Middle East Partners
Consultancy & Management Support

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DAILY BUSINESS

Strategy

Provision of wastewater services Informal Tented Settlements in Lebanon

FINAL (version 1.6)

Beirut, 4 January 2017

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Acronyms

- AUF – Anaerobic Upflow Filter
- BOD - Biochemical Oxygen Demand
- BORDA - Bremen Overseas Research and Development Association
- BOT – Build Operate Transfer
- BST – Baffled Septic Tank (= Anaerobic Baffle Reactor)
- CBO - Community-Based Organization
- CDA - Community Development Association
- COD - Chemical Oxygen Demand
- CW – Constructed Wetland
- DEWATS - Decentralized Water Treatment System (Borda, Bremen)
- EAWAG - Swiss Federal Institute of Aquatic Science & Technology
- EKN – Embassy of the Kingdom of The Netherlands
- FC – Faecal Coliform
- ha – hectare
- INGO – International Non-Governmental Organization
- IS – Informal Settlement
- ITS – Informal Tented Settlement
- JMP – Joint Monitoring Program on Development Goals
- LAF - Lebanese Armed Forces
- mg - milligram
- ml – millilitre
- mln. - Million
- MoE – Ministry of Environment
- MoEW – Ministry of Energy and Water
- NGO – Non Government Organization
- O&M – Operation and Maintenance
- PE – Poly Ethylene
- Shawwish – middleman between the ITS community and the landlord
- SDG – Sustainable Development Goals
- SFS – Solids Free Sewerage
- SBS – Small Bore Sewerage
- SME - small and medium size enterprise
- TC – Total Coliform
- ToR - Terms of Reference
- VFCW – Vertical Flow Constructed Wetland
- WASH – Water And Sanitation and Hygiene
- WB - World Bank
- WSP - Waste Stabilization Ponds
- WW - Wastewater
- WWTP - Wastewater Treatment Plant

0. Executive summary

Background. UNICEF, through its partners, provides 52% of the individuals in all existing Informal Tented Settlements (ITS[1]) with temporary toilets and regular desludging services. The efficiency and cost effectiveness of this initiative has been questioned and several cases of groundwater pollution from the wastewater produced by the population living in ITSs have been observed. In addition, desludging activities are very expensive and can't be maintained for a long period.

Therefore, UNICEF has been requested by the Ministry of Energy and Water (MoEW) to find alternative technological solutions and to propose a strategy on UNICEF's response in providing sanitation and wastewater services in ITSs in close collaboration with the MoEW and the Ministry of Environment (MoE).

It is expected that UNICEF's investments in ITS follow the strategy lined out in this document. Funding for the ITS programme for 2017 is not secured yet, but it can be expected to have the same financial envelope as in 2016. One of the purposes of this study is to find cost effective solutions for the wastewater management approach. See Appendix 1: Terms of Reference.

Findings.

- The fact that since 2012 no major epidemics have occurred in and around the ITSs can partly be contributed to work of NGOs and local communities;
- Because of the massive construction of toilet systems, black water does not present an immediate problem in the ITSs, but desludging is a major financial burden and the wastewater ends up untreated in the environment;
- Most Wastewater Treatment Plants (WWTP), where sludge from the ITSs is disposed, are not operational;
- Grey water and storm water, especially during the winter is seen as a bigger issue by the residents of the ITSs. This often in combination with solid waste. Simple interventions can produce good results;
- The free aid approach of INGOs has made many ITS residents dependent on WASH services delivered by these INGOs, which will hamper an exit strategy in the near future;
- Various technological wastewater management options suggested by INGOs could be integrated in an overall wastewater strategy for the ITSs;
- Two years of savings (8 million dollars) by reducing the desludging interval from once a month to once a year will cover the entire hardware investment for the suggested wastewater management in the ITSs;
- The suggested combination of relatively simple and proven wastewater technologies will produce a wastewater that meets the Lebanese effluent standards;
- Lebanese communities dealing with similar wastewater challenge as the ITSs can benefit from the introduction of the new wastewater program for the ITSs.

Classification of black water systems present in the field. Figure 1 provides an overview of the information retrieved from the database managed by the WASH sector coordinator in Beirut on the black water[2] systems. The figure is based on information of all 'active' Informal Tented Settlement (ITS) locations including those with less than 4 tents. Around 40% of the information is not available.

[1] In this report, we use ITS as abbreviation for Informal Settlement as alternative to IS.
[2] Black water is the mixture of faeces, urine and water used for anal cleansing.

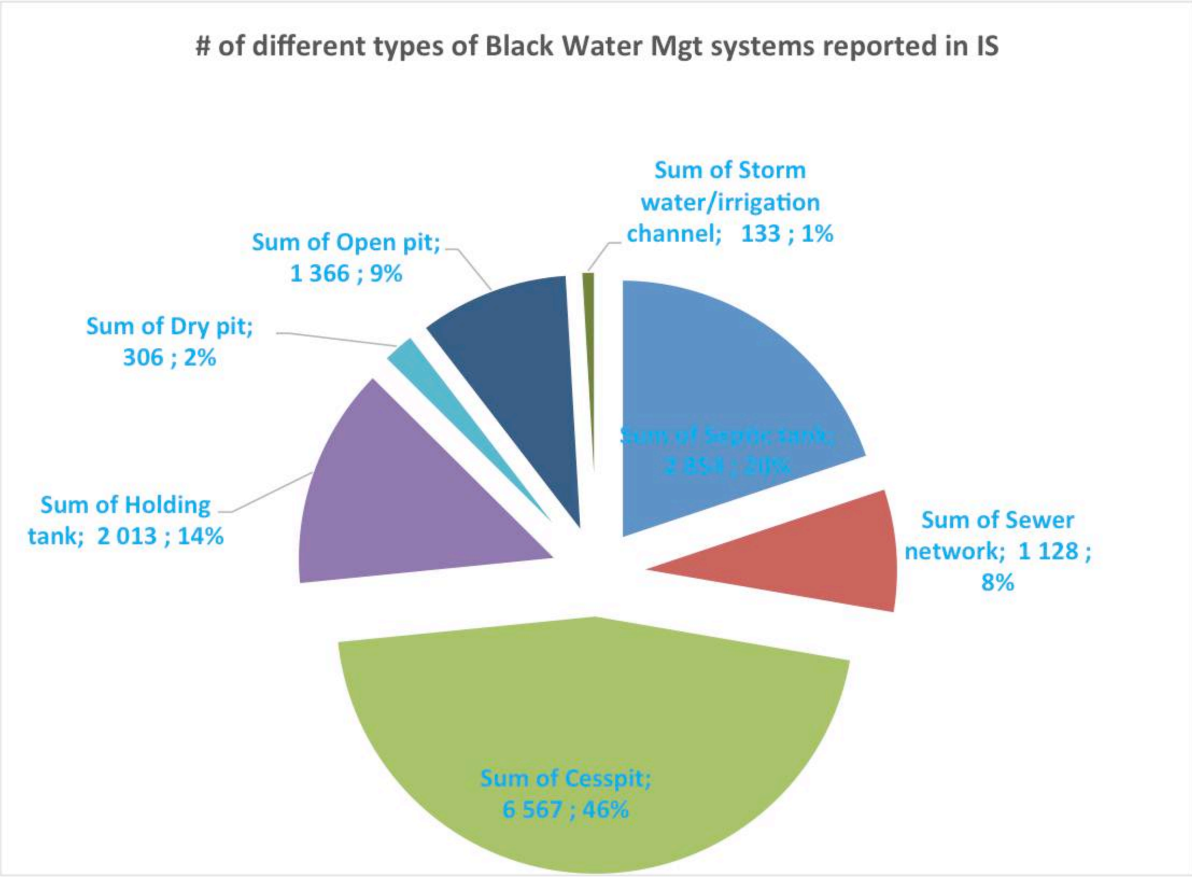


Figure 1: Overview actual black water systems all ITS locations including less than 4 tents (Source: database managed by UNICEF Beirut, accessed 21 November 2016) N.B.: IS = Informal Settlements

Criteria for project area selection black water systems. We have developed two sets of criteria for prioritization/project area selection for ITS locations to be upgraded.

The first set is a 'technological' set based on reducing the potential risk of environmental pollution and reducing the operation and maintenance costs of the current practices. Based on the information available, we assume that the ITS locations that currently are reported to convey the black water into sewers (red triangles in the map in Figure 2) do not need any action, except the verification of the level of treatment and any accompanying improvements of the sewage treatment. This is outside the scope of our Terms of Reference. For the ITS locations that do not convey the black water into the sewers, we recommend prioritizing as follows:

- The **first priority** is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into the **open channels** (pink triangles in the map in Figure 2). This needs verification in the field;
- The **second priority** is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into **open pits** (yellow triangles in the map in Figure 2). This needs verification in the field;
- The **third priority** is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into **cesspits** (green triangles in the map in Figure 2). If these pits are less than 2 meters from the groundwater table in sandy areas or located in karst rock areas, groundwater might be at risk. This needs verification in the field;

- The **fourth priority** is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into **septic tanks** that drain into the subsoil (purple triangles in the map in Figure 2). If these pits are less than 2 meters above the highest groundwater table in sandy areas or located in karst rock areas, groundwater might be at risk. This needs verification in the field;
- The **fifth priority** is to improve the systems in those ITS locations where there are high operation and maintenance costs as the black water is currently reported to be discharged into **holding tanks** (blue triangles in the map in Figure 2). These tanks fill up within 2-4 weeks and need desludging, leading to high operation costs. This needs verification in the field.

Discussions with UNICEF on 7 December 2016 revealed that the distinctions between the ITSs based on this typology is less straightforward than it seems. In practice, many ITSs have a mix of systems. As it is not very logical to focus improvement on only part of an ITS, in practice prioritization need to be based on mixed of the above-mentioned priorities.

An overview of the locations of the different systems is presented in Figure 2.

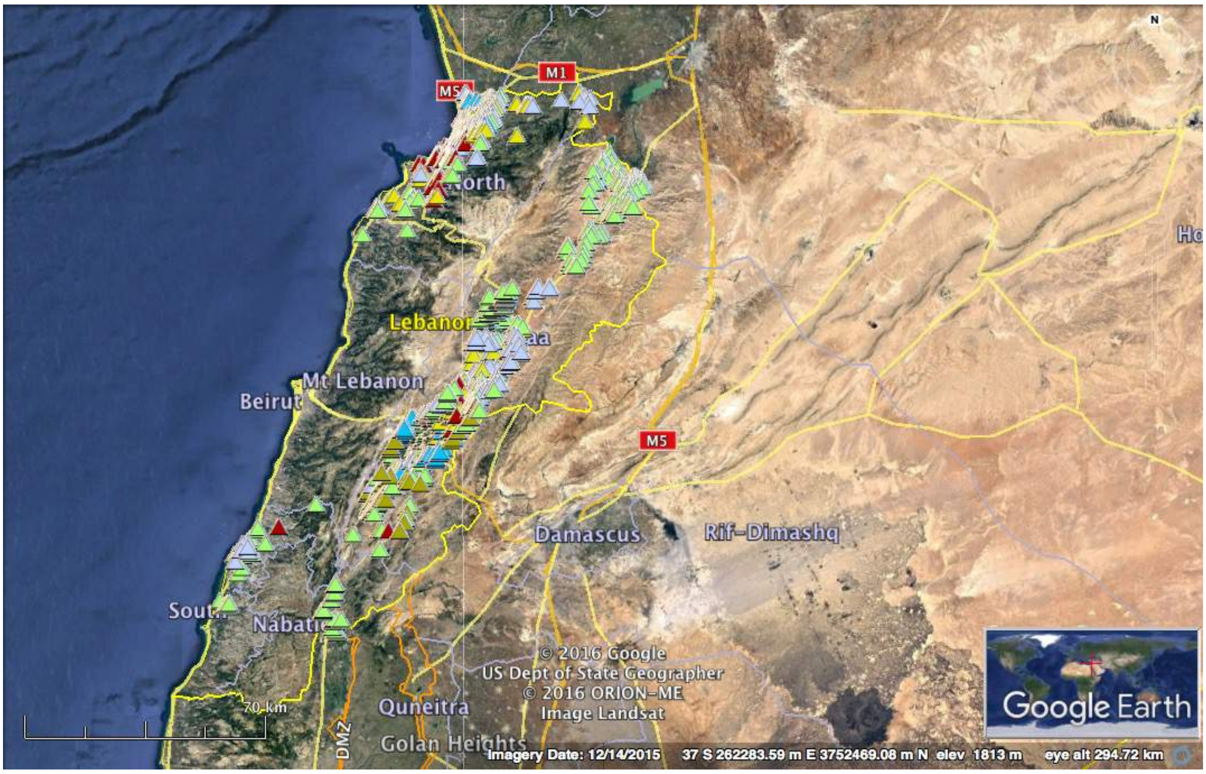


Figure 2: Overview reported types of discharge of black water in ITS

The second set of criteria is based on the premise that investment choices should both benefit the ITSs and the hosting Lebanese communities. The investment should relate to the current physical situation in the ITSs and to get to terms with the current reality to shape better realities in the nearby future. It's better to ask the following question now than when funding stops. *In which ITSs and how can INGOs minimize and eventually stop providing WASH services?* In the context of this report and its technical recommendation to deal with waste water management, we suggest adopting a second systematic approach in the order of intervention: where do we start first, and which ITSs are not suitable for the implementation of the WW management improvements recommended? It should be emphasized that to implement and maintain this wastewater strategy, the WASH sector should pay attention to the local institutional environment, which needs to be strengthened.

Where not?

1. ITSs that are in a good condition and need only small improvements. These camps include mainly those that are connected to a sewer network, and very isolated ITSs where the environmental capacity to absorb and treat the relatively small volume of wastewater is sufficient. Efforts should be made to phase out these ITSs and hand over responsibility to the ITS community, municipality and Lebanese NGOs. We recommend that UNICEF and its INGOs develop an 'exit strategy' for these ITSs to be able to concentrate on 3;
2. ITSs that are in unsuitable locations (such as flood prone, too close to military installations and military transport corridors), where conditions are unfit for living, improvement will be extremely difficult and expensive, and will not result in real changes. In such situations we may conclude that the community should be reallocated to a different ITS or location. Further assistance could be reduced to encourage people to seek alternative shelter.

Where should we improve? And what criteria could be applied?

3. ITSs that host larger numbers of displaced persons and have basis for improvements, and thus can be prioritized based on a set of transparent criteria as lined out in Table 1.

Table 1: 2nd set of selection criteria

	Criterion	Score
1	Close distance to a drinking water source	High
	Main water well (10), private bore hole (1), none (3)	
2	Density of inhabitants (people per ha)[3]	High
	low (10), average (5), high (0)	
3	Soil structure	Medium
	Rocky (5), clay (3), sand (1)[4]	
4	Cooperation of local community/municipality	Medium
	Bad (5), neutral (3), good (1)	
5	Cooperation of IS community	Medium
	Bad (5), none (4), moderate (3), good (4), excellent (1)	
6	Cooperation of landlord	Medium
	Bad (4), fair (3), good (2), excellent (1)	
7	Flood prone area during the winter	High
	Most parts of the IS (20), substantial parts of the IS (10), specific limited locations (3), hardly to no locations (0)	
8	Vulnerability of the host community	High

[3] More precise 'people per hectare' criteria need to be determined in consultation with NGO currently responsible for the management of WASH services in ISs.
[4] Sand is a good filter medium for natural treatment of waste water

	Criterion	Score
	Low (5), average (3), high (1)	
9	Access for desludging truck	Medium
	Difficult (3), fair (2), good (1)	
10	Distance to sludge disposal point	Medium
	more than 10 km (5), 5-10 km (3), less 5 km (1)	
11	Risk of eviction	High
	High (10), unknown (5), low (1)	
12	Health situation	High
	Bad (7), poor (5), moderate (3), good (1), very good (0)	
13	Mobility of ITS community	Medium
	High (5), medium (3), low (1)	
14	General cleanliness of IS (incl. solid waste)	High
	Bad (7), poor (5), moderate (3), good (1), very good (0)	

Note: The lower the score, the higher the suitability of the location.

Technological strategy for black water. The technological strategy for black water is illustrated in Table 2. We distinguish the following typical situations:

Sewers. Where municipal / water establishment sewers are nearby, the preferred option is to connect the ITS location to these sewers and treat the effluent in the existing Wastewater Treatment Plant (WWTP). In this way, the environment is protected and costs are minimized, especially the Operation and Maintenance (O&M) costs. A serious point of concern is the fact that now very few WWTP treat the water up to the required effluent standards. We have not further elaborated on this approach because of lack of reliable data. We understand that UNICEF is hiring a consultant to assess the actual location, state and performance in terms of Operation and Maintenance (O&M) of the WWTPs in Lebanon in the framework of the Joint Monitoring Programme (JMP) on the Sustainable Development Goals (SDGs);

Shared wastewater treatment. For very small ITS locations of around 4 households, the preferred option is to install a PE shared wastewater treatment facility:

- In Karst rock areas or areas where the groundwater is likely to be contaminated, the recommended treatment technology facility is a shared PE 6 m^3 Baffled Septic Tank (BST), followed by a 15 m^2 Vertical Flow Constructed Wetland[5] (VFCW), that discharges either into the subsoil, an irrigation system, soil absorption doughnuts or surface water. The current water tanks used as 'holding tanks' are not suitable (see discussion on environmental impact), masonry/concrete is not allowed, hence PE BSTs need to be developed and be made available to the Lebanese market. UNICEF could play a role in this;

[5] Provided sufficient slope is available

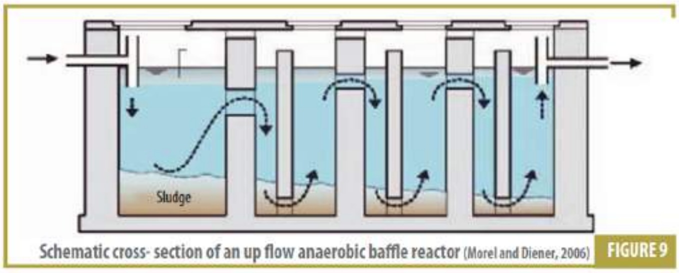


Figure 3: Baffled Septic Tank (UN HABITAT, 2008)

Figure 4: Prefab Settling chamber and baffle tank (Borda)

Figure 5: Constructed Wetland

- In sandy/loam soils with low groundwater table where there is not enough space to share the treatment facilities, the recommended treatment technology is a 0.83 m^3 (black water only) – 1.22 m^3 (black and grey water) 2-chamber Poly Ethylene (PE) household Septic Tank (ST, see Figure 6) where BOD/COD is removed, with an Anaerobic Upflow Filter (AUF, **Figure 7**) that traps the suspended solids. The solids free effluent is then infiltrated into the subsoil in a soakaway pit with the bottom at least 2 m’ above the highest groundwater table. This 2 m’ of soil/loam assures the die-off of all pathogens. The current practice of using drinking water tanks for wastewater should be abandoned, as they are not suitable;

Figure 6: Prefab septic tanks

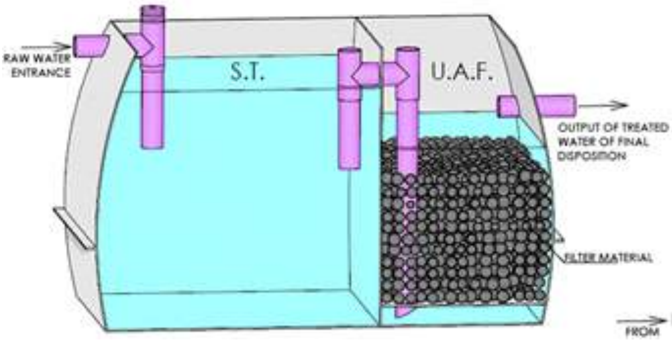


Figure 7: Septic tanks with Anaerobic Upflow Filter (source: http://depuragua.co.cr/en/improved_septic_tank.html)

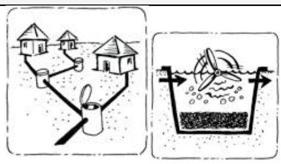
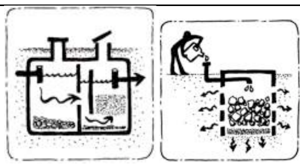
- For larger ITS communities where PE holding tanks are in use, these should be converted into one chamber 'septic tanks' by adding a 'Tee shaped' outlet and proper fittings. Where this is not possible or where PE holding tanks are not installed, 0.83 m^3 2 chamber PE Septic Tanks need to be installed. Both the converted holding tanks and the new septic tanks are to be connected to a PVC Solids Free Sewerage system 50-75 mm diameter. This system disposes into a communal BST (24 m^3 for 100 households) and a communal VFCW (700 m^2 for 100 households of 15 persons, 0.5 m^2/person). The VFCW (not necessarily one large one, but more likely several smaller ones) discharges either into the subsoil, an irrigation system (if and when appropriate), soil absorption doughnuts or surface water;
- The sludge collected from the ITS needs to be treated properly, either in existing WWTPs or in special Sludge Treatment Plants[6], preferably (planted) sludge drying beds, see Figure 8. The existing WWTPs need to be adapted to be able to receive and treat partially digested sludge from ITS locations.

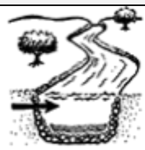
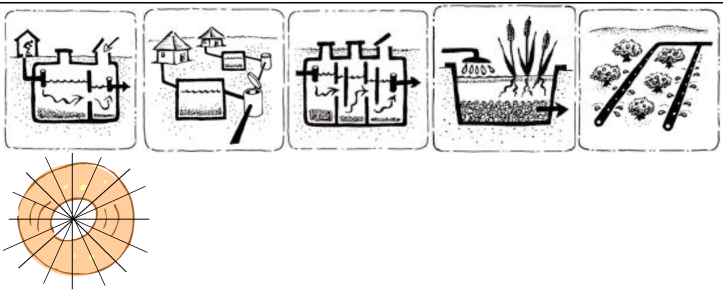
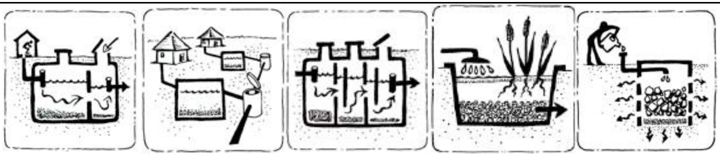
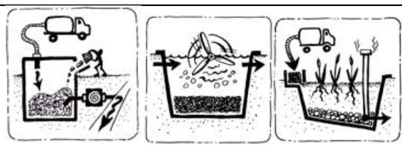
Recommendation: *request WET Consulting engineers to investigate whether existing WWTPs can receive and treat partially digested sludge from ITSs. Where WWTPs are not suitable, implement planted sludge drying beds, preferably at the site of the WWTP to reduce environmental nuisance.*

[6] Special Sludge Treatments Plants do currently not exist in Lebanon. Therefore, we suggest making use of the sludge drying facilities at WTTPs.

Figure 8: Sludge drying bed (Surabaya, 2010)

Table 2: Technological strategy

Existing situation	System	Illustration
Sewerage nearby	Use existing Sewerage and assist Water Establishment in adequate wastewater treatment	
Small communities with inadequate sanitation / sandy-loam soil and low groundwater table	Septic Tanks & Anaerobic Upflow Filter / Infiltration > 2 m' above highest ground water level	
Small communities with inadequate sanitation / Rocky (Karst) soils or areas	Shared Baffled Septic Tanks / Vertical Flow Constructed Wetland / Infiltration OR	

Existing situation	System	Illustration
high water table and sufficient slope	Reuse/Agriculture OR Absorption in doughnuts OR discharge into open water	
Large communities with inadequate sanitation / Rocky (Karst) soil and adequate slope	(Septic) Tanks / Solids Free Sewerage / Baffled Septic Tanks / Vertical Flow Constructed Wetland / reuse or doughnuts	
Large communities with inadequate sanitation / sandy-loam soils	(Septic) Tanks / Solids Free Sewerage / Baffled Septic Tanks / Vertical Flow Constructed Wetland / Infiltration / reuse or doughnuts	
Sludge disposal	Into existing (trunk) sewers – WWTPs / (Planted) sludge drying beds	

Investment costs. The total net investment costs of improvement of all (± 16,787) systems are estimated at $ 8 mln[7]. The gross investment costs, including overhead, contractor margin, VAT etc. are around $ 10 mln.

See the breakdown in Figure 9. The number 16,787 is calculated as follows:

- Number of systems 'known': 13,043;
- Number of 'unknown' systems: 5,208[8];
- Total number of systems considered: 18,251;
- Number of systems connected to sewers and not being considered for improvement: 1,047 + proportionally part of the 'unknown' systems, total 1,465 systems;
- Remaining number of systems to be considered for improvement and costing 18,251 minus 1,465 = 16,787.

See Table 3 for details and see Table 4 for systems to be improved in ITSs with more than 4 tents.

[7] mln. = million
[8] Information UNICEF by e-mail on 16 December 2016

Table 3: Overview current systems in ITSs with more than 4 tents (source: database managed by UNICEF Beirut, sent by e-mail mid-December 2016)

System	***Numbers***	***Users***
Cesspit	5 905	56 603
Septic tank	2 607	25 753
Open pit	1 238	10 567
Sewer network	1 047	10 691
Holding tank	1 920	20 945
Dry pit	207	1 595
Storm water/irrigation channel	119	1 180
Sub-total known systems	***13 043***	***127 334***
Unknown	5 208	50 844
Total	***18 251***	***178 178***

Table 4: Overview systems to be improved in ITSs with more than 4 tents

Priority	**To be improved**	**no. of systems**	**System proposed**	**Unit Cost**	**Investment ($US million)**
1	Storm water/irrigation channel	167	ST&SBS&VFCW	$520	$0.09
2	Open pit	1 732	ST&SBS&VFCW	$520	$0.90
3	Dry pit	290	ST&SBS&VFCW	$520	$0.15
4	Cesspit	8 263	ST&SBS&VFCW	$520	$4.30
5	Septic tank	3 648	SBS & VFCW	$400	$1.46
6	Holding tank	2 687	SBS & VFCW	$400	$1.07
	Total	**16 787**			**$7.97**

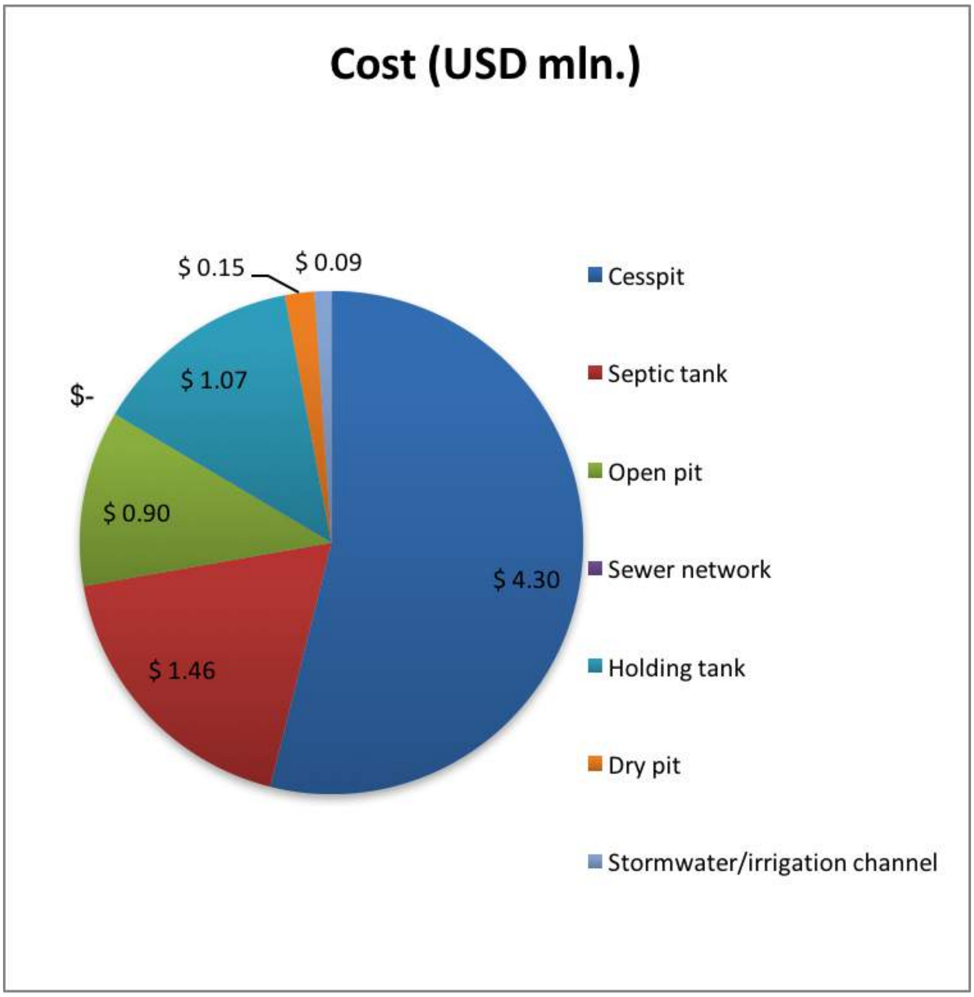


Figure 9: Investment cost improvement black water ITS locations with more than 4 tents

Note on the scope of the intervention. The costs calculated here, are based on four assumptions which need to be verified during implementation:

- **100% of the ITS locations:** we have assumed that the improvements are not only required in the locations financed by UNICEF and the partners but in **all** sites at risk;
- **Only in ITS with > 4 tents**: for reasons of efficiency and effectiveness, we propose to concentrate on those areas where the health/ environmental risk is most obvious, hence those areas with more than 4 tents;
- **No additional latrines:** we have assumed that the areas are served adequately in terms of number of facilities per person (around 10 persons/latrine) which is (far) less than the 'standard' of 15 persons per latrine;
- **Interventions are possible everywhere:** we have assumed that it is always possible to come up with a (if necessary modified) solution.

Impact. The expected impact on the environment is substantial. It is estimated that the proposed interventions will remove around 4 tons Biochemical Oxygen Demand (BOD_5) per day, compared to 1 tons BOD_5/day now. Hence, the BOD_5 generated by the ITS locations will decrease from 3.45 tons BOD_5/day to 0.5 tons BOD_5/day. In the ITS locations, the average BOD_5 of the effluent is expected to decrease from 625 mgBOD_5/l to 25 mgBOD_5/l, which is in line with the Lebanese standard (Decision 8/1 of 2001). The Coliform Bacteria count is expected to decrease from 1,000,000 TC 37^o /100ml to 1,000 TC 37^o /100ml, which is below the Lebanese standard of 2,000 TC 37^o/100ml (Refer

Environmental Limit Values for wastewater discharge into surface water from new WWTPs, issued under Decision 8/1 of 2001[9]).

Observations and recommendations. Apart from the 'technological' observations above we have several observations and recommendations that are based on our findings in the field and discussions with stakeholders. They are presented in Table 5.

Table 5: Observations and Recommendations

Observation	Recommendation
The local WASH committees in their current shape do not serve their purpose adequately. Other less ambitious, simple and more practical forms of community participation seem to work better. People in the ITSs might take responsibility when they know that UNICEF and with it, the INGOs, are planning to phase out their WASH involvement. Giving them that chance and time must be part of the exit strategy.	INGOs identify and formulate the work that has to be done by and in the ITSs to sustain wastewater services as part of WASH, and determine who does what, when and how.
INGOs know that they have to leave when funding gets low. Therefore, one of their core tasks to work based on an exit strategy. It cannot be their aim to evolve into a business, but they can support others do so.	INGOs take a supporting role, in particular the international staff. Its main focus should be on building (on) local initiates that can professionally implement core activities to sustain wastewater management.
UNICEF expects that the costs of wastewater management (mainly desludging) cannot be sustained and has been informed that GoL is concerned about the water pollution from ITSs. Any exit strategy would mean a deliberate move from emergency sanitation to a broader environmental WASH approach.	UNICEF takes a 'intermediate' leading role for the development and implementation of an WASH exit strategy from ITSs in Lebanon.
The Lebanese policy regarding ITSs is to opt for temporary services rather than creating permanent structures. The technological and institutional options identified in this report serve both hosting communities and ITSs alike. The bottom line is that the hosting society as a whole benefits from the support that international humanitarian organizations provide to the ITSs.	UNICEF develops a transparent approach based on the legal framework of the wastewater sector to engage with Water Establishments and municipalities in order to develop sustainable waste water (incl. sludge collection, disposal and treatment) services in Lebanese municipalities.
WASH sector partners are working independently under difficult circumstances and could all benefit from regular exchange of experience and guidance. The guidelines document of 2013 has proven to be a good	UNICEF sets up a platform as a temporary initiative aiming at facilitating the work of the sector partners. In a later stage, this platform could become part of a Lebanese institution, which hosts water, sanitation and wastewater

[9] Info MoE per e-mail 16 December 2016

Observation	Recommendation
reference tool for some standardization but still the variety of different sanitation solutions in the ITSs underlined that more can be done towards creating coherence, increasing efficiency through standardization, and scaling-up of waste water management systems that have proven to meet minimum standards.	research and education. We have included some useful internet references in Appendix 3: Useful websites.
The preferred solution of wastewater management in ITS locations is connection to and discharge into sewers. Up to date information is missing at the moment. UNICEF is hiring a consultant to assess the actual location, state and performance in terms of Operation and Maintenance (O&M) of the WWTPs in Lebanon in the framework of the Joint Monitoring Programme (JMP) on the Sustainable Development Goals (SDGs)	Update this study after the finalization of the JMP survey on the SDGs that assesses the WWTPs in Lebanon. Request the consultant to include information on the appropriateness to receive and treat partially digested sludge.
It is not permitted to implement 'permanent' concrete wastewater structures. The 1 m^3 PE drinking water tanks that are used at the moment for individual households are not suitable as wastewater treatment.	UNICEF facilitates the production of off-the shelf 0.83 and 1.22 m^3 PE two-chamber septic tanks Figure 6 where the 2nd chamber can be used as Anaerobic Upflow Filter. See Figure 6 .
The 3 m^3 PE drinking water tanks that are used at the moment for communal wastewater treatment are not suitable as wastewater treatment.	UNICEF facilitates the production of off-the shelf 6 m^3 PE Baffled Septic Tanks that can be used in a modular way to form a 24 m^3 communal BST.
The majority of the underground in Lebanon consists of karst rock, where any pollution can travel very far and very fast. The primary treatment systems proposed remove an important part of the BOD_5 load, but the effluent still contains Coliforms.	The effluent of the septic tanks and Baffled Septic Tanks need to be treated in Vertical Flow Constructed Wetlands to assure that the effluent fulfils Lebanese Environmental effluent standards in terms of both BOD_5 and Total Coliforms.
The upgrading of renewal of 15,500 systems is a serious task that needs to be undertaken with a systematic approach. Despite the fact that the systems are simple and use proven technologies, are relatively new to Lebanon and need to be introduced with care (such as EIA).	Assess relevant existing (pilot) projects and implement, when necessary, proposed systems on a pilot scale and monitor the operation and maintenance and evaluate the appropriateness for Lebanon before embarking on full-scale implementation.

1. Introduction

1.1. Background

UNICEF, through its partners, provides most the existing Informal Tented Settlements (ITS) in Lebanon with temporary toilets and regular desludging services. Nonetheless the efficiency and cost effectiveness of this initiative has been questioned and several cases of groundwater pollution from the wastewater produced by the population living in ITSs have been observed. In addition, desludging activities are very expensive and can't be maintained for a long period of time.

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1.2. Classification of black water systems

Classification of black water systems present in the field. Figure 10 provides an overview of the information retrieved from the database managed by UNICEF Beirut on the black water[10] systems. The figure is based on information of all 'active' Informal Tented Settlement (ITS) locations, including those with less than 4 tents. Around 40% of the information is not available.

[10] Black water is the mixture of faeces, urine and water used for anal cleansing.

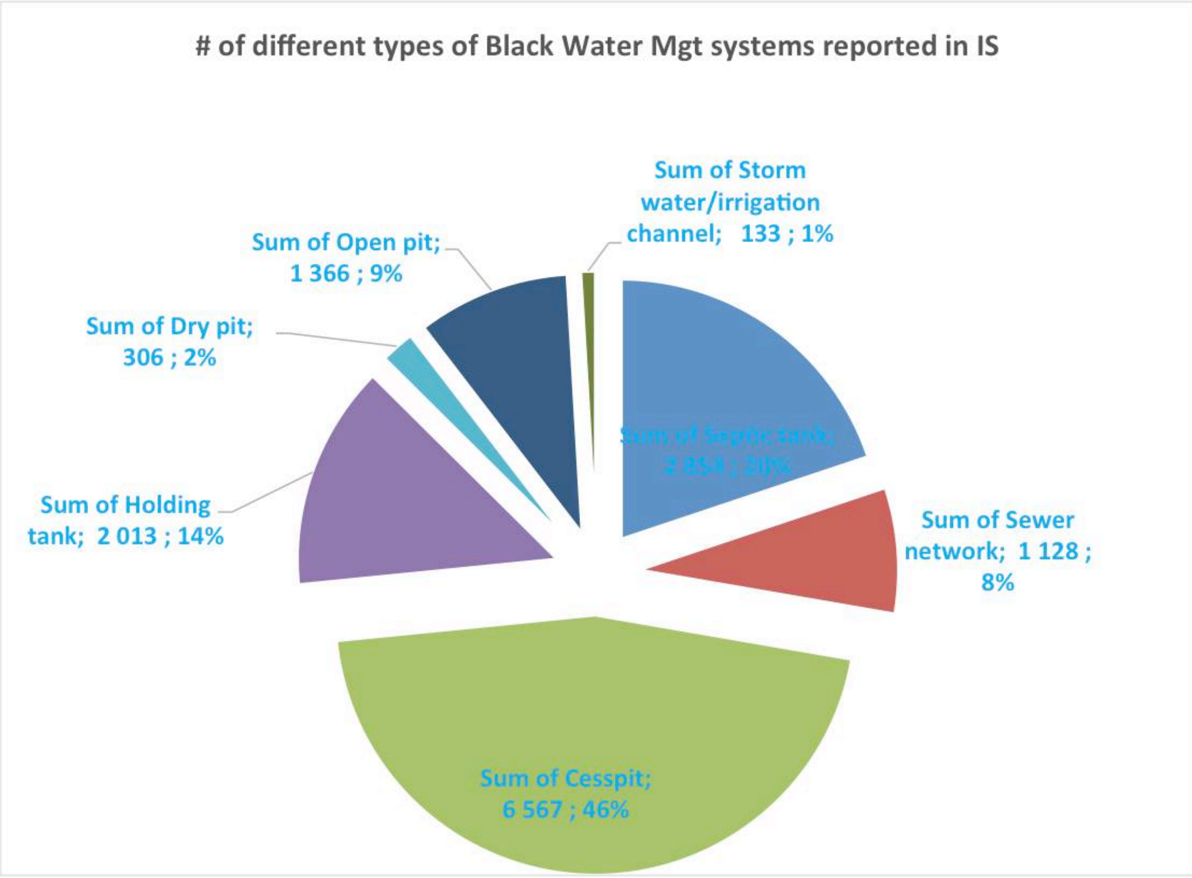


Figure 10: Overview actual black water systems including ITS locations with less than 4 tents (Source: database managed by UNICEF Beirut, accessed 21 November 2016)

Recommendation. *It is recommended to continue the efforts to complete the information on the black water systems and incorporate the information of 5,208 'unknown' systems.*

1.3. Findings in the field

1.3.1. Informal Tented Settlements in Lebanon

25% of the Lebanese population consists of Palestinian, Syrian and other refugees and Lebanon has the world's highest number of refugees per inhabitant. In the Fact Sheet 'Environmental Assessment of the Syrian Conflict' (MOE/EU/UNDP, 2014) it is estimated that in 2016, 1.5 million Syrian refugees live in Lebanon. Around 15 % of them live in informal tented settlements (ITSs), the subject of this report. These are estimates because UNHCR stopped registering new refugees as many Syrians pass the border illegally and others have lost their temporary residence permit. International NGOs (INGOs) record a continuing increase of refugees they serve since 2014. All people living in ITSs that are part of the UNICEF program receive WASH services free of charge, those in other locations are serviced by similar programs of ECHO[11], UNHCR and others. Lebanon hosts more than 4,300 ITSs with a total population of around 227,780[12]. The other Syrians are hosted within, mostly poor, Lebanese and Palestinian communities.

From the outside, the ITSs look very similar in terms of the shapes of the self-made tents. However, in reality they differ in size, groundwater condition, soil type, and encounter various social realities:

[11] European Humanitarian Aid and Civil Protection
[12] Information UNICEF per 31 August 2016

different landlords, municipalities, economic realities and threats for eviction. Furthermore, the internal relations and social cohesion of the ITSs determine their relative strength and coping mechanism.

The political decision not to recognize these settlements has consequences: all structures so far need to be temporary – no structures should give the impression of permanence. This is the major challenge for delivering good WASH services. Connecting ITSs to local drinking water and wastewater network is officially not allowed.

Most ITSs are located on agricultural land, and many of them existed long before the conflict in Syria as residential areas for Syrian seasonal agricultural workers. When the conflict started, these men brought their families. Before the crisis, the infrastructure consisted of shelters and sanitation, such as latrines, open pits and cesspits. Over the last years these settlements grew in size and density, causing problems comparable to these in informal settlements in the mega cities in the developing world. These primitive circumstances are especially difficult for women, children and elderly persons.

Observations by the mission in a selected number of locations, showed the following problems INGOs face in providing WASH services in Informal Tented Settlements:

- In the ITSs on agricultural land, the shallow **groundwater is polluted** as a result of the abundant use of insecticides and fertilizers over many years. The wastewater from ITSs adds to an existing problem. The people are well aware of the bad quality of the groundwater and use it only for cleaning, laundry and showers. Nevertheless, skin and eye irritation after washing with this water is common. Many the ITSs receive drinking water from water trucks (until December 2016 ~ 35 litres per capita per day). This water needs to be chlorinated because it comes from sources that is often polluted. Because people tend to dislike the taste of chlorine, many of them prefer polluted water after performing '*the tea test'* to judge the quality of the water[13];
- Many refugee families are under **threat of eviction** by landowners, municipalities or the Lebanese Armed Force (LAF). These are a result of ambiguous land ownership, the role of the 'Shawwish[14]' of the ITSs, the lack of cooperation of some hosting communities and municipalities. ITSs are often evacuated by the LAF for security reasons: regularly families are forced to move from one settlement to an other;
- Families pay between **US$ 50-100 per month,** either in cash or labour, for renting the land to build their tents. Women and girls working for around US$ 6 per day as agricultural workers; half the salary that was formerly paid to the men. Families are often forced to have one female working unpaid in return for the permission to camp on the land of the owner. Men and boys tend to seek other, better paid jobs, often unsuccessfully;
- Toilet systems are a **potential threat to the environment**. Only 8 % of the settlements are allowed by the landlord and municipality to be connected to the existing sewer network. This may seem a good option for ITSs, but adds to the disposal of untreated wastewater practised by Lebanese communities as in many cases, these networks are not connected to a wastewater treatment plant (WWTP), or to a WWTP that is not operational;
- Poor storm drainage in footpaths and alleys causes **flooding in winters**. Storm water can infiltrate into the cesspits, and so faecal sludge is spread throughout the ITS mixed with grey water which may infiltrate into drinking water bore holes and hand dug wells. Unfortunately, landlords and municipalities often forbid the digging of trenches for drainage or neighbours prevent drained water from exiting the ITS. See Figure 11.

[13] The Tea Test: testing the quality of water by making tea means that if the tea is clear the water is good (for tea). High chlorine residual in the water increases the turbidity of tea, meaning the water is not good (for tea).
[14] Middleman between the landowner and the community of the ITS

Figure 11: ITS T'nayel 005, Lebanon: flooded areas in winter, left water bore hole, right grey water infiltration pit

- **High groundwater tables in the winter** may lead to floating of wastewater holding tanks, especially when they are emptied;
- In some cases, **grey water discharge linked to water drainage** causing damage of the system and accumulation of waste (See Figure 12)

Figure 12: ITS Zahle Mualaqa 019 grey water connected to storm water drain

Figure 13: I ITS Zahle Mualaqa 019: drainage pipes cut open every 15 cm to allow storm water infiltration

- INGOs are facing the challenge that many ITSs residents have become **dependent on free WASH** services provision. The general assumption is that the UN and INGOs are there to provide continuous services. Although people pay rent to landlords, and in some cases for solid waste collection, water and sanitation is assumed to be free of charge. Even small repairs, replacements and O&M are considered part of these WASH services. Decreasing donor aid will force INGOs to reconsider their roles.

1.3.2. Waste water management in Lebanon

The environment is negatively impacted by the ITSs in term of solid waste, water pollution, land use and ecosystems. However, these problems have been neglected for years. Mounting concerns about the social and environmental stability of the country strengthened by the current influx of Syrian refugees and the duration of the crisis cannot hide that the environmental sustainability of Lebanon has been under threat for decades. The impact of the Syrian crisis, in combination with the impact of climate change on the water resources, is now alarming.

The increase of the domestic water demand for displaced people was estimated between 43 and 70 million cubic meters (8-14% of the national water demand) by the end of 2014. Subsequently, a similar volume of wastewater (34-56 million cubic meters per year) is generated.[15]

In terms of pollution the EASC update (2015) estimates that the displaced population produces annually 40,000 tons of Biochemical Oxygen Demand (BOD), equivalent to around 34% of the total BOD generated at national level. Although the mission questions these percentages, it does agree that the Syrian crisis is substantial. The additional wastewater from displaced people in and outside the ITSs adds to the existing water and soil contamination.

Until the beginning of this century, Lebanon had a weak legal wastewater framework and even weaker enforcement mechanism. The current laws and policies[16] may have resulted in the construction of (expensive) WWTPs for almost 3 million people, but only 8% of the wastewater is (partially) treated. In practice, most wastewater is discharged into the sea and (dry) riverbeds, as the sewer networks are not connected to WWTPs and WWTPs are not operational because of high O&M costs (energy). In November 2016, the Lebanese Agricultural Resource Institute published a report that shows that more than 90% of the tested water resources all over the country are chemically (industry and agriculture) and/or bacteriological (residential) polluted. Wastewater management is a national problem.

Although the mission was asked to suggest solutions for the wastewater produced in the ITSs, we could not avoid taking notice of the bad solid waste situation, the waste pollution from Lebanese cities and villages, the water shortages and the effects of the lack of land use planning. The percentage of the wastewater in Lebanon that is treated safely before discharge into watercourses can be neglected, despite the many WWTPs that have been built over the last years.

If the current Syrian crisis compounds this, it is hopefully a wake-up call and can present an opportunity to address these issues. This report will demonstrate that an environmental approach to the wastewater problem in ITSs also presents a strategy for Lebanese communities that lack proper water and waste water management.

1.3.3. Groundwater pollution from ITSs

Recently the Ministry of Environment (MoE) filed a report stating that the surface and groundwater is being put at risk by ITSs. The MoE alerts were initiated by complaints of landlords and municipalities that ITSs were causing health threats because of wastewater disposal into the environment. One of these locations was Zahle, where farmers are using wastewater from pools created by ITSs. Other warnings came for Marj El Khokh, where the ITS is situated near an important communal water well.

[15] *Lebanon Environmental Assessment of the Syrian Conflict % Priority Interventions Update Fact Sheet – December 2015*

[16] Municipal Law, No. 118 (June 30, 1977) including 3% municipal tax for public works (such as sewerage); Law 221 (May 29, 2000) that organizes the water and sanitation sector; National Strategy for the Waste Water Sector, resolution No. 35 (December 17, 2012), does not cover most the agricultural areas.

Figure 14: Zahle 001 Grey water pond used as irrigation source in the field on the right. Other ponds contain black water as well

The MoE visually verified the complaints. However, the water quality was not tested: MoE has neither the budget nor the facilities to conduct these tests. In case of complaints of ITSs, INGOs were asked to test the drinking water, as some of them have their own testing facilities and budget. UNICEF partners (and ITSs water committees equipped with water testing kits) regularly test the water quality at source and user point. These tests are done to assess the drinking water quality and not for identifying pollution risks by the ITSs. Wastewater quality testing is not conducted.

Although the wastewater quality is not tested, it can safely be assumed that ITSs contribute to water pollution in Lebanon. Their potential impact may be limited on a national scale, but can be substantial in specific locations where ITSs are concentrated. There is also evidence that farmers (not ITSs) are using wastewater for irrigation; close to these fields, the wastewater of the city of Zahle is disposed untreatedly into the Litany River.

Figure 15: Untreated waste water for the city of Zahle flows into the Litany

To put things in perspective, the potential pollution of the ITSs on the water resources in relation to that from Lebanese towns and villages is still low. Based on international data the mission estimated that the Lebanese families produce less BOD than the average European, and the non-Lebanese population even less because of their life style and diet. These assumptions need to be verified, but give an impression of the proportion of the problem. See Table 6.

Table 6: Estimated production of BOD per population group in Lebanon

	LCRP, 2016	$gBOD_5/d$ [17]	kg BOD_5/day produced	
Lebanese population	5,565,000	45	250,425	84.28%
Syrian refugees	1,280,000	25	32,000	10.77%
Syrian refuges ITSs	**220,000**	**25**	**5,500**	**1.85%**
Palestinian refugees	320,000	25	8,000	2.69%
Lebanese returnees	35,000	35	1,225	0.41%
Total	**7,420,000**		**297,150**	

Referring to the calculations in Table 6, one cannot expect that the implementation of the recommendations in this report will have a huge effect on the water quality in Lebanon as a whole. However, because of the concentration of the ITSs, the effect of good wastewater management will certainly be noticed locally; in particular, when local Lebanese institutions, organizations and communities adopt a similar approach, the effect of the recommendation will go beyond the scope of this mission. Connecting households to and operation of the already constructed WWTPs can result in a reduction of BOD of more than 50% on a national level.

1.3.4. Lebanese response to the immigration of Syrian refugees

The response by the international humanitarian community to the Syrian crisis in Lebanon in the absence of a governmental policy was mixed in terms of technical solutions. A variety of toilets and faecal storage practices can found in the ITSs. Surprised by the magnitude of the influx of Syrian immigrants in 2014 and as a result of the laissez-faire policy of the government, the refugees who set up shelters were seasonal Syrian workers (husbands and sons) who used to work as agricultural workers during the summer. The role of the 'Shawwish', a Syrian middleman for Lebanese landowners cannot be underestimated, nor the interest for the landlords as both benefit from the refugees as cheap illegal labourers and tenants. They charge the refugees rent for land to put up shelters, assuming correctly that basic facilities such as WASH services are provided by INGOs. Landowners rather than municipalities determine what the tenants are allowed to do on the land, which can result in horrible living conditions. In the end, it is in the interest of the landowner to have good WASH services in the ITSs.

The policy of the national government of prohibiting ITSs from connecting to drinking water and sewer networks and prohibiting permanent structures in the ITSs present another major challenge to those who want to provide efficient WASH services.

Lebanon's troubled past is part of the reason why the Lebanese authorities are reluctant to recognize the status of refugees from Syria officially[18]. Unlike in Turkey and Jordan, there are no

[17] *Average derived from the average BOD/p/d in the Europe (54), assuming that these figures are somehow lower among the Lebanese population because of lifestyle, and significantly lower for refugees because of poor diet as result of poverty, it will not be very difficult to establish better data for Lebanon.*
[18] *Lebanon is not a signatory to the 1951 Refugee Convention.*

'formal' refugee camps in Lebanon. The Lebanese government's refusal to recognize the status of refugees increases their vulnerability. As they are unable to obtain formal employment, many refugees end up working illegally in poorly paid jobs. In addition, one month after their arrival, many refugees have still not registered with one of the UNHCR's four registration centres (Beirut, Tripoli, Zahle and Tyre) and thus receive no humanitarian assistance.

To ensure a coherent response, mechanisms for coordinating the activities of Lebanese NGOs and around 40 international NGOs working in the water supply and sanitation sector have been introduced. Since January 2016, the government has been playing an active role in coordinating aid. The 'Energy and Water' sector (as of 2017 'water sector) is now led by MoEW, and coordinated by UNICEF and includes the main sector stakeholders. The main aim of this group is to develop a harmonised approach to provide a coordinated response. To this end, the UN agencies are mapping all projects and identified needs.[19]

These efforts have been very useful as many of the current data based on which the mission could make its calculations were taken from the database that UNICEF has established with the support of all the INGOs working in the WASH sector.

1.3.5. Cooperation between the Lebanese government and UNICEF-WASH program

As the Syrian crisis is becoming a 'normal' phenomenon, each neighbouring country had to reconsider its position towards the Syrian refugees/immigrants. The Government of Lebanon decided until now to maintain a hands-off approach and relies heavily on the international community.

In 2015 UNICEF took over the responsibility to coordinate the WASH services by INGOs in the ITSs from UNHCR. By that time, the WASH program in ITSs run by the INGOS and supported by UNICEF was the largest in the country.

Unlike UNHCR, UNICEF has a responsibility towards *all* children in Lebanon, whether Lebanese or Syrian.[20] Therefore, UNICEF has now a dual program: one for the vulnerable Lebanese communities and one for the Syrian ITSs. The Syrian refugees (80%) that are living among the Lebanese communities are as such an indirect target group of the UNICEF WASH program. That program has formal relations with four Lebanese ministries.

UNICEF works in schools on hygiene education and WASH in schools with the **Ministry of Education.**

UNICEF- WASH team supports the **Ministry of the Environment and Ministry of the Interior** in municipal management of solid waste. Up to now, this program focussed on delivery of equipment (budget US$ 4-5 million per year). For 2017, an integrated approach and support has been planned for those municipalities that have a dumpsite[21].

The solid waste program is also a way to improve the relationship with municipalities in order to facilitate UNICEF partners to provide services in ITSs, and to persuade municipalities to protect the Syrian refugees. The work with both ministries strengthens UNICEF's position to work with vulnerable communities, whether Lebanese or Syrian.

[19] *Refugees in Lebanon - Aligning Emergency Response and Development, Claire Papin-Stammose, PSeau*
[20] *UNWRA is responsible for the Palestinian refugee children in the 12 Palestinian camps in Lebanon.*
[21] *On 12 Nov 16, residents of various towns in north, south and Mount Lebanon staged protests over authorities' decision to establish landfills near their homes. Demonstrators in the town of Sfira in the Minyeh-Dinnieh district burnt tires along a main road in protest of a municipal decision to establish a landfill and a waste sorting plant outside the town. They argued that the landfill would have a negative impact on both the local residents and the environment.*

UNICEF provides expert support for the MoE to allow it to play a pro-active role in the protection of the environment, now under extra stress because of the influx of about 1.8 million Syrian refugees (formally 1.5 million).

The UNICEF WASH program in ITSs originally fell under the **Ministry of Public Health** and UNICEF continues to support a surveillance program on epidemiology. Experts at UNICEF believe that Lebanon has been very lucky that until today no major epidemics have occurred in and around the ITSs. UNICEF supports also drinking water quality monitoring program.

Since January 2016, the UNICEF WASH program falls under the **Ministry of Energy and Water**. This ministry is keen to see that 251 selected Lebanese municipalities benefit from the water and wastewater infrastructural funds of UNICEF (US$ 20-25 million per year). The program consists of rehabilitation of networks and water wells, followed by expansion and finally the construction of new reservoirs and wells. 251 municipalities (out of over 1,000) have been selected, based on their relative social-economic vulnerability. Despite these criteria, many ITSs are located outside these 251 selected municipalities.

The other half of the UNICEF WASH budget is spent on ITSs and is the main WASH funding for the seven UNICEF partners[22].

Annually, UNICEF spends US$ 20 million on WASH services in ITSs divided over:
- Water trucking: US$ 10 million;
- Desludging: US$ 5 million;
- WASH construction: US$ 5 million.

1.4. Opportunities beyond the ITSs

Finance. Considering the high desludging costs and the environmental pollution it is expected that the Lebanese communities will benefit from the UNICEF ITSs WASH program. The technological recommendations in this report illustrate that win-win solutions are realistic, cheaper and result in a healthier environment. The sustainable approach is expected to attract the interest of donor countries, and more importantly on the long run, interest from local Lebanese and expatriate investors.

The Sustainable Finance Program of Netherlands Water Partnership (NWP, see www.nwp.nl) demonstrates that local finance and international private investors can be mobilized to invest development projects for local communities. This option should be explored in Lebanon as well, as there is no reason to believe that this would be impossible.

Properly designed and maintained wastewater systems based on a realistic operational budget (and business case) can convince investors or donors to sustain support for the Lebanese water sector. The UNICEF WASH program presents an opportunity to showcase these opportunities if they are designed with a long-term perspective. Ad hoc solutions will not attract interest of others apart from the relief donors.

Role of the private sector. The local private sector, particularly the small and medium size enterprises (SMEs) are crucial for the delivery of sanitation services, but it seems that these hands-on environment services do not receive sufficient attention from the Lebanese government.

[22] *ACF, CISP, Concern Worldwide, LOST, Mercy CORPS, Solidarité s International, World Vision*

Currently the main part of the UNICEF wastewater budget is spent on desludging, which is done by the SMEs. Toilets, run-offs, drainage, sludge storage within the camps are constructed by local contractors. As such, the Lebanese private sector benefits from the ITSs and will remain to do so, also after the INGOs have left Lebanon.

Role of the government and municipalities. Governmental institutions are meant to support private and the general public interests by providing a minimal enabling environment based on a medium and long-term vision. Promotion of a role for the private sector in providing WASH services to ITSs, will depend on consistent policies, a legal framework and enforcement by relevant ministries, Water Establishments and/or municipalities. Recently published water quality reports indicate that almost all Lebanese water resources are polluted. Therefore, the importance of efforts to protect the water resources will become a major national issue, and the country will benefit from recommendations and initiatives such as has been suggested in this report.

Relevance of a WASH sector ITS support program. The implementation of the recommended ITS WASH program will deal with challenges such as:

- Contracting private sector product and service delivery;
- Design and construction of decentralized networks and WWTPs;
- Quality control of delivered and construction;
- Monitoring operation and maintenance.

Experience and dealing with these challenges will form a basis for the parallel services delivery in Lebanese communities, extending positive employment and environmental impact beyond the ITSs and current troubling period.

2. Potential project areas and criteria for project area selection

2.1. Introduction

We have developed two sets of criteria for prioritization. The first set is a 'technological' set based on reducing the potential risk of environmental pollution and reducing the operation and maintenance costs of the current practices. See § 2.2. The second set is an 'institutional' set, see § 2.3.

2.2. Technological criteria and location project areas

The 'technological' criteria are based on reducing the potential risk of environmental pollution and reducing the operation and maintenance costs of the current practices. Based on the information available, we assume that the locations that currently are reported to convey the black water into sewers (red triangles in the map in Figure 16) do not need any action, except the verification of the level of treatment and any accompanying improvement of the sewage treatment. This is outside the scope of our Terms of Reference. For the area that do not convey the black water into the sewers, we recommend prioritizing as follows:

- The **first priority** is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into open channels (pink triangles in the map in Figure 16 and Figure 17). This needs verification in the field;
- The **second priority** is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into open pits (yellow triangles in the map in Figure 16 and Figure 18). This needs verification in the field;
- The **third priority** is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into cesspits, which is the most common disposal method in Lebanon (green triangles in the map in Figure 16 and Figure 19). If these pits are less than 2 meters (see § 3.3) from the highest groundwater table in sandy-loam areas or located in karst rock areas, groundwater might be at risk. This needs verification in the field;
- The **fourth priority** is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into septic tanks that drain into the subsoil (purple triangles in the map in Figure 16). If these pits are less than 2 meter (see § 3.3) above the highest groundwater table in sandy areas or located in karst rock areas, groundwater might be at risk. This needs verification in the field;
- The **fifth priority** is to improve the systems in those ITS locations where there are high operation and maintenance costs as the black water is currently reported to be discharged into holding tanks (blue triangles in the map in Figure 16). These tanks fill up within 2-4 weeks and need desludging, leading to high operation costs. This needs verification in the field.

Discussions with UNICEF on 7 December 2016 revealed that the distinctions between the ITSs based on this typology is less straightforward than it seems. In practice, many ITSs have a mix of systems. As it is not very logic to focus improvement on only part of an ITS, in practice prioritization needs to be based on a mix of the above-mentioned priorities.

An overview of the locations of the different systems is presented in Figure 16 .

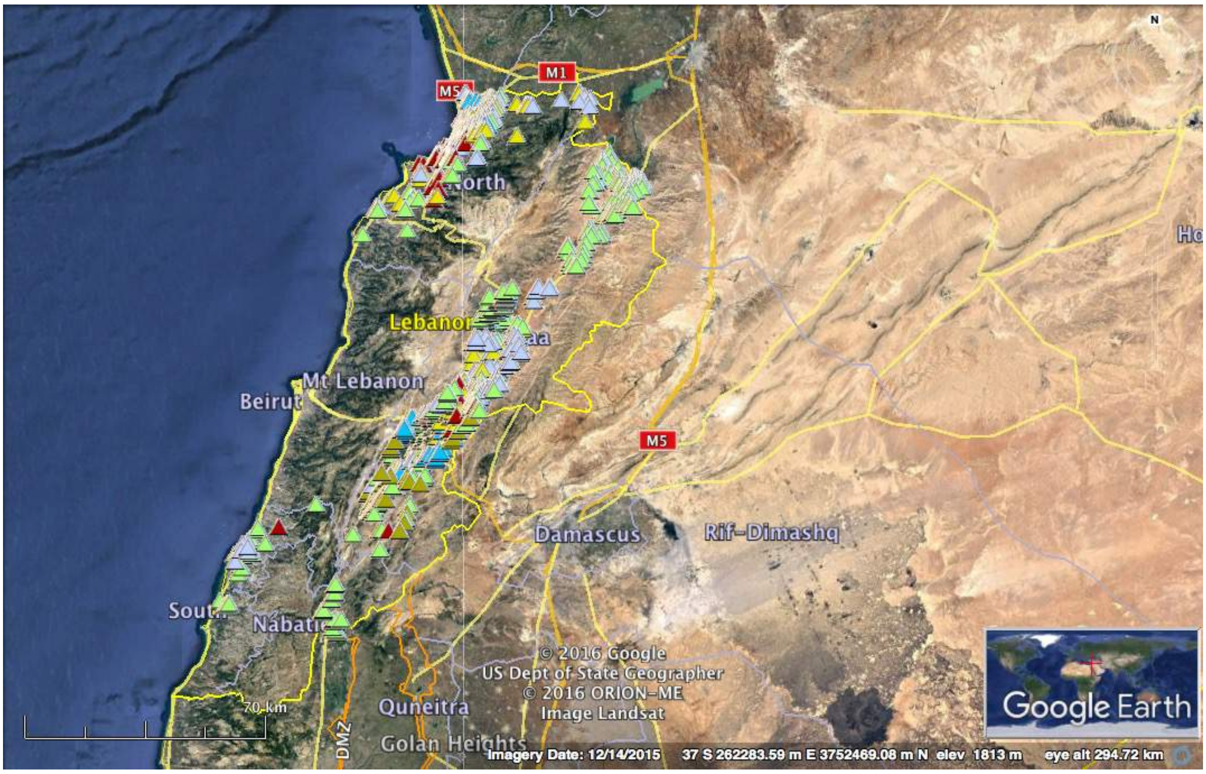


Figure 16: Overview reported types of discharge of black water in ITS locations

Figure 17: Discharge of black water into open channels

Figure 18: Discharge of black water in open (dry) pit

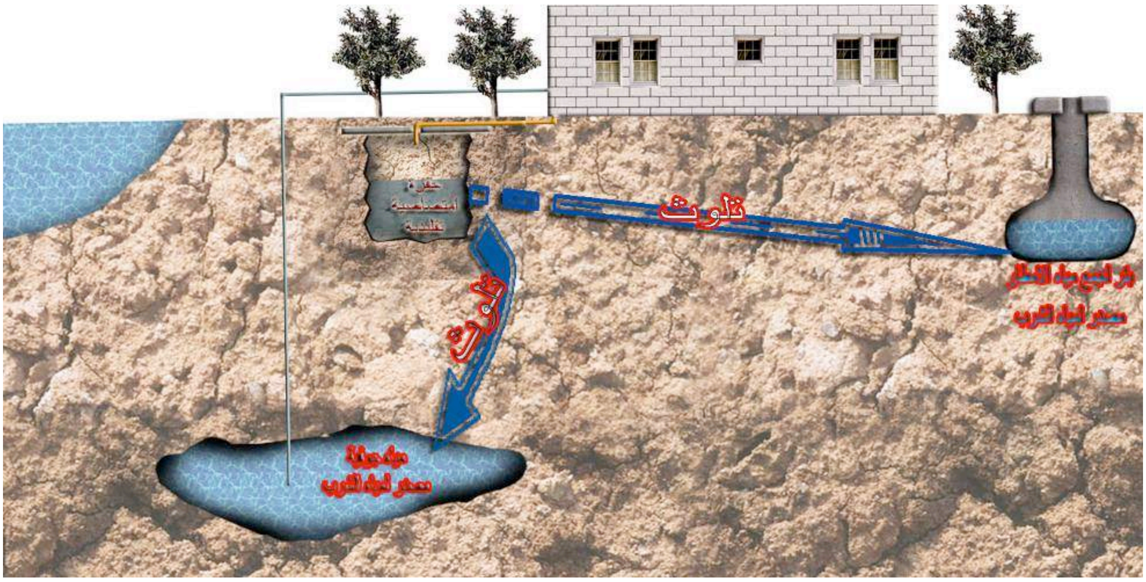


Figure 19: Pollution by cesspit in Karst rock areas

2.3. Non-Technological criteria and location project areas

Classification of ITSs. To make investment choices for the benefit of both the ITSs and hosting Lebanese communities, in relation to the current physical situation in the ITSs we must get to terms with the current reality to shape better realities in the nearby future. The question can better be asked now than when funds have dried up: ***In which ITSs and how can INGOs minimize and eventually stop providing WASH services?***

In the context of this report and its technical recommendations for wastewater management, we suggest adopting a systematic approach for the order of interventions: **Where do we start first? Which ITS locations are suitable and which are not suitable for main wastewater management investments?**

It should be emphasized that to implement and to maintain the recommended wastewater strategy, the WASH sector should pay more attention to the local institutional, environmental and social aspects.

We distinguished three types of ITSs. For two of them we have good reasons to continue providing wastewater services. For most the ITSs we believe that the recommended wastewater management is applicable and suitable.

In which ITSs should WASH services be minimized and/or eventually stopped?

1. ITSs that are in a good condition and need little improvements. These settlements include mainly those that are connected to a sewer network or very isolated ITSs, where the environmental capacity to absorb and treat the relatively small amount of wastewater is adequate. Efforts should be targeted towards a withdrawal from these ITSs and handing over responsibility to the ITSs, municipalities and Lebanese NGOs.

Recommendation. *UNICEF and INGOs to develop a wastewater management exit strategy for these ITSs to be able to concentrate attention to category 3 (ITSs best suited for wastewater investments).*

2. ITSs that are unfit for human settlement or where improvements are extremely difficult and expensive due to their location.[23]

Recommendation. *UNICEF and INGO develop an exit and relocation strategy from these ITSs to be able to concentrate category 3 (ITSs best suited for wastewater investments).*

Which ITSs are best suited for major wastewater management investments?

3. ITSs that host many refugees and that have a solid basis for improvements and thus can be prioritized based on a set of transparent criteria.

To have a transparent approach in combination with the two environmental criteria the team took the initiative to develop a tool that can assist in answering the questions which ITSs are best suited and therefore should be fist served by the recommended wastewater management approach.

Where do we start?
In the context of this report and its technical recommendations for waste water management, we suggest adopting a systematic approach based on the following concerns:

- Does wastewater threaten a communal water source (such as drinking water wells) and is the ITS served from a private bore hole (after purification of this water), or is the ITS dependant on water trucking;
- As investments are more efficient in bigger settlements, we suggest considering starting with these ITSs;
- Rocky soil can increase the costs of making simple trenches for networks, digging holes for septic tanks and constructed wetlands. Locations in loam or sandy soils are better;

[23] *For example, Te'nayel 002 has multiple problems. The ITS is located along a highway (which is being constructed currently) and flooded in winter. A drainage channel was dug, but is currently full of solid waste. ACF is prepared to clean the channel before the winter, but the municipality does not permit this because it wants to use the situation to put pressure on the families to pay US$ 16 per month per family for solid waste services. Another severe problem is that most of the latrines have a cesspit dug by the people themselves under and in the very narrow alleys between the tents. There is no desludging possible at all. Many of the cesspits are full, connected to a pipe ending in semi open pits in the neighbouring land. Grey water is discharged into holding tanks, emptied manually and discharged on the edge of the ITS or in the drainage canal.*

- O&M of a wastewater system needs minimum understanding by staff of municipalities (and Water Establishments);
- Wastewater systems need minimum appreciation and care by the ITS communities;
- The wastewater system implies minimal infrastructural arrangement and space, and therefore the approval of the landlord;
- Flood prone location should be avoided;
- Vulnerable communities may get preference;
- ITSs where access by vacuum truck is difficult, should be reconsidered for reallocation;
- ITSs closer to WWTPs will decrease the costs of desludging;
- ITSs that may be evicted should get less priority, from a point of financial efficiency;
- Locations with a shallow ground water table are a concern;
- Stable ITS communities will appreciate a good wastewater management more than those who move regularly;
- ITSs families that manage their toilets, solid waste, grey and storm water properly should be rewarded.

Based on the above, we developed a tool that can assist from an environmental, institutional and social perspective by indicating which ITSs should get priority in planning the wastewater management improvements. Financial considerations may receive more attention in the final order of works.

Table 7: 2nd set of selection criteria

	Criterion	Score
1	Close distance to a drinking water source	High
	Main water well (10), private bore hole (1), none (3)	
2	Density of inhabitants (people per ha)	High
	Low (10), average (5), high (0)	
3	Soil structure	Medium
	Rocky (5), clay (3), sand (1)	
4	Cooperation of local community/municipality	Medium
	Bad (5), neutral (3), good (1)	
5	Cooperation of IS community	Medium
	Bad (5), none (4), moderate (3), good (4), excellent (1)	
6	Cooperation of landlord	Medium
	Bad (4), fair (3), good (2), excellent (1)	
7	Flood prone area during the winter	High
	Most parts of the IS (20), substantial parts of the IS (10), specific limited locations (3), hardly to no locations (0)	

	Criterion	Score
8	Vulnerability of the host community	High
	Low (5), average (3), high (1)	
9	Access desludging trucks	Medium
	Difficult (3), fair (2), good (1)	
10	Distance to sludge disposal point	Medium
	More than 10 km (5), 5-10 km (3), less than 5 km (1)	
11	Risk of eviction	High
	High (10), unknown (5), low (1)	
12	Health situation	High
	Bad (7), poor (5), moderate (3), good (1), very good (0)	
13	Mobility of ITS community	Medium
	High (5), medium (3), low (1)	
14	General cleanliness of ITS (incl. solid waste)	High
	Bad (7), poor (5), moderate (3), good (1), very good (0)	

Note: The lower the score, the higher the suitability of the location.

3. Outline technological approach

3.1. Overview black water systems

Classification of black water systems present in the field. Figure 20 provides an overview of the information retrieved from the database managed by UNICEF Beirut on the black water[24] systems. The figure is based on information of all 'active' Informal Tented Settlement (ITS) including those with less than 4 tents, totalling 13,043 systems. Around 40% of the information is not available.

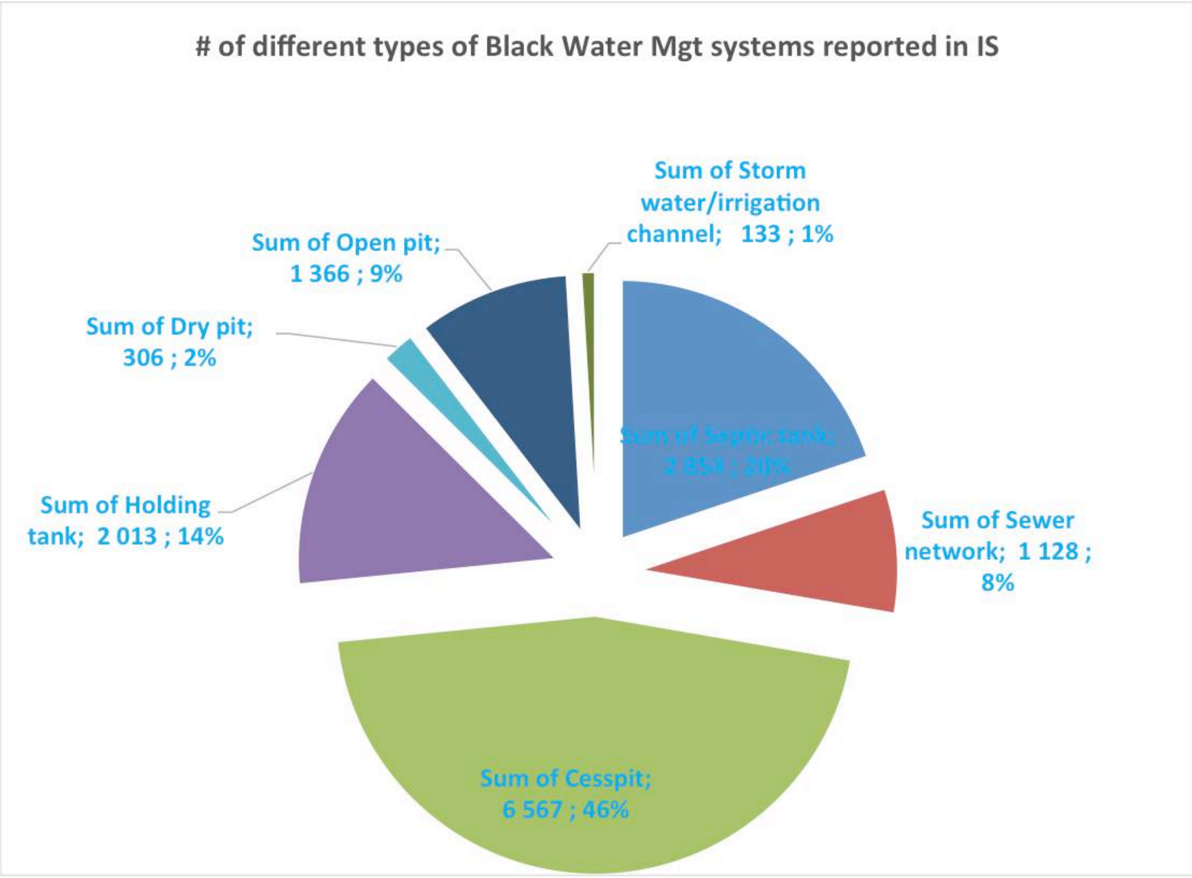


Figure 20: Overview actual black water systems (Source: database managed by UNICEF Beirut, accessed 21 November 2016)

3.2. Technological interventions

The strategy for black water is illustrated in Table 8. We distinguish between the following typical situations:

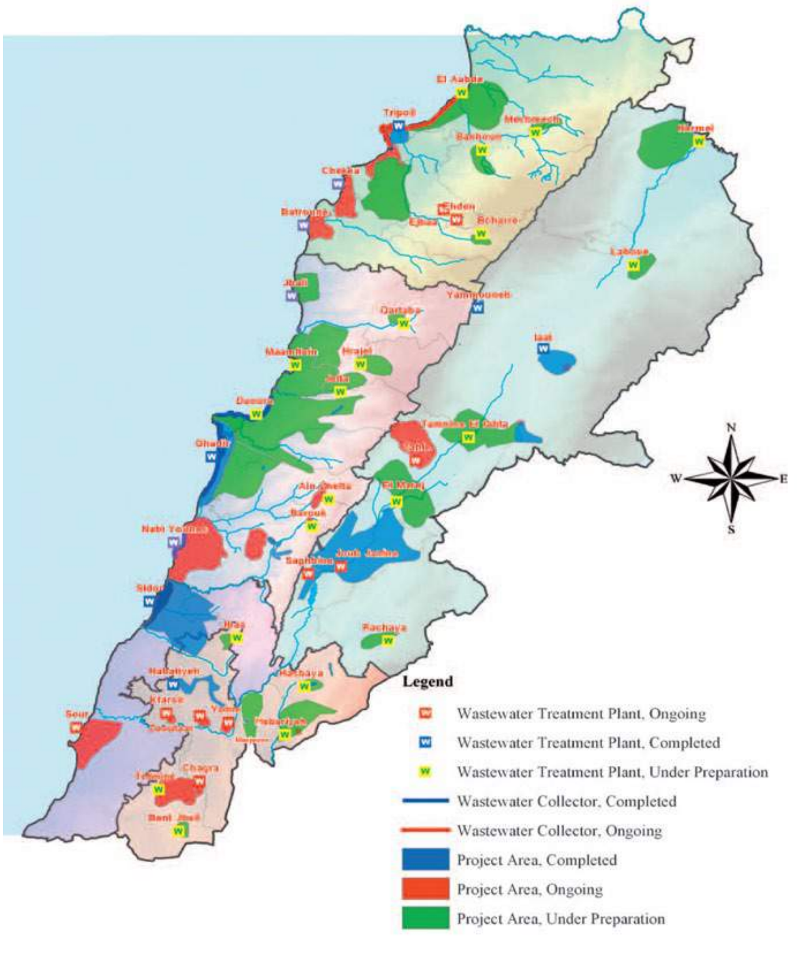
- Where municipal / water establishment sewers are nearby, the preferred option is to connect the ITS locations to these sewers and treat the effluent in the existing Wastewater Treatment Plant (WWTP), see map in Figure 21. In this way, the environment is protected and costs are minimized, especially the Operation and Maintenance (O&M) costs. A serious point of concern is the fact that now very few WWTP treat the water up to the required effluent standards. We have not elaborated on this approach because of lack of reliable data. We understand that UNICEF is hiring World Engineering & Technology (W.E.T.) Consultants to assess the actual location, state and performance in terms of Operation and Maintenance (O&M) of the WWTPs

[24] Black water is the mixture of faeces, urine and water used for anal cleansing.

in Lebanon in the framework of the Joint Monitoring Programme (JMP) on the Sustainable Development Goals (SDG);

Recommendations:

1. *Update the presented report after the finalization of the JMP survey on the SDGs that assesses the WWTPs in Lebanon;*
2. *Take idle WWTP into operation;*
3. *Connect households within 30 m of the lateral sewers to sewerage network.*



Map 3.2 WWTP completed, on-going and under preparation projects (CDR, November 2013)

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Figure 21: Map with completed, on-going and under preparation projects (MOE/EU/UNDP, 2014)

- For very small ITS locations of around 4 households, the preferred option is to install a PVC/PE communal wastewater treatment facility:
    - In Karst rock areas or areas with a high water table, the recommended treatment technology facility is a shared PE 6 m^3 Baffled Septic Tank (BST), followed by a 15 m^2 Vertical Flow Constructed Wetland (VFCW), that discharges either into the subsoil, an irrigation system, soil absorption doughnuts or surface water;

Recommendation: *facilitate the production of off-the shelf 6 m^3 PE Baffled Septic Tanks.*

-
    - In sandy/loam soils with low groundwater table where shared facilities are not possible, the recommended treatment technology is a 0.83 m^3 (black water only) – 1.22 m^3 (black and grey water) 2-chamber Poly Ethylene (PE) Septic Tank (ST) where BOD/COD is removed, with an Anaerobic Upflow Filter (AUF) that traps the suspended solids. The solids-free effluent is then infiltrated into the subsoil in a soakaway pit with the bottom at least 2 m above the highest groundwater table. This 2 m of soil/loam ensures all pathogens die off. The current practice of using drinking water tanks for wastewater should be abandoned, as they are not suitable;

Recommendation: *facilitate the production of off-the shelf 0.83 and 1.22 m^3 PE two-chamber septic tanks where the 2nd chamber can be converted into an Anaerobic Upflow Filter.*

- For larger ITS communities with existing PE holding tanks, these should be converted into one chamber ‘septic tanks’ by adding a ‘Tee shaped’ outlet. Where PE holding, tanks are not installed, 0.83 m^3 2-chamber PE Septic Tanks need to be installed. Both the converted holding tanks and the new septic tanks are to be connected to a PVC SFS (Solids Free Sewerage) system 50-75 mm diameter. This system ends up in a communal BST (24 m^3 for 100 households of 15 persons/household) and a communal VFCW (700 m^2 for 100 households of 15 persons/household). The VFCW discharges either into the subsoil, an irrigation system, soil absorption doughnuts or surface water.

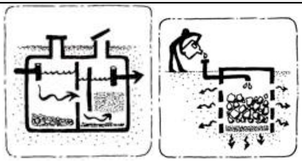
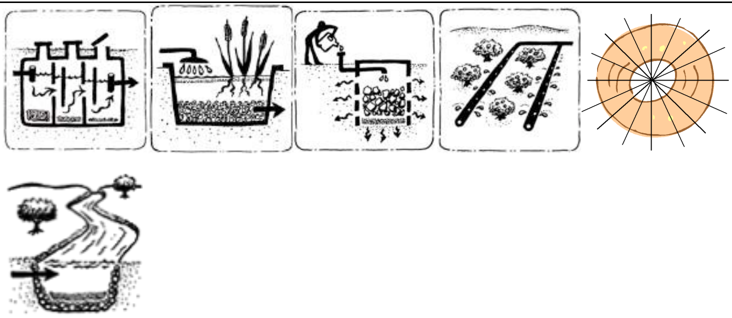
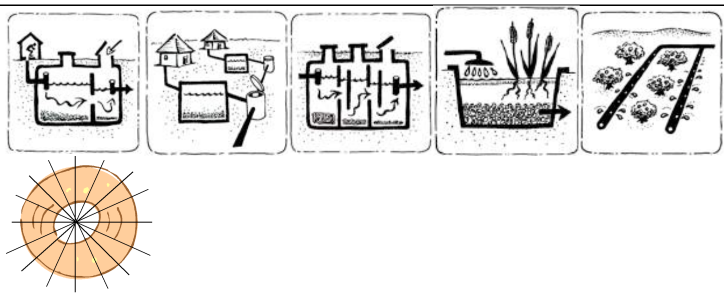
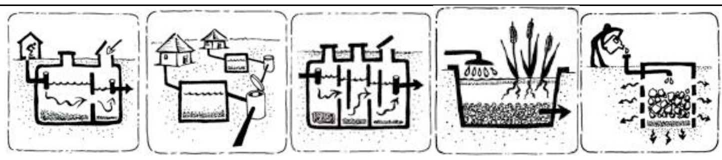
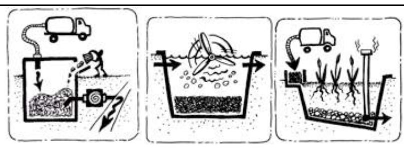
Recommendation: *facilitate the production of off-the shelf 6 m^3 PE BSTs that can be used in a modular way to form a 24 m^3 communal BST.*

- The sludge collected from the ITS needs to treated properly, either in existing WWTPs or in special Sludge Treatment Plants, preferably planted sludge drying beds. The existing WWTPs need to be adapted to be able to receive and treat partially digested sludge from ITS locations.

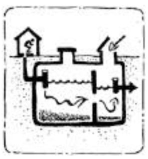
Recommendation: *request WET Consulting engineers to investigate whether existing WWTPs can receive and treat partially digested sludge from ITSs. Where WWTPs are not suitable, implement planted sludge drying beds, preferably at the site of the WWTP to reduce environmental nuisance.*

Table 8: Technological strategy

Existing situation	System	Illustration
Sewerage nearby	Use existing Sewerage and assist Water Establishment in adequate wastewater treatment	 

Existing situation	System	Illustration
Small communities with inadequate sanitation / sandy-loam soil and low groundwater table	Septic Tanks & Anaerobic Upflow Filter / Infiltration > 2 m' above highest ground water level	
Small communities with inadequate sanitation / Rocky (Karst) soils or areas high water table	Shared Baffled Septic Tanks / Vertical Flow Constructed Wetland / Infiltration OR Reuse/Agriculture OR Absorption in doughnuts OR discharge into open water	
Large communities with inadequate sanitation / Rocky (Karst) soil	(Septic) Tanks / Solids Free Sewerage / Baffled Septic Tanks / Vertical Flow Constructed Wetland / reuse or doughnuts	
Large communities with inadequate sanitation / sandy-loam soils	(Septic) Tanks / Solids Free Sewerage / Baffled Septic Tanks / Vertical Flow Constructed Wetland / Infiltration / reuse or doughnuts	
Sludge disposal	Into existing (trunk) sewers – WWTPs / (Planted) sludge drying beds	

3.3. Septic Tank



A (low cost) septic tank is a good way to replace existing cesspits and open pits in the ITS locations and connect them to a Solids Free Sewer (SFS) system, see § 3.6. A Septic

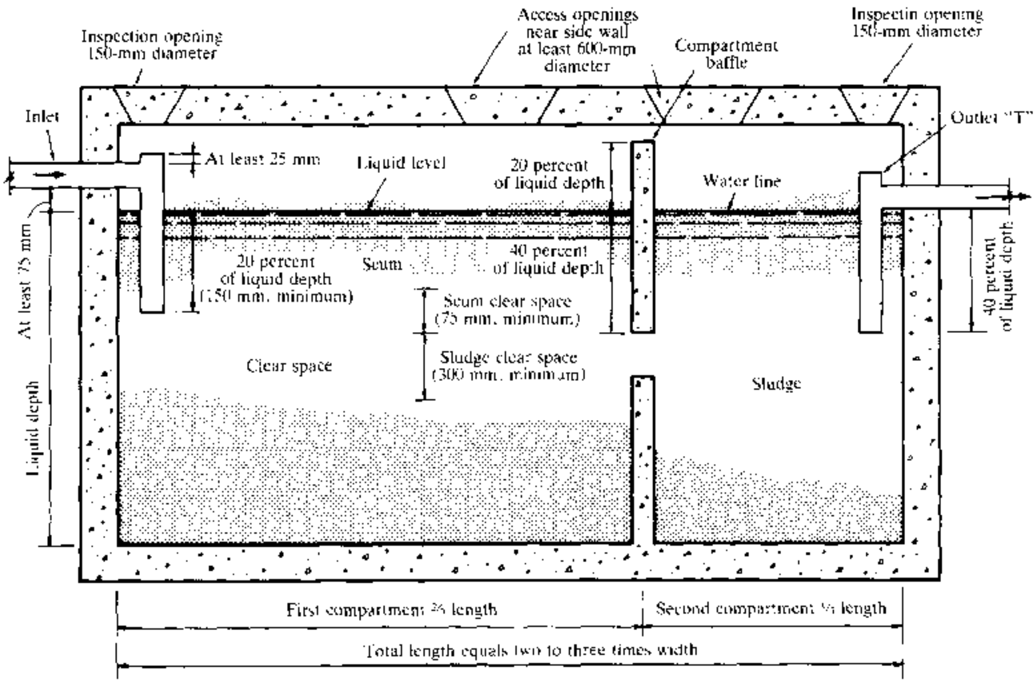
Tank[25] is a watertight chamber made of PVC or PE, for the storage and treatment of black water. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate**.**

A Septic Tank (Figure 22**) should typically have at least two** chambers. Liquid flows into the tank and heavy particles sink to the bottom, while scum (oil and fat) floats to the top. The first chamber should be at least 50% of the total length and when there are only two chambers, and it should be two-thirds of the total length. The first chamber is used to settle the solids. Wastewater enters the first chamber of the tank, allowing solids to settle and scum to float. The settled solids are anaerobically digested, reducing the volume of solids. The liquid component flows through the dividing wall into the second chamber, where further settlement takes place, with the excess liquid then draining in a relatively clear condition from the outlet into the SFS. For more details see

[25] After Tilley (2008)

Appendix 4: Septic Tank.

Figure 14-1. *Schematic of Conventional Septic Tank*
(millimeters)



Note: If vent is not placed as shown on figure 13-2, -3, and -4, septic tank must be provided with a vent.

Figure 22: Specification conventional septic tank (Kalbermatten, 1982)

Septic Tanks to be applied in the ITS locations are preferably made of pre-fab HDPE, see Figure 23.

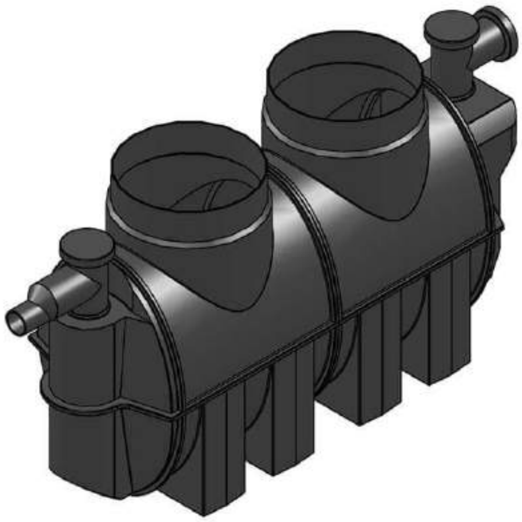


Figure 23: Pre-fab HDPE septic tank 1100 litres

3.4. Baffled Septic Tank

The Baffled Septic Tank (or Anaerobic Baffle Reactor) is the most appropriate 'stand-alone' treatment system for a cluster of households. The Baffled Septic Tank (BST) is an improved septic tank because of the series of baffles under which the wastewater is forced to flow. See Figure 24. The increased contact time with the active biomass (sludge) results in improved treatment. For more detailed information see § 3.7.

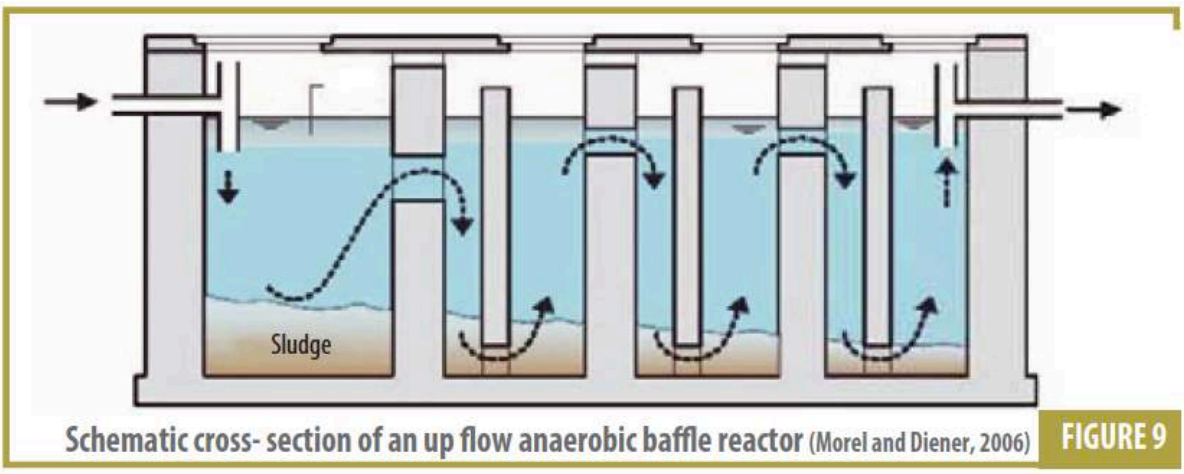


Figure 24: Baffled Septic Tank (UN HABITAT, 2008)

3.5. Anaerobic Upflow Filter

An **Anaerobic Upflow Filter** (UAF) is a fixed-bed biological reactor. As wastewater flows through the filter material, particles are trapped and organic matter is degraded by the biomass that is attached to the filter material. See Figure 25. This technology consists of a sedimentation tank (or septic tank) followed by one or more filter chambers. It is recommended for small ITS locations where it is not possible to apply communal wastewater treatment systems and where the soil is suitable for infiltration (sandy-loam soils, > 2 m' above the highest groundwater table). The filter reduces the danger of clogging of the soak away. For more information, see Appendix 5: Anaerobic Upflow Filter.

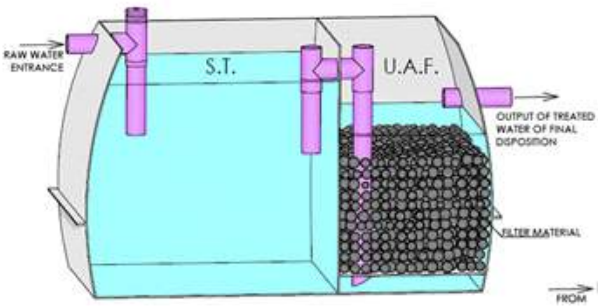


Figure 25: Anaerobic Upflow Filter (http://depuragua.co.cr/en/improved_septic_tank.html)

3.6. Solids Free Sewerage


Sewerage is implemented for user convenience and can have environmental benefits if operated well on a municipal scale. However, a well-designed, well-operated on-site system can have more environmental benefits than a poorly managed sewerage system that discharges its effluent untreated into rivers or the sea, which contributes to environmental degradation.

Separate Conventional Gravity Sewers are large networks of underground pipes that convey only black water and grey water. **Shallow Sewers** or Simplified Sewers describe a sewerage network that is constructed using smaller diameter pipes laid at a shallower depth and at a flatter gradient than conventional sewers. The Simplified Sewer allows for a more flexible design associated with lower costs and a higher number of connected households. See Figure 26.

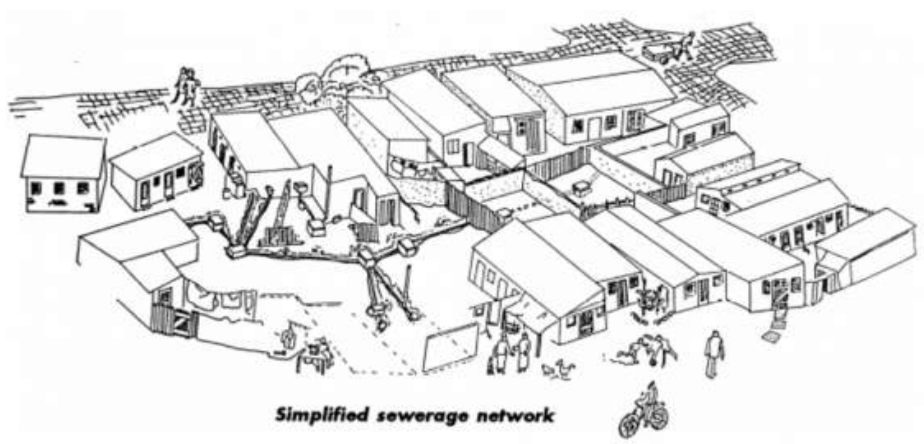
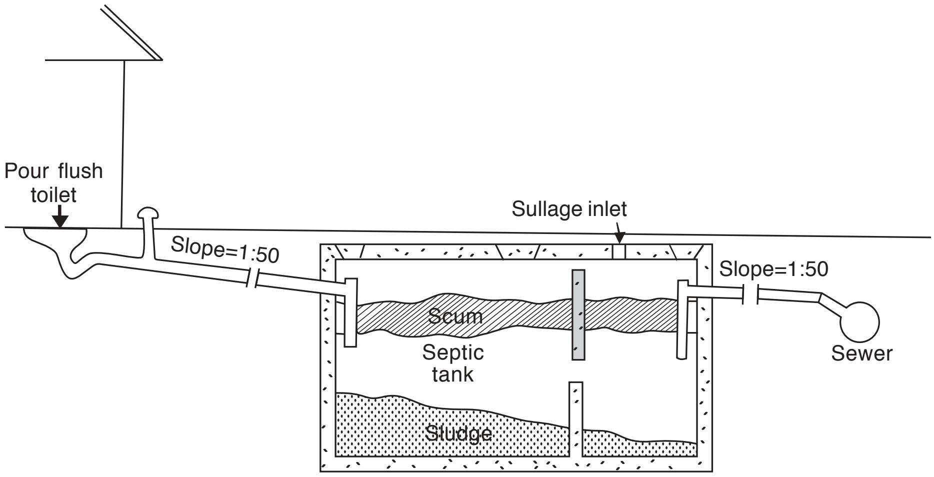


Figure 26: Simplified sewerage network

Solids Free Sewerage (SFS) is a network of small diameter pipes that transports solids-free or pre-treated wastewater (such as septic tank or settling tank effluent) to a treatment facility for further treatment or to a discharge point. SFS are also referred as settled, small bore, small-diameter, variable grade gravity, or septic tank effluent gravity sewers. See Figure 27. SFS is a good way to upgrade ITS location with (septic) tanks and reduce the costs of desludging as now also wastewater is removed. For more information, see Appendix 6: Solids Free Sewerage.



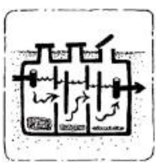
Source: After Kalbermatten et al. 1982.

Figure 27: Solids Free Sewerage (Kalbermatten, 1982)

Table 9: Advantages and disadvantages Solids Free Sewers

Advantages	Points of attention in ITS locations
• Grey water can be managed at the same time • Can be built and repaired with locally available materials • Construction can provide short-term employment to local labourers • Capital costs are less than for conventional gravity sewers • Appropriate for densely populated areas with sensitive groundwater or no space for a soak pit or leaching field	• Requires repairs and removals of blockages • Requires expert design and construction supervision • Requires education and acceptance to be used correctly • Effluent requires secondary treatment in an BST (see § 3.7) and VFCW (see 3.8) • Sludge from the septic tanks requires appropriate discharge to WWTPs • The septic tank can overflow when they have not been desludged in time • The system can become blocked because of illegal connections that by-pass the interceptor tank • Solids Free Sewerage systems are basically only suitable where there are septic tanks • The need to desludge the interceptor tank regularly requires adequate organization and operating procedures

3.7. Informal Settlement Sewage Treatment: Baffled Septic Tank



Anaerobic treatment in a **Baffled Septic Tank (BST)** (see Figure 28) is the most appropriate treatment system to treat the effluent of the Solids Free Sewers. When it is followed by a Vertical Flow Constructed Wetland (See § 3.8), the effluent is fit for infiltration, reuse in agriculture or disposal in a nearby stream. A BST is an improved septic tank because of the series of baffles under which the wastewater is forced to flow. The increased contact time with the active biomass (sludge) results in improved treatment.

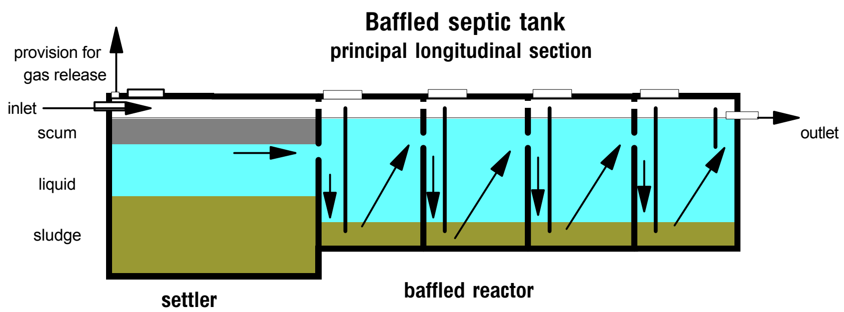


Figure 28: Baffled Septic Tank (Sasse, 1998)

To assure an adequate design and flexibility, we propose to purchase a mould and have the ABR produced in Lebanon. See Figure 29.

Figure 29: Prefab Settling chamber and baffle tank (Borda)

For more information, see Appendix 7: Baffled Septic Tank.

3.8. Vertical Flow Constructed Wetland

A Vertical Flow Constructed Wetland (VFCW) is a filter bed that is planted with aquatic plants. See Figure 30. Wastewater is poured or dosed onto the wetland surface from above using a mechanical dosing system. The water flows vertically down through the filter matrix. The important difference between a vertical and horizontal wetland is not simply the direction of the flow path, but also the aerobic conditions.

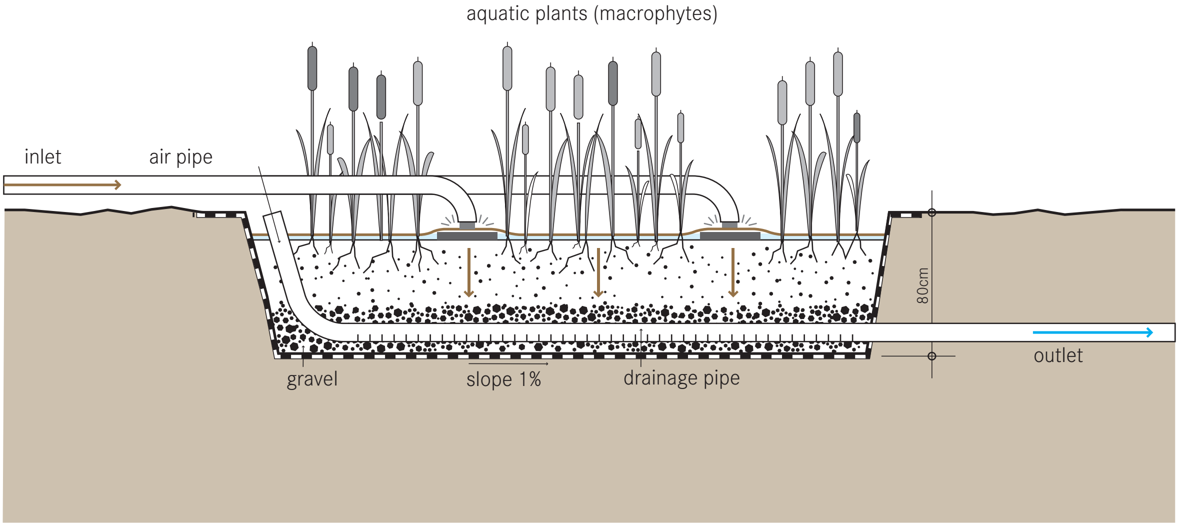


Figure 30: Vertical Flow Constructed Wetland (Tilley, 2008)

The VFCW is excellent technology for the treatment of the effluent of the BST in the ITS locations as it can be made from locally available material. The karst rock formations are protected from pollution by the application of PE foil at the bottom. See Figure 31.

Figure 31: HDPE lining (source: www.energyglobe.info, accessed 25 November 2016)

3.9. Grey water and effluent disposal systems

Grey water should be disposed of as close as possible to the source of its production to avoid (expensive) piping. We suggest the following technologies:

- Soakaway, see § 3.9.1;
- Evapotranspiration, § 3.9.2;
- Doughnut absorption, see 3.9.3.

3.9.1. Soak away

When the soil is sufficiently permeable, the grey water can be discharged in a soakaway / soak pit. A soakaway (see Figure 74) is a covered, porous-walled chamber that allows water to slowly soak into the ground. Grey water is discharged to the underground chamber from where it infiltrates into the surrounding soil. The soakaway can be left empty and lined with a porous material (to provide support and prevent collapse), or left unlined and filled with coarse rocks and gravel. The rocks and gravel will prevent the walls from collapsing, but will still provide adequate space for the wastewater. In both cases, a layer of sand and fine gravel should be spread across the bottom to help disperse the flow. The soakaway should be between 1.5 and 4 meters deep, but never less than 1.5 meters above the ground water table. As grey water percolates through the soil from the soakaway, the soil matrix filters out small particles and organics are digested by microorganisms. Thus, soakaways are best suited to soils with good absorptive properties. Clay, hard packed or rocky soils are not suitable**.** People should be advised not to restrict the use of detergents or other chemicals.

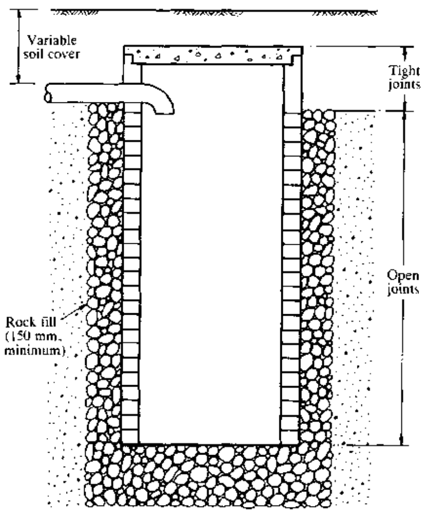


Figure 32: Soakaway (Kalbermatten, 1982)

3.9.2. Evapotranspiration

An evaporation field is a simple method to dispose of grey water in impermeable soils. The wastewater effluent is discharged into sealed up receptacles where the water evaporates from the soil or transpires from the plants growing there. Bacteria remove the dissolved organic matter and plants take up the remaining nutrients. See **Figure 33**.

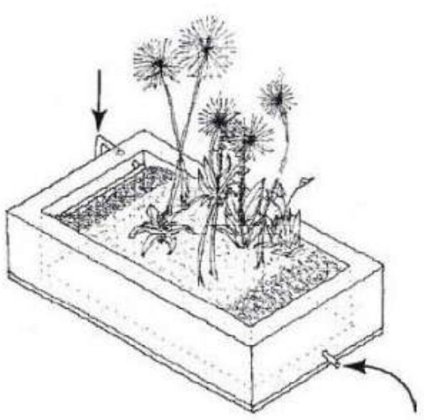
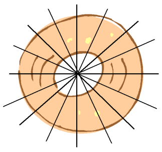


Figure 33: Evapotranspiration field (SSWM)

Evaporation fields are a low-cost technology that allows for a secondary treatment of grey water. The grey water can be discharged by gravity into sealed up planting beds, containers (see Figure 34), inverted tires or the like where it will be absorbed by soil particles and moves both horizontally and vertically through the soil pores. The liquid fraction moves upwards by capillary action and either evaporates at the surface or is taken up by plants or trees and transpires. The plants/trees take up the remaining nutrients and bacteria living in the soil remove the dissolved organic material in the effluent. Eucalyptus trees are well suited for evaporation fields and known for this in Lebanon.

Figure 34: Evapotranspiration bed

3.9.3. Absorption in soil doughnuts



A soil doughnut is a simple method to dispose of grey water in impermeable soils using absorption capacity of nearby soils. The wastewater effluent is discharged into the middle of a circular shaped soil 'doughnut-like' structure, where the water is absorbed and evaporates from the soil. Once the soil is fully saturated with Phosphates and Nitrates the soil is renewed and the saturated soil used as a soil improvement. See Figure 35.

Figure 35: Soil doughnut (Malawi)

3.10. Sludge drying

Existing WWTPs should be made suitable to receive sludge. As most WWTPs are not suitable / designed for this, a recommended short-term action is to dry it at sludge drying beds at WWTP locations. An Unplanted Drying Bed is a simple, permeable bed that, when loaded with sludge, collects percolated leachate and allows the sludge to dry by evaporation. See Figure 36. Approximately 50 % to 80 % of the sludge volume drains off as liquid that needs to be treated in the WWTP. The sludge however, is not stabilized or treated and should be stored for 2 years to assure the die-off of pathogens. Alternatively, Planted Drying Beds can be used with the additional advantage of transpiration and improved treatment.

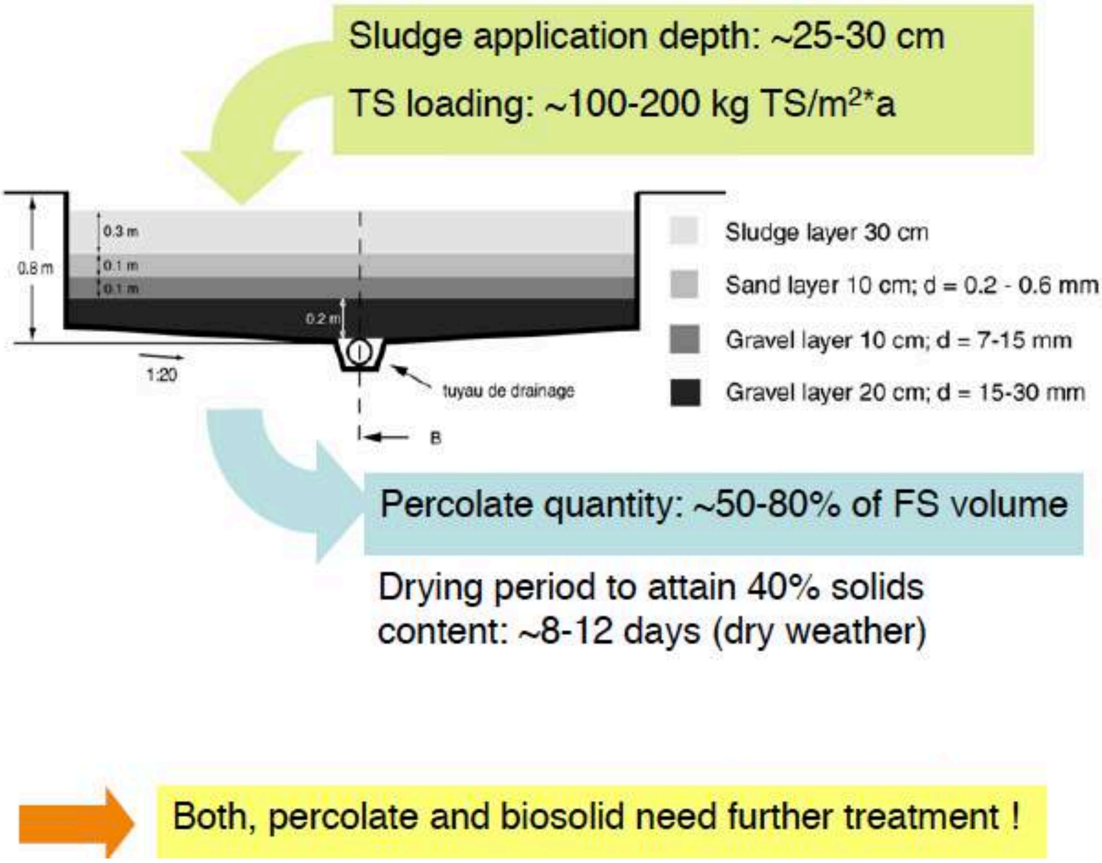


Figure 36: Unplanted sludge drying bed (EAWAG, 2006)

The bottom of the drying bed is lined with perforated pipes that drain away the leachate. On top of the pipes are layers of sand and gravel that support the sludge and allow the liquid to infiltrate and collect in the pipe. The sludge should be loaded to approximately 200 kg TS/m^2 and it should not be applied in layers that are too thick (maximum 20 cm), or the sludge will not dry effectively. The final moisture content after 10 to 15 days of drying should be approximately 60%. A splash plate should be used to prevent erosion of the sand layer and to allow the even distribution of the sludge. When the sludge is dried, it must be separated from the sand layer and disposed of. The effluent that is collected in the drainage pipes must also be treated properly. The top sand layer should be 25 to 30cm thick as some sand will be lost each time the sludge is manually removed. See Figure 37

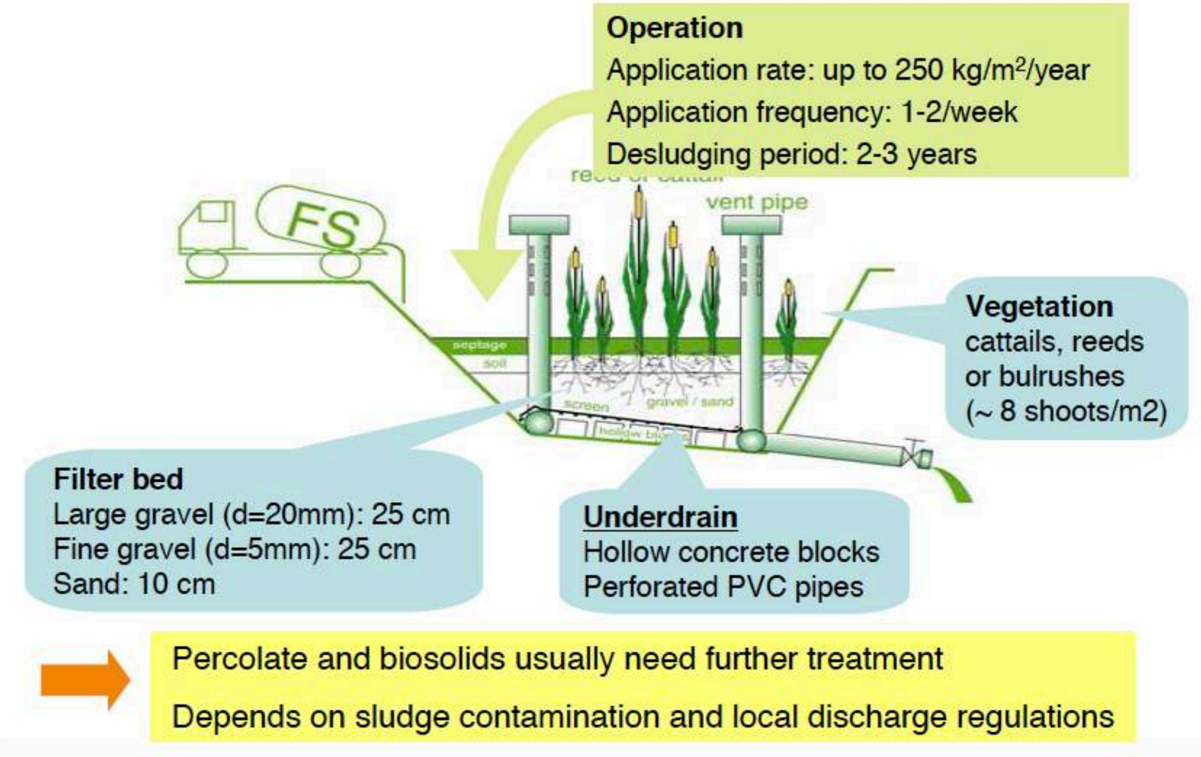


Figure 37: Planted sludge drying bed (EAWAG, 2006)

For more information, see Appendix 9: Sludge drying.

3.11. Standardization of existing WASH services

During the UNICEF WASH partner meeting (2 November 2016) in Beirut there was a consensus that the technology and approach of the partners should be 'standardized' to improve services and decrease costs. Similarly, the ToR of the mission was to look at options to decrease the costs of desludging and decrease the chance of (ground-) water pollution, with a focus on wastewater management.

Because all elements of the sanitation chain have an impact on the final quality of the wastewater, we were also asked to provide suggestions on the improvement of other WASH activities in the ITSs. As most of our ideas have been discussed and can already been seen in the field, we are confident that 'our ideas' will not come as a surprise and are feasible from a technical point of view.

We encourage UNICEF and all sector partners to agree on a process to swiftly encourage standardization. Although this is a continuous process, quick gains can easily be accomplished. We hope that the following suggestions are helpful to this respect:

Toilet. Although the current toilet designs in ITSs are of remarkable good quality, some simple adjustments (for future construction or renovation) can make a big difference, and decrease costs.

Toilet location and access for desludging. Culturally, and in terms of personal safety and privacy the toilets are located near the tents. However, this should not disrupt the desludging. For efficiency and public health purposes, the toilets should be located as close as possible to the street to facilitate easy desludging by the vacuum trucks.

Recommendation. *Avoid having vacuum trucks enter the ITSs, because it is unhygienic, unpleasant and may* *cause damage to road and other infrastructure in the ITSs.*

Toilet platform size and access. The current toilets and platforms (100 x 100 cm) do meet international standard and the expectations of the users. Smaller measurements are not recommended. One should pay attention to the height of the platform. It should be high enough to avoid flooding in the winter, but accessibility for children and the elderly should not be compromised.

***Recommendation.** Steps should be added when the platform is higher than 20 cm.*

Toilet superstructure. The toilets made of iron frames and painted metal sheets are in most cases well-constructed and robust enough to last for several years. However, most toilets start rusting from below. Using cement blocks for the first 20 - 40 cm of the walls can minimize that.

***Recommendation.** We advise to consider making the toilet of cement blocks, which is cheaper in terms of construction and maintenance. They can be easily destroyed once an ITS community is evicted or relocated.*

Ventilation. As most toilets use a squatting pan with connecting gooseneck and the tanks or pits are not located directly under the toilet, no ventilation of the sewer system has been installed. The odour from the toilets was acceptable and could escape from the screens, holes and openings in the superstructure. Ventilation of the holding tank, septic tank or pit has not yet seemed to be essential because gas formation is prevented as the sludge is removed regularly.

***Recommendation.** For sealed septic tanks and Solid Free Sewers, ventilation of the system will be required.*

Rodent and fly barriers. The open structure of many toilets (including open doors) make it very easy for flies and rodents to enter and have a free lunch, allowing spreading of diseases. Several toilets demonstrated that NGOs took care of this problem, but the use of metal frames and sheeting contributes to the fact that openness remains an issue.

***Recommendation.** More attention should be paid to avoid and close openings to the toilets, making doors fit.*

Locking doors. It has been noticed that toilet doors were often deliberately left open (‘to make it easier for small children to enter’), which for the reason mentioned above should be avoided. Simple locks, springs and locks and keys are simple improvements, but may be not durable when people are not convinced that flies and rodents are an issue.

***Recommendation.** An effective argument is that locked toilets are private and easier to keep clean. The practice of providing locks should be a standard procedure.*

Cleaning tools and water use (water use reduction). To our big surprise some toilets were equipped with inside water taps (for anal cleansing). In other toilets, small water buckets are used for that purpose.

***Recommendation.** Do not install water taps inside the toilets, as water taps will increase the use of water for cleaning substantially, and subsequently the wastewater volume. Water for (anal) cleansing can be provided in buckets.*

Hand washing facility and drainage (see further grey water). Hand washing facilities (with soap) are not installed near all toilets. In the visited ITSs in the Bekaa we did not notice handwashing facilities. People prefer water taps inside their tents to prevent water from being stolen. People claim that they wash their hands inside the tents, however many children said they don’t. In the North, hand washing taps seem to be common, though in some cases even unnecessarily expensive, and in other ITSs they do not supply water.

Recommendation. *Simple hand washing facilities next to the toilet.*

3.12. Desludging

Desludging is done by private contractors who, when given the chance, dump the content of the pits into agricultural canals, wadis and rivers. The need for control of performance is evident. Like in other parts of the world, these services are expensive. Extra control by INGOs makes the costs of desludging costlier.

GPS tracking (instead of voucher system). Most INGOs use a voucher system to encourage vacuum truck drivers to dispose the sludge at agreed disposal points. Other methods are random checks or sending a volunteer with the trucks.

All INGOs agree that these control mechanisms can be rigged and bypassed. Nevertheless, the general impression is that most sludge is disposed at WWTPs. In some areas, monitoring is difficult because of security issues.

ACF and WVI pilot GPS systems for tracking vacuum trucks to check where they dispose the sludge and how much. If this system works in the Lebanese context, it will contribute, as a spinoff of the ITS programme, to the Lebanese WASH sector. Though the crucial element of our wastewater management proposal is the reduction the frequency of desludging to 10% and treatment of the sludge and therefore the reduction of its environmental impact, the remaining thousands of trips from the ITSs to the sludge disposal facilities still need to be monitored.

Recommendation. *Evaluate the two pilot projects and agree on preferably one tracking system for application by all WASH partners.*

Price benchmarking / quality of service. Data from the UNICEF partners demonstrate a wide range of prices of water trucking, desludging and solid waste collection. Various arrangements are made with private service providers who seem to operate on a 'catch what you can' basis.[26] Part of the price difference can be argued, but in many cases not. There is a need for the standardization of prices, quality of services as well as control of desludging and disposal of sludge in the form of a Standard Operation Performance (SOP) contract. This needs coordination with all relevant stakeholders: regional water establishments, WWTPs and municipalities and desludging companies. With respects to ITSs, international humanitarian organizations have taken up this role as a result of the Syrian crises, but should be aware that their role is also to assist local stakeholders to gain experience and take over responsibility.

Although at an energy and water sector meeting in Zahle (9 November 2016) several partners felt that private companies were not sensitive to rational pricing, we believe that common benchmarking will strengthen each UNICEF partner in its negotiations with the contractors. It can also be instrumental for the Regional Water Establishments in its attempts to regulate the water sector on behalf of municipalities and customers.

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[26] *For example, one ITS in the Zahle area was charged 25000 per month per tent for solid waste collection by a private company (15,000 lira for collection and 10,000 lira for tipping fee for the municipality). In the same area, the Aldalhamiya citizen council organizes the same service for both. The Lebanese families pay 10,000 lira per month and each ITS tent pays a fee of 5000. The ITS was remarkably clean, despite the difficulties faced by volunteers collecting fees from all families.*

Recommendation. *Develop, agree and negotiate based on set of criteria for the desludging price: distance to sludge disposal site, volume of emptied sludge, accessibility of storage tank (septic tank), thickness of sludge and need for 'fishing' of any rubbish.*

Emptying tanks. The current seemingly logical practice is to ask the contractor to empty the storage tanks completely. The effect is that the anaerobic bacteria never get the chance to develop to become active. This prevents any digestion (and reduction) of the solid component of the sludge. For the suggested wastewater system, it is important that the tanks will *never* be fully emptied, and even at this stage we recommend emptying the tanks only 90%.

Recommendation. *Emptying around 90% of the capacity of the storage. When possible emptying tanks should be avoided when the water table is high, as empty tanks can easily be pushed up by the groundwater.*

Once the sludge arrives at a WWT, in most cases it will not be treated or only screened as most WWTPs are not, or are only partly, operational.

In Lebanon, 11 main WWTPs have been constructed with a total capacity for almost 2.7 million people. However, most of these plants only screen the wastewater, which is thereafter disposed of without any treatment into the sea or rivers. Another four plants for a total of 300 thousand people have been built but are not operational at all. In addition, 23 plants are under construction or study for a total capacity of 3.6 million people. According to the information of MoEW, the total capacity of all WWT treatments plants in the next decade will be for about 6.6 million people.

Other WWTPs include 65 smaller WWTPs built by USAID and plants built by municipalities. Those constructed by the USAID (since 2000) were built assuming that the municipalities would take the responsibility for O&M. The main problem is that these WWTPs consume a lot of energy to operate. Electricity is provided only between 6-8 hours a day and municipalities find it difficult to operate generators and make budgets available to do so.

The mission could not establish the exact number of constructed and planned WWTPs, but estimates a capacity for more than 7.5 million people. An UNICEF consultant is assessing the WWTPs that are reported to be operational in November and December 2016. We suggest that based on their report, several these WWTPs are selected for a sludge disposal for ITSs and Lebanese communities, depending on the proximity of the WWTPs to the maximum number of ITSs.

Recommendation. *Select WWTs to serve an optimal number of ITSs, based on the capacity of the sludge drying beds and location in areas with a high density of ITSs, to minimise transport.*

3.13. Grey water

Grey water is a main problem in almost all ITSs. It is disposed directly into drainage and irrigation channels. Families connect grey water pipes from the kitchen/bath room to storm water drains and pathways. During the dry season these methods are somehow adequate because of the high evapotranspiration. So are temporary storage pools, buckets, perforated tanks, irrigation and manual disposal outside the ITS.

During the winter these methods are not sufficient. Roads and paths become muddy and flooded during the rainy season with mix of grey water and storm water. Drains are full and clogged causing flooding of the ITSs and tents. Grey water is one of the biggest problems in many ITSs and formally not dealt with by WASH actors but by shelter actors. Coordination between both service providers proves to be difficult, but nevertheless essential

Recommendation. *As coordinated field visits, can improve grey water management, it is better when grey and* *storm water management becomes part of WASH.*

From health or environmental perspective grey water does not constitute a major risk[27], however proper grey water management does improve the living environment in the ITSs substantially, and can be dealt with by the ITS communities themselves. There is no need, and it may even make things worse if infrastructural solutions, such as grey water networks are being constructed. In exceptional cases, grey water may be disposed into the black water system, but avoid allowing grey water to enter toilet systems, to prevent unnecessary desludging costs and environmental costs (increase of pathogen proliferation). The main strategy to develop efficient waste water systems (as part of the mission's recommendation) is to reduce the volume and desludging intervals.

Recommendation. *Grey water should not be linked to toilet systems and managed separately.*

It is useful to differentiate between various types of grey water:

- Kitchen wastewater, which contains little soap, oils and fat and hardly any pathogens;
- Laundry water contains a lot of soap and few pathogens;
- Shower water contains less soap and few pathogens;
- Water from the hand washing facilities at the toilets a little soap and few pathogens.

Because of these characteristics, specific disposal and reuse options (and combinations) can be suggested. Their adaptation will depend on the preference of family members and the concrete situation in the ITSs. Workshops in which examples are giving and shared (also using social media such as YouTube) can inspire creativity and new ideas.

Recommendation. *Grey water should not become or remain a responsibility of an INGO, but should be the concern of the ITS families who can be advised and sometimes trained to deal with it.*

3.14. Storm water

Almost all ITSs are affected by the poor drainage of storm water. During the mission that could not be witnessed as November 2016 was an unusual dry month. In anticipation of expected floods ITS communities and INGO staff pointed to critical areas and expected problems in winter. In several camps, an INGO called Medair had constructed a storm water drainage using 8 inch PVC pipes that were halve sliced every 10-15 cm (see Figure 13) to allow storm water to infiltrate. The pipes were laid in trenches about 30 cm deep and backfilled with stones. In all the camps we visited, this system that was built last year was dysfunctional. Mostly because the pipes were broken by water trucks and the use of the drains to dispose of grey water, causing grease accumulation in the manholes and pipes.

As gravel is relatively cheap in Lebanon and widely used in the ITSs for road pavement, we suggest that a simple shallow trench system filled with stones will be sufficient to deal with most of the storm water. In the small alleys between the tents the trenches can be 20 cm, and in the main road 30-40 cm depending on the design. Construction and simple O&M can be considered part of housing and therefore efforts of the (men of the) family. NGOs should only advise on the design, and provide the gravel.

Recommendation. *Storm water drainage becomes part of the WASH program, but include minimal infrastructure and more O&M attention by the ITS communities*

[27] The consultants did not find evidence of heavy use of detergents in the ITSs it is important to check this, and include the need for minimal use of chemicals for cleaning purposes.

3.15. Solid Waste

Solid waste management is a problem associated with grey and storm water management. Plastic waste is filling grey and storm systems leading eventually to rivers such as the Litany. These wadis and rivers are filled with solid waste coming only partly from the ITSs. Some ITSs do manage solid waste within the settlements and have arrangements with local garbage collectors. These ITSs are clean and demonstrate that the communities can deal with this problem themselves. This can be encouraged to by linking free WASH service to the self-management of the ITSs.

Recommendation. *Make free WASH services depending on good solid waste, grey and storm water management by the ITS communities.*

4. Bills of Quantities and Costing

4.1. Introduction

In this section, we summarize the sizing of the elements and present an estimate of the costs. The unit costs used are based on the info collected in the field and the 'Sanitation Technical Brief – WASH Sector Working Group of 5 July 2013', corrected for inflation. In previous sections we explained that the works proposed are supposed to be pre-fabricated PE units. These are not available yet. To obtain an idea of the costs we have used concrete, which is more expensive than the pre-fab PE units.

Design and costs of an individual septic tank including superstructure

Table 10 presents the design and costs of a septic tank for 1 household. The septic tank needs to be made of pre-fab PVC or Poly Ethylene (PE). As they do not exist now we have taken the costs as if they were made from (reinforced) concrete, which is on the high (=safe) side.

Table 10: Design Septic Tank 1 Household (black water only)

Description	Unit	Quantity
Households served	[nos.]	1
Household size	[cap/hh]	15
Persons served	[cap]	15
Annual faecal sludge production	[litres/cap/year]	25
Daily wastewater production	[lcd]	15
Desludging interval	[years]	1
Volume sludge	[m^3]	0.4
Hydraulic retention time just before desludging	[days]	2.0
Volume wastewater	[m^3]	0.45
Total volume tank	[m^3]	0.83
Width	[m']	0.6
Height liquid	[m']	0.8
Length first chamber	[m']	1.15
Length second chamber	[m']	0.6
Freeboard	[m']	0.3
Total tank depth	[m']	1.1

Table 11: BoQ and costs Septic Tank

Description	Unit	Quantity	Unit Price	Cost
Squatting pan pour-flush toilet plus pipe	[nos]	1	$17	$17
Temporary superstructure plus foundation	[nos]	1	$250	$250
Reinforced concrete 10 cm thick	[/m^2]	2.1	$16	$34
Reinforced concrete 10 cm thick	[m^2]	5.1	$16	$83
Total Investment				**$384**

Design and costs shared and communal Baffled Septic Tank

Table 12 presents the design a Baffled Septic Tank (BST) for one ITS location of 100 households and a shared BST for 4 households.

Table 12: Design Baffled Septic Tanks

Description	Unit	Value	Value
Households	[households]	100	4
Persons served	[cap]	1 500	60
Per capita wastewater flow	[lcd]	28	15
Daily Capacity	[m^3/day]	23	0.90
Peak factor	[ ]	4	4
Peak flow	[m3/hour]	3.8	0.15
SETTLING COMPARTMENT			
Hydraulic detention time peak flow	[hours]	1.50	1.50
Liquid volume	[m^3]	6	0.23
Average sludge production	[litres/cap/year]	5	25
Desludging interval	[months]	3	12
Sludge volume	[m^3]	2	1.50
Volume settling compartment	[m^3]	8	2
number	[units]	4	1
Depth sludge compartment	[m']	0.80	0.80
Surface Area 1 compartment	**[m^2]**	**2.50**	**2.50**
length/width	[1/1]	1.50	1.50
Width	[m']	1.30	1.30
Length	[m']	1.95	1.95
Freeboard	[m']	0.30	0.30
Total depth	[m']	1.10	1.10
BAFFLE AREA			
Upflow velocity	[m/hr]	1.80	1.80
Surface Area upflow 1 chamber	**[m^2]**	**0.52**	**0.08**
Width	[m']	1.30	1.30
Length	[m']	0.40	0.40
Length down flow area 1 chamber	[m']	0.13	0.13
Total area 1 chamber	**[m^2]**	0.69	0.69
Number of upflow chambers in series	[nos]	4	4
Length baffled area	[m']	2	2
Surface area baffled area	**[m^2]**	3	3
Total length	[m']	**4.08**	**4.08**
Total width	[m']	**5.20**	**1.30**
Total area	**[m^2]**	**21**	**5**

Table 13 presents the Bills of Quantities of a BST for one Informal settlement of 100 households and a shared BST for 4 households. These BSTs need to be made of pre-fab PE. As they do not exist now we have taken the costs as if they were made from(reinforced) concrete, which is on the high side.

Table 13: BoQ and cost estimate Baffled Septic Tanks

Description	Unit	Quantity	Unit Price	Cost
Baffled Septic Tank	**Households**	**100**		
Excavation	[m^3]	30	$8	$240
Reinforced concrete 10 cm thick	[m^2]	130	$16	$2 359
Sub-total				**$2 299**
Piping		15%	$2 299	$354
Total investment				**$2 713**
Baffled Septic Tank	**Households**	**4**		
Excavation	[m^3]	10	$8	$80
Reinforced concrete 10 cm thick	[m^2]	30	$16	$652
Sub-total				**$732**
Piping		15%	$569	$110
Total investment				**$842**

4.2. Design and costs Vertical Flow Constructed Wetland

Table 14 presents the design and Table 15 the costs of a Vertical Flow Constructed Wetland for one Informal Tented Settlement of 100 households.

Table 14: Design Vertical Flow Constructed Wetland 100 households

Description	Unit	Value
Households	[nrs]	100
Persons served	[cap]	1 500
Per capita wastewater flow	[lcd]	28
Daily Capacity	[m^3/day]	42
Hydraulic retention time	[days]	3
Volume required	[m^3]	126
Pore volume wetland	[%]	30%
Height sand bed	[m']	0.60
Volume per m^2	[m^3/m^2]	0.18
Surface area	[m^2]	700

Table 15: BoQ and Costs VFCW 100 households

Description	Unit	Quantity	Unit Price	Cost
Excavation	[m^3]	700	$8	$5 600
PE lining	[m^2]	880	$9	$7 920
Gravel	[m^3]	350	$22	$7 700
Sand	[m^3]	420	$20	$8 400
Sub-total				**$29 620**
Siphon / tipping chamber		1%	$29 620	$296
Piping		2%	$29 620	$592
Total investment				**$30 509**

4.3. Design and costs Solids Free Sewerage Informal Settlement 100 tents

Figure 38 shows a typical lay out of an Informal Settlement of 100 households and Table 16 the BoQ and Cost estimate.

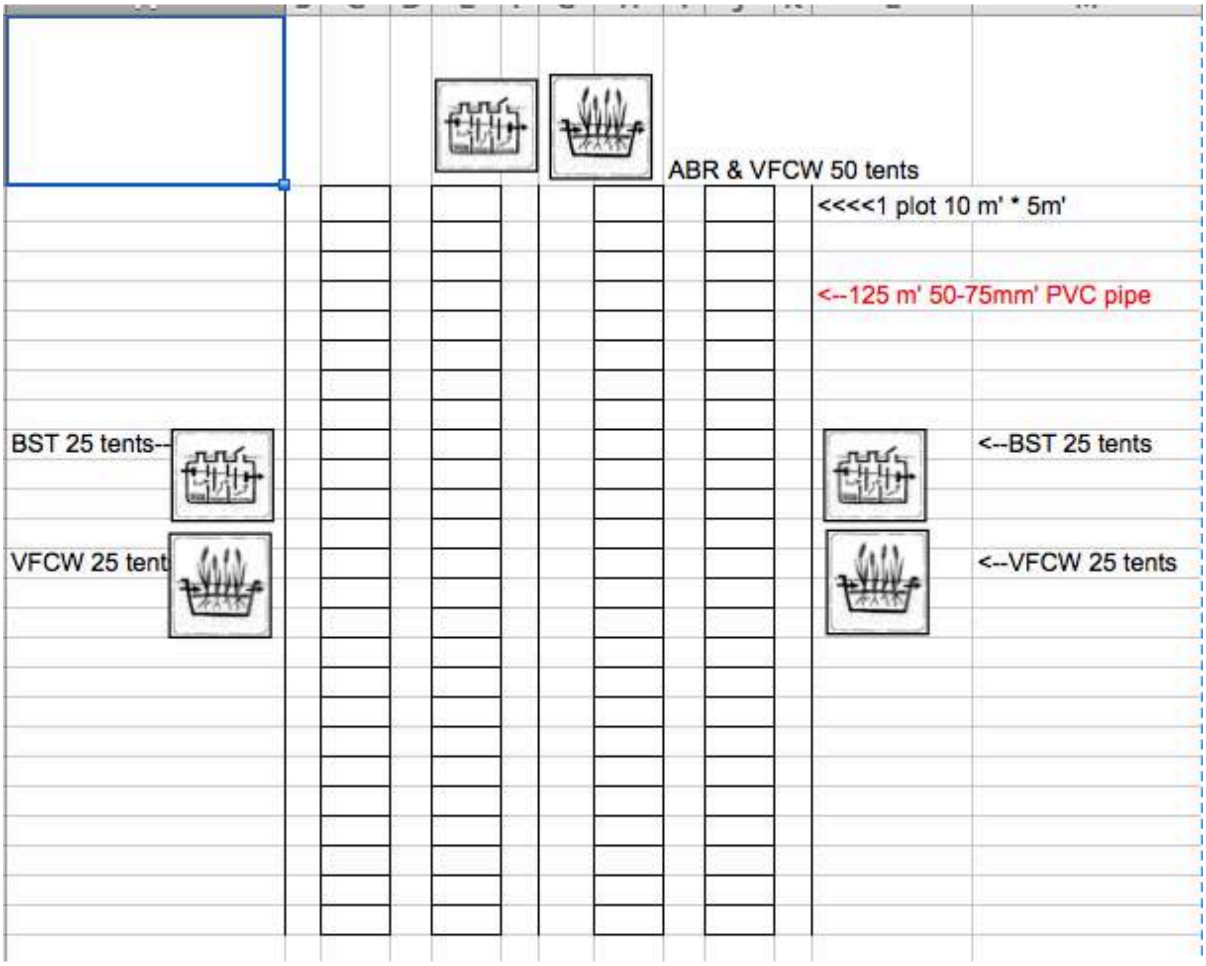


Figure 38: Typical lay-out Informal Settlement 100 households with SBS, BST and VFCW

Table 16: Costs SBS 100 households

Description	Unit	Quantity	Unit Price	Cost
PVC Sewer line 4" including manholes excavation, auxiliaries, backfill etc.	[/m']	500	$14	$6 750
Total investment				**$6 750**

4.4. Overview cost of proposed interventions

The sludge collected from the ITS needs to be treated properly, either in existing WWTPs or in special Sludge Treatment Plants, preferably sludge drying beds or planted sludge drying beds (See Figure 39). The existing WWTPs need to be adapted to treat partially digested sludge.

Recommendation. *Request WET Consulting Engineers to investigate whether existing WWTPs can receive and treat partially digested sludge. Where WWTPs are not suitable, implement (planted) sludge drying beds at the site of the WWTP to avoid environmental nuisance (smell) problems.*

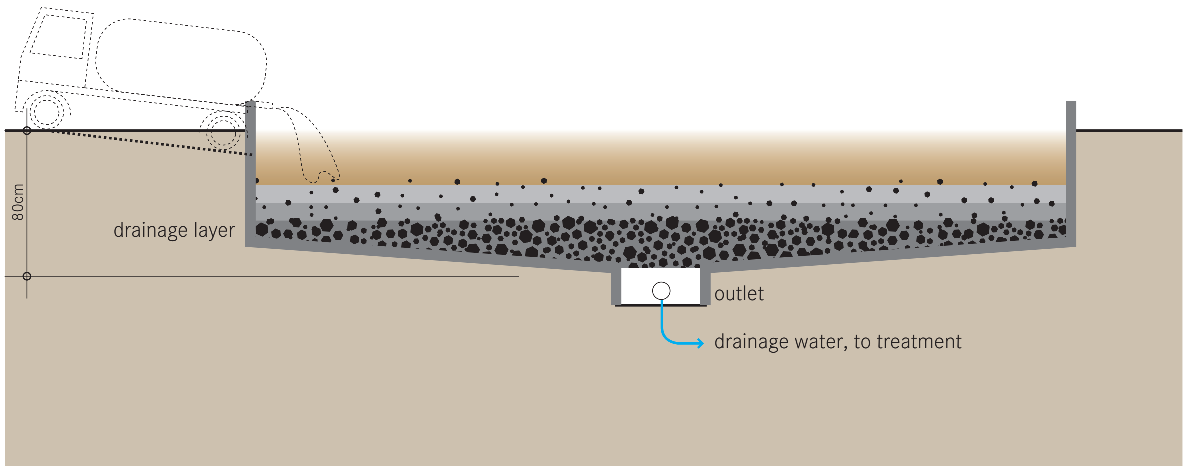


Figure 39: Sludge drying bed (Tilley, 2008)

Table 17 shows the calculated per household intervention costs.

Table 17: Investment costs per proposed intervention per household of 15 persons

Existing situation	System	Cost per household based on camp size of 100 households (ex-Contractor Fee – 25%, ex VAT – 1.7%)
Sewerage nearby	Use existing Sewerage and assist Water Establishment in adequate wastewater treatment	$ 67.50 -> $ 70
Small communities with inadequate sanitation / Rocky (Karst) soil	Shared Baffled Septic Tanks / Vertical Flow Constructed Wetland / Infiltration-Reuse-Doughnut (BST&VFCW)	$ 200 + $ 300 = $ 500
Small communities with inadequate sanitation / Sandy soil	Septic Tanks & Anaerobic Upflow Filter / Infiltration (ST&AUF)	$ 120 + $ 75 = $ 195 → $ 200
Large communities with inadequate sanitation	Solids Free Sewerage / Baffled Septic Tanks / Vertical Flow Constructed Wetland / reuse or doughnuts (SBS&BST&VFCW)	$ 67.50 + $ 27.50+ $ 305 = $ 400

Calculation payback period. Assuming:

- A household of 15 persons produces 15 capita * 30 days * 5 lcd / 1,000 litres = 2.25 m^3/month;

- Desludging costs per year: 12 months * 2.25 * $ 8 / m3 = $ 216 / year;
- Payback period most expensive option $ 400 / $ 216 ± 2 years.

N.B. if the household produces more water, the payback period becomes shorter, so this is a conservative approach.

4.5. Investment required

Investment costs. The total net investment costs of improvement of all (± 16,787) systems are estimated at $ 8 mln[28]. The gross investment costs, including overhead, contractor margin, VAT etc. are around $ 10 mln. See the breakdown in Figure 40.

The number 16,787 is calculated as follows:

- Number of systems 'known': 13,043;
- Number of 'unknown' systems: 5,208[29];
- Total number of systems considered: 18,251;
- Number of systems connected to sewers and not being considered for improvement: 1,047 + proportionally part of the 'unknown' systems, total 1,465 systems;
- Remaining number of systems to be considered for improvement and costing 18,251 minus 1,465 = 16,787.

See Table 18 for details and see Table 20 for systems to be improved in ITSs with more than 4 tents.

Table 18: Overview current systems in ITSs with more than 4 tents (Source: database managed by UNICEF, sent by e-mail mid-December 2016)

System	***Numbers***	***Users***
Cesspit	5 905	56 603
Septic tank	2 607	25 753
Open pit	1 238	10 567
Sewer network	1 047	10 691
Holding tank	1 920	20 945
Dry pit	207	1 595
Storm water/irrigation channel	119	1 180
Sub-total known systems	***13 043***	***127 334***
Unknown	5 208	50 844
Total	***18 251***	***178 178***

[28] mln. = million
[29] Information UNICEF by e-mail on 16 December 2016

Table 19: Overview systems to be improved in ITSs with more than 4 tents

Priority	To be improved	no. of systems	System proposed	Unit Cost	Investment ($US million)
1	Storm water/irrigation channel	167	ST&SBS&VFCW	$520	$0.09
2	Open pit	1 732	ST&SBS&VFCW	$520	$0.90
3	Dry pit	290	ST&SBS&VFCW	$520	$0.15
4	Cesspit	8 263	ST&SBS&VFCW	$520	$4.30
5	Septic tank	3 648	SBS & VFCW	$400	$1.46
6	Holding tank	2 687	SBS & VFCW	$400	$1.07
	Total	**16 787**			**$7.97**

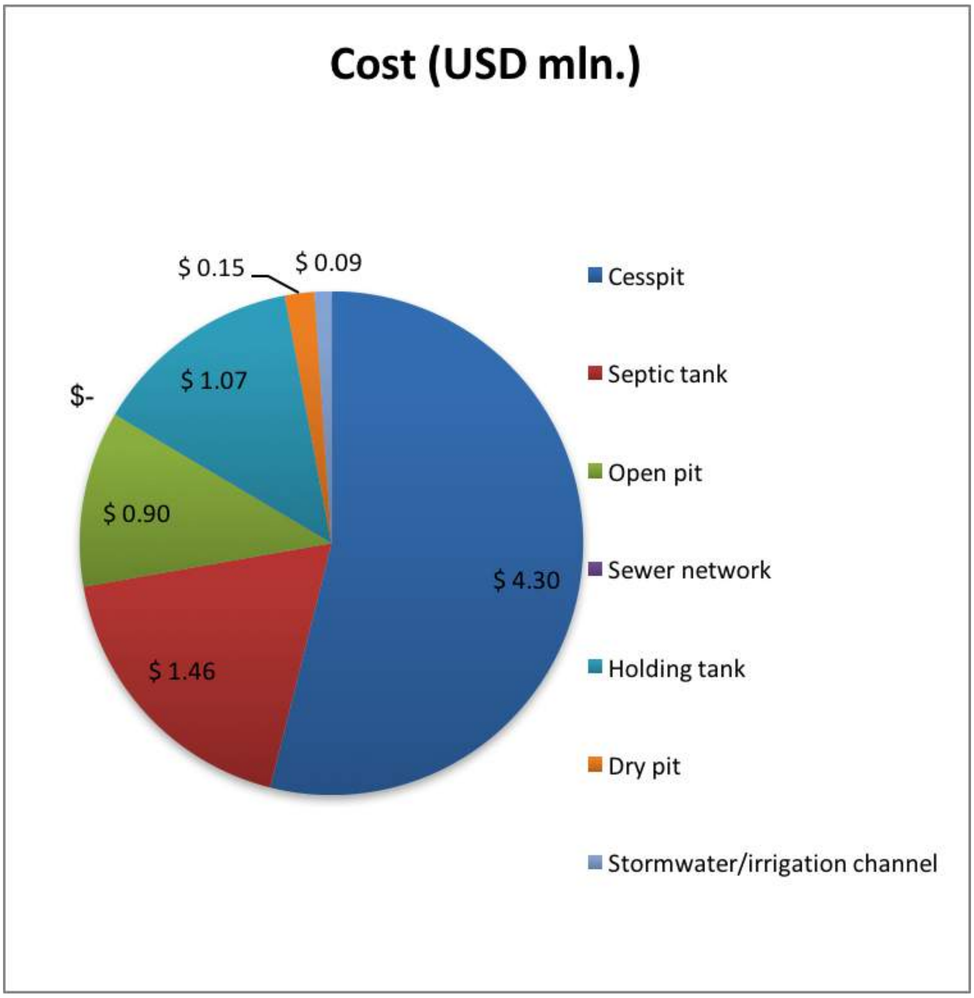


Figure 40: Investment cost improvement black water ITS locations with more than 4 tents

Note on the scope of the intervention. The costs calculated here are based on four assumptions, which need to be verified during implementation:

- **100% of the ITS locations:** we have assumed that the improvements are not only required in the locations financed by UNICEF and the partners but in **all** sites at risk;
- **Only in ITS with > 4 tents**: for reasons of efficiency and effectiveness, we propose to concentrate on those areas where the health/ environmental risk is most obvious, hence those areas with more than 4 tents;

- **No additional latrines:** we have assumed that the areas are served adequately in terms of number of facilities per person (around 10 persons/latrine) which is (far) less than the 'standard' of 15 persons per latrine;
- **Interventions are possible everywhere:** we have assumed that it is always possible to come up with a (if necessary modified) solution of what we are proposing.

5. Environmental Impact

5.1. Introduction

In this chapter, we present an estimate of the environmental impact of the interventions proposed in section 4. Given the short duration of our assignment we underline that this assessment is a very first rough step and needs to be updated once more information has been made available to us.

5.2. Basic assumptions

Lacking reliable basic data, we have estimated the parameters as presented in Table 20 as a basis for our calculations. Our estimates are based on data from different parts of the world. We kindly invite the responsible authorities to provide more reliable information.

Table 20: Basic assumptions Environmental Impact calculations

Description	**Unit**	**Value**	**Value**
Assumptions		Before intervention	After intervention
Per capita BOD 1 person ITS location	[$gBOD_5$/day]	25	25
Water provided	[lcd]	35	35
Return ratio	[%]	80%	80%
Per capita wastewater generated (black and grey)	[lcd]	28	28
Black water strength	[mg BOD_5/l]	893	893
BOD removal rate Septic Tanks	[$\%BOD_{5influent}$]	30%	30%
BOD removal rate Baffled Septic Tanks (70-90%)	[$\%BOD_{influent}$]		80%
BOD removal rate secondary systems (Vertical Flow Constructed Wetland, Soak away > 2 m' above high groundwater) (75-90%)	[$\%BOD_{5influent}$]		85%
Faecal Coliform (FC) removal rate primary systems (Septic Tanks, Baffled Septic Tanks, etc.)	[log unit]	1	1
FC removal rate secondary systems (Vertical Flow Constructed Wetland, Soak away > 2 m' above hgwt)	[log unit]		2
BOD removal 1st & 2nd treatment	[$\%BOD_{5influent}$]	30%	97%
FC removal 1st & 2nd treatment	[log unit]	1	4

5.3. Environmental impact of the proposed interventions

Based on the assumptions of Table 20 and the information of the database at UNICEF (accessed 14 December 2016) we arrive at an overall BOD removal of the actual systems of 23% and 1 log unit removal of Faecal Coliforms.

Table 21: Assessment current performance black water systems

System	Numbers	Users	BOD removal actual systems (% BOD influent)	FC removal actual systems (log units)
Cesspit	5 905	56 603	30%	5 905
Septic tank	2 607	25 753	30%	2 607
Open pit	1 238	10 567	30%	1 238
Sewer network	1 047	10 691	0%	1 047
Holding tank	1 920	20 945	0%	1 920
Dry pit	207	1 595	30%	207
Storm water/irrigation channel	119	1 180	30%	119
Sub-total known systems	***13 043***	***127 334***	***23%***	***13 043***
Unknown	5 208	50 844	23%	5 208
Total	***18 251***	***178 178***	***23%***	***18 251***

The performance of the systems after the interventions is presented in Table 22.

Table 22: Performance after interventions

Actual System	Future System	Systems	Users	BOD removal future systems (% BOD influent)	FC removal actual systems (log units)
Cesspit	Septic Tank, Solids Free Sewer, Baffled Septic Tank, Vertical Flow Constructed Wetland	8 263	79 204	97%	4
Septic tank	Solids Free Sewer, Baffled Septic Tank, Vertical Flow Constructed Wetland	3 648	36 036	97%	4
Open pit	Septic Tank, Solids Free Sewer, Baffled Septic Tank, Vertical Flow Constructed Wetland	1 732	14 786	97%	4
Sewer network	No change	1 465	14 960	0%	-
Holding tank	Solids Free Sewer, Baffled Septic Tank, Vertical Flow Constructed Wetland	2 687	29 308	97%	4
Dry pit	Septic Tank, Solids Free Sewer, Baffled Septic Tank, Vertical Flow Constructed Wetland	290	2 232	97%	4
Storm water/irrigation channel	Septic Tank, Solids Free Sewer, Baffled Septic Tank, Vertical Flow Constructed Wetland	167	1 651	97%	4
Total		***18 252***	***178 177***	***89%***	***3.66***

Conclusion. The expected positive impact on the ground water and soil quality is substantial. It is estimated that the suggested intervention will remove around 4 tons Biochemical Oxygen Demand (BOD_5) per day, compared to 1 tons BOD_5/day now. Hence, the BOD_5 generated by the ITS locations will decrease from 3.45 tons BOD_5/day to 0.49 tons BOD_5/day. In the ITS locations, the average BOD_5 of the effluent is expected to decrease from 625 mgBOD_5/l to 25 mgBOD_5/l, which is the Lebanese standard (Decision 8/1 of 2001). The Coliform Bacteria count is expected to decrease from 1,000,000 TC 37^o /100ml to 1,000 TC/100ml, which is below the Lebanese standard of 2,000 TC 37^o/100ml (Refer Environmental Limit Values for wastewater discharge into surface water of new WWTPs issued under Decision 8/1 of 2001[30]). For details of the calculations, see Table 23. The net cost effectiveness is USD 2 mln. per ton BOD_5 removed per day. This is relatively low, when compared to other interventions in Lebanon, for instanced the WWTP of Tripoli: cost effectiveness around USD 5 mln. per ton BOD_5 removed per day.

Table 23: Environmental impact proposed interventions

Description	**unit**	**value**	**value**	**Norm Lebanon**
Assumptions		Before intervention	After intervention	
Overall results				
Average BOD removal rate	[%BOD removed]	23%	89%	
Average effluent strength	[mg BOD_5/l]	692	98	
Total Coliforms influent	[TC/100 ml]	1E+07	1E+07	
Average TC removal	[log unit]	1	4	
Total Coliforms effluent	[TC/100 ml]	1E+06	2E+03	
ITS population	[capita]	178 177	178 177	
Ton BOD into environment per day	[ton BOD/day]	3.45	0.49	
Ton BOD removed per day	[ton BOD/day]	1.00	3.96	
Net investment	[mln. USD]		$7.97	
Investment cost per ton BOD removed per day	[mln. USD/ ton BOD removed/day]		$2.01	
Specific results for ITS locations				
Average BOD removal rate	[%BOD removed]	30%	97%	
Average effluent strength	***[mg BOD_5/l]***	***625***	***25***	***25***
Average FC removal	[log unit]	1	4	
Faecal Coliforms effluent	***[E-coli/100 ml]***	***1 000 000***	***1 000***	***2 000***

[30] Info MoE per e-mail 16 December 2016

6. Program implementation 2017

6.1. Aim

- Implementation of SFS systems in high priority ITSs in 2017 as the first phase of a two-three-year program (2017-2019) in settlements with 1st and 2nd priority, and a selection of ITSs of 3rd to 5th priority[31];
- Concentration of ITSs in appropriate locations to provide better and cheaper services;
- Planning and preparation of the completion of the program (2018-2019);
- Building up of capacity within local companies, NGOs and responsible institutions, communities for waste water management in small Lebanese hamlets and informal settlements;
- Develop an exit strategy for/with INGOs;
- Establish a WW platform knowledge and training.

6.2. Project management

In 2017, the project we will rely on the INGOs to supervise the contractors and strengthen local organizations to take for their role in 2018 and 2019. The participating INGO will second at least one member of staff during 2017 to the project office as liaison officer and to become a trainer. They will be trained to design the systems, plan and prepare the first projects, supervise the preparation of the tender for works done by the Lebanese contractors and train local firms/NGOs to supervise and control the work of the local contractors.

The project team will also offer on-the-job training for staff of the Water Establishments and municipalities to monitor the construction, maintenance and operation of the WW systems.

The team will associate itself with a Lebanese firm that will gradually take over all tasks and the support team resort to back-stopping on demand before the first phase ends. The main tasks of the project office after 2017 will be:

- Design and planning construction of SFS systems;
- Contracting private sector for product and service delivery;
- Quality control of delivered construction;
- Monitoring O&M.

6.3. Programme

The programme contains three elements: the construction of SFS systems, development of an exit strategy with INGOs and the establishment of a WW platform.

Construction of Solid Free Sewer Systems. Where sewers are present, the black water will continue to be conveyed into municipal sewers. It is also foreseen that the team will identify other ITSs that can be connected to existing sewer networks.

The other disposal practices such as discharging into open channels, open pits and cesspits need to be stopped to protect the environment. The expensive monthly emptying of wastewater holding tanks will be avoided by converting these tanks to treatment systems that require emptying once a year.

[31] We have developed two sets of criteria for prioritization/project area selection for ITS locations to be upgraded: (1) a 'technological' set based on reducing the potential risk of environmental pollution and reducing the operation and maintenance costs of the current practices; and (2) a broad set of criteria to determine where investment will benefit the ITS communities, as well as the hosting Lebanese communities, based in outcome of using weighting tool, financial and logistic considerations.

During phase one (2017) the focus is to replace the discharge of wastewater into open channels, open pits and cesspits by disposing it into prefabricated polyethylene (PE) household septic tank. The settled effluent of these household tanks is collected in a solids free sewer network: 2”-3” PE (plastic) pipes that conveys the wastewater to a centrally located effluent treatment system consisting of a communal baffled septic tank that further removes the biological and chemical oxygen demand (BOD/COD) and a plastic lined vertical flow constructed wetland that eliminates the remaining pathogens. A plastic lining prevents pollution of groundwater in the karst rock formations or shallow ground water. The treated effluent can safely be disposed into the environment. Once a year, residual sludge is removed from the septic tanks and transported to Wastewater Treatment Plants (WWTPs), where we propose to use (planted) drying beds to decrease the volume and to sanitize the sludge.

Exit Strategy. The exit strategy means a deliberate move from emergency sanitation to a broader environmental WASH approach. The team will support UNICEF to take a leading role in the development and implementation of a WASH exit strategy from ITSs in Lebanon.

The program will support INGOs to take a supporting role in building (on) local initiates that can implement core activities to sustain wastewater management.

We will assist INGOs to reach out and invest in those municipalities that are willing to cooperate with local NGO’s and private business. We will work primarily with the local staff of the INGOs, with support of the international staff.

The INGO will be encouraged to enhance the professional skills of existing private companies and local NGOs, or start-ups by current local staff of INGOs, whose main work concerns:

- Negotiating MoUs with landlords;
- Design and supervision of SFS networks;
- Installation (baffled) septic tanks;
- Design and construction of vertical flow constructed wetlands;
- Monitoring and maintenance of the systems;
- Collection of connection fees;
- Organizing and supervising the desludging work;
- Regular testing of effluent from VFCWs.

Similarly to the INGOs, for UNICEF this means seeking cooperation with and investing in Lebanese water institutions to enable them to take on their long-term responsibilities.

The project team will support UNICEF to lead the exit strategy towards:

- Supporting relocation to environmentally less vulnerable locations;
- Fewer and bigger ITSs (first target 1000 with an average of 220 people / ten families);
- Standardized practice and approach of partners (and sector);
- Development of an WW investment and implementation plan for ITSs;
- Establishing a learning and coordination platform (see below);
- Having regular meetings as sector lead with Water Establishments and Associations of Municipalities;
- Exploring conversion with other relevant UN (UNHCR and UNDP) and bilateral programs

Platform. A platform will be set-up for to facilitate the work of the sector partners by training and knowledge sharing, but may later become part of a Lebanese institution, which hosts water and sanitation research and education.

To establish a web-based knowledge platform with a mobile phone application is an obvious choice. This platform can become active tool backed-up by regular sector meetings.

The platform can facilitate:

- Sharing and learning;
- Back-stopping by the team;
- Standardization process;
- Cooperation to create synergy, avoid duplication and good use of resources;
- Development of tools and training for local engineers and practitioners;
- Inputs from professionals and experts.

Planning

Inception phase (January-March 2017)

- Update the sector database for Prioritization of ITSs and sequence of works in selected ITSs;
- Setting-up a project office within an existing organisation or firm in Zahle;
- Recruitment of support staff and liaison persons among INGOs;
- Preparation of a detailed work plan with stakeholders;
- Association with a local consultancy firm that can provide field surveys;
- Preparation of designs (SFD and VFCW) based on the findings in the field;
- Preparation of typical designs guidelines;
- Detailed engineering designs and tender documents;
- Design moulds for prefab septic tank and baffled septic tank;
- Contractors are contracted by INGOs and trained to do the works;
- Update the implementation budget.

Finance. During this period MoEW and UNICEF need to provide the basic project requirements as well as to secure the funds for implementation.

Support and guidance of the first batch of 10 typical locations (March – May 2017)

- proposed technology (prefab septic tank, solids free sewer, prefab baffled septic tank and constructed wetland) are tailored to the specific needs and requirements of the situation in the ITSs and Lebanese communities;
- In 10 locations, the SFS systems are to be installed by contractors and supervised by INGOs
- Performance of the systems will be evaluated thoroughly;
- Develop a O&M system defining separate responsibilities of all stakeholders (ITSs, private sector, WEs and NGOs);
- Setting up a platform to facilitate the WWT work of the sector partners;
- Selected firm, WE staff and NGOs will be trained and instructed intensively;
- At the end of this period, the programme office will formally be handed over to the associate firm.

Backstopping (May – December 2017) during implementation of the second and third batch in the North and Bekaa.

- The team restricts itself to supervision of topographical and soil surveys, designs, tender documents and implementation;
- Knowledge platform is handed over to a Lebanese institution, which hosts a water and sanitation research and education;

- Stakeholders will have the opportunity to be trained in the design, construction and operation and maintenance of the proposed technology in practical hands-on-training sessions.

Investment costs. The average investment costs of the proposed improvements are estimated at $45 per person.

7. Recommended phasing

7.1. Introduction

In this chapter, we present a detailed phasing of the improvements described in chapter 4. Figure 41 shows the locations ITS where information could be obtained and the method of discharge of the black water.

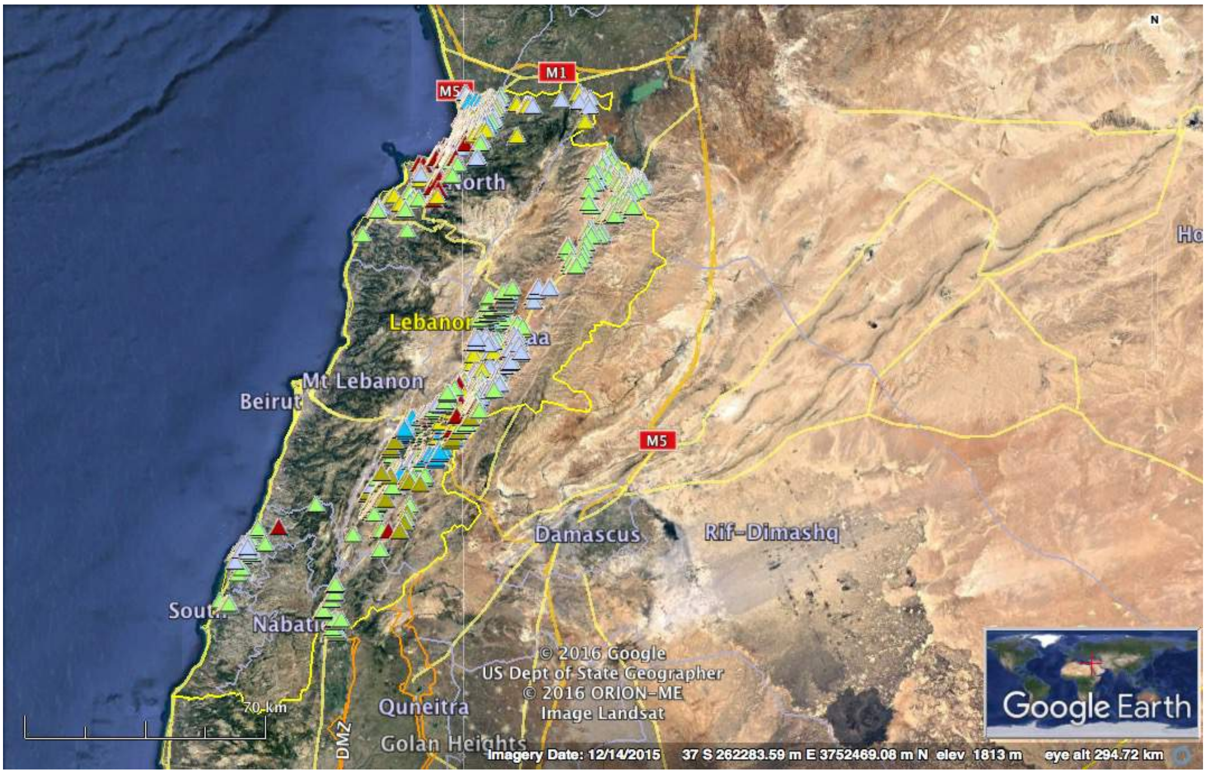


Figure 41: Overview types of discharge of black water in ITS

We assume that the areas that discharge into existing municipal sewers or straight into the sewers of the water establishment do not need to be taken care of anymore although it is known that this black water is only partially treated, if treated at all. The ITS locations that discharge into sewers are presented in Figure 42.

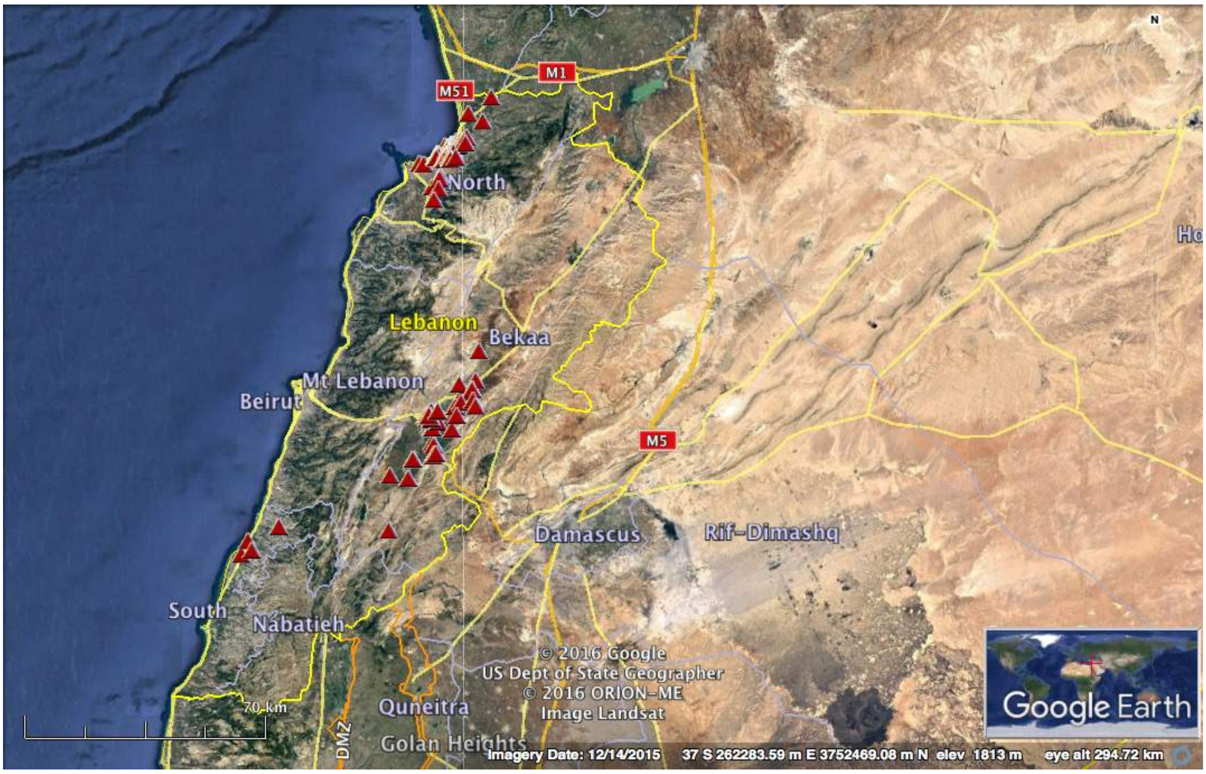


Figure 42: ITS locations reported to discharge into (municipal) sewers

7.2. Priority 1: Improve systems that discharge into open channels

The first priority is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into the open channels. This needs verification in the field. Their locations are presented in Figure 43. Unfortunately, we were not able to generate a list with the names of the locations and their coordinates. This needs to be done by the database specialists in Beirut.

Figure 43: ITS locations reported to discharge into open channels

Among these locations are several located in most vulnerable (black), 2nd most vulnerable (red), 3rd most vulnerable (orange) and 4th most vulnerable (yellow) locations identified by the Ministry of the Environment[32]. See Figure 44 and Figure 45. For information of the definition of vulnerability, see text box.

> *UNHCR, in coordination with UNICEF and the Presidency of the Council of Ministers, have developed a tool to assess community vulnerability in relation to Syrian refugees. Using two indices (poverty and refugees), this tool assumes that a high percentage of refugees correlated with a high percentage of poverty increases the vulnerability of the area. Accordingly, UNHCR defined five levels of vulnerability, from most vulnerable (denoted "1") to least vulnerable ("5"). According to the first vulnerability map produced in July 2013, there were about 30 most vulnerable communities in Lebanon, covering about 750 km2 (7% of the territory). By July of 2014, the number had increased to 45 and their area to about 900 km2 (8.6% of the territory). The impact of vulnerability on natural areas including environmental sensitive areas and agricultural lands is variable and depends on land cover and land use patterns in host communities.*
>
> ***Source: Meeting Vulnerable Municipalities, July 2013 (UNHCR, UNICEF, and PCM), updated July***

[32] Source: MOST VULNERABLE LOCALITIES IN LEBANON, March 2015, Interagency Coordination Lebanon

2014 in MOE/EU/UNDP, 2014

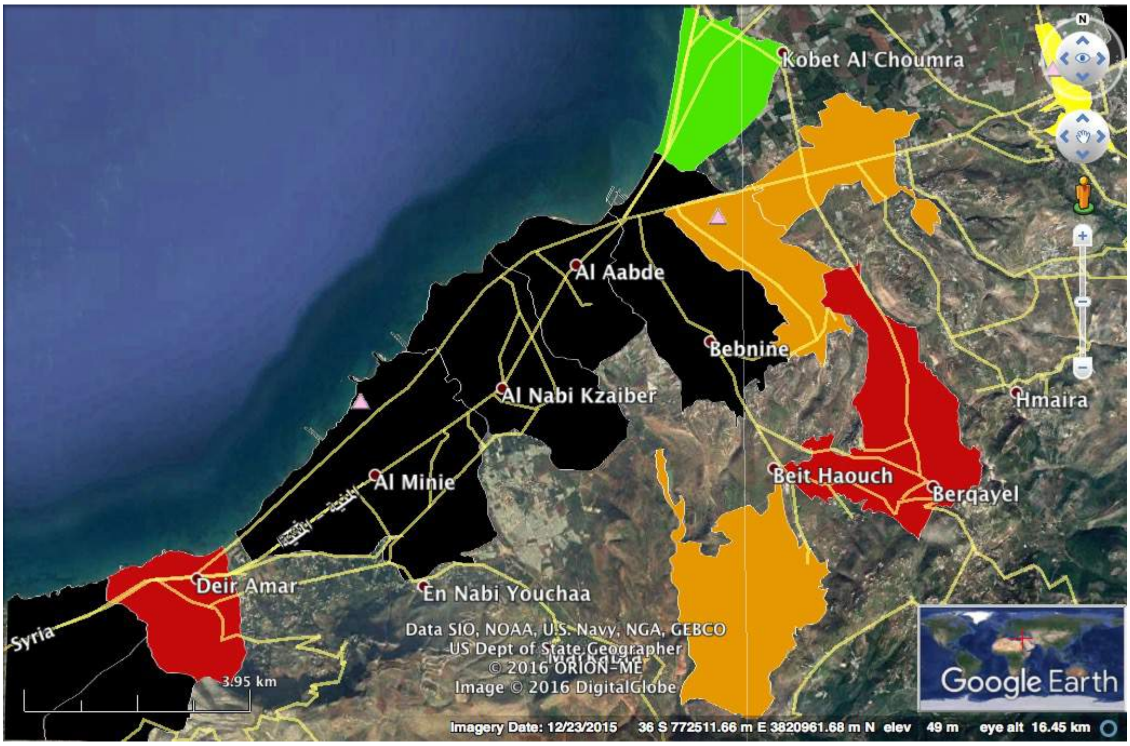


Figure 44: Location open channel discharge relative to vulnerability

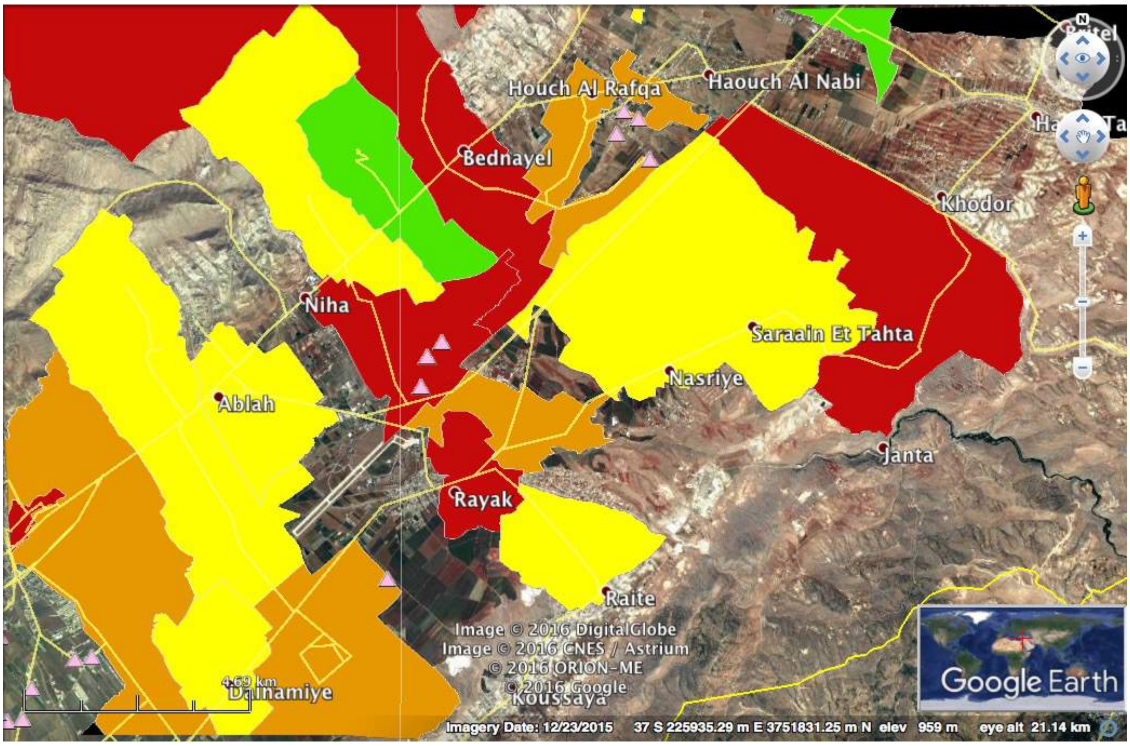


Figure 45: Location open channel discharge relative to vulnerability in the Bekaa

7.3. Priority 2: Improve systems that discharge into open pits

The second priority is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into open pits. This needs verification in the field. Their locations are presented in Figure 46. The open/wet pits are coloured light yellow and the open/dry pits are coloured dark yellow. Unfortunately, we were not able to generate a list with the names of the locations and their coordinates. This needs to be done by the database specialists in Beirut.

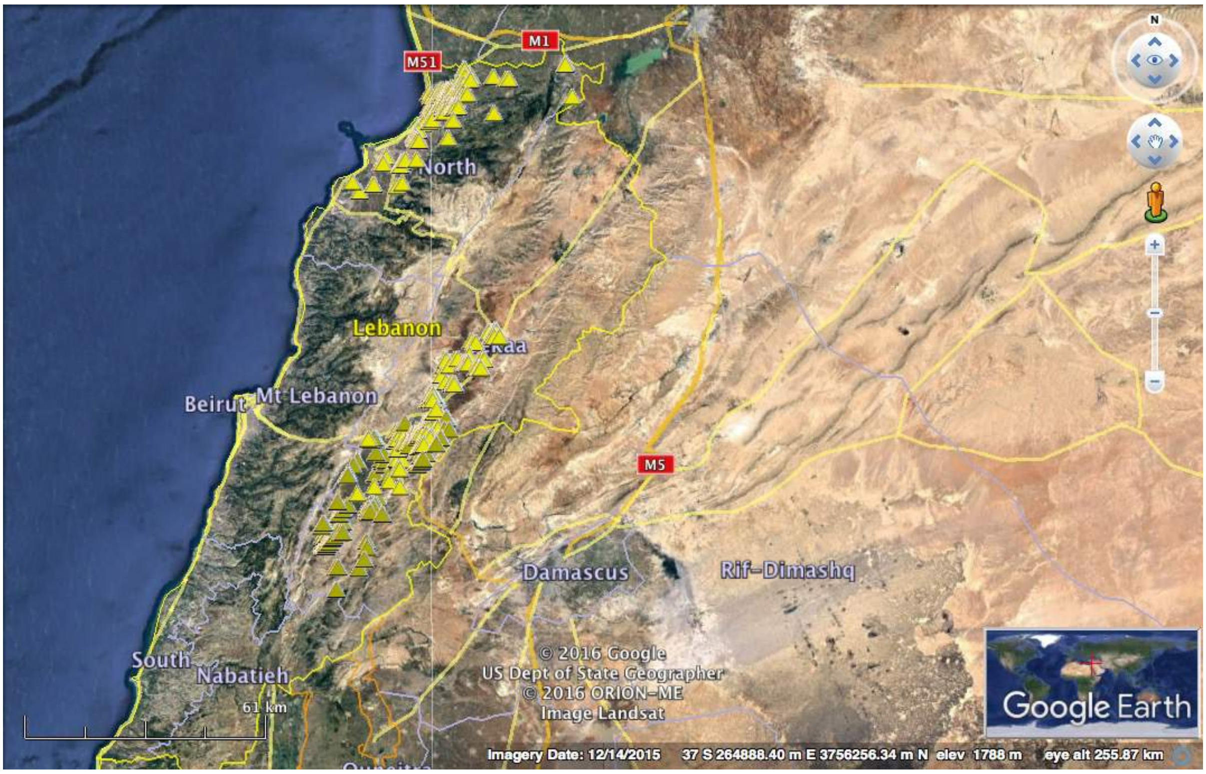


Figure 46: ITS locations reported to discharge into open wet (light yellow) and dry (dark yellow) pits

Among these locations are several located in most vulnerable (black), 2nd most vulnerable (red), 3rd most vulnerable (orange) and 4th most vulnerable (yellow) locations identified by the Ministry of the Environment[33]. See Figure 47 and Figure 48.

[33] Source: MOST VULNERABLE LOCALITIES IN LEBANON, March 2015, Interagency Coordination Lebanon

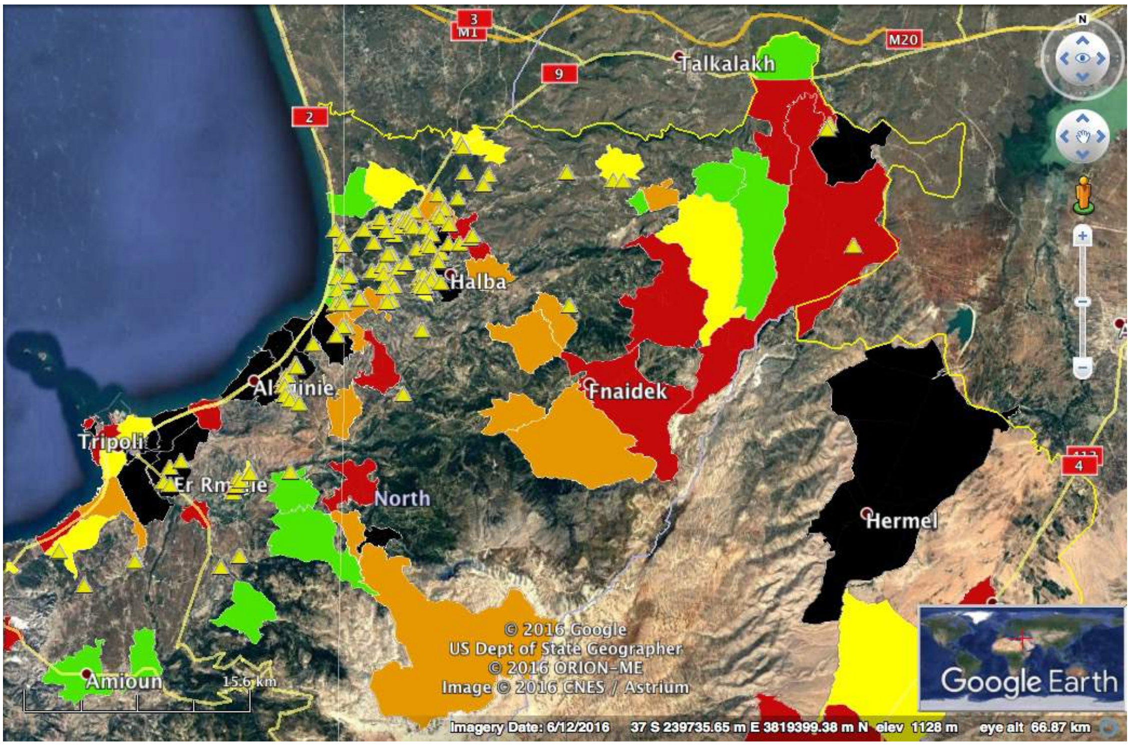


Figure 47: Location pit disposal relative to vulnerability in the North

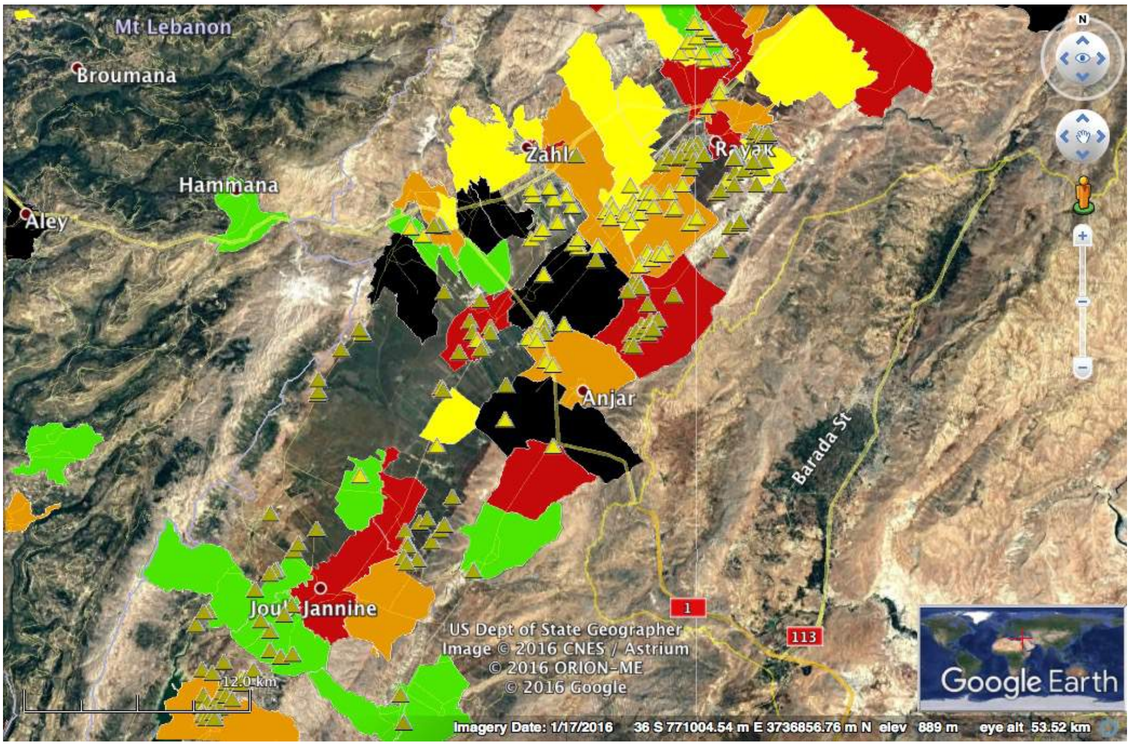


Figure 48: Location pit disposal relative to vulnerability in the Bekaa

7.4. Priority 3: Improve systems that discharge into cesspits

The third priority is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into cesspits. If these pits are less than 2 meters from the groundwater in sandy areas or located in karst rock areas, groundwater might be at risk. This needs verification in the field. Their locations are presented in Figure 49. Unfortunately, we were not able to generate a list with the names of the locations and their coordinates. This needs to be done by the database specialists in Beirut.

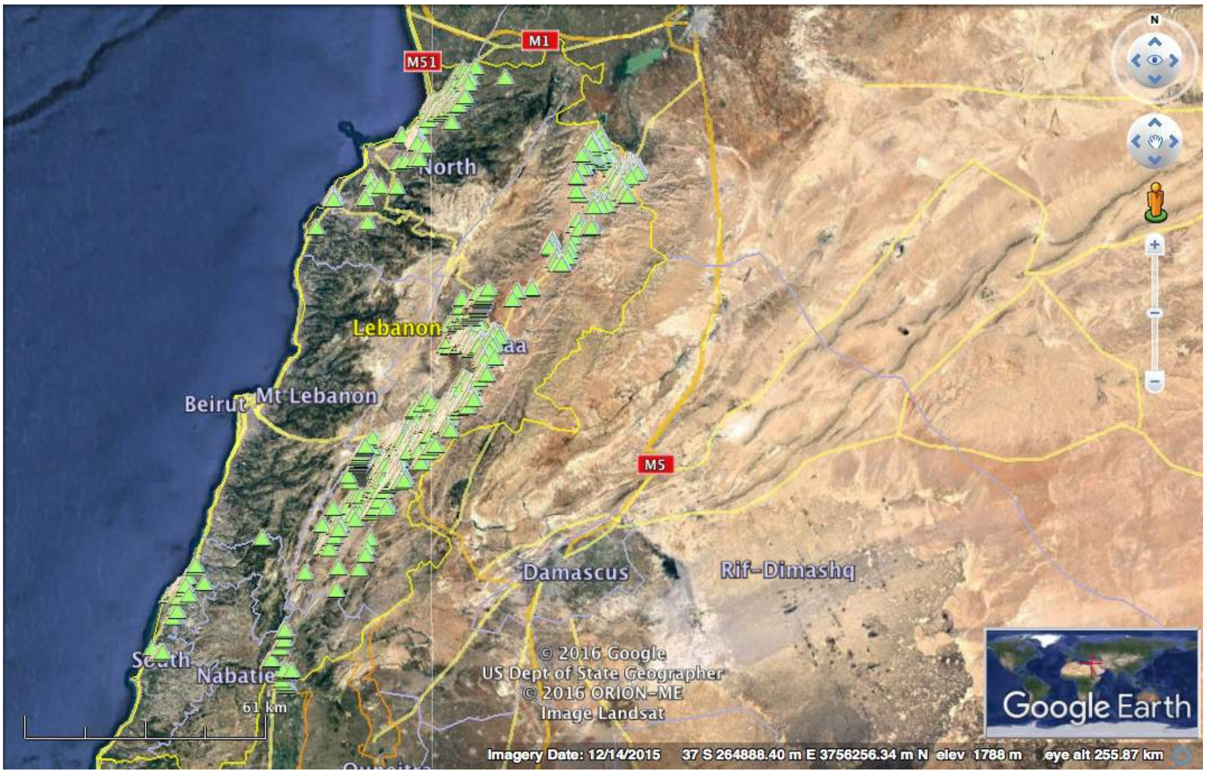


Figure 49: ITS locations reported to discharge into cesspits

Among these locations are several located in most vulnerable (black), 2nd most vulnerable (red), 3rd most vulnerable (orange) and 4th most vulnerable (yellow) locations identified by the Ministry of the Environment[34]. See Figure 50 and Figure 51.

[34] Source: MOST VULNERABLE LOCALITIES IN LEBANON, March 2015, Interagency Coordination Lebanon

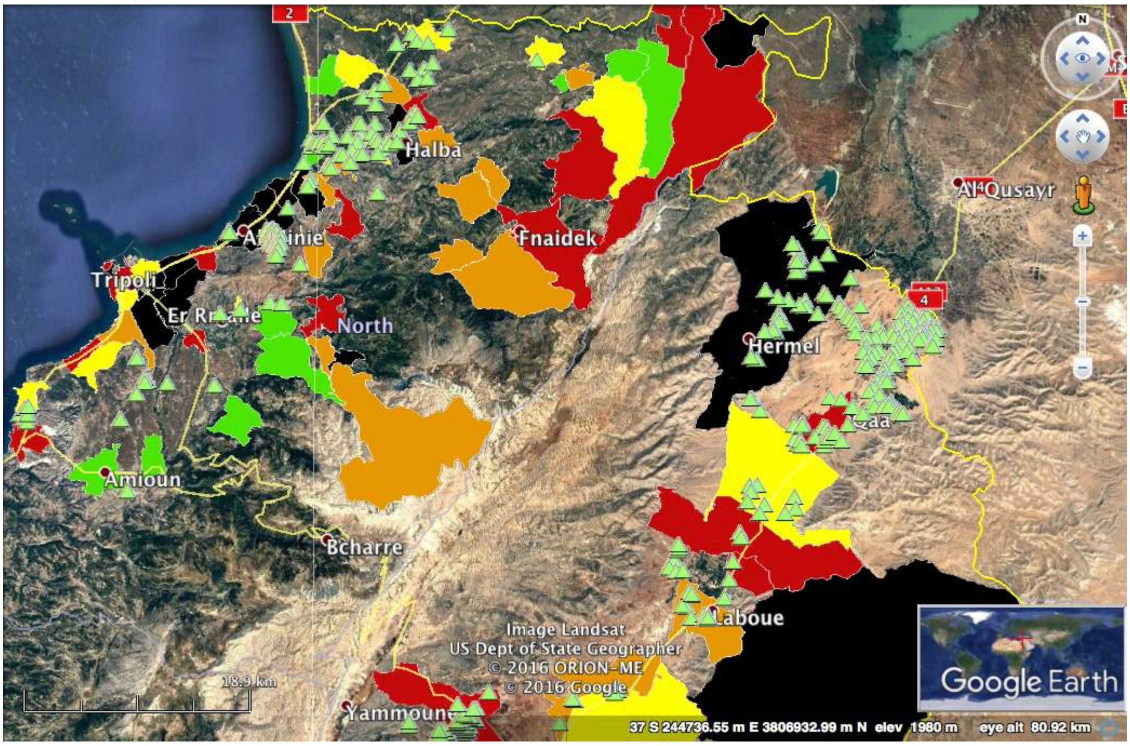


Figure 50: Location cesspit disposal relative to vulnerability in the North

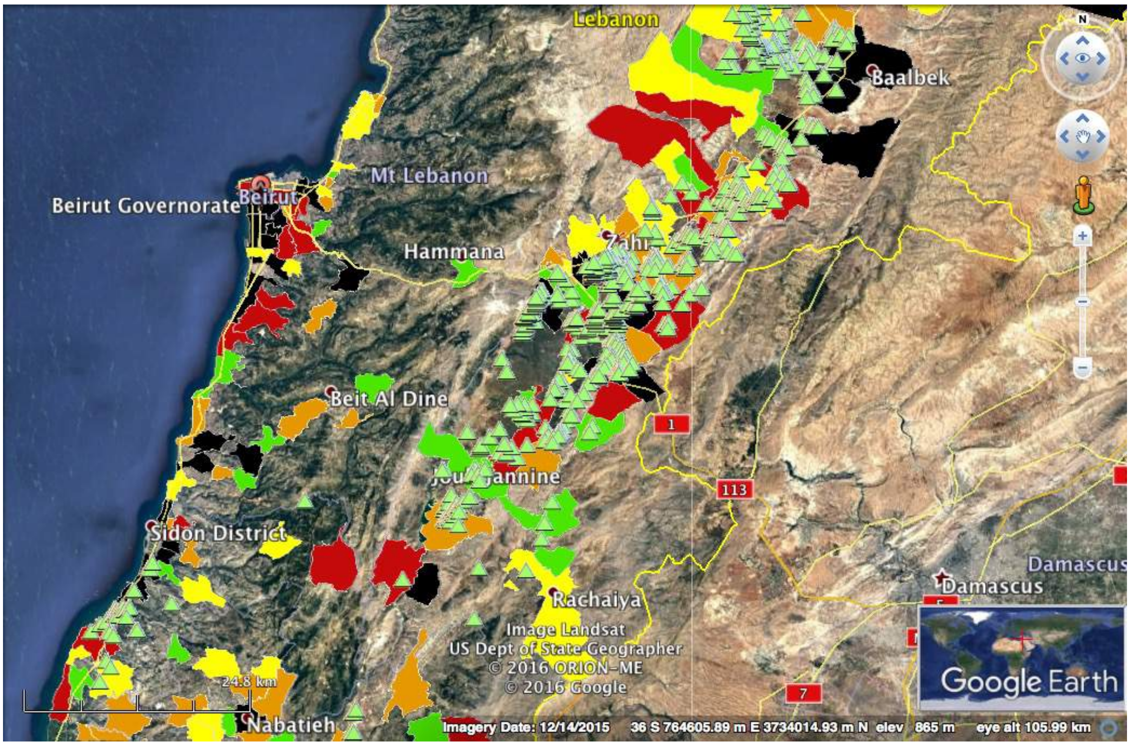


Figure 51: Location cesspits relative to vulnerability in the South, the Bekaa and Mount Lebanon

7.5. Priority 4: Improve systems that discharge into septic tanks

The fourth priority is to improve the systems in those ITS locations where there is a possible negative impact on the environment as the black water is currently reported to be discharged into septic tanks that drain into the subsoil. If these pits are less than 2 meter above the highest groundwater table in sandy areas or located in karst rock areas, groundwater might be at risk. This needs verification in the field. Their locations are presented in Figure 52. Unfortunately, we were not able to generate a list with the names of the locations and their coordinates. This needs to be done by the database specialists in Beirut.

Figure 52: ITS locations reported to discharge into septic tanks

Among these locations there several located in most vulnerable (black), 2nd most vulnerable (red), 3rd most vulnerable (orange) and 4th most vulnerable (yellow) locations identified by the Ministry of the Environment[35]. See Figure 53 and Figure 54.

[35] Source: MOST VULNERABLE LOCALITIES IN LEBANON, March 2015, Interagency Coordination Lebanon

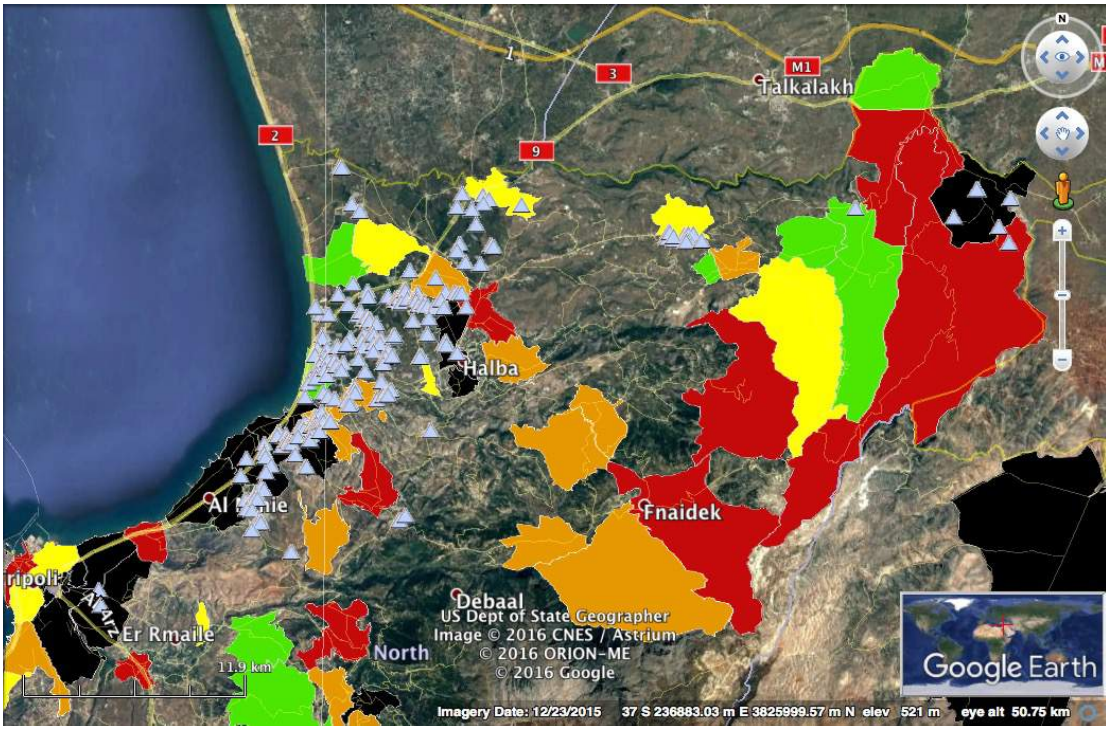


Figure 53: Location septic tanks relative to vulnerability in the North

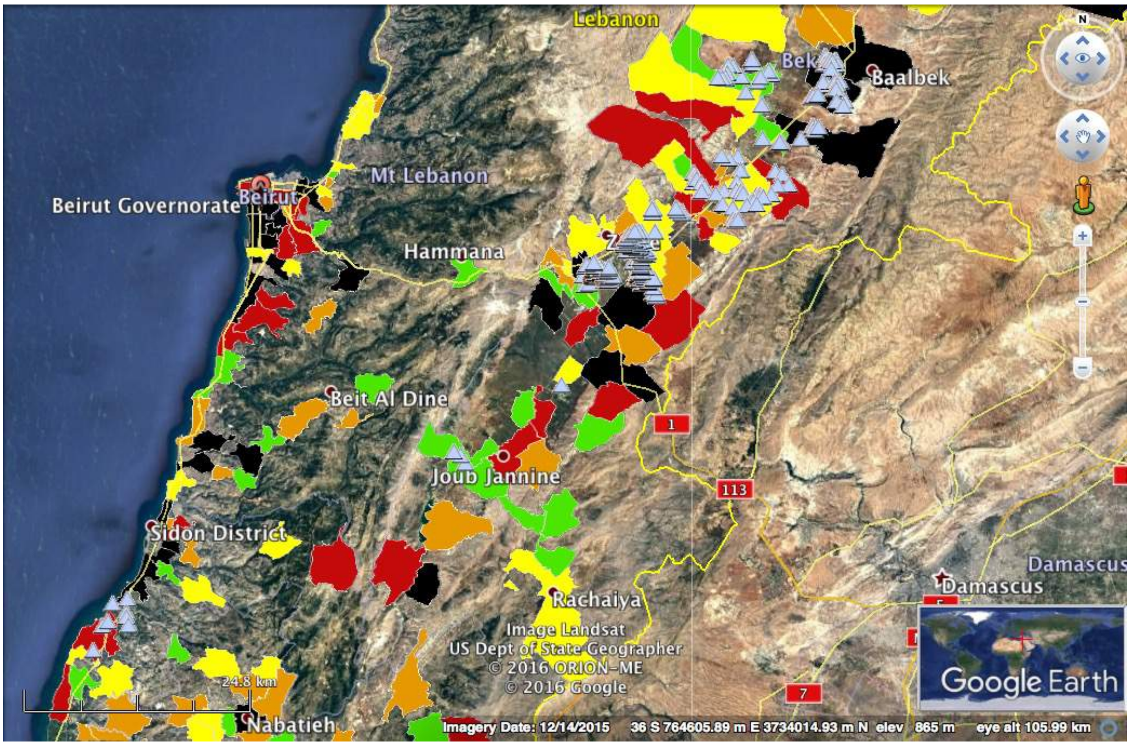


Figure 54: Location septic tanks relative to vulnerability in the South, the Bekaa and Mount Lebanon

7.6. Priority 5: Improve systems that discharge into holding tanks

The fifth priority is to improve the systems in those ITS locations where there are high operation and maintenance costs as the black water is currently reported to be discharged into holding tanks. These tanks fill up within 2-4 weeks and need desludging, leading to high operation costs. This needs verification in the field. Their locations are presented in Figure 55. Unfortunately, we were not able to generate a list with the names of the locations and their coordinates. This needs to be done by the database specialists in Beirut.

Figure 55: ITS locations reported to discharge into holding tanks

Among these locations are several located in most vulnerable (black), 2nd most vulnerable (red), 3rd most vulnerable (orange) and 4th most vulnerable (yellow) locations identified by the Ministry of Environment[36]. See Figure 56 and Figure 57

[36] Source: MOST VULNERABLE LOCALITIES IN LEBANON, March 2015, Interagency Coordination Lebanon

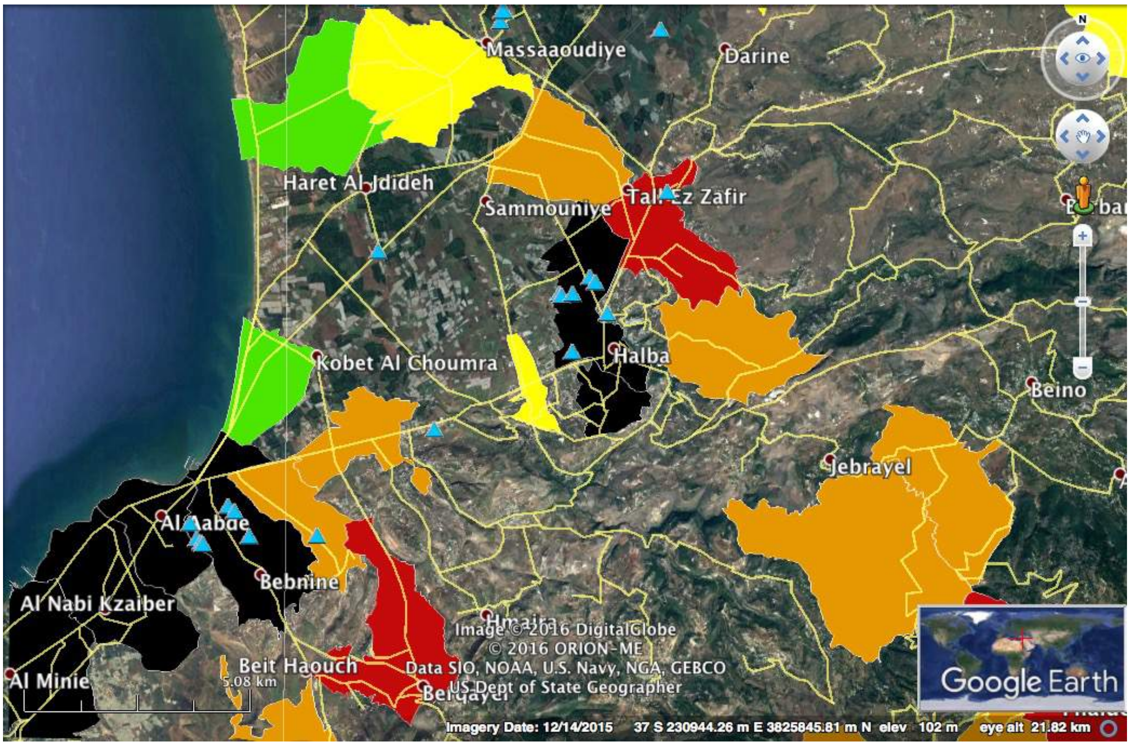


Figure 56: Location holding tanks relative to vulnerability in the North

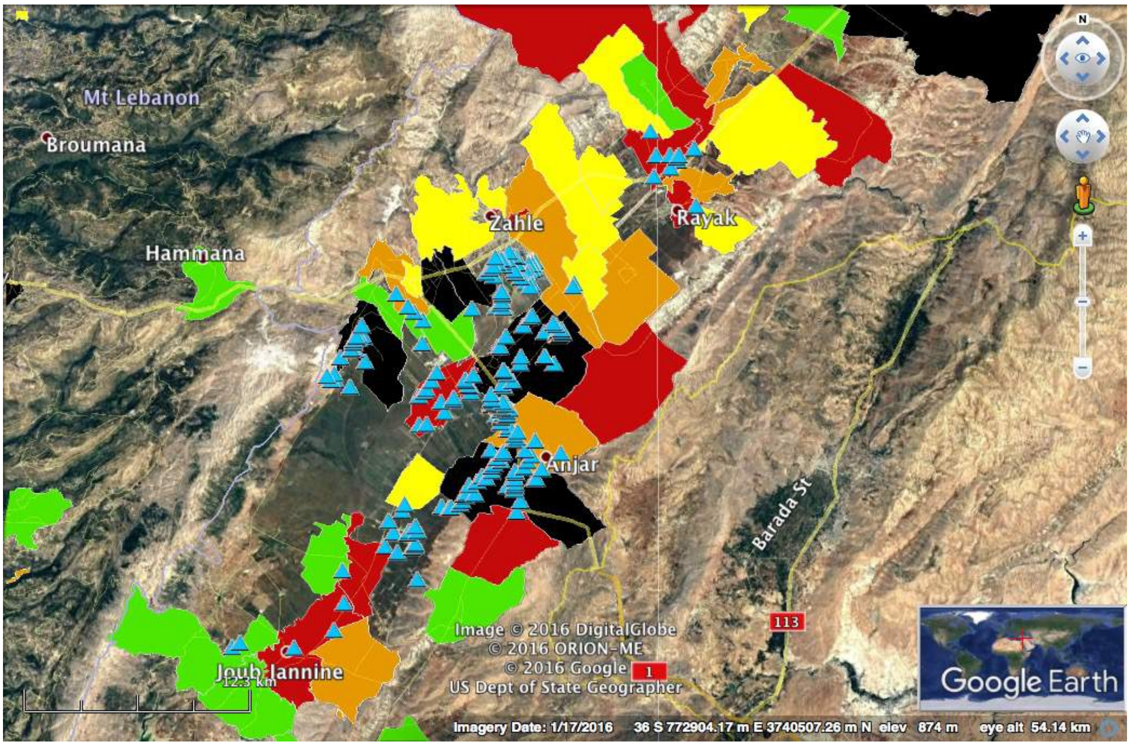


Figure 57: Location holding tanks relative to vulnerability in the Bekaa

Appendix 1: Terms of Reference

UNITED NATIONS CHILDREN'S FUND
ToR – SBP Request

DUTY STATION: Beirut, Lebanon **Title: WASH Specialist** **Level:** P4/P5	
PURPOSE OF MISSION: UNICEF provides more than 66% of existing Informal Settlements with temporary toilets and regular desludging. Nonetheless the efficiency and cost effectiveness of this initiative has been questioned and several cases of groundwater pollution from the wastewater produced by the population living in Informal Settlements have been observed. In addition, desludging activities are very expensive and can't be maintained for a long period of time. Therefore UNICEF has been requested by the Ministry of Energy and Water to find alternative technical solutions and to propose a global strategy on UNICEF response in providing wastewater services in Informal Settlement. The purpose of the deployment is to produce this document in close collaboration with the Ministry of Energy and Water and the Ministry of Environment.	**REPORTS TO:** Chief of WASH, Beirut **NUMBER/LEVEL OF POSTS SUPERVISED:** Nil
MAIN DUTIES/RESPONSIBILITIES: 1. Based on the mapping of Informal Settlements and hydrogeological surveys, identify the areas where the Informal Settlements are the most at risk of polluting the groundwater. 2. Identify the lowest cost solutions for the management of wastewater for the risky areas considering constraints (temporary design without electricity), including potential improvement of existing disludging. 3. Finalize a comprehensive strategic document on the provision of wastewater services in IS in Lebanon, recommending the most effective and ad hoc solutions.	**QUALIFICATIONS AND COMPETENCIES:** **Education and work experience** • Master degree in water/wastewater or civil engineering • At least 10 years technical experience in the area of wastewater management, including in the private sector. Knowledge and experience in decentralized small scale sanitation • Knowledge on sanitation related technical guidelines, standards, and indicators. • Basic/Advance security training online ***Key competencies:*** • Good communication and interpersonal skills • Good written and oral presentation skills; ability to communicate verbally and in writing, • Good team worker. • Willingness and ability to work in hardship environments • Cultural and Gender sensitivity • Technical Competencies • Software Skills a. Data capture and analysis b. MS Excel, Word, Power Point (Essential) c. Ability to master a GIS software is an asset • Report generation ***Languages:*** Fluency in English language required. Knowledge of French and/or Arabic an asset ***Duration:*** 3 months with possibilities to extend

PREPARED BY: Olivier Thonet, Chief WASH **Date:** 02/09/16

APPROVED BY: Tanya Chapuisat, Representative **Date:** 02/09/2016

Appendix 2: References

BAKALIA, ALEXANDER (1994), Albert Wright, Richard Otis and Jose de Azevedo Netto, Simplified Sewerage, Design Guidelines, UNDP/World Bank

BURNAT, JAMAL (2010): The Practical Manual For Installation of the Household Grey Wastewater Treatment System, FAO – Project No:- OSRO/GAZ/909/SPA

EAWAG (2005): Household-Centred Environmental Sanitation, Implementing the Bellagio Principles in Urban Environmental Sanitation, Provisional Guideline for Decision-Makers, Eawag: Swiss Federal Institute of Aquatic Science and Technology

JEHSE (2015) Journal of Environmental Health Science Engineering, The estimation of per capita loadings of domestic wastewater in Tehran

KALBERMATTEN JOHN M, DEANNE S. JULIUS, CHARLES G. GUNNERSON (1982): Appropriate Sanitation Alternatives, A Technical and Economic Appraisal, World Bank.

KALBERMATTEN, JOHN M., DEANNE S. JULIUS, CHARLES G. GUNNERSON, AND D. DUNCAN MARA (1982): Appropriate Sanitation Alternatives, A Planning and Design Manual, World Bank.

MARA, DUNCAN (1976): Sewage treatment in hot climates, John Wiley & Sons, Chichester.

MARA, DUNCAN (2001), Andrew Sleigh and Kevin Tayler: PC--based Simplified Sewer Design *School of Civil Engineering University of Leeds* and *GHK Research & Training*, London

MCLLWAINE STEPHEN (2010) AND MARK REDWOOD, Grey water Use in the Middle East Technical, Social, Economic and Policy Issues

MOE/EU/UNDP (2014), Ministry of Environment Lebanon: Environmental Assessment of the Syrian Conflict and Priority Interventions

SASSE, LUDWIG (1998): DEWATS Decentralized Wastewater Treatment in Developing Countries, Borda.

TILLEY, E.; LUETHY, C.; MOREL, A.; ZURBRUEGG, C.; SCHERTENLEIB, R. (2008): Compendium of Sanitation Systems and Technologies. Duebendorf and Geneva: Swiss Federal Institute of Aquatic Science and Technology (EAWAG).

TILLEY, ELIZABETH AND SYLVIE PETERS (2008): Sandec Training Tool: Module 4 Sandec: Department of Water and Sanitation in Developing Countries, Sanitation Systems & Technologies EAWAG.

UDERT, KAI AND TILLEY, ELIZABETH (2008), Sanitation systems and technologies for developing countries, EAWAG, 2010

WHO (2006): Guidelines for the safe use of wastewater, excreta and grey water

WSP (2007): Philippines Sanitation Sourcebook and Decision Aid

Appendix 3: Useful websites

http://www.susana.org/en/working-groups/emergency-reconstruction-situations

http://www.sswm.info

http://waste-dev.akvo.org/dst/sanitation/

http://www.emergencysanitationproject.org

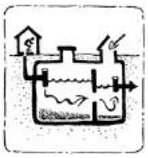
http://www.speedkits.eu

http://www.waste.nl

http://www.pseau.org

http://data.unhcr.org/syrianrefugees/country.php?id=122

Appendix 4: Septic Tank

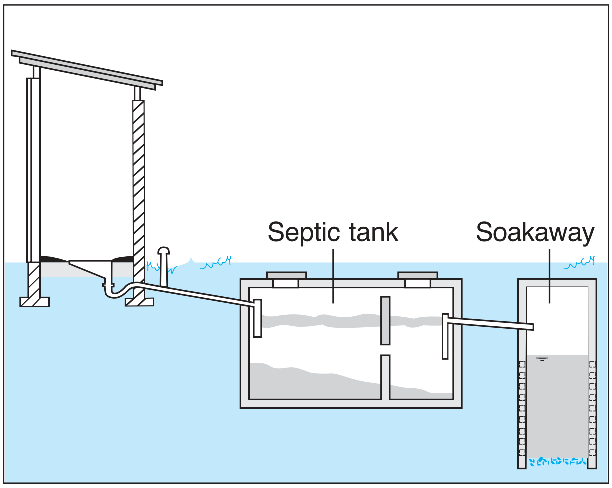


A (low cost) septic tank is a good way to replace existing cesspits and open pits in the ITS locations and connect them to a Solids Free Sewer (SFS) system, see Appendix 6: Solids Free Sewerage. A Septic Tank[37] is a watertight chamber made of PVC or PE, for the storage and treatment of black water. Settling and anaerobic processes reduce solids and organics, but the treatment is only moderate**.**

A Septic Tank (Figure 58**) should typically have at least two** chambers. Liquid flows into the tank and heavy particles sink to the bottom, while scum (oil and fat) floats to the top. The first chamber should be at least 50% of the total length and when there are only two chambers, and it should be two-thirds of the total length. The first chamber is used to settle the solids. Wastewater enters the first chamber of the tank, allowing solids to settle and scum to float. The settled solids are anaerobically digested, reducing the volume of solids. The liquid component flows through the dividing wall into the second chamber, where further settlement takes place, with the excess liquid then draining in a relatively clear condition from the outlet into the SFS. The inlet pipe from the toilet itself to the septic tank should also have a slope of around 1/40 angling towards the tank to reduce the rate of entry of the effluent into the tank. A lesser gradient could create blockages, whilst a sharper gradient could have too forceful entry of effluent into the tank. A 'T-shaped' inlet will further dissipate the rate of the incoming effluent that prevents the settling solids below from being disturbed. The baffle, or the separation between the chambers, is to prevent scum and solids from escaping with the effluent. A 'T-shaped' outlet pipe will further reduce the scum and solids that are dis-charged. With time, the solids that settle to the bottom are degraded anaerobically. As the system relies on bacteriological action for decomposition, therefore placing any chemicals or inorganic materials (such as pesticides, herbicides, paints or solvents) and detergents with high concentrations of bleach or caustic soda should not enter the system, as they will prevent the bacteria and system from functioning. Excess water, oils and grease may also prevent the decomposition rate and render the system ineffective (noticed by increase in bad smell which relates to poor decomposition) and could also block the inlet pipe. The septic tank works under anaerobic conditions, which means bacteria operating in a non-oxygen environment. Oxygen should not be allowed to enter, as it will destroy the bacteria used for decomposition and result in the septic tank working less efficiently. However, during the decomposition dangerous gases are created such as carbon dioxide and methane therefore a ventilation pipe with a screen (to prevent vectors entering and existing the tank) needs to be fitted either on entry point of the inlet tank or on the second chamber of the septic tank.

Generally, Septic Tanks should be emptied every 2 to 5 years, although they should be checked yearly to ensure proper functioning. Placing any non-biodegradable products into the system will just fill the tank and require it is be emptied more frequently. The design of a Septic Tank depends on the number of users, the amount of water used per capita, the average annual temperature, the pumping frequency and the characteristics of the wastewater. The retention time should be designed for 48 hours to achieve moderate treatment. The liquid effluent must be dispersed by using a Soak Pit or Leach Field or by transporting the effluent to another treatment technology via a Solids Free Sewers System (see Appendix 6: Solids Free Sewerage).

[37] After Tilley (2008)



Source: WHO 2003. Reproduced with permission from the World Health Organization, Geneva.

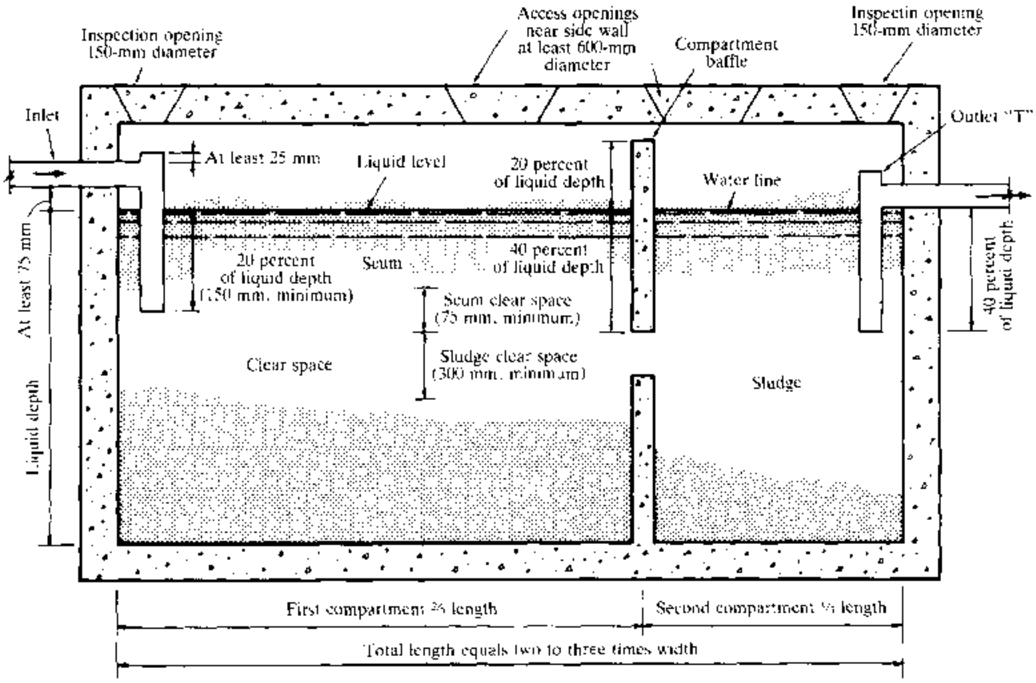
Figure 58: Septic tank and soakaway (WSP, 2008)

Figure 59: HDPE Septic Tank

Adequacy Because the Septic Tank must be desludged regularly, a vacuum truck should be able to access the location. If Septic Tanks are used in densely populated areas such as ITS locations, onsite infiltration/leach fields for the liquid effluent should not be used otherwise the ground will become oversaturated and excreta may rise up to the surface posing a serious health risk. Instead, the Septic Tank should be connected to a Solids Free Sewerage System (see § 3.6) and the liquid effluent should be transported to a subsequent treatment (see § 3.8). Larger, multi-chamber Septic Tanks can be designed for groups of houses and/or public buildings (i.e. schools). Generally, the removal of 50 % of solids, 30 to 40 % of Biochemical Oxygen Demand (BOD) and a 1-log removal of E-coli can be expected in a well-designed Septic Tank although, efficiencies vary greatly depending on operation and maintenance and climactic conditions. Even though the Septic Tank is watertight, care should be taken if constructed in areas with high groundwater tables or where there is frequent flooding.

Adjustment existing tanks in ITS locations. In order to function as a septic tank, the water tanks that are now being used in the informal settlements need to be adjusted. This means not only adding a 'Tee' at the inlet and outlet but also adding a dividing wall as shown in Figure 61. Care should be taken to assure a watertight connection between the T-inlet and the wall of the tank. The current practice of using acryl kit will cause leakage and is not very adequate, see Figure 62. Instead a good sleeve is needed. For new Informal Settlements adequate PE septic tanks (see Figure 59) need to be used instead of water tanks.

Figure 14-1. *Schematic of Conventional Septic Tank*
(millimeters)



Note: If vent is not placed as shown on figure 13-2, -3, and -4, septic tank must be provided with a vent.

Figure 60: Specification conventional septic tank (Kalbermatten, 1982)

Health Aspects/Acceptance Although the system does not provide total pathogen removal, as the entire tank is below ground, users therefore do not come in contact with any of the wastewater. Users should be careful when opening the tank because noxious and flammable gases may be released. A vacuum truck should be used to empty the sludge from the Septic Tank.

Figure 61: Low cost septic tank for black water only

Figure 62: Connection pipe and tank using acryl kit

Design & Maintenance. Septic Tanks should be checked to ensure that they are watertight. Because of the bacteriological content, care should be taken not to discharge harsh chemicals such as disinfectant into the Septic Tank. The digestion of waste creates bad smell and dangerous gases so a vent pipe should always be installed. 300mm should be kept between the top of the scum layer (on top of the liquid) and the bottom of the septic tank lid to allow for gases and a vent pipe should installed be made of galvanised steel and screened with mosquito mesh on top to prevent vectors entering.

The outlet pipe should also have T-section and be 75 mm lower than inlet. For discharge of the liquid effluent, the 'Two Meter Rule' can be applied where, if there is 2 m' of fine sand or loam separating the drain field and the ground water then virtually all pathogens will be removed[38]. This must be true all year round. Water is safe after travelling for ten days. So water can be extracted at least 15 m' away from a soakaway if the soil is fine. Limestone or fissured rock allows pathogens to travel much further.

The first compartment is usually twice the size of the second. The liquid depth is 1 to 2 m' and the overall length-to-width ratio is 2 or 3 to 1. Experience has shown that, if sufficiently quiescent conditions for effective sedimentation of the sewage solids are to be provided, the liquid retention time should be at least twenty-four hours, preferably 48 hours. To size the septic tank, it is important to determine the rate at which sludge (including faeces, urine and anal cleansing material) will accumulate, and volume of wastewater.

The approximate volume of the septic tank can be calculated as a function of the following equations:

- $V = N/1000 * (S * T + q * HRT)$

Where:
V = Tank volume (m^3);
N = Number of users (capita);
S = Sludge accumulation rate (lcy, litres/cap/year);
T = Desludging Period (years);
q = Amount of wastewater (lcd);
HRT = Hydraulic Retention Time (days).

---

38 Pickford, J. Low Cost Sanitation. IT Publications. 1995.

For a rectangular tank for a household of 15 persons (N=15), a sludge accumulation rate of 25 lcy (S=25) and a desludging period of 1 year (T = 1), only black water disposal of 15 lcd (q = 15) and a Hydraulic Retention Time of 2 days (HRT=2):

- V = 15/1000 * (25 * 1 + 15 * 2) = 0.825 m^3, say tank depth 0.8 m', tank width 0.6 m', length first compartment 1.2 m', length second compartment 0.6 m';
- Total tank depth: 0.8 m' + 30 cm freeboard = 0.8 + 0.3 = 1.1 m'.

For a rectangular tank for a household of 15 persons (N=15), a sludge accumulation rate of 25 lcy (S=25) and a desludging period of 1 year (T = 1), black and grey water disposal of 28 lcd (q = 28) and a Hydraulic Retention Time of 2 days (HRT=2):

- V = 15/1000 * (25 * 1 + 28 * 2) = 1.22 m^3, say tank depth 0.8 m', tank width 0.7 m', length first compartment 1.45 m', length second compartment 0.7 m';
- Total tank depth: 0.8 m' + 30 cm freeboard = 0.8 + 0.3 = 1.1 m'.

Table 24: Advantages and disadvantages Septic Tank

Advantages	**Disadvantages**
• Can be built and repaired with locally available materials • Long service life • No real problems with flies or odours if used correctly • Low capital costs, moderate operating costs depending on water and emptying • Small land area required • No electrical energy required	• Low reduction in pathogens, solids and organics • Effluent and sludge require secondary treatment and/or appropriate discharge • Requires constant source of water

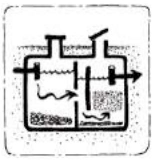
Table 25: Septic Tank at a glance

Working Principle	Basically a sedimentation tank (physical treatment) in which settled sludge is stabilised by anaerobic digestion (biological treatment). Dissolved and suspended matter leaves the tank more or less untreated.
Capacity/Adequacy	Household and community level; Primary treatment for domestic grey- and blackwater. Depending on the following treatment, septic tanks can also be used for industrial wastewater. Not adapted for areas with high groundwater table or prone to flooding.
Performance	BOD: 30 to 50%; TSS: 40 to 60 %; E. coli: 1 log units HRT: about 1 day
Costs	Low-cost, depending on availability of materials and frequency of de-sludging.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Should be checked for water tightness, scum and sludge levels regularly. Sludge needs to be dug out every 1 to 5 years and discharged properly (e.g. in composting or drying bed). Needs to be vented.
Reliability	When not regularly emptied, wastewater flows through without being treated. Generally good resistance to shock loading.
Main strength	Simple to construct and to operate.
Main weakness	Effluent and sludge require further treatment. Long start-up phase.

Effluent quality. As explained, the BOD and pathogen removal of a septic tank is limited:

- BOD removal efficiency 30%-50%. At a removal efficiency of 40%, the effluent of a Septic Tank that holds black water is (100%-40%) * 520 mgBOD/l = 320 mgBOD/l;
- E-coli removal: log 1 units. At an influent quality of a Septic Tank that holds black water at 10^5 E-coli/100 ml, the bacteriologic quality of the effluent is $10^{(5-1)}$= 10^4 E-coli/100ml.

Appendix 5: Anaerobic Upflow Filter



An **Anaerobic Upflow Filter** (UAF) is a fixed-bed biological reactor. As wastewater flows through the filter material, particles are trapped and organic matter is degraded by the biomass that is attached to the filter material. See Figure 63. This technology consists of a sedimentation tank (or septic tank) followed by one or more filter chambers.

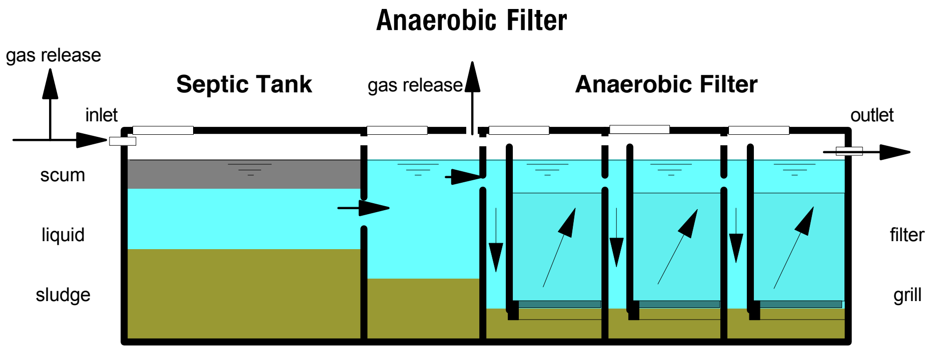


Figure 63: Anaerobic Upflow Filter (Sasse, 1998)

Filter material commonly used includes gravel or specially formed plastic pieces (see Figure 64). The application of crushed rocks (**Figure 65**) is not recommended as these rocks may be subject to decomposition due to the low pH of the wastewater and/or might clog. Typical filter material sizes range from 12 to 55 mm in diameter. Ideally, the material will provide between 90 to 300 m^2 of surface area per 1 m^3 of reactor volume. By providing a large surface area for the bacterial mass, there is increased contact between the organic matter and the active biomass that effectively degrades it. The Anaerobic Filter can be operated in either upflow or down flow mode. The upflow mode is recommended because there is less risk that the fixed biomass will be washed out. The water level should cover the filter media by at least 0.3 m' to guarantee an even flow regime. Studies have shown that the HRT is the most important design parameter influencing filter performance. A Hydraulic Retention Time (HRT) of 0.5 to 1.5 days is a typical and recommended. A maximum surface-loading (i.e. flow per area) rate of 2.8 m^3/m^2.d has proven to be suitable. Suspended solids and BOD removal can be as high as 85% to 90% but is typically between 50 % and 80 %. Nitrogen removal is limited and normally does not exceed 15% in terms of total nitrogen (TN).

To assure an adequate design and flexibility, we propose to purchase a mould and have the AUF produced in Lebanon. See Figure 66 and Figure 67.

Figure 64: Plastic Filter Media (Sasse, 1998)

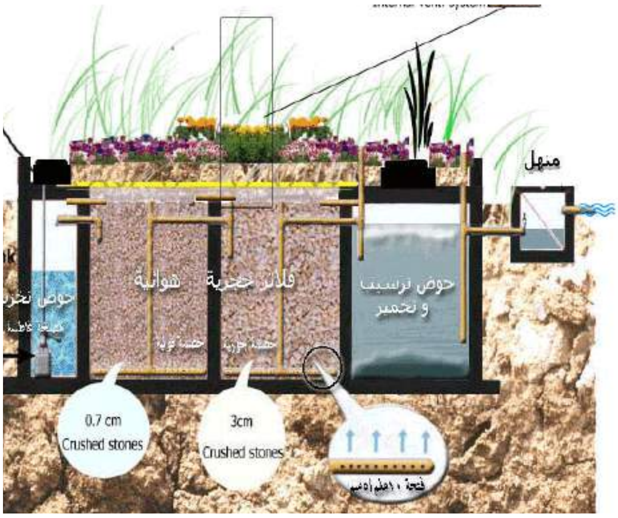


Figure 65: Crushed stone AUF UF (Burnat, 2010)

Figure 66: Prefab UAF

Figure 67: Interior Anaerobic Upflow Filter Tank

Adequacy. This technology is easily adaptable and can be applied at the household level or a small neighbourhood. An Anaerobic Filter can be designed for a single house or a group of houses that are using a lot of water for clothes washing, showering, and toilet flushing. It is only appropriate if water use is high, ensuring that the supply of wastewater is constant. The Anaerobic Filter will not operate at full capacity for six to nine months after installation because of the long start up time required for the anaerobic biomass to stabilize. Therefore, the Anaerobic Filter technology should not be used when the need for a treatment technology is immediate. Once working at full capacity it is a stable technology that requires little attention. The Anaerobic Filter should be watertight but care should be taken for construction in areas with high groundwater tables or where there is frequent flooding. Depending on land availability and the hydraulic gradient of the sewer (if applicable), the Anaerobic Filter can be built above or below ground.

Health Aspects/Acceptance. Because the Anaerobic Filter unit is underground, users do not come in contact with the influent or effluent. Infectious organisms are not sufficiently removed, so the effluent should be further treated or discharged properly. The effluent, despite treatment, will still have a strong odour and care should be taken to design and locate the facility such that odours do not bother community members. To prevent the release of potentially harmful gases, the Anaerobic Filters should be vented. The desludging of the filter is hazardous and appropriate safety precautions should be taken.

Maintenance. Active bacteria must be added to start up the Anaerobic Filter. The active bacteria can come from sludge from a septic tank that has been sprayed onto the filter material. The flow should be gradually increased over time, and the filter should be working at maximum capacity within six to nine months. With time, the solids will clog the pores of the filter. As well, the growing bacterial mass will become too thick and will break off and clog pores. A sedimentation tank before the filter is required to prevent the majority of settleable solids from entering the unit. Some clogging increases the ability of the filter to retain solids. When the efficiency of the filter decreases, it must be cleaned. Running the system in reverse mode to desludge accumulated biomass and particles cleans the filters. Alternatively, the filter material can be removed and cleaned. For ease of removal, it is recommended to use reinforce concrete slabs to cover the Filter in future to ensure easy operation and maintenance.

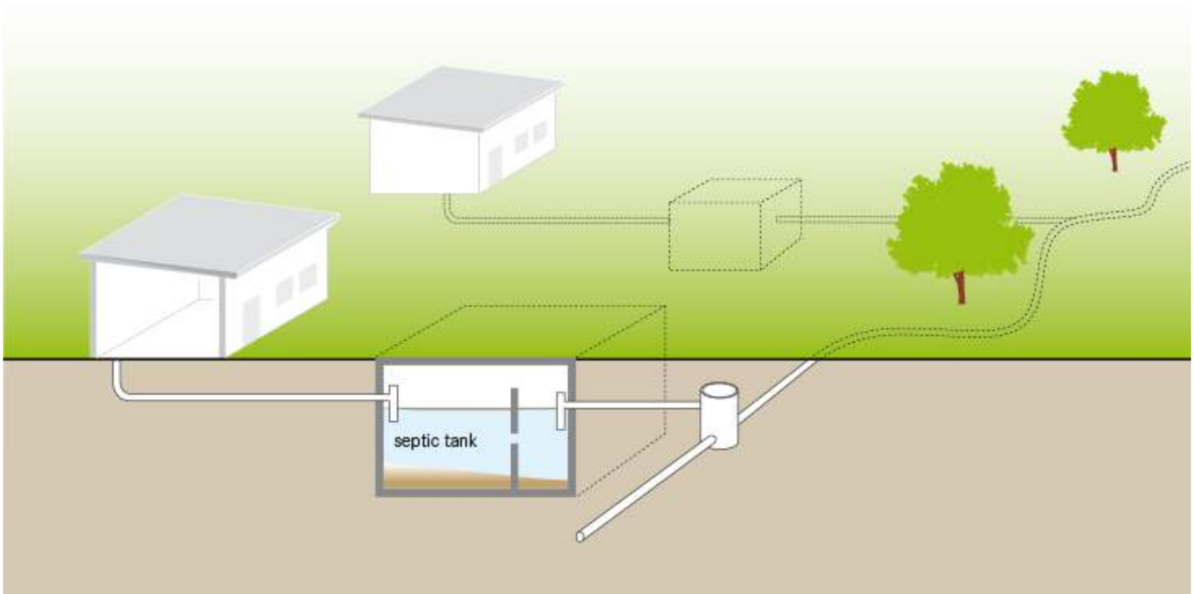
Appendix 6: Solids Free Sewerage

A solids-free sewer is a network of small-diameter pipes that transports pre-treated and solids-free wastewater (such as septic tank or biogas settler effluent) to a treatment facility for further treatment or to a discharge point. As solids are removed, the diameter of the sewers can be much smaller than for conventional sewers. It can be installed at a shallow depth and does not require a minimum wastewater flow or slope to function. Thus, significant lower construction costs are required than for conventional sewers. Solids-free sewers can be built for new areas or where soil infiltration of septic tanks effluents (e.g. via leach fields) is not appropriate anymore (i.e. densely populated areas, clogging of sub-surface). Although solids-free sewers require a constant supply of water, less water is needed compared to conventional sewers because self-cleansing velocities are not required.

In	Out
Black water, Grey water, Brown water, Urine or Yellow water, Non-biodegradable Wastewater	Black water, Non-biodegradable Wastewater

Introduction. Solids-free sewer systems are like conventional sewer systems, with the difference that the wastewater is pre-settled and solids removed. Solids-free sewers are also referred to as settled, small-bore, small-diameter, variable-grade gravity, or septic tank effluent gravity sewers. A precondition for solids-free sewers is efficient primary treatment at the household level. An interceptor, typically a single-chamber Septic Tank, biogas settler or anaerobic baffled reactor), captures settleable particles that could clog small pipes. The solids interceptor also functions to attenuate peak discharges. Solids-free sewers bring the pre-treated wastewater to a further treatment (e.g. free-surface or horizontal and vertical subsurface flow wetlands, waste stabilisation ponds, etc.) or to a discharge point connected to another sewer system. Because there is little risk of depositions and clogging, solids-free sewers do not have to be self-cleansing, i.e., no minimum flow velocity or tractive tension (see also vacuum sewers or pressurised sewers) is needed. They require few inspection points, can have inflective gradients (i.e., negative slopes) and follow the topography. Due to the simplified design, solids-free sewers can be built cheaper. Nevertheless, expert design and construction supervision is essential and repairs and removal of blockages may be required more frequently than for a conventional gravity sewer. Moreover, effluent and sludge (from interceptors) require secondary treatment and/or appropriate discharge (e.g. settling and thickening, drying and mineralization, non-planted filters, mechanical dewatering, composting, further anaerobic digestion at large scale). Small-bore sewers also require a certain level of responsibility of users, because maintenance is high due to the high risk of clogging in case of bad operation and maintenance (e.g. clandestine discharge of grey water etc. that has not been pre-settled).

When the sewer roughly follows the ground contours, the flow can vary between open channel and pressure (full-bore) flow.



Schematic of the solids-free sewer system installed in a small neighbourhood. Source: TILLEY et al. (2014)

Design Considerations. A precondition for solids-free sewer networks is an efficient pre-treatment at the household level. If the interceptors (e.g. septic tank, biogas settler or anaerobic baffled rector) are correctly designed and operated, this type of sewer does not require self-cleansing velocities or minimum slopes. Even inflective gradients are possible, as long as the downstream end of the sewer is lower than the upstream end. Solids-free sewers do not have to be installed on a uniform gradient with a straight alignment between inspection points. The alignment may curve to avoid obstacles, allowing for greater construction tolerance. When the sewer roughly follows the ground contours, the flow in the sewer is allowed to vary between open channel flow and pressure flow. However, care should be taken with negative slopes as they may lead to surging above the ground level during peak flows. Inspection points (see picture) should be provided at major connection points or when the size of the pipe changes. At high points in sections with pressure flow, the pipes must be ventilated. A minimum diameter of 75 mm is required to facilitate cleaning. When choosing a pipe diameter (at least 75 mm), the depth of water in the pipe during peak flow within each section must be less than the diameter of the pipe. In sections where there is pressure flow, the invert of any interceptor tank outlet must be higher than the hydraulic head within the sewer just prior to the point of connection. Otherwise, the liquid will backflow into the tank. If this condition is not met, then either select the next larger pipe diameter for the sewer or increase the depth at which the sewer is laid.

Expensive manholes are not needed because access for mechanical cleaning equipment is not necessary. Cleanouts or flushing points are sufficient and are installed at upstream ends, high points, intersections, or major changes in direction or pipe size. Compared to manholes, cleanouts can be more tightly sealed to prevent storm water from entering. Storm water must be excluded as it could exceed pipe capacity and lead to blockages due to grit depositions. Ideally, there should not be any storm- and groundwater in the sewers, but, in practice, some imperfectly sealed pipe joints must be expected. Estimates of groundwater infiltration and storm water inflow must, therefore, be made when designing the system. The use of PVC pipes can minimize the risk of leakages.

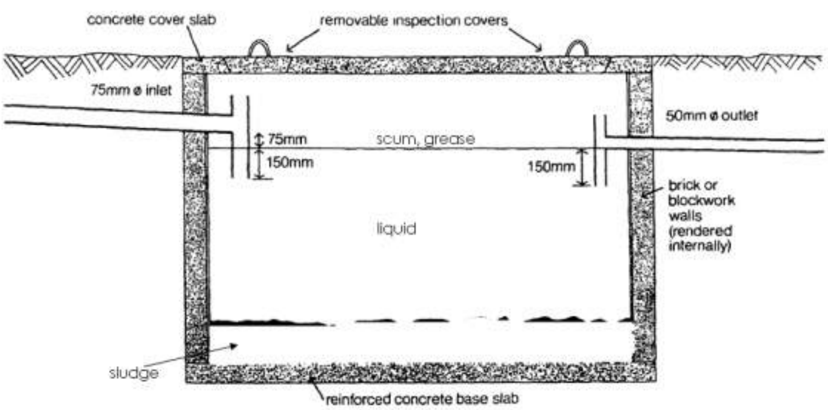
Pumping may be necessary where the elevation differences do not permit gravity flow. The operation of a pressure sewer, however, relies on a reliable source of electricity.

Health Aspects/Acceptance. If well-constructed and maintained, sewers are a safe and hygienic means of transporting wastewater. Users must be well trained regarding the health risks associated with removing blockages and maintaining interceptor tanks.

Costs Considerations. Due to the simplified design, solids-free sewers can be built for 20% to 50% less costs than conventional sewerage. However, expert design and construction supervision is essential. Moreover, repairs and removal of blockages may be required more frequently than for a conventional gravity sewer. Also the costs for emptying the pre-settling unit (e.g. septic tank, biogas settler) must be considered.

Operation & Maintenance. Trained and responsible users are essential to avoid clogging by trash and other solids. Regular desludging and emptying (see human powered or motorised emptying and transport) of the pre-settling units such as septic tanks, biogas settler, is critical to ensure optimal performance of the sewer. Periodic flushing of the pipes is recommended to insure against blockages.

The risk of pipe clogging is low if the sewers are well operated and maintained, however, some maintenance is required periodically. Regardless of performance, the sewers should be flushed once a year.



Typical solids interceptor tank. It has primary four functions: Sedimentation, storage, digestion of the sludge/scum and flow attenuation (reducing of peak flow). Source: OTIS and MARA (1985)

Typical solids interceptor tank. It has primary four functions: Sedimentation, storage, digestion of the sludge/scum and flow attenuation (reducing of peak flow). Source: OTIS and MARA (1985)

Special precautions should be taken to prevent illegal connections, since it is likely that interceptors would not be installed and solids would enter the system. The water establishment, a private contractor or user's committee should be responsible for the management of the system, particularly, to ensure that the interceptors are regularly desludged and to prevent illegal connections.

Applicability. This type of sewer is best suited to medium-density (peri-) urban areas and less appropriate in low-density or rural settings. It is most appropriate where there is no space for a Leach Field or a soak pit, or where effluents cannot otherwise be disposed of onsite (e.g., due to low infiltration capacity or high groundwater). It is also suitable where there is undulating terrain or rocky soil. A solids-free sewer can be connected to existing septic tanks where infiltration is no longer appropriate (e.g., due to increased housing density and/or water use).
As opposed to a Simplified Sewer a solids-free sewer can also be used where domestic water consumption is limited, as it requires a constant supply of water, although less water is needed compared to conventional sewers.

This technology is a flexible option that can be easily extended as the population grows. Because of shallow excavations and the use of fewer materials, it can be built at considerably lower cost than a Conventional Gravity Sewer.

Solids-free sewer systems should be installed in areas with a high willingness to pay (for the operation and maintenance) and with locally available expertise and resources. Furthermore, users should receive some basic training to prevent clandestine discharge of non-pre-settled wastewater into the sewers. Moreover, responsibilities of sewerage authority, a private contractor or user's committee for the regular control and management of the systems have to be clear.

Advantages
- Does not require a minimum gradient or flow velocity
- Can be used where water supply is limited
- Can be built and repaired with locally available materials
- Lower capital costs than conventional gravity sewers; low operating costs
- Construction can provide short-term employment to local labourers
- Can be extended as a community grows
- Greywater can be managed concurrently
- Appropriate for densely populated areas with sensitive groundwater or no space for a soak pit or leaching field

Points of attentions
- Space for interceptors is required
- Interceptors require regular desludging to prevent clogging
- Requires training and acceptance to be used correctly
- Requires repairs and removals of blockages more frequently than a conventional gravity sewer
- Requires expert design and construction
- Leakages pose a risk of wastewater exfiltration and groundwater infiltration and are difficult to identify
- Effluent and sludge (from interceptors) requires secondary treatment and/or appropriate discharge

References: http://www.sswm.info/category/implementation-tools/wastewater-collection/hardware/sewers/solids-free-sewers

Appendix 7: Baffled Septic Tank

Anaerobic treatment in a **Baffled Septic Tank (BST)** is the most appropriate treatment system to treat the effluent of the Solids Free Sewers. When it is followed by a Vertical Flow Constructed Wetland (See Appendix 8: Vertical Flow Constructed Wetland), the effluent is fit for infiltration, reuse in agriculture or disposal in a nearby stream. A BST is an improved septic tank because of the series of baffles under which the wastewater is forced to flow. The increased contact time with the active biomass (sludge) results in improved treatment.

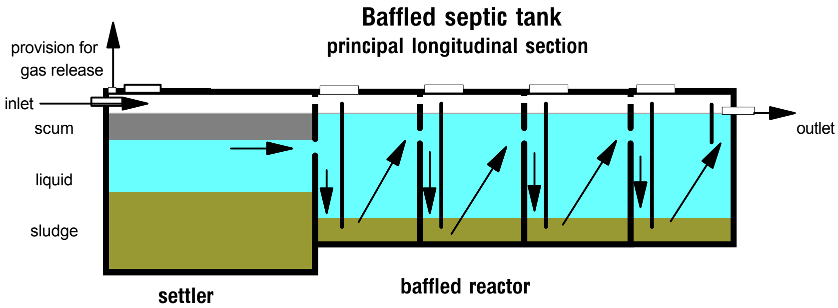


Figure 68: Baffled Septic Tank (Sasse, 1998)

The majority of settleable solids are removed in the sedimentation chamber at the beginning of the ABR, which typically represents 50% of the total volume. The up- flow chambers provide additional removal and digestion of organic matter: BOD may be reduced by up to 90 %, which is far superior to that of a conventional septic tank. As sludge is accumulating, desludging is required every 2 to 3 years. Critical design parameters include a hydraulic retention time (HRT) between 48 to 72 hours, up-flow velocity of the wastewater less than 0.6 m'/h and the number of up-flow chambers (2 to 3).

Adequacy. This technology is easily adaptable and can be applied at the household level or for a settlement up to 2000 inhabitants. This technology is also appropriate for areas where land may be limited since the tank is installed underground and requires a small area. It should not be installed where there is a high groundwater table as infiltration will affect the treatment efficiency and contaminate the groundwater. Typical inflows range from 2,000 to 200,000L/day. The BST will not operate at full capacity for several months after installation because of the long start up time required for the anaerobic digestion of the sludge. Therefore, the BST technology should not be used when the need for a treatment system is immediate, unless it followed by a Vertical Flow Constructed Wetland. To help the BST to start working more quickly, it can be 'seeded', i.e. active sludge can be introduced so that active bacteria can begin working and multiplying immediately. Because the BST must be emptied regularly, a vacuum truck should be able to access the location.

In order to assure an adequate design and flexibility, we propose to purchase a mould and have the ABR produced in Lebanon. See brochure of Borda in Figure 69 and Figure 70.

Health Aspects/Acceptance. Although the removal of pathogens is not high, the BST is contained so users do not come in contact with any of the waste- water or disease causing pathogens. Effluent and sludge must be handled with care as they contain high levels of pathogenic organisms. To prevent the release of potentially harmful gases, the tank should be vented.

Maintenance. BSTs should be checked to ensure that they are watertight and the levels of the scum and sludge should be monitored to ensure that the tank is functioning well. Because of the delicate ecology, care should be taken not to discharge harsh chemicals into the BST. The sludge should be removed using a vacuum truck to ensure proper functioning of the BST.

Table 26: BST

Working Principle	Vertical baffles in the tank force the pre-settled wastewater to flow under and over the baffles guaranteeing contact between wastewater and resident sludge and allowing an enhanced anaerobic digestion of suspended and dissolved solids; at least 1 sedimentation chamber and 2-5 up-flow chambers.
Capacity/Adequacy	Community (and household) level; For pre-settled domestic or (high-strength) industrial wastewater of narrow COD/BOD ration. Typically integrated in DEWATS systems; Not adapted for areas with high ground-water table or prone to flooding.
Performance	70- 95% BOD; 80% - 90% TSS; Low pathogen reduction. HRT: 1 to 3 days
Costs	Generally low-cost; depending on availability of materials and economy of scale.
Self-help Compatibility	Requires expert design, but can be constructed with locally available material.
O&M	Should be checked for water tightness, scum and sludge levels regularly; Sludge needs to be dug out and discharged properly (e.g. in composting or drying bed); needs to be vented.
Reliability	High resistance to shock loading and changing temperature, pH or chemical composition of the influent; requires no energy.
Main strengths	Strong resistance; built from local material; biogas can be recovered.
Main weakness	Long start-up phase.

Table 27: Advantages and disadvantages of a BST

Advantages	Disadvantages
• Extremely stable to hydraulic shock loads • High treatment performance (for all, grey-, black- and industrial wastewater) • Simple to construct and operate • No electrical requirements (only physical mixing) • Construction material locally available • Low capital and operating costs, depending on economy of scale, • Ability to partially separate between the various phases of anaerobic catabolism • Low sludge generation, • Reduced clogging • Biogas can be recovered, • Low HRT, long biomass retention time	• Needs expert design Long start-up phase • Needs strategy for faecal sludge management (effluent quality rapidly deteriorates if sludge is not removed regularly) • Effluent requires secondary treatment and/or appropriate discharge • Needs water to flush • Clear design guidelines are not available yet Low reduction of pathogens • Requires expert design and construction

Figure 69: Brochure Borda page 1

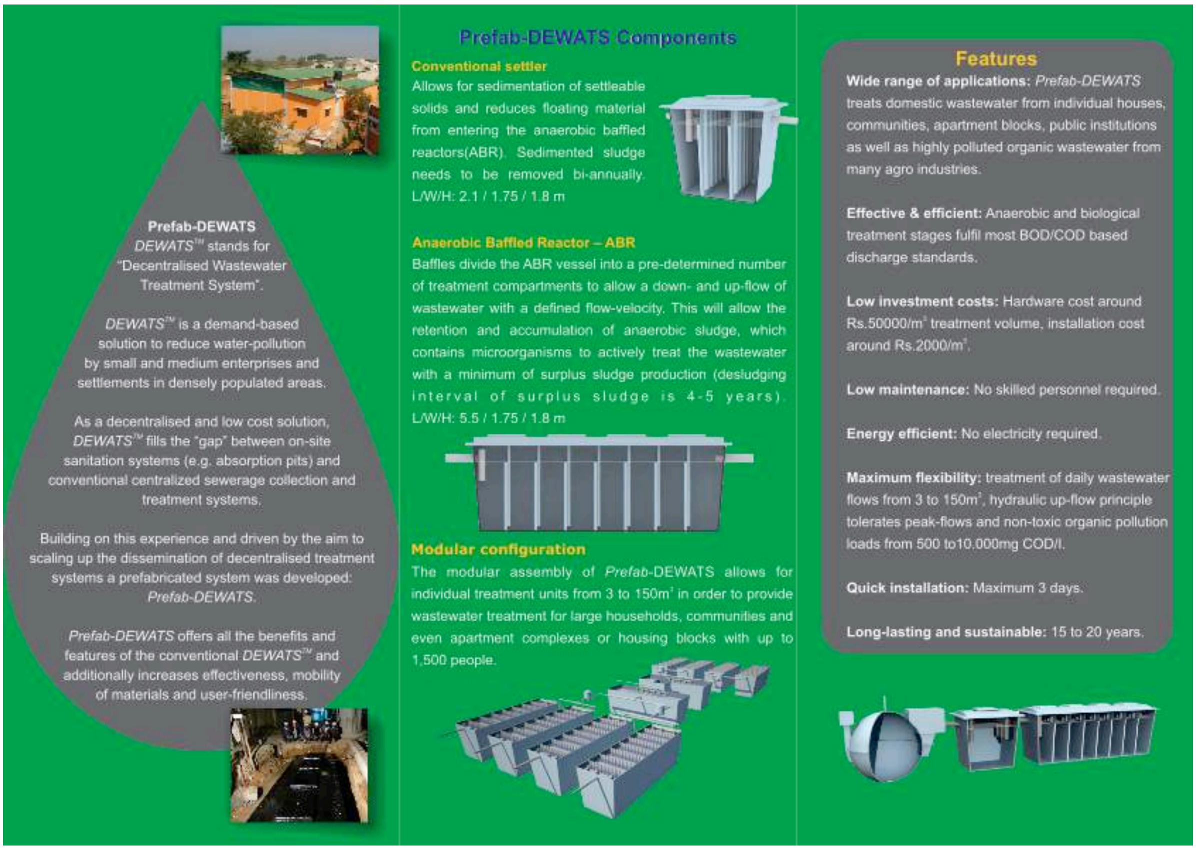
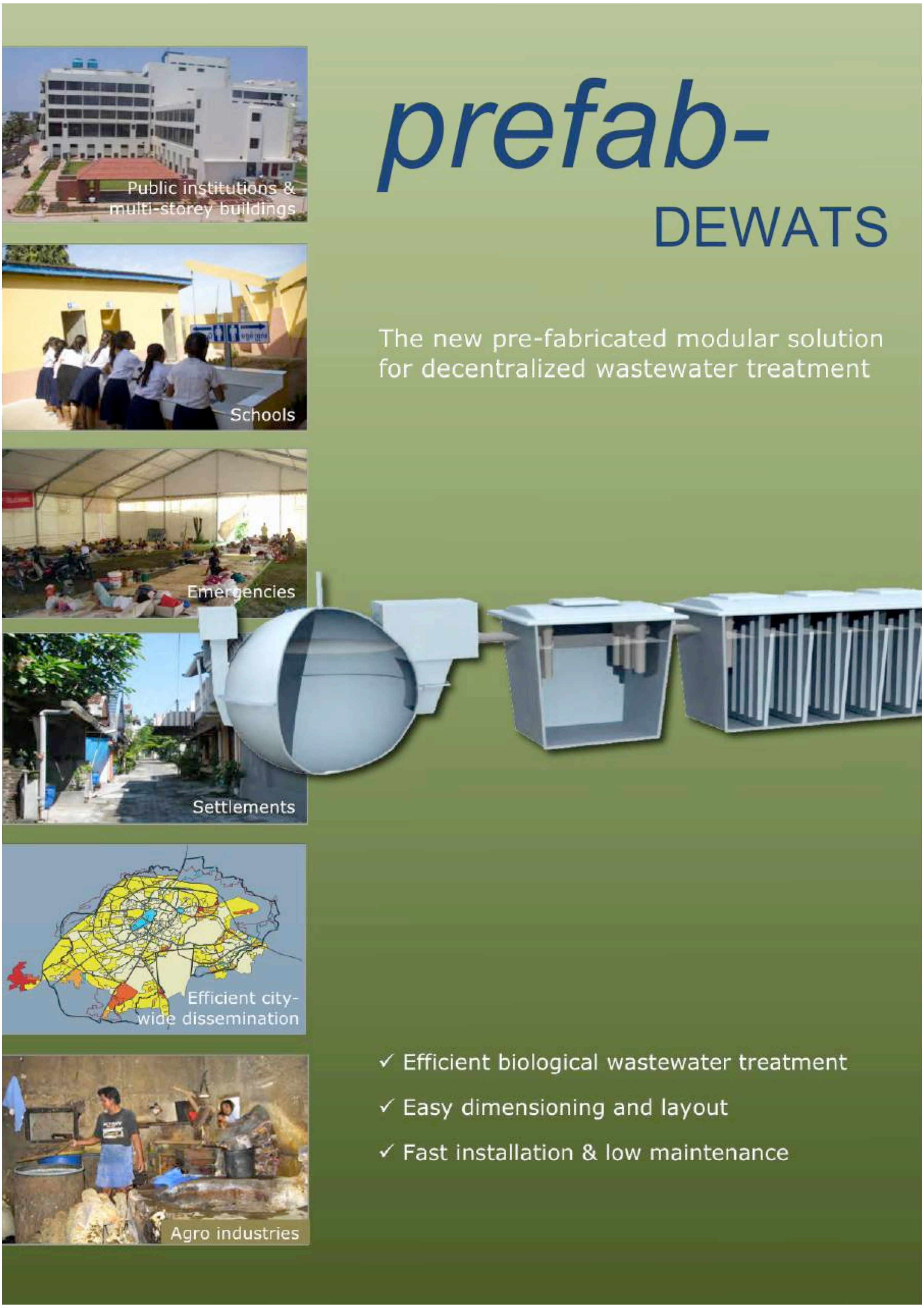


Figure 70: Brochure BORDA, page 2


Public institutions &
multi-storey buildings
Schools
Emergencies
Settlements
Efficient city-
wide dissemination
Agro industries
prefab-
DEWATS
The new pre-fabricated modular solution
for decentralized wastewater treatment
✓ Efficient biological wastewater treatment
✓ Easy dimensioning and layout
✓ Fast installation & low maintenance

Background and history

DEWATS stands for „Decentralized Wastewater Treatment System". *DEWATS* was developed in 1998 as a demand-based solution to reduce water-pollution by small and medium enterprises and settlements in densely populated areas. Combined with toilets and washing facilities this modular wastewater treatment system is the core element of Community Based Sanitation (CBS) which improves significantly livelihoods and sanitation infrastructure.

As a decentralized and low cost solution, *DEWATS* fills the "gap" between on-site sanitation systems (e.g. absorption pits) and conventional centralized sewerage collection and treatment systems.

Today *DEWATS* is disseminated by public authorities, urban planners, architects and NGOs in Asia and Africa. Its approach and its significant impact for livelihoods and environment is acknowledged by international experts and decision makers.

Building on this experience and driven by the aim to up-scale the dissemination of decentralized treatment systems a prefabricated system was developed: *prefab-DEWATS*.

Prefab-DEWATS offers all the benefits and features of the conventional *DEWATS* and additionally increases effectiveness, mobility and user-friendliness.

prefab-DEWATS and conventional *DEWATS* plant (small photo) under construction

General *DEWATS* performance data (domestic wastewater)

Parameter	Inflow concentration	Outflow concentration	Parameter	Inflow concentration	Outflow concentration
BOD (mg/L)	440 - 540	40 - 50	**TSS** (mg/L)	120 - 160	20 - 35
COD (mg/L)	790 - 970	90 - 100	**pH**	7,2 - 7,8	6,8 - 7,2

Advantages of *prefab-DEWATS*

A proven solution
Treatment efficiency is documented in over 1000 *DEWATS* wastewater treatment plants in operation.

Effective & efficient
Mechanic and biological treatment stages fulfil most BOD / COD based discharge standards at low-investment and running costs.

Low investment costs
Hardware cost +/- € 500 per cbm treatment volume, installation cost +/- € 100 per cbm additional costs for excavation and concrete foundation.

Low maintenance
Minimum maintenance requirements, no skilled personnel required for operation & maintenance.

Maximum flexibility
The modular design of *prefab-DEWATS* allows for treatment of daily wastewater flows from 3 to 150 m^3, hydraulic up-flow principle tolerates peak-flows & non-toxic organic pollution loads from 500 to 10.000 mg COD / l.

Energy efficient
No electricity required for pumps and blowers. Addition of biogas module generates gas for cooking.

Quick installation
Prefabrication reduces installation time by 95 %. Most plants are installed within 1-3 days.

Long-lasting and sustainable
High-tech design, exclusive use of premium composite materials and quality management result in a product lifetime of +/- 15 years. All implementation operation & maintenance tasks are carried out by local craftsmen.

Up scaling possible
Compared with conventional construction procedures pre-fabrication, modular designs and easy installation allow for a simultaneous implementation of a large number of DEWATS projects.

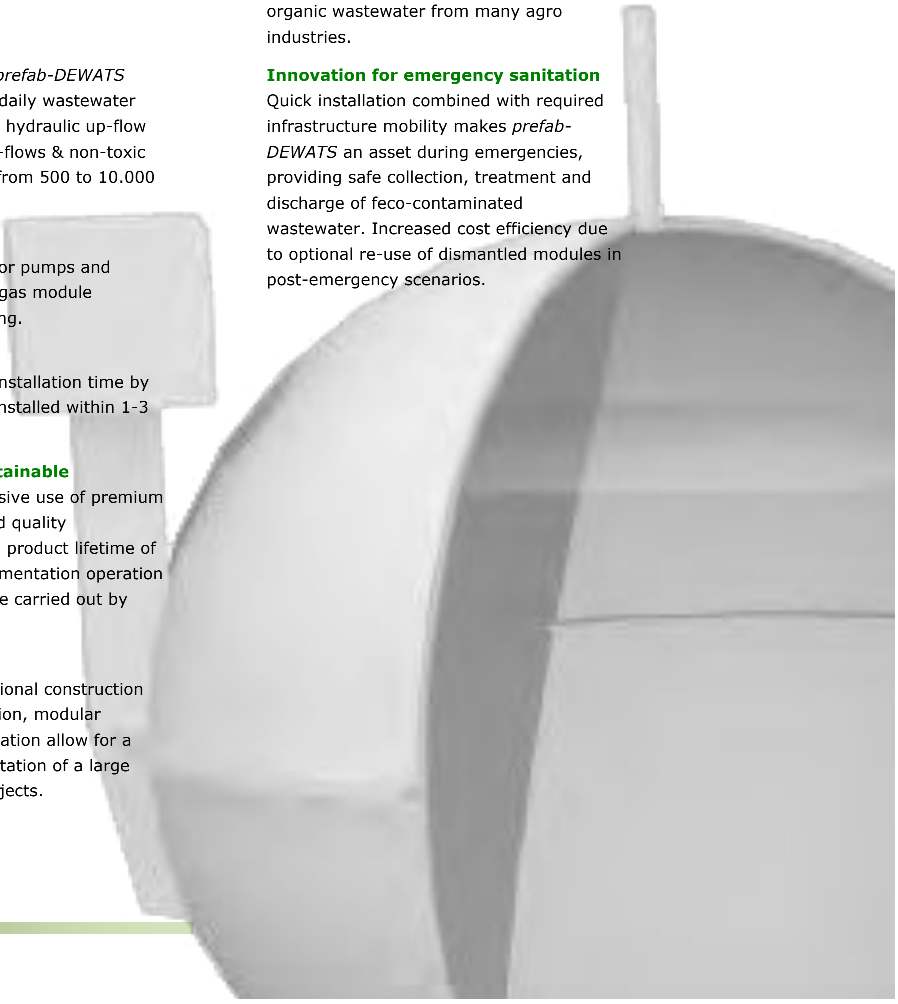
***prefab-DEWATS* bioprocess technology**
Multi-chamber digesters with partial separation of the anaerobic microbiological processes cause a significant acceleration of the anaerobic digestion process.

Retention of microorganisms within the treatment system causes a maximizing of the flow-capacity and a minimizing of the reactor volume.

Absence of moving parts, the anaerobic fully mixed digester principle and smart fluid engineering ensure low maintenance.

Wide range of applications
prefab-DEWATS treats domestic wastewater from individual houses, communities, apartment blocks, public institutions as well as highly polluted organic wastewater from many agro industries.

Innovation for emergency sanitation
Quick installation combined with required infrastructure mobility makes *prefab-DEWATS* an asset during emergencies, providing safe collection, treatment and discharge of feco-contaminated wastewater. Increased cost efficiency due to optional re-use of dismantled modules in post-emergency scenarios.



prefab-DEWATS components …

Divider-weir

Allows for a bypass of wastewater in case of heavy inflows (e. g. caused by heavy showers or flooding) that exceed the designed inflow capacity of prefab-DEWATS by over 200 %.

Grease trap

Eliminates fat and grease before it enters the settler / sedimentation chamber. Fat and grease must be removed weekly from the surface.

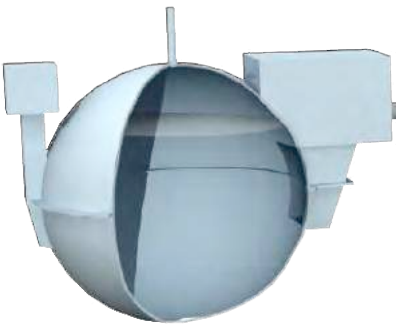
For 1 household:
l/w/h: 0,45 / 0,3 / 0,41 m

For 2-3 households:
l/w/h: 0,6 / 0,45 / 0,48 m

Conventional settler / sedimentation chamber

Allows for sedimentation of settleable solids and reduces floating material from entering the anaerobic baffled reactors (ABR). Floating material has to be removed and disposed as solid waste on a weekly / monthly basis. Sedimented sludge needs to be removed bi-annually.

l/w/h: 2,1 / 1,75 / 1,8 m



Biogas settler

Allows for sedimentation and generation of methane gas for cooking in circumstances where highly loaded organic wastewater can be collected. Useful for treatment of domestic wastewater in case „black-water" stream can be separated from „gray-water" stream.

∅: 2,25 m
Digester volume: 6 m^3
Gas storage volume 1,5 m^3

4

… ready for specific demands

Anaerobic baffled reactor - ABR

A variety of ABR **(small vessel, medium vessel, large vessel)** sizes are designed for different wastewater inflows (= hydraulic loads). The modular design allows for optimal configurations to establish *prefab*-DEWATS plants for treatment of up to 150 m^3 wastewater per day. Baffles divide the ABR vessel into a pre-determined number of treatment compartments to allow a down- and up-flow of wastewater with a reduced flow-velocity. This will allow the retention and accumulation of anaerobic sludge, which contains microorganisms to actively treat the wastewater with a minimum of surplus sludge production (desludging interval of surplus sludge is 4-5 years).

Large Vessel

l/w/h: 5,5 / 1,75 / 1,8 m

Medium Vessel

l/w/h: 2,8 / 1,75 / 1,8 m

Small Vessel

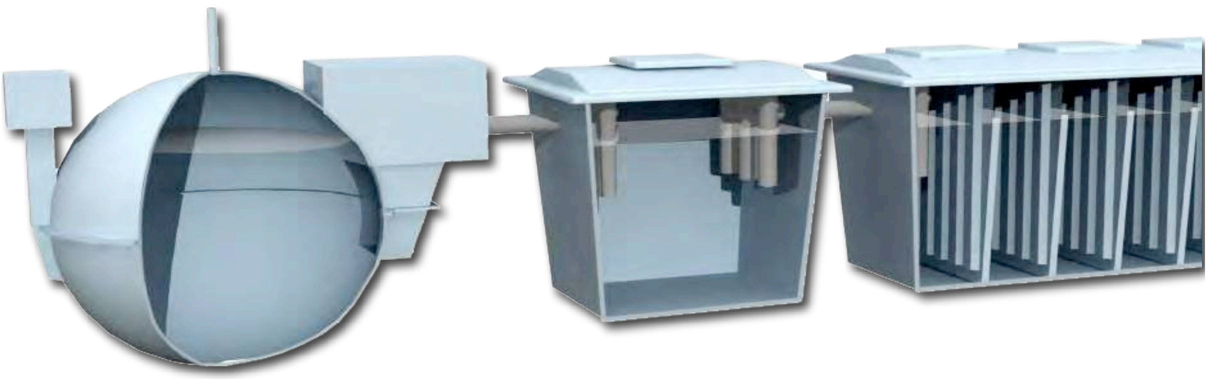
l/w/h: 2,1 / 1,75 / 1,8 m

Control Box

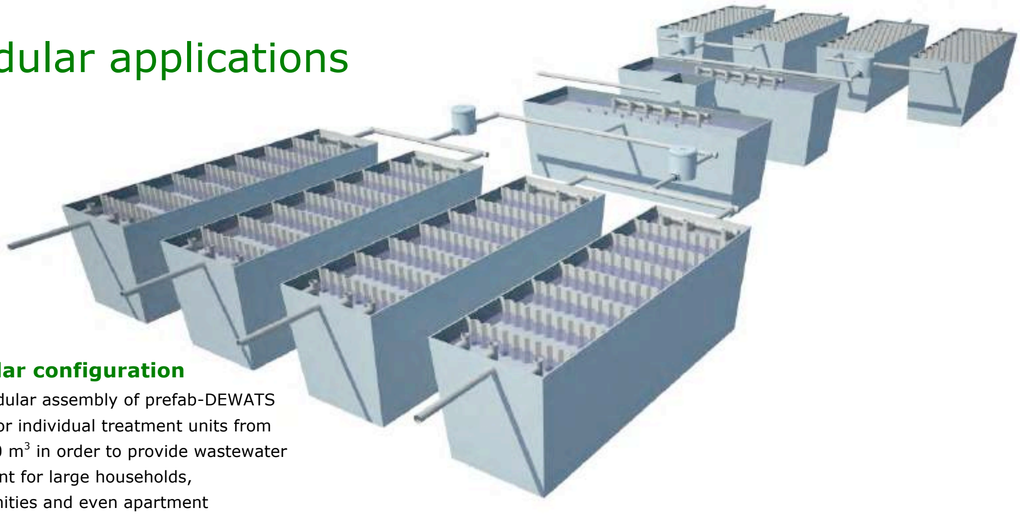
∅/h: 0,5 / 0,5
Diameter: 0,5 m
Height 0,5 m

prefab-DEWATS configurations

	Conditions		>>	Modular Solutions			
	Sanitation Type and Wastewater Volume	Wastewater inflow/day (m^3)	>>	Biogas Settler	Small Vessel	Medium Vessel	Large Vessel
50 persons	Shallow sewer system (SSS) 100L/person/day	5	>>		1	1	
	Public sanitation facilities 60L/person/day	3	>>	1		1	
	Sanitation blocks (emergency sanitation) 15L/person/day	0,75	>>			1	
100 persons	Shallow sewer system (SSS) 100L/person/day	10	>>		1		1
	Public sanitation facilities 60L/person/day	6	>>	1			1
	Sanitation blocks (emergency sanitation) 15L/person/day	1,5	>>	1		1	
150 persons	Shallow sewer system (SSS) 100L/person/day	15	>>		2		1
	Public sanitation facilities 60L/person/day	9	>>	1	1		1
	Sanitation blocks (emergency sanitation) 15L/person/day	2,3	>>				1
200 persons	Shallow sewer system (SSS) 100L/person/day	20	>>				2
	Public sanitation facilities 60L/person/day	12	>>	1			2
	Sanitation blocks (emergency sanitation) 15L/day/person	3	>>	1			1
500 persons	Shallow sewer system (SSS) 100L/person/day	50	>>				6
	Public sanitation facilities 60L/person/day	30	>>	4			5
	Sanitation blocks (emergency sanitation) 15L/person/day	7,5	>>	2		1	2
1000 persons	Shallow sewer system (SSS) 100L/person/day	100	>>			6	8
	Public sanitation facilities 60L/person/day	60	>>	6		1	8
	Sanitation blocks (emergency sanitation) 15L/person/day	15	>>	3		2	4



Modular applications



Modular configuration

The modular assembly of prefab-DEWATS allows for individual treatment units from 3 to 150 m³ in order to provide wastewater treatment for large households, communities and even apartment complexes or housing blocks with up to 1.500 people.

Emergency sanitation

Quick installation combined with required infrastructure mobility makes *prefab-DEWATS* an asset during emergencies, providing safe collection, treatment and discharge of feco contaminated wastewater. Thus prefab-DEWATS offers a significant improvement of emergency sanitation.

Other examples of modular application:

- Housing blocks
- Real estates
- School and community Based Sanitation
- Hospitals
- Agro industries
- Emergencies and others

prefab-DEWATS services

Planning

- Evaluation of site conditions and assessment of applicability
- Estimation of required number and types of modules
- Cost estimation including costs for transportation and installation
- Detailed Design, BoQ,
- Implementation task lists

Post-implementation services

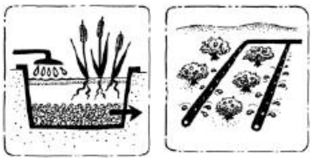
- Operation and maintenance training for user and operator
- Customer support via telephone and email
- On-site monitoring of *prefab-DEWATS* performance
- Facilitation of community health and hygiene training

Installation

- Organisation of transport of materials
- Provision of experts for on-site installation
- Commissioning

The *prefab-DEWATS* system has been developed by BORDA with support of the German Federal Ministry for Economic Cooperation and Development (BMZ). *Prefab-DEWATS* components and modules are manufactured by local companies in demand regions.

Appendix 8: Vertical Flow Constructed Wetland



A Vertical Flow Constructed Wetland (VFCW) is a filter bed that is planted with aquatic plants. See Figure 71. Wastewater is poured or dosed onto the wetland surface from above using a mechanical dosing system (Figure 72) or a siphon (Figure 73). The water flows vertically down through the filter matrix. The important difference between a vertical and horizontal wetland is not simply the direction of the flow path, but rather the aerobic conditions.

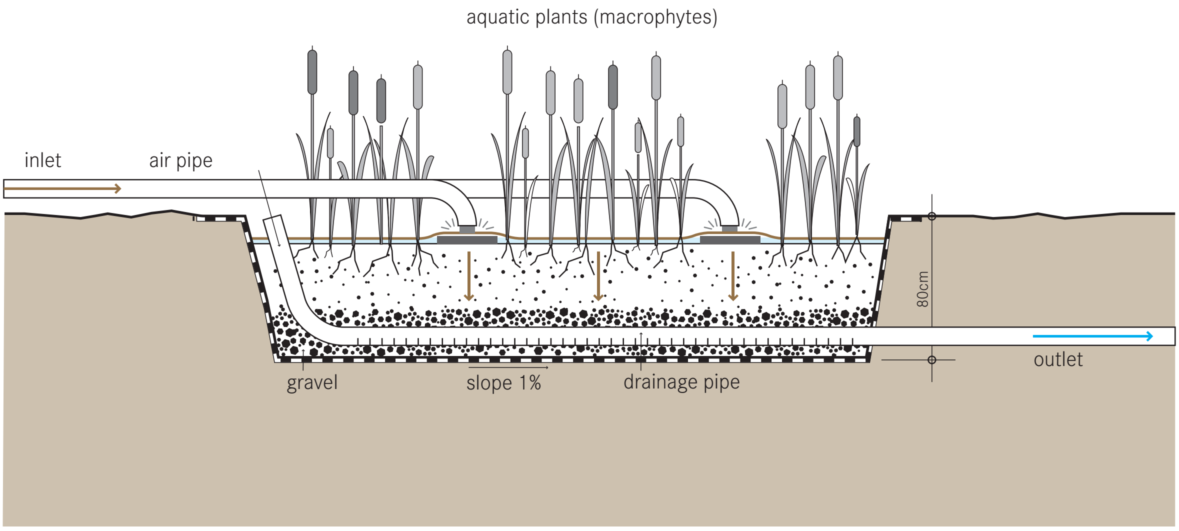


Figure 71: Vertical Flow Constructed Wetland (Tilley, 2008)

By dosing the wetland intermittently (four to ten times a day), the filter goes through stages of being saturated and unsaturated, and accordingly, different phases of aerobic and anaerobic conditions. The frequency of dosing should be timed such that the previous dose of wastewater has time to percolate through the filter bed so that oxygen has time to diffuse through the media and fill the void spaces. The Vertical Flow Constructed Wetland can be designed as a shallow excavation or as an above ground construction. Each filter should have an impermeable liner and an effluent collection system. Vertical Flow Constructed Wetlands are most commonly designed to treat wastewater that has undergone primary treatment.

Structurally, there is a layer of gravel for drainage (a minimum of 20 cm), followed by layers of either sand or gravel (for settled effluent) or sand and fine gravel (for raw wastewater). The filter media acts as both a filter for removing solids, a fixed surface upon which bacteria can attach and a base for the vegetation. The top layer is planted and the vegetation can develop deep, wide roots, which permeate the filter media. Depending on the climate, Phragmites australis, Typha cattails or Echinochloa Pyramidalis are common options. The vegetation transfers a small amount of oxygen to the root zone so that aerobic bacteria can colonize the area and degrade organics. However, the primary role of vegetation is to maintain permeability in the filter and provide habitat for microorganisms. During a flush phase, the wastewater percolates down through the unsaturated bed and is filtered by the sand/gravel matrix. Nutrients and organic material are absorbed and degraded by the dense microbial populations attached to the surface of the filter media and the roots. By forcing the organisms into a starvation phase between dosing phases, excessive biomass growth can be decreased and porosity increased. A drainage network at the base collects the effluent. The design and size of the wetland is dependent on hydraulic and organic loads. Pathogen removal is accomplished by natural decay, predation by higher organisms, and sedimentation.

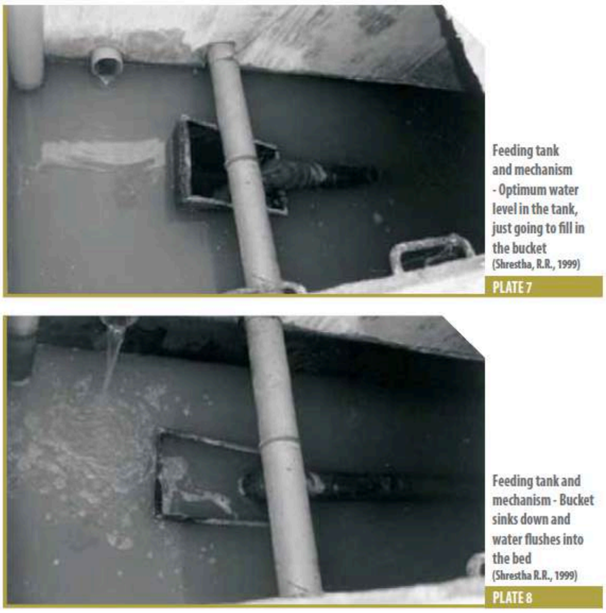


Figure 72: Feeding mechanism using tipping bucket (UN HABITAT, 2008)

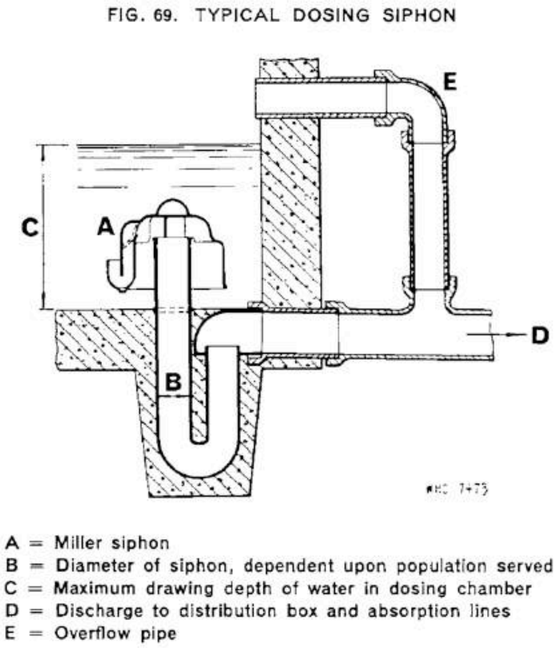


Figure 73: Dosing Siphon (Kalbermatten, 1982)

Adequacy. Clogging is a common problem. Therefore, the influent should be well settled with primary treatment before flowing into the wetland. This technology is not appropriate for untreated domestic wastewater (i.e. black water). This is a good treatment for grey water to be used in agriculture. This is a good option where land is cheap and available, although the wetland will require maintenance for the duration of its life. There are many complex processes at work, and accordingly, there is a significant reduction in BOD, solids and pathogens. In many cases, the effluent will be adequate for discharge without further treatment. Because of the mechanical dosing system, this technology is most appropriate for communities with trained maintenance staff, constant power supply, and spare parts. Vertical Flow Constructed Wetlands are best suited to treat the water of Informal Settlements.

Health Aspects/Acceptance. The risk of mosquito breeding is low since there is no standing water. The system is generally aesthetic and can be integrated into wild areas or parklands. Care should be taken to ensure that people do not come in contact with the influent because of the risk of infection.

Maintenance. With time, the gravel will become clogged with accumulated solids and bacterial film. The material may have to be replaced every 8 to 15 or more years. Maintenance activities should focus on ensuring that primary treatment effectively lowers organics and solids concentrations before entering the wetland. Testing may be required to determine the suitability of locally available plants with the specific wastewater. The vertical system requires more maintenance and technical expertise than other wetland technologies.

Table 28: Vertical Flow Constructed Wetland at a glance

Working Principle	Pre-treated grey- or blackwater is applied intermittently to a planted filter surface, percolates through the unsaturated filter substrate where physical, biological and chemical processes purify the water. The treated wastewater is collected in a drainage network (adapted from MOREL and DIENER 2006).
Capacity/Adequacy	It can be applied for single households or small communities as a secondary or tertiary treatment facility of grey- or blackwater. Effluent can be reused for irrigation or is discharged into surface water (MOREL and DIENER 2006).
Performance	BOD = 75 to 90%; TSS = 65 to 85%; TN < 60%; TP < 35%; FC ≤ 2 to 3 log; MBAS ~ 90%; (adapted from: MOREL & DIENER 2006)
Costs	The capital costs of constructed wetlands are dependent on the costs of sand and gravel and also on the cost of land required for the CW. The operation and maintenance costs are very low (MOREL and DIENER 2006).
Self-help Compatibility	O&M by trained labourers, most of construction material locally available, except filter substrate could be a problem. Construction needs expert design. Electricity pumps may be necessary.
O&M	Emptying of pre-settled sludge, removal of unwanted vegetation, cleaning of inlet/outlet systems.
Reliability	Clogging of the filter bed is the main risk of this system, but treatment performance is satisfactory.
Main strength	Efficient removal of suspended and dissolved organic matter, nutrients and pathogens; no wastewater above ground level and therefore no odour nuisance; plants have a landscaping and ornamental purpose (MOREL and DIENER 2006).
Main weakness	Even distribution on a filter bed requires a well-functioning pressure distribution with pump or siphon. Uneven distribution causes clogging zones and plug flows with reduced treatment performance; high quality filter material is not always available and expensive; expertise required for design, construction and monitoring (MOREL and DIENER 2006).

Design. The approximate area of the wetland can be calculated as a function of the following equation:

- $A = N * q * HRT / 1000 / p / D$

Where:
A = Wetland area (m^2);
N = Number of users (capita);
q = Amount of wastewater (lcd, litres / cap / day);
HRT = Hydraulic Retention Time (days);
p = pore space (%);
D = Effective depth (m’).

The wetland area for an Informal Settlement of 100 households, 1,500 persons (N=1,500), black and grey water disposal of 35 lcd (q = 35), a Hydraulic Retention Time of 3 days (HRT=3), a pore space of 30% (p=0.30) and an effective depth of 60 cm (D=0.6 m'):

- A = 1,500 * 35 * 3 / 1000 / 0.30 / 0.6 = 875 m^2.

Effluent quality:

- At a BOD grey and black water: 280 mgBOD/l
- Removal BOD: 90%
- BOD effluent: (100%-90%)*280 = 28 mg BOD/l
- E-coli in grey water: 10^5 / 100 ml
- Removal: 3 log units
- E-coli effluent: $10^{(5-3)} = 10^2$ / 100ml
- → Unrestricted irrigation (WHO, 2006)

Table 29: Advantages and disadvantages Vertical Flow Constructed Wetland

Advantages	Disadvantages
• Utilisation of natural processes • No chemical & electrical energy required • Low operation and maintenance • Can be built and repaired with locally available materials • Does not have mosquito or odour nuisance problems since there is no surface water Less clogging than in a horizontal flow constructed wetland • High reduction in BOD, suspended solids and pathogens • Construction can provide short-term employment to local labourers	• Long start up time to work at full capacity • Requires large land area • Requires expert design and supervision • High quality filter material is not always available and expensive • Moderate capital cost depending on land, liner, fill, etc.; low operating costs • Pre-treatment is required to prevent clogging • Dosing system requires more complex engineering except when siphons are used

Further reading:

- UN HABITAT, 2008, Constructed Wetland Manual

Appendix 7: Soakaway

When the soil is sufficiently permeable, the grey water can be discharged in a soakaway / soak pit. A soakaway (see Figure 74) is a covered, porous-walled chamber that allows water to slowly soak into the ground. Grey water is discharged to the underground chamber from where it infiltrates into the surrounding soil. The soakaway can be left empty and lined with a porous material (to provide support and prevent collapse), or left unlined and filled with coarse rocks and gravel. The rocks and gravel will prevent the walls from collapsing, but will still provide adequate space for the wastewater. In both cases, a layer of sand and fine gravel should be spread across the bottom to help disperse the flow. The soakaway should be between 1.5 and 4 meters deep, but never less than 1.5 meters above the ground water table. As grey water percolates through the soil from the soakaway, the soil matrix filters out small particles and organics are digested by microorganisms. Thus, soakaways are best suited to soils with good absorptive properties; clay, hard packed or rocky soils are not appropriate**.**

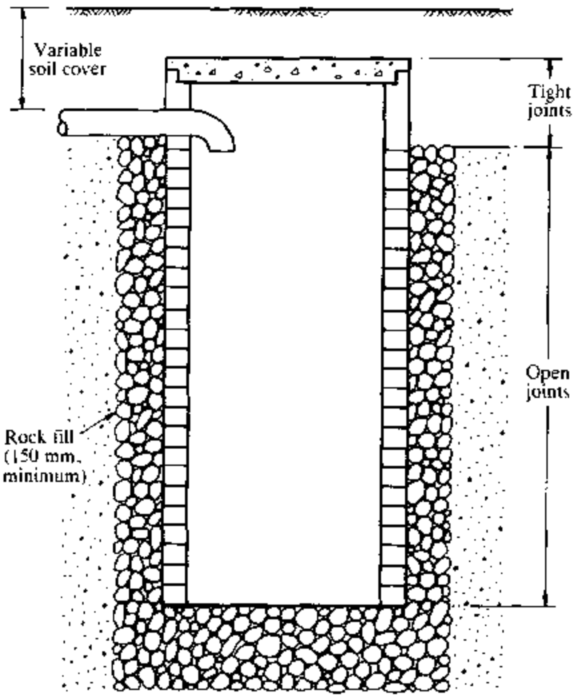


Figure 74: Soakaway **(Kalbermatten, 1982)**

Adequacy A Soakaway does not provide adequate treatment for raw wastewater and the pit will clog quickly. A soakaway should be used for discharging grey water. Soakaways are appropriate for rural and peri-urban settlements. They depend on soil with a sufficient absorptive capacity. They are not appropriate for areas that are prone to flooding or have high groundwater tables.

Health Aspects/Acceptance As long as the soakaway is not used for raw sewage, health concerns are minimal. The technology is located underground and humans and animals should have no contact with the effluent. It is important however, that the soakaway is located a safe distance from a drinking water source (ideally 30 meters). Since the soakaway odourless and not visible, even the most sensitive communities should accept it.

Maintenance A well-sized soakaway should last between 3 and 5 years without maintenance. To extend the life of a soakaway, care should be taken to ensure that the effluent has been clarified and/or filtered well to prevent excessive build-up of solids. The soakaway should be kept away from high-traffic areas so that the soil above and around it is not compacted. When the performance of the soakaway deteriorates, the material inside the soak pit can be excavated and refilled. To allow for future access, a removable (preferably concrete) lid should be used to seal the pit until it needs to be maintained. Particles and biomass will eventually clog the pit and it will need to be cleaned or moved.

Table 30: Advantages and disadvantages Soakaway

Advantages	**Disadvantages**
• Can be built and maintained with locally available materials • Small land area required • Low capital cost; low operating cost • Simple technique for all users	• May negatively affect soil and groundwater properties

The approximate dimension of the soakaway can be calculated as a function of the following equations:

- F = N * q / i

Where:

F = Infiltration area (m^2);

N = Number of users (capita);

q = Amount of water used (lcd);

i = infiltration capacity soil ($l/m^2/day$).

For a square soakaway, for a family of 10 persons (N=10), a per capita effluent of 20 lcd (grey water) (q = 20), and infiltration rate of 25 $l/m^2/day$ (I = 25), Infiltration area (F) is:

- F = 10 * 20 / 25 = 8 m^2, hence a liquid depth of 1.6 m’ in a square soakaway of 1.2 m’ wide and 1.2 m’ long.

Appendix 8: Evapotranspiration

An evaporation field is a simple method to dispose of grey water in impermeable soils. The wastewater effluent is discharged into sealed up receptacles where the water evaporates from the soil or transpires from the plants growing there. Bacteria remove the dissolved organic matter and plants take up the remaining nutrients. See Figure 75.

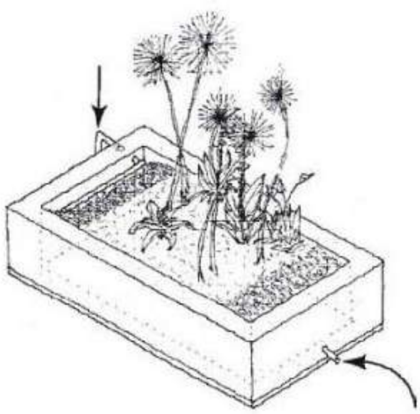


Figure 75: Evapotranspiration field (SSWM)

Evaporation fields are a low-cost technology that allows for a secondary treatment of grey water. The grey water can be discharged by gravity into sealed up planting beds, containers, inverted tires or the like where it will be absorbed by soil particles and moves both horizontally and vertically through the soil pores. The liquid fraction moves upwards by capillary action and either evaporates at the surface or is taken up by plants or trees and transpires. The plants/trees take up the remaining nutrients and bacteria living in the soil remove the dissolved organic material in the effluent. Eucalyptus trees are well suited for evaporation fields and known for this in Lebanon.

Design. The approximate dimension of the evaporation field can be calculated as a function of the following equations:

- E = N * q / iE

Where:
E = Evaporation area (m^2);
N = Number of users (capita);
q = Amount of grey water (lcd, litres / cap / day);
iE = Evaporation rate (mm/day = l/m^2/day).

When no local evaporation rates are known, they can be estimated by the rates provided by the FAO:

- Evapotranspiration rates (FAO):
    - Cool (~10°C): 2-4 mm/day
    - Moderate (20°C): 4-6 mm/day
    - Hot (30°C): 6-8 mm/day

(source: http://www.fao.org/docrep/x0490e/x0490e04.htm , accessed 8 April 2012)

Hence, for a household of 15 persons (N=15), a per capita grey water effluent of 8 lcd (q = 8), and an evaporation rate of 8 mm/day (iE = 8), Evaporation area (E) is:

- $E = 15 * 8 / 8 = 15\ m^2$.

Table 31: Advantages and disadvantages evaporation field

Advantages	**Disadvantages**
• Low-cost solution • Easy to construct • Easy to use • Easy to repair if damage occurs	• Tends to clog or overflow • May constitute a risk during the presence of small children • Tends to smell slightly • May attract insects • Evaporation process requires time

Appendix 9: Sludge drying

Existing WWTPs should be made suitable to receive sludge. As most WWTPs are not suitable / designed for this, a recommended short-term action is to dry it at sludge drying beds at WWTP locations. An Unplanted Drying Bed is a simple, permeable bed that, when loaded with sludge, collects percolated leachate and allows the sludge to dry by evaporation. See Figure 76. Approximately 50 % to 80 % of the sludge volume drains off as liquid that needs to be treated in the WWTP. The sludge however, is not stabilized or treated and should be stored for 2 years to assure die-off of pathogens.

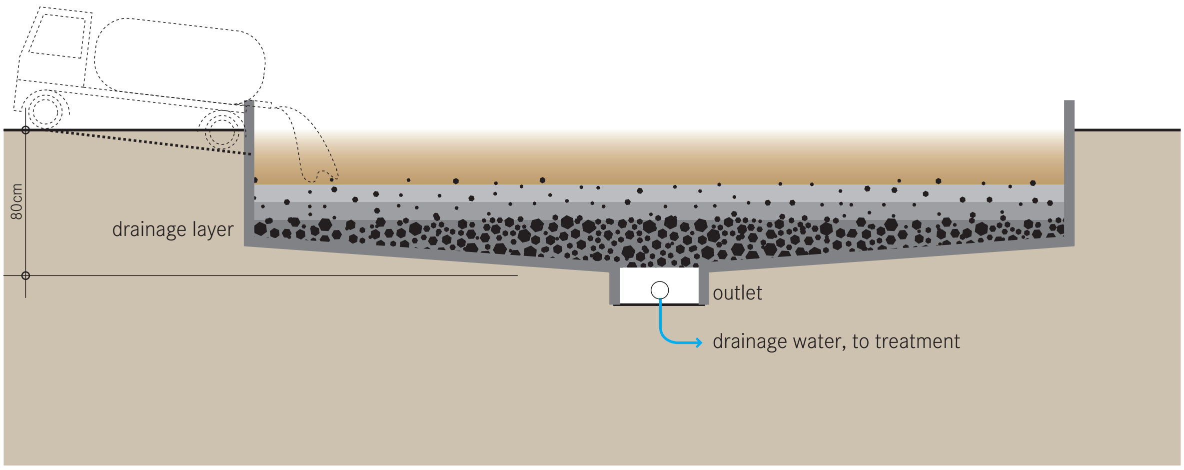


Figure 76: Sludge drying bed (Tilley, 2008)

The bottom of the drying bed is lined with perforated pipes that drain away the leachate. On top of the pipes are layers of sand and gravel that support the sludge and allow the liquid to infiltrate and collect in the pipe. The sludge should be loaded to approximately 200 kg TS/m^2 and it should not be applied in layers that are too thick (maximum 20 cm), or the sludge will not dry effectively. The final moisture content after 10 to 15 days of drying should be approximately 60%. A splash plate should be used to prevent erosion of the sand layer and to allow the even distribution of the sludge. When the sludge is dried, it must be separated from the sand layer and disposed of. The effluent that is collected in the drainage pipes must also be treated properly. The top sand layer should be 25 to 30cm thick as some sand will be lost each time the sludge is manually removed.

Adequacy. Sludge drying is an effective way of decreasing the volume of sludge, which is especially important when it requires transportation elsewhere for direct use, Co-Composting, or disposal. The technology is not effective at stabilizing the organic fraction or decreasing the pathogenic content. Sludge drying beds are appropriate for small to medium communities with populations up to 100,000 people and there is inexpensive, available space that is far from homes and businesses. It is best suited to rural and peri- urban areas. If it is designed to service urban areas, it should be on the edge of the community. The sludge is not sanitized and requires further treatment before disposal. Ideally this technology should be coupled with a Co-Composting facility to generate a hygienic product. Trained staff for operation and maintenance is required to ensure proper functioning.

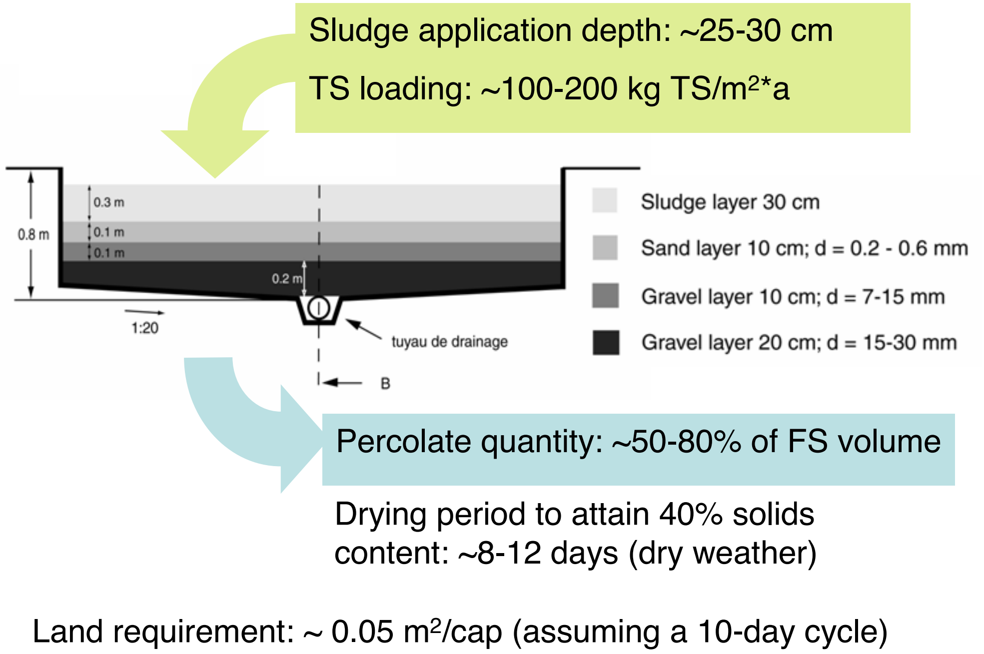


Figure 77: Main Features Sludge drying (AEWAG)

Health Aspects/Acceptance The incoming sludge is pathogenic, so workers should be equipped with proper protection (boots, gloves, and clothing). The thickened sludge is also infectious, although it is easier to handle and less prone to splashing and spraying. The pond may cause a nuisance for nearby residents due to bad odours and the presence of flies. Therefore, the pond should be located sufficiently away from urban centres.

Maintenance. The Unplanted Drying Bed should be designed with maintenance in mind; access for humans and trucks to pump in the sludge and remove the dried sludge should be taken into consideration.

Dried sludge must be removed every 10 to 15 days. The discharge area must be kept clean and the effluent drains should be flushed regularly. Sand must be replaced when the layer gets thin.

Table 32: Sludge drying at a glance

Working Principle	Drying beds are simple sealed shallow ponds filled with several drainage layers. Sludge is applied on the top and dried by percolation and evaporation. In planted drying beds, the plants maintain the porosity of the soil and enhance the evaporation by transpiration (evaporation). Dried sludge can be used as biosolid in agriculture.
Capacity/Adequacy	Requires large land-surfaces and can cause odour; therefore generally installed in rural areas.
Performance	Depends strongly on the local climate (rain, runoff); TS content of 20 to 70 % can be achieved. Some of NH_4 is lost to air. Pathogen removal is moderate for unplanted beds with short retention time, but high for planted drying beds with long retention times.
Costs	Moderate investment costs and low operation costs
Self-help Compatibility	Can be produced with locally available material, but requires expert design. Operation is simple but staff/community should be trained.
O&M	Application of sludge, desludging, control of drainage system and of the secondary treatment for percolate or dried sludge. Desludging for unplanted beds every one to several weeks and every 5 to 10 years for planted drying beds.
Reliability	High, if the area is kept dry (rain, runoff).
Main strength	Low-tech and no requirement of energy.
Main weakness	Requires space; odour can occur; (and frequent desludging in the case of unplanted beds).

Table 33: Advantages and disadvantages Sludge Drying

Advantages	**Disadvantages**
• Dried sludge can be used as fertiliser (either directly in the case of planted beds or after composting in the case of unplanted beds) • Easy to operate (no experts, but trained community required) • High reduction of sludge volume • Can achieve pathogen removal • Can be built with locally available materials	• Requires large land area • Requires treatment of percolate • Only applicable during dry seasons or needs a roof and contour bund • Manual labour or specialised equipment is required to remove dried sludge from beds • Can cause odour problems