient water available and the quantity of water consumed is over 50L/person/day.

☐ ☐ There is a local pit emptying service or a sewerage system that serves the site of the anaerobic filter.

☐ ☐ Water can subsequently be used for irrigation or pass through infiltration trenches.

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years (hardy and robust system)
Efficiency	High (good level of treatment)
Investment costs	150 to 400 euro/household for the construction of an anaerobic filter
Operating costs	2 to 4 euro/year/household for the operation of an anaerobic filter
Design	High-level skills (engineering firm specializing in sanitation)
Operation	High-level skills (qualified and experienced people)

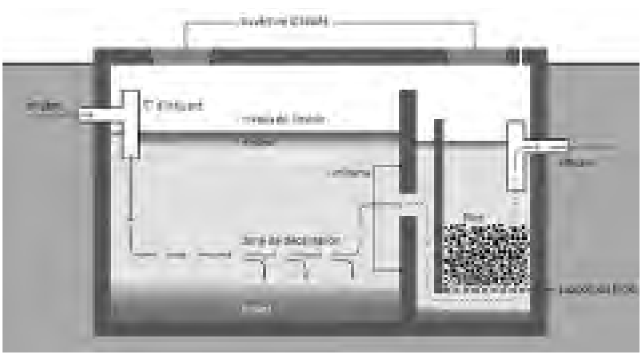


Diagram: Tilley Elisabeth, et al., 2008

Design and construction

• Anaerobic filters consist of gravel and stones, cinder or plastic pieces designed specifically for the filter. 2 to 3 layers of filtering materials are recommended, with a minimum depth of between 0.8 and 1.2m; the filter should be covered with at least 0.3m of liquid. The footprint is estimated to be around $0.5m^2$/person.

• The main design criteria are (1) the quantity of wastewater to be treated, (2) the materials used for the filter, (3) the retention time of water in the system.

Care and maintenance

• *Main operating activities:* vchecking the level of water above the filter once a day, cleaning the filter once every two years when it becomes too thick (the 'biofilm' takes 6 to 9 months to form before becoming completely effective) and replacing the filter once it becomes too difficult to clean.

• *Main equipment and human resources required:* one operator is in charge of the technical management of the filter (the tasks involved in cleaning the filter are complex).

Variations and upgrades

Anaerobic filters can be used in conjunction with anaerobic baffled reactors (T07) for the complete treatment of wastewater, which can then be discharged in accordance with current standards.

Photo: Sasse L., 1998

ADVANTAGES

• No electrical energy required.
• Can be constructed and repaired using locally available materials.
• This system has a long lifespan.
• Medium investment costs, low operating costs.
• Efficient system for reducing BOD* and solids.
• Small footprint.

DISADVANTAGES

• High-level skills required for design and construction.
• Consumes high levels of water.
• Long start up time (treatment is effective after 6 to 9 months).

FURTHER INFORMATION

Ref. 1: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.75-78; design and sizing: pp.131-133).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.97-98).

Ref. 3: Morel A., Diener S., 2006, *Greywater management in low and middle-income countries, EAWAG* (technical description: pp.28-30).

Ref. 4: WHO, 2006, *WHO guidelines for the safe use of wastewater, excreta and greywater*, Volume IV Excreta and greywater use in agriculture.

Anaerobic Baffled Reactor

Anaerobic baffled reactors work on the same principle as septic tanks, but provide improved treatment because of the series of baffles they contain. This system is a form of anaerobic treatment. The baffles lead to increased contact between the microorganisms and the wastewater to be treated.

The resulting effluent requires further treatment by an anaerobic filter (T06), for example, placed downstream from this technology. Sludge produced by the anaerobic baffled reactor also needs to be treated, using drying beds (T01 and T02) and composting (T03) or by an anaerobic biogas reactor (T05).

PREREQUISITES

YES	NO	
☐	☐	The quantity of water to be treated is between 1,000 and 200,000L/day.
☐	☐	There is a subsequent system in place for treating or using the resulting sludge.

! If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	High (high level of wastewater treatment)
Investment costs	150 to 400 euro/household for the construction of an anaerobic baffled reactor
Operating costs	2 to 4 euro/year/household for the operation
Design	High-level skills (for the design, sizing and construction)
Operation	Low-level skills (for maintenance and emptying)

ADVANTAGES

- Can withstand variations in inflow.
- Small footprint.
- No electrical energy required.
- Can be constructed and repaired using locally available materials.
- Long lifespan.
- No smells.
- High reduction of organic matter.

DISADVANTAGES

- Complex design.
- Long start up time (3 to 6 months).
- High investment costs.

Diagram: Kopitopoulos D ., 2005

Design and construction

• An anaerobic baffled reactor consists of (1) a first chamber (which receives the wastewater through a T-shaped pipe) that allows sludge to settle on the bottom and a scum of oils and grease to form on the surface; this chamber is equipped with a ventilation pipe that eliminates the gas created by the anaerobic bacteria, (2) (at least 3) chambers separated by baffles, the last of these is equipped with an effluent outlet pipe connected to an infiltration or sewerage system.

• The main design criteria are: (1) the retention time in the reactor, (2) the quantity of wastewater to be treated per day.

Care and maintenance

• *Main operating activities:* checking the level of solids in the reactor, emptying the pit (once every 3 years).

• *Main equipment and human resources required:* two operators are in charge of the technical management of the site.

Variations and upgrades

To ensure complete wastewater treatment, an anaerobic filter can be constructed after the anaerobic baffled reactor (see factsheet T06).

FURTHER INFORMATION

Ref. 1: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.79-82; design and sizing: pp.134-136).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: pp.95-96).

Ref. 3: Morel A., Diener S., 2006, *Greywater management in low and middle-income countries, EAWAG* (technical description: pp.26-27).

Ref. 4: Unesco, Unep, http://www.training.gpa.unep.org.

Ref. 5: Foxon KM., Pillay S., Lalbahadur T., Rodda N., Holder F., Buckley CA., 2004, *The anaerobic baffled reactor (ABR): An appropriate technology for on-site sanitation*, pp.44-50.

Ref. 6: Marchaim U., 1994, *Les procédés de production de biogaz pour le développement de technologies durables*, FAO.

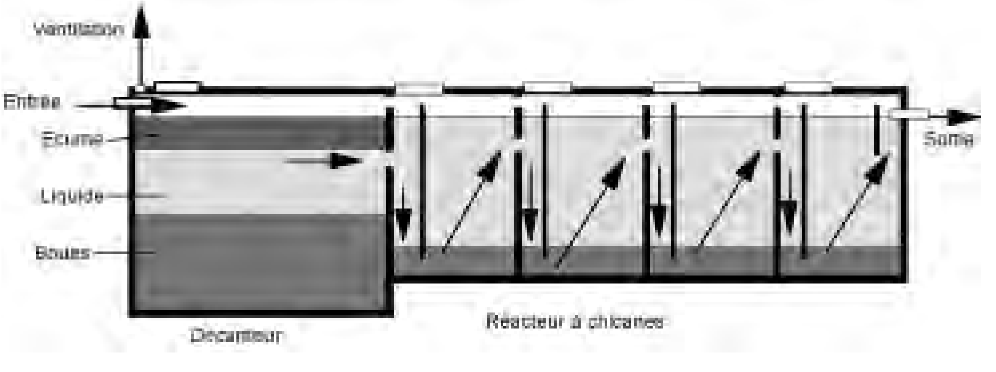


Diagram: from Sasse L., 1998

Imhoff Tank

Imhoff tanks are systems used for pretreating wastewater. They are, in effect, improved septic tanks in that they prevent solids from being suspended in the effluent once this has been treated by the tank.

This system needs to be followed by another technology (anaerobic filter (T06), for example) to ensure the water has undergone sufficient treatment. The sludge that forms in the tank also needs secondary treatment using a drying bed (T01 and T02), composting (T03) or anaerobic biogas reactor (T05).

PREREQUISITES

YES	NO	
☐	☐	The area of intervention contains a maximum of 1,000 inhabitants.
☐	☐	There is a subsequent system in place for treating the pretreated water coming from the Imhoff tank.
☐	☐	There is a subsequent system in place for treating or using the resulting sludge.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	High (high level of wastewater treatment)
Investment costs	150 to 400 euro/household for the construction of an Imhoff tank
Operating costs	2 to 4 euro/year/household for the operation and regular emptying
Design	High-level skills (for the design, sizing and construction)
Operation	High-level skills (for maintenance and emptying)

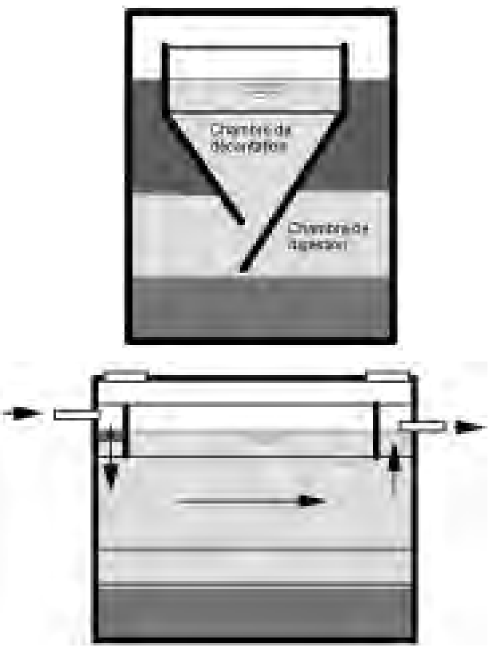


Diagram: from Sasse L., 1998

Design and construction

• An Imhoff tank consists of (1) a V-shaped settling chamber that receives the wastewater and from which the sludge slides down the bottom slope into, (2) a digestion chamber that is located beneath the settling chamber and receives the sludge from the settling chamber, (3) gas and water vent located either side of the settling chamber, (4) a sludge outlet pipe leading out of the digestion chamber.

• The main design criteria are (1) the retention time in the tank, (2) the quantity of wastewater to be treated per day and its composition.

Care and maintenance

• *Main operating activities:* removing grease, scum and solids from the air vents, cleaning the sides and the slot in the settling chamber, controlling the scum level, removing the sludge, cleaning out the sludge outlet pipe.

• *Main equipment and human resources required:* two operators are in charge of the technical management of the site.

ADVANTAGES

• Small footprint.

• More efficient than a septic tank.

• No smells.

DISADVANTAGES

• Requires regular maintenance.

• Wastewater requires secondary treatment.

• Medium investment and operating costs.

FURTHER INFORMATION

Ref. 1: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries,* BORDA (technical description: pp.73-75; design and sizing: pp.129-130).

Ref. 2: WSP., GTZ., AusAid., 2005, Philippines Sanitation *Sourcebook and decision aid - Water supply and sanitation Performance Enhancement Project*, WSP-EAP.

Ref. 3: Alexandre O., Boutin C., Duchène P., Lagrange C., Lakel A., Liénard A., Orditz D., 1997, *Filières d'épuration adaptées aux petites collectivités*, Ministère de l'Agriculture et de la Pêche.

Ref. 4: http://water.me.vccs.edu/courses/ENV149/Imhoffb.htm

Waste Stabilization Ponds

The waste stabilization pond treats the wastewater naturally through the action of the sun's rays and vegetation. This technology uses macrophytes (floating vegetation, such as duckweed, or planted vegetation, such as water hyacinth) or microphytes (algae). Waste stabilization ponds with macrophytes are more appropriate for wastewater with high levels of solids and phosphorus; waste stabilization ponds with microphytes are more suitable for treating water high in pathogens. Wastewater entering a waste stabilization pond needs to have been pretreated using a grease trap and/or a settled sewerage system.

The treated water can either be discharged downstream or used for irrigation or aquaculture.

PREREQUISITES

YES NO
- ☐ ☐ The quantity and composition of the wastewater to be treated has been established or can be established.
- ☐ ☐ There is sufficient space available for the construction of a waste stabilization pond (minimum of 1m²/inhabitant).
- ☐ ☐ The stabilization pond is located away from housing or against the wind (note: if the process is carried out correctly there should be no flies or smells).
- ☐ ☐ It is possible to put in place a system for treating the sludge that forms in the ponds.

❗ If you answered 'no' to at least one of these questions, this technology is not suitable for your area of intervention. Please refer back to the decision-making process at technology or chain level.

GENERAL CHARACTERISTICS

Lifespan	25-50 years
Efficiency	High (possible to use the treated water in agriculture)
Investment costs	15 to 100 euro/household for the construction of a waste stabilization pond
Operating costs	5 to 50 euro/year/household for the operation of a waste stabilization pond
Design	High-level skills for the design; can be constructed locally
Operation	Low-level skills (prior training required for monitoring and maintenance)

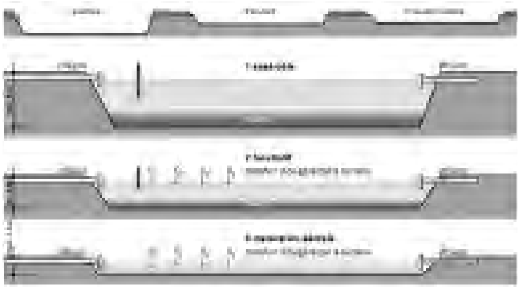


Diagram: Tilley E. et al., 2008

Photo: Maiga A. H. et al., 2002

Design and construction

• A waste stabilization pond system consists of (1) an interceptor to trap large particles, (2) a grease trap to remove oils and grease, (3) a deep anaerobic pond (over 2.5m deep) to remove solids and organic matter, (4) a facultative pond (between 1 and 2m deep) to remove pathogens and minerals, (5) a maturation pond (between 1 and 2m deep) to complete the treatment.

• The main design criteria are the quantity of wastewater to be treated and its composition, total retention time in the system, the depth of the different ponds, the type of vegetation used, the average temperature of the coldest month.

• **Attention:** waste stabilization ponds are considered a simple technology to size and operate. Nonetheless, it is not rare to see waste stabilization pond systems that no longer work due to poor sizing and/or lack of sufficient maintenance.

Care and maintenance

• *Main operating activities:* monitoring the quality of effluent, measuring the rate of flow, maintaining the vegetation (algae, floating or planted vegetation) and regular sludge removal.

• *Main equipment and human resources required:* two people are in charge of operating the site.

ADVANTAGES

- Very efficient at removing pathogens.
- Can be constructed and repaired using locally available materials.
- Low investment costs (but these are linked to the cost of land).
- No electrical energy required.

DISADVANTAGES

- Long start up time.
- Has a very large footprint.
- System requires very regular monitoring and maintenance.
- Sludge requires secondary treatment (solar or planted drying bed, plus composting).
- Possible to utilize the effluent, but only under certain conditions.
- Presence of smells and flies if the process is not properly controlled.

FURTHER INFORMATION

Ref. 1: Sasse L., 1998, *DEWATS Decentralised Wastewater Treatment in Developing Countries*, BORDA (technical description: pp.95-103; sizing: pp.141-146).

Ref. 2: Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, *Compendium of sanitation systems and technologies, EAWAG* (technical description: p.99-100).

Ref. 3: Mara D., 2003, *Domestic Wastewater treatment in Developing Countries,* Earthscan ed. (technical description: pp.85-157; design and sizing: pp.158-174; maintenance: pp.175-187).

Ref. 4: Seidl M., Mouchel J-M., 2003, Action A10 - Rapport final - *Valorisation des eaux usées par lagunage dans les pays en voie de développement- Bilan et enseignements pour une intégration socio-économique viables*, Cereve.

Ref. 5: Maiga A H., Wethe J., Dembele A., Klutse A ., 2002, *Action A10 - Rapport final - Valorisation des eaux usées par lagunage dans les pays en voie de développement,* EIER.

Ref. 6: Maiga A. H., Wethe J., Dembele A.., Kluste A., 2002, *Action A10 - Volume 2: monographie des stations étudiées*, EIER-ETSHER.

ANNEX 1

Example of a table for characterizing areas (to be completed)

Criteria		Questions
PHYSICAL	**Soil type**	Does the soil enable the absorption of wastewater and excreta in the area of intervention?
		Is the soil rocky?
	Groundwater table	Is there a groundwater table near the surface? At what depth?
	Topography	Is the gradient sufficient to enable the gravitational flow of effluent?
		Is there a natural outlet downstream of the area (river, stormwater system, etc.)?
URBAN	**Population density**	What is the population density?
	Available surface area	Does the population have sufficient surface area in their homes (in the house or yard) to install a system that provides access to sanitation?
	Land status	Is this area a planned or unplanned settlement? (i.e.: has the land status been secured?)
SOCIO-ECONOMIC	**Water consumption**	What is the level of household water consumption?
	Local investment capacity	What level of investment can be mobilized?
	Local technical skills	What level of local technical skills is available for building the infrastructure? For operating the facilities?
	Local financial management skills	What level of local financial management skills is available?

Example of a table for characterizing areas (to be completed)

AREA OR NEIGHBORHOOD	AREA OR NEIGHBORHOOD 2	AREA OR NEIGHBORHOOD 3	ETC.
☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO	...
☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO	...
☐ YES ☐ NO Depth: ...... meters	☐ YES ☐ NO Depth: ...... meters	☐ YES ☐ NO Depth: ...... meters	...
☐ YES (> 1 % (1m/100 m) ☐ NO (< 1 %)	☐ YES (> 1 % (1m/100 m) ☐ NO (< 1 %)	☐ YES (> 1 % (1m/100 m) ☐ NO (< 1 %)	...
☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO	...
☐ Low (< 16,000 inhab./km^2) ☐ High (> 16,000 inhab./km^2)	☐ Low (< 16,000 inhab./km^2) ☐ High (> 16,000 inhab./km^2)	☐ Low (<16,000 inhab./km^2) ☐ High (>16,000 inhab./km^2)	...
☐ Small: < 2 m^2 ☐ Average: between 2 m^2 and 20 m^2 ☐ Large: > 20 m^2	☐ Small: < 2 m^2 ☐ Average: between 2 m^2 and 20 m^2 ☐ Large: > 20 m^2	☐ Small: < 2 m^2 ☐ Average: between 2 m^2 and 20 m^2 ☐ Large: > 20 m^2	...
☐ Planned ☐ Unplanned	☐ Planned ☐ Unplanned	☐ Planned ☐ Unplanned	...
☐ Low: < 30 l/d/inhab. ☐ Average: between 30-50 l/d/inhab. ☐ High: > 50 l/d/inhab.)	☐ Low: < 30 l/d/inhab. ☐ Average: between 30-50 l/d/inhab. ☐ High: > 50 l/d/inhab.)	☐ Low: < 30 l/d/inhab. ☐ Average: between 30-50 l/d/inhab. ☐ High: > 50 l/d/inhab.)	...
☐ Low: < 200 €/household ☐ Average: >30l/d/inhab. and <80 l/d/inhab. ☐ High: > 500 €/household	☐ Low: < 200 €/household ☐ Average: >30l/d/inhab. and <80 l/d/inhab. ☐ High: > 500 €/household	☐ Low: < 200 €/household ☐ Average: >30l/d/inhab. and <80 l/d/inhab. ☐ High: > 500 €/household	...
☐ Low ☐ High	☐ Low ☐ High	☐ Low ☐ High	...
☐ Low ☐ High	☐ Low ☐ High	☐ Low ☐ High	...

ANNEX 2

Example of a Summary Table of the chains and technical solutions selected (to be completed)

Direction of the planning process →

STEP 1	STEP 2	STEP 3	
AREA	CHAIN SELECTED	SEGMENT	APPROPRIATE TECHNOLOGICAL SOLUTION(S)[1]
AREA 1		Access	
		Evacuation	
		Treatment	
AREA 2		Access	
		Evacuation	
		Treatment	
AREA 3		Access	
		Evacuation	
		Treatment	
Etc.	...	...	...

[1] It is possible to select several technological solutions for a segment in any given area (in particular for the Access segment so that households are given the choice of facilities they wish to use).

Technical glossary

Aerobic the aerobic processes considered here involve the breaking down of organic matter into simpler components in the presence of oxygen (O_2).

Anaerobic the anaerobic processes considered here involve the breaking down of organic matter by microorganisms in the absence of oxygen (O2), producing gases such as methane.

Blackwater this is a mixture of excreta (urine + feces) and flush water (for flush toilets), water and materials used for anal cleansing (toilet paper, etc.). This can also be called 'sewage'.

BOD Biochemical Oxygen Demand (also known as Biological Oxygen Demand). This is a procedure for measuring the quantity of oxygen (O2) used by bacteria to break down organic matter in a given sample of wastewater (expressed in mg/L, for a sample incubated at 20°C for 5 days). The BOD therefore provides a measurement of the degree of organic pollution of a sample of wastewater.

Chain the wastewater and excreta sanitation chain refers to all the steps that need to be followed to ensure complete and effective sanitation management, from the collection of wastewater at household level through to its final treatment, following its evacuation from residential areas. A distinction is made between on-site sanitation (toilet – pit emptying – sludge treatment), conventional sewerage systems (toilet – conventional sewerage system – wastewater treatment) and the small-piped sewerage system sanitation chain (toilet – small-piped system - treatment).

Clogging this is where the pipes of a sewerage system can become blocked due to the build-up of solid matter and/or grease on the inside of the pipes.

Disposal this relates to the emptying of sludge from a vacuum truck (or tank-cart).

Effluent this is a liquid resulting from the storage (Access segment) or treatment (Disposal/Treatment) of wastewater and excreta that has already undergone partial or complete treatment. Depending on the level of treatment already applied, it can be used or discharged, or have to undergo further treatment.

Excreta excreta is a combination of urine and excrement (feces).

Greywater this is water used in domestic activities such as washing up, cooking, laundry and bathing.

Leaching the influx of a large quantity of water (due to flooding or heavy rain) into a treatment pond (a waste stabilization pond, for instance) can heavily dilute the bacteria used to treat the wastewater. If this level of dilution is too great, the treatment will no longer be efficient (not enough bacteria remain).

Technical glossary

Outlet	a place used for the final discharge of wastewater. This can be a natural outlet (river, lake, irrigation channel, etc.) or a sewerage system that transports the wastewater to a treatment plant or natural outlet.
Pathogenic bacteria	a microbes or micro-organisms that can cause disease.
Segment	the sanitation chain is divided into three successive segments: (1) Access - the collection of wastewater and excreta, (2) Evacuation - the evacuation of wastewater and excreta, and (3) Disposal/Treatment - the treatment/utilization of wastewater and excreta.
Sludge	this is the solid or liquid matter removed from wastewater and excreta storage pits/tanks (Access segment). It can have undergone partial treatment during storage, or be untreated.
Wastewater	this is a general term to refer to all water used in domestic activities (greywater + blackwater).

ANNEX 4

Bibliography

GUIDES FOR NORTHERN COUNTRIES

Agence de l'eau Artois-Picardie, *Guide de l'assainissement des communes rurales.*

Agence de l'eau Rhin-Meuse, 2007, *Les procédés d'épuration des petites collectivités du bassin Rhin-Meuse.*

Alexandre O. et al, 1997, *Filières d'épuration adaptées aux petites collectivités, Ministère de l'Agriculture et de la Pêche.*

CAUE de l'Ardèche, 2002, *L'assainissement communal, Guide des procédures à l'usage des maires.*

Commission Européenne, 2001, *Procédés extensifs d'épuration des eaux usées adaptés aux petites et averagenes collectivités (500-5000 eq-inhab.).*

Eisenbeix P., 1998, *Etudes préalables au zonage d'assainissement, Guide méthodologique à l'usage des techniciens*, Ministère de l'Agriculture et de la Pêche.

Morissette M., 2007, *Traitement des eaux usées des résidences isolées, Partie A et Partie B, Direction des politiques de l'eau,* Service des eaux municipales.

Satin M., Selmi B., 2006, 3e éd., *Guide technique de l'assainissement,* Ed. Le moniteur, Coll. Moniteur Référence Technique.

GENERAL GUIDES FOR SOUTHERN COUNTRIES

Action Contre la Faim, 2006, *Eau-Assainissement-Hygiène pour les populations à risques.*

Agudelo C., Mels A., Braadbart O., 2007, *Multi-criteria framework for the selection of urban sanitation systems*, 2nd SWITCH Scientific Meeting.

De Lavergne C., Gabert J., 2005, *Monter un projet d'assainissement dans les quartiers urbains pauvres de pays en développement: une autre approche. Pistes de réflexion pour les monteurs de projets,* Experians.

Frias J., Mukherjee N., 2005, *Harnessing Market Power for Rural Sanitation, Private sector delivery in Vietnam, Water and Sanitation Program*, Field Note.

www.netssaftutorial.com

Kopitopoulous D., 2005, *Guide pour l'assainissement liquide des douars marocains*, Office Nationale de l'Eau Potable, Banque mondiale.

Mara D., 1996, Low-cost urban sanitation, Department of Civil Engineering, University of Leeds, U.K.

Mara D., Sleigh A., Tayler K., 2001, *PC-based Simplified Sewer Design*, University of Leeds, GHK Research&training.

Martin, E.J, *Technologies for small water and wastewater systems,* Environmental Engineering series.

Bibliography

Mehta M., 2008, *Assessing microfinance for water and sanitation*, exploring opportunities for scaling up, Bill & Melinda Gates Foundation.

Parkinson J., Tayler K.,Colin J., Nema A., 2008, *Technology options for Urban Sanitation in India*, Water and sanitation program (WSP), Government of India.

Paterson C., Mara D., Curtis T., 2006, *Pro-poor sanitation technologies, Geoforum* 2007, Elsevier.

Sannan D., Moulik S-G., 2007, *Community-Led Total Sanitation in Rural Areas, An approach that work*, Water and Sanitation Program, Field note.

Tilley E., Lüthi C., Morel A., Zurbrügg C., Schertenleib R., 2008, Compendium des systèmes et technologies d'assainissement, EAWAG.

RéFEA, Réseau Francophone sur l'Eau et l'Assainissement, www.oieau.fr/ReFEA

Valiron F., *Manuel d'assainissement spécifique pour les pays à faible revenu*, Agence de coopération culturelle et technique, Presses Universitaires de France.

Vesilind P.A., Pierce J.J., Weiner W.F., 1994, *Environmental Engineering, Third Edition*, Ed. Butterworth-Heinemann.

WASTE, 2006, *Des solutions adaptées pour l'assainissement, Exemple de technologies innovantes à faible coût pour la collecte, le transport, le traitement et la réutilisation des produits de l'assainissement*, NWP, ICCO.

WSP., GTZ., AusAid., 2005, *Philippines Sanitation Sourcebook and decision aid, Water supply and sanitation Performance Enhancement Project*, WSP-EAP.

WSP-EAP., 2002, *Selling Sanitation in Vietnam, What Works?*, Water and Sanitation Program East Asia and the Pacific.

GUIDES RELATING TO SPECIFIC TECHNOLOGICAL GROUPS

Sanitation overviews

Albigès L., 2009, *Gestion des déchets et assainissement à Fada N'Gourma: deux réalités, un récit*, Etude et travaux n° 20.

Bouju J. et al, 2002, *Une anthropologie de la fange, conception culturelles, pratiques sociales et enjeux institutionnels de la propreté urbaine à Ouagadougou et Bobo-Dioulasso*, SHADYC, Programme de gestion durable des déchets et de l'assainissement urbain.

Deutch J.C., Tassin B., 2000, *Instruction technique relatives aux réseaux d'assainissement des agglomérations*, ENPC, CEREVE.

Granier A-L., Issouf H., Hochet P., 2007, De la cour à la rue. Ethnographie de l'assainissement dans deux petites villes du Burkina Faso (Réo, Boromo), Etude et travaux n° 16.

Morella E., Foster V., Beenerjee G., 2008, L'état de l'assainissement en Afrique subsaharienne, Diagnostic infrastructures nationales Afrique, Résumé du document de référence 13.

Guides relating to the collection and storage of wastewater and excreta

Alves Miranda L., 2008, *Etude des latrines/douches publiques et des latrines institutionnelles au Burkina Faso*, Hydroconseil, 51 p.

Department: Water affairs and forestry, 2002, *Sanitation technology options.*

Esrey S., et al., 1998, Assainissement écologique, Sida.

Franceys R., Pickford J., Reed R., 1995, *A guide to the development of on-site sanitation, Water engineering and Development Centre*, Loughborough University of Technology, WHO.

Jha P.K., 2005, *Sustainable technologies for on-site human waste and wastewater management: Sulabh experience*, Workshop on sanitation and water management, ADB.

Morgan P., *Latrine à compost, Des latrines hygiéniques à faible coût qui produisent du compost pour l'agriculture dans un contexte africain*, CREPA, EcosanRes.

Obika A., *Catalogue of low-cost toilet options, social marketing for urban sanitation*, DFID.

Parry-Jones S., 2005, *On-site sanitation in areas with a high groundwater table*, www.lboro.ac.uk/well/resources

Reiff S., Clégbaza M-G., 1999, *L'expérience PADEAR au Bénin des latrines familiales no-subventionnées, le marketing social et a promotion du petit secteur privé*, Programme pour l'eau et l'assainissement, Note d'information.

Roberts M., Long A., 2007, *Demand assessment for sanitary Latrines in rural and urban areas of Cambodia*, Initiative Development Enterprises.

Roberts M., Long A., 2007, *Supply chain assessment for sanitary latrines, in rural and urban areas of Cambodia*, Initiative Development Enterprise.

WSP, 2005, *A review of EcoSan experience in Eastern and Southern Africa*, Water and Sanitation Program Africa.

WSP, MDR, 2009, *Latrine construction manual, a guide to constructing a latrine prescribed in informed choice manual on rural household latrine selection*, Second Edition.

Guides relating to sewerage systems

Bakalian A., Wright A., Otis R., Netto J.A., 1994, *Simplified sewerage design*, UNDP-WB, Water and Sanitation Program.

Melo J-C., 2007, *La ciudad y el saneamiento - Sistemas condominiales: Un enfoque diferente para los desagüës sanitarios urbanos*, WSP.

RPS pour le MAINC, 2000, *Réseaux d'eau communautaires, Guide d'information technique.*

Steiner M., *Evaluation des égouts faibles diamètre dans des quartiers défavorisés de Bamako au Mali*, EPFL.

Guides relating to sludge

Klingel F., Montangero A., Koné D., Strauss M., 2002, La gestion des boues de vidange dans les pays en développement, manuel de planification, EAWAG, SANDEC.

Klutse A., Ouattara R., Tandia C . T., 2004, Etude comparative des modes de gestion des boues de vidange en Afrique de l'Ouest, Analyse des problèmes et recommandations, Crepa.

Kone D., 2009, La situation et les défis de la gestion des boues de vidange, EAWAG, Présentation à AAA.

Maria S. Muller, Rijnsburger J., 1992, MAPET, A neighbourhood based pit emptying service with locally manufactured handpump equipment in Dar es Salaam, Tanzania, WASTE.

Steiner M., 2006, Initiatives prometteuses pour une gestion des boues de vidange, EAWAG, SANDEC Symposium, Dakar.

Yoke P. T., R. Templeton M., Mansoor A., 2009, Pit latrine emptying: technologies, challenges and solutions, EWB-UK Research Conference.

Guides relating to treatment and subsequent utilization

Koné D., 2002, *Epuration des eaux usées par lagunage à microphytes et à macrophytes (Pistia Stratiotes) en Afrique de l'Ouest et du Centre: Etat des lieux, performances épuratoires et critères de dimensionnement*, Ecole polytechnique fédérale de Lausanne.

Koné D., Seignez C., Holliger C., 2002, *Etat des lieux du lagunage en Afrique de l'ouest et du centre*, EIER, Laboratoire de Biotechnologie Environnementale, Ecole polytechnique fédérale de Lausanne.

Le Blanc R. J., Matthews P., Richard R. P., 2006, *Global atlas of excreta, wastewater, sludge and biosolids management: moving forward the sustainable and welcome uses of a global resource*, UN-HABITAT.

Maiga H., Konaté Y., Wethe J., Denyigba K., Zoungrana D., Togola L., 2006, *Performances d'une filière de trois bassins de lagunage à microphytes sous climat Sahélien: cas de la station de traitement des eaux usées* de l'EIER, Sud sciences et technologies.

Bibliography

Mara D., 1997, *Design manual for waste stabilization ponds in India*, University of Leeds, DFID.

Mara D., 2003, *Domestic Wastewater treatment in Developing* Countries, Earthscan ed.

Pena Varon M., Mara D., 2004, *Waste Stabilization Ponds*, Universidad del Valle, University of Leeds, IRC.

Rose G. D., 1999, *Community-based technologies for domestic wastewater treatment and reuse: options for urban agriculture*, International Development Research Centre, Ottawa.

Seidl M., Mouchel J-M., 2003, *Valorisation des eaux usées par lagunage dans les pays en voie de développement*, Cereve.

Wett B., Buchauer K., 2003, C*omparison of aerobic and anaerobic technologies for domestic wastewater treatment based on case studies in Latin America*, Universidad Nacional De Colombia (Hrsg): Problemas Y Soluciones Ambientales Aquas Residuales Y Residuos Solidos.

WSP, *Constructed Wetlands: a promising wastewater treatment system for small localities, Experiences from Latin America*, 2008.

CMS Methodological Guides
on water and sanitation

NUMBER 1
How to develop a concerted municipal strategy for water and sanitation in large towns in Africa

NUMBER 2
How to create a regional dynamic to improve local water supply and sanitation services in small towns in Africa

NUMBER 3
How to analyze the demand of current and future users for water and sanitation services in towns and cities in Africa

NUMBER 4
How to select appropriate technical solutions for sanitation

NUMBER 5
How to manage public toilets and showers

The aim of the CMS Methodological Guides series is to provide aids and tools that correspond to water and sanitation service-related issues to best meet the needs of sector stakeholders. These guides are designed to evolve over time and be regularly updated. To assist with this process, please send any feedback or suggestions for improving this publication to the following address: **le-jalle@pseau.org**

How to select appropriate technical solutions for sanitation

Methodological Guide n° 4

In many developing countries, particularly in Africa, access to water supply and sanitation comes under the remit of local authorities. To assist the local contracting authorities in developing this service, programme Solidarité Eau (pS-Eau) and the Municipal Development Partnership (MDP) have initiated and coordinated the Concerted Municipal Strategies program (CMS – water and sanitation for all). This program has enabled pilot municipal strategies for water and sanitation to be developed in twelve large towns in West, Central and East Africa and has led to greater consideration being given to the concept of pooling resources on a regional scale so as to improve services in small towns in three countries of West Africa.

The five CMS guides are intended for local authorities, local water and sanitation service stakeholders and their development partners (NGOs, consultancy firms, etc.). Methodological tools are provided to assist these local authorities and stakeholders at each stage of the process when developing and implementing a water and sanitation services development strategy.

The purpose of this guide is to assist local contracting authorities and their partners in identifying those sanitation technologies best suited to the different contexts that exist within their town.

The first part of the guide contains a planning process and a set of criteria to be completed; these assist you in characterizing each area of intervention so that you are then in a position to identify the most appropriate technical solutions.

The second part of the guide consists of technical factsheets which give a practical overview of the technical and economic characteristics, the operating principle and the pros and cons of the 29 sanitation technology options most commonly used in sub-Saharan Africa.

Concerted Municipal Strategies (CMS), a program coordinated
by the Municipal Development Partnership (MDP): **pdm@pdm-net.org**
and programme Solidarité Eau (pS-Eau): **le-jalle@pseau.org**

www.pseau.org/smc

This publication has been prepared with the financial support of the AFD and the European Commission's ACP-EU Water Facility.

COMMISSION EUROPEENNE

acp★eu
Facilité pour l'eau

Agence Française de Développement