Republic of Uganda
Ministry of Water and Environment

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

german cooperation
DEUTSCHE ZUSAMMENARBEIT

CONSULTANCY SERVICES FOR CONSTRUCTION, SUPERVISION AND OPERATOR TRAINING & SUPPORT FOR THE NEW FSTP IN APAC AND FOR THE DEVELOPMENT OF NATIONAL GUIDELINES ON PLANNING, IMPLEMENTATION, O&M AND MONITORING OF SIMILAR FSTPS IN SMALL TOWNS

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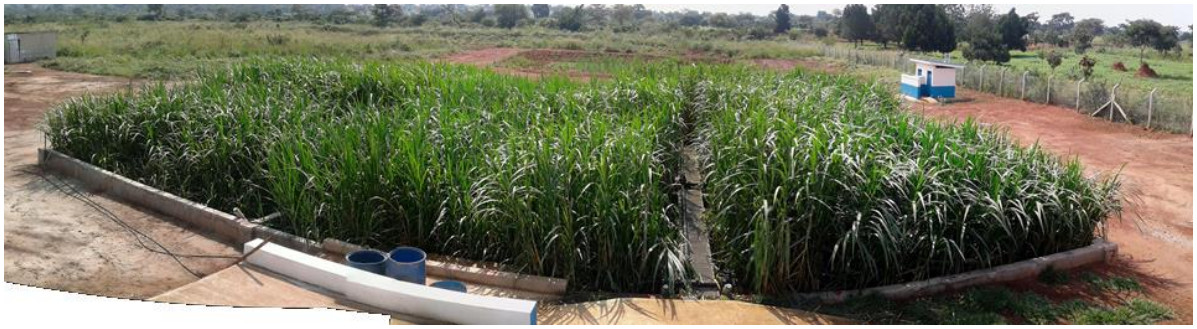

NATIONAL GUIDELINES

October 2019

FICHTNER
WATER & TRANSPORTATION

CONSULTANCY SERVICES
FOR
CONSTRUCTION, SUPERVISION AND OPERATOR TRAINING & SUPPORT FOR THE NEW FSTP IN APAC AND FOR THE
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Abbreviations

a	Annum (year)
AMCOW	African Ministers' Council on Water
BoQ	Bill of Quantities
C/N	Ratio of carbon content and nitrogen content
cfu	Colony-forming unit (number of viable bacteria, etc., in a sample)
DALY	Disability Adjusted Life Years
DN	Nominal pipe diameter (in mm)
DNP	Defects Notification Period
DSC	Dry solid content
DWD	Directorate of Water Development of the MWE
EUR	Euros
ESIA	Environment and Social Impact Assessment
FS	Faecal Sludge
FSM	Faecal Sludge Management
FWT	Fichtner Water & Transportation GmbH
FSTP	Faecal Sludge Treatment Plant
GIZ	Deustche Gesellschaft für Internationale Zusammenarbeit GmbH
HFCW	Horizontal flow constructed wetland
ID	Identification Code
l/c/a	Litre per capita per annum
Mio	Million
MoH	Ministry of Health
MoU	Memorandum of Understanding
MWE	Ministry of Water and Environment
NEMA	National Environmental Management Authority
NWSC	National Water and Sewerage Corporate
O&M	Operation and Maintenance
OD	Outer pipe diameter (in mm)
OHS	Occupational Health and Safety
OSS	Onsite Sanitation
PE	Population Equivalent

PDB	Planted Drying Bed
PN	Nominal pressure
SDG	Sustainable Development Goals
SDR	Standard dimension ratio of pipe (outer diameter divided by wall thickness)
SI	Statutory Instrument
SN	Nominal pipe stiffness in kN/m²
SOP	Standard Operating Procedure
STF	Sanitation Task Force
TS	Total Solids
TSP	Town Sanitation Plan
TP	Treatment Plant
UGX	Ugandan Shillings
UN	United Nations
UnPDB	Unplanted Drying Bed
USD	United States of America Dollars
UWSSD	Urban Water Supply and Sewerage Department of DWD
VFCW	Vertical flow constructed wetland
WHO	World Health Organization
WSDF-N	Water and Sanitation Development Facilities – Northern Region
WSP-WB	Water and Sanitation Program of the World Bank

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[3] Sustainable Development Goals, 2015, UN

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[11] WHO Guidelines on Safe Use of Wastewater, Excreta and Greywater in Agriculture, 2006, WHO

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0. GENERAL INFORMATION

0.1 Background

With its “Reform of the Urban Water and Sanitation Sector Programme” (RUWASS) and the successor program “Enhanced Water Security and Sanitation Programme” (ENWASS) GIZ aims at contributing to sustainably improve the access to adequate and equitable sanitation services in Uganda.

Within this context, GIZ together with USAID spearheaded a two years sanitation project to promote the development and implementation of TSPs in 6 selected towns in Lango sub-region in Northern Uganda:

- In Oyam District: Oyam, Kamdini and Loro.
- In Apac District: Aduku, Ibuje and Apac.

This sanitation project was implemented in close cooperation with Water and Sanitation Development Facility North (WSDF-N), which is a devolved unit of the Ministry of Water and Environment (MWE) under the Directorate of Water Development (DWD).

It resulted in particular in Town Sanitation Plans (TSPs) in 2016 but other activities were also implemented (e.g. in schools). TSPs included a detailed baseline survey (households and institutions) and resulted in a list of measures to be implemented. One of Apac TSP’s measures ([2]) included the construction of a new FSTP, whose construction ended in 2018.

The construction of a new FSTP in Apac financed by GIZ and the issues mentioned above encouraged GiZ to mandate a Consultant:

- For supporting activities related to the Apac FSTP construction, FSTP start-up and training.
- To draft a baseline of similar treatment plants existing in Uganda.
- To draft national guidelines for the planning, implementation, O&M and monitoring of similar FSTPs in small towns, using the ongoing Apac FSTP project as a pilot.

Hence these Guidelines are basing on very concrete experiences and activities. However, they shall be updated at regular intervals in order to reflect the most recent experience and good practice in Uganda.

0.2 Purpose and Scope of the Guidelines

The Ministry of Water and Environment herewith presents its national guidelines (hereafter Guidelines) for the planning, implementation, O&M and monitoring of small FSTPs (up to about 5,000 m³/a).

They can be complemented in the future with:

- Guidelines for medium and larger FSTP capacity.
- And a technical manual, even if the present document already includes essential design aspects.

It is expected that these Guidelines will contribute to enhance the cost efficiency and sustainability of FSTP investments and meet the development partners' expectations by ensuring that they are based on high-quality standards that reflect both the international state of the art and the best practices identified for Uganda.

The intention of the present Guidelines is to provide practical guidance to key actors:

- Planners and decision-makers,
- Designers and engineers,
- Utilities,
- Authorities in charge of monitoring and regulation enforcement,

on key stages of a FSTP project lifecycle including operation:

1. Planning,
2. Detailed design,
3. Authorizations,
4. Construction,
5. Hand over and agreements,
6. O&M,
7. Monitoring.

It is also intended to facilitate a strategic, integrated planning process and to anchor sector policies in implementation practice.

However, most of the stages addressed by these Guidelines remain individually relevant. Thus O&M and monitoring aspects are for example relevant for FSTPs that already exist.

The Guidelines provide concrete figures where appropriate, but only general guidance on design processes and procedures or references to other documents and standards in those cases where discussing the details would go beyond the scope of this format.

In all cases, the Guidelines cannot replace the expertise and sound judgment of an experienced Consultant.

Finally, it must be emphasized that the Guidelines' scope does not cover the full sanitation value chain.

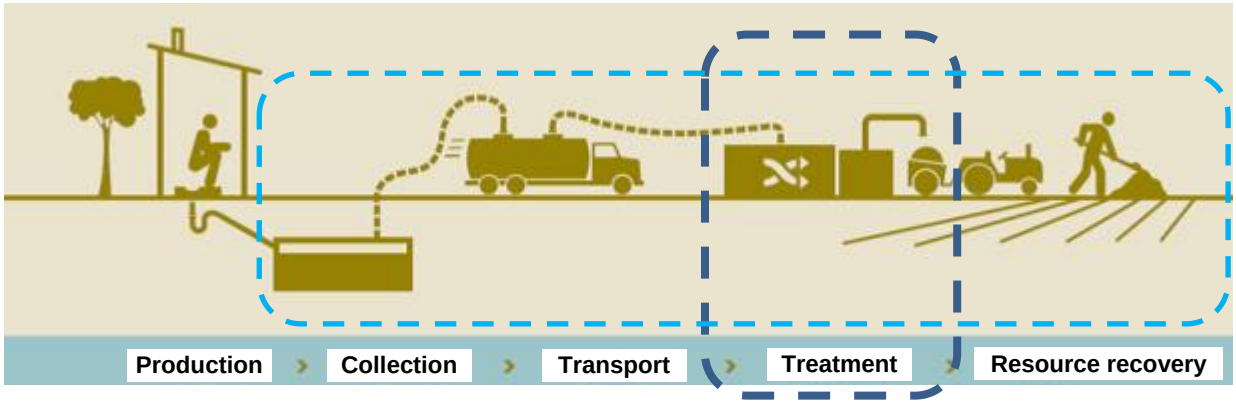


Fig. 0-1: OSS value chain

Nevertheless, other aspects than treatment have to be sufficiently considered for the Guidelines and their use, in particular collection and transport as well as recycling (i.e. resource recovery).

0.3 Framework and Actors

The regulatory and institutional frameworks were addressed in detail during the past five years. Following paragraphs are based on excerpts of the most recent documents ([4] and [5]).

0.3.1 Regulatory Framework

There is a large set of laws and regulations available, but their enforcement overall is a major challenge for the sector. The table hereafter summarizes the most relevant current regulatory documents:

Tab. 0-1: Regulatory documents

Document	Remark
Building Control Act 2013	- A person shall not carry out a building operation unless he or she has a valid building permit issued by a Building Committee. - Issuance 60 days at the latest after application. - Application has to be made by a nationally registered Engineer.
Public Health Act 2000	- Sanitation is governed by this Act. It empowers the local authorities to carry out inspections of the hygiene and safety standards of public places and households to ensure health, hygiene and safety of the occupants to minimize disease transmission.
Water Act 1997	*- "domestic sewage" includes faecal matter, urine, household slops and other liquid house refuse* *- ''waste" includes sewage and any other matter or thing, whether wholly or partly in solid, liquid or gaseous state, which if added to any water may cause pollution*
National Environmental Act 2019	- Establish NEMA as the authority for "*coordination, monitoring and supervision of all activities in the field of the environment*". *- NEMA may, by notification in the Gazette, designate as many officers as it deems fit from duly qualified public officers, whether by name or by title of office, to be environmental inspectors within such local limits as may be specified in the notification*. *- "effluent" means waste water or other fluid of domestic agricultural trade or industrial origin, treated or untreated and discharged directly or indirectly into the aquatic environment*; - Defines projects for which a "Project brief" is required, and projects for which an ESIA is required (FSTP not explicitly mentioned and generally no size threshold. - "*The Minister may, on the advice of the board, by statutory instrument, amend*" the listing of project types subject to ESIA.
National Environment regulations, Statutory Instrument 5, **Effluent standards** 1999	- Defines for the effluent to be discharged maximum values for various parameters.
National Environment regulations, Statutory Instrument 153-2, **Waste management** 1995	*- "waste" includes any matter prescribed to be waste, and any radioactive matter, whether liquid, solid, gaseous or radioactive which is discharged, emitted or deposited into the environment in such volume, composition or manner as to cause an alteration of the environment* - NEMA is the authority in charge of establishing regulations, licencing for transportation and storage of waste, for owning a treatment plant or disposal site, for operating a treatment plant or disposal site. - Biannual reporting to NEMA of the licensed activities.

Document	Remark
Water Regulations, Statutory Instrument 32, **Waste Discharge** 1998	- These regulations set out the procedure for seeking permission to discharge *effluent or waste onto land or into the aquatic environment*. - Vague application criteria.
NWSC Act 1995	NWSC's functions related to sanitation only include: *- The provision of sewerage services, in any area in which it may be appointed to do so under this Act or the Water Act, to the extent and standards that may be determined by its corporate plan, any performance contract, and regulations made under this Act or the Water Act*. *- To do anything connected or incidental to the above*.
Sanitation- and waste- related **ordinances and bylaws**	- Each local government is supposed to make its own sanitation ordinances and bylaws. Some local governments have not enacted such laws. - These are developed and passed by the local authorities from time to time to address key challenges in service delivery. Some relate directly with water and sanitation services in the towns.

Neither National Acts nor Statutory Instruments are addressing explicitly faecal sludge. However, it can legally be considered as "waste", "waste water" and "effluent".

Better enforcement could be achieved with:

1. More precise scopes of regulation application (more differentiation).
2. Less stringent regulations (more realistic but foreseeing a planned and gradual increase).

A Consultancy is currently addressing the ***development of a National Standard for the treatment of faecal sludge for safe recycling and/or disposal***. It would be relevant if its output would allow considering:

- The WHO guidelines (2006), i.e. an integrated approach, particularly with regard to sludge and effluent recycling.
- A staged approach differentiating the requirements depending for example:
  - on the loads,
  - on the environment where effluent and/or biosolids are discharged and/or recycled.
- The economic impacts of standards thus also taking in consideration the financing. This also implies that actually, there must be a clear translation between for example limit values and the resulting treatment/recycling/disposal processes.
- To not necessarily set limit values, but like in many countries:
  - simply define "appropriate treatment/recycling/disposal processes",
  - leave the choice to not overpass limit values or to reach minimum pollution removal efficiencies.

0.3.2 Institutional Framework

The institutional framework of the water and environmental sector is illustrated by the following diagrams.

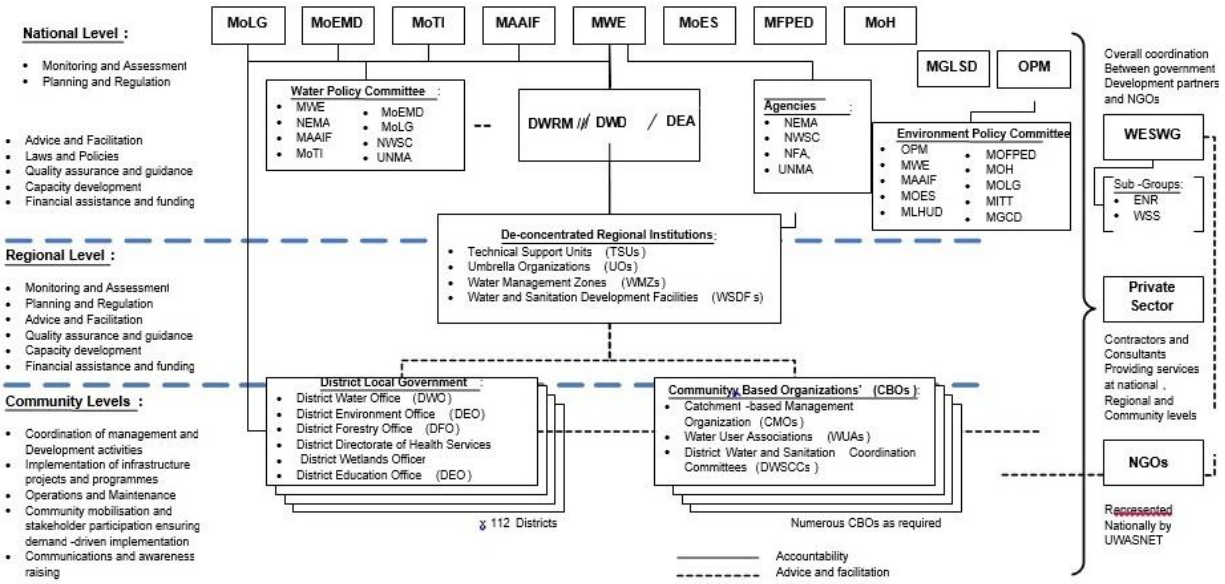


Fig. 0-2: Water and Environment Sector institutional framework

(Source: www.mwe.go.ug, 07/2019)

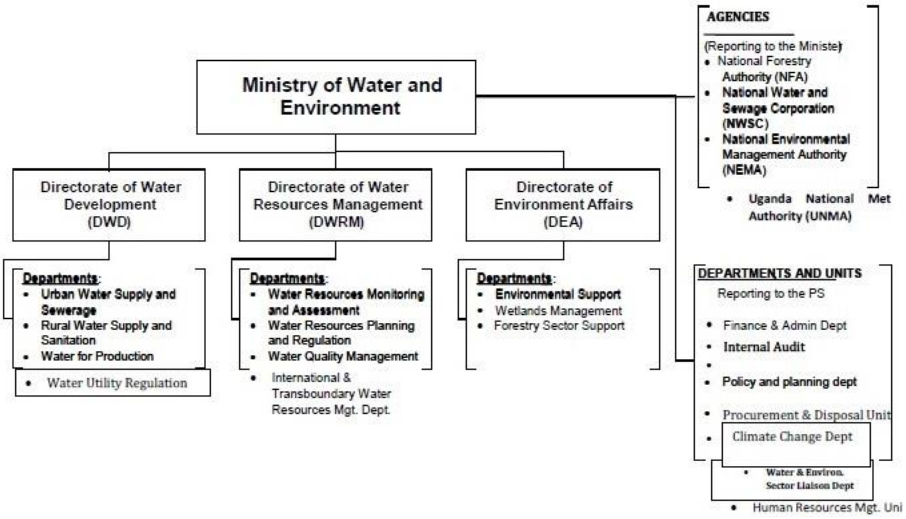


Fig. 0-3: MWE structure

(Source: www.mwe.go.ug, 07/2019)

It must be mentioned for clarity sake that NWSC has no legal mandate to transport or treat FS. However, in practice:

- NWSC owns and operate vacuum truck for FS emptying and transport
- NWSC owns and operate combined wastewater and FS treatment plants (WW/FSTP) as well as dedicated FSTPs

Following table intends to clarify the roles and responsibilities of the key actors for two typical cases:

Tab. 0-2: Actors and their responsibilities

Responsibilities	Actors of a conventional public project	Actors of a private project
Regulation planning	MWE, NEMA (National) and Local governments (orinances and bylaws)	MWE, NEMA (National) and Local governments (orinances and bylaws)
Regulation enforcement	NEMA, Environmental inspector, Empowered public officer	NEMA, Environmental inspector, Empowered public officer
Financing	GoU, International funding	Private
Project owner	DWD (national level) , WSDF (regional level), Local governement	Private
Planning	Experienced private Consultant	Private
Land ownership	??	Private
Facility ownership	??	Private
Technical design	Public (DWD (national level) , WSDF (regional level)) or Private engineering company	Private engineering company
Authorization	NEMA	NEMA
Construction tendering and contract award	Project owner	Private
Construction	Private	Private
Construction supervision	Public (DWD (national level) , WSDF (regional level)) or Private engineering company	Private
Handing over, agreements	Project owner	Private
O&M and self monitoring	Umbrella, other??	Private
External monitoring	NEMA	NEMA

It must be noticed that:

- Financing: public investment have to be subsidized due to the current limited financing capacities of project owners.
- Local governments, unless exceptions to be justified, which might be concerned by such project, do not have yet the capacities to plan, design and supervise the construction, etc.
- Technical design: national capacities need to be improved for optimization of the investments (public and private sector).
- For publicly owned: in case of experienced, strong and willing project owners, they can take over themselves more responsibilities than indicated above.

1. PLANNING

1.1 Current Strategy and Recommendations

The National Faecal Sludge Assessment for Small Towns in Uganda (2013, WSP / MWE, [1]) is the only document available for national strategic planning, i.e. with definition of clusters and estimates of demand for FS emptying and treatment.

The demand assessment method used is the same as the one used for the detailed design of the FSTP of Ntungamo, Buwama and Bukakata ([7] 2012, FWT/MWE), and is basing on:

- Forecasts of population within the cluster
- Forecasts of distribution of OSS types used by the population (service levels)
- Sludge production depending on the OSS type
- Sludge collection and treatment rates depending on the OSS type

Since the construction of these 3 first FSTPs and the release of the National Faecal Sludge Assessment in 2013, 14 other plants were or are currently being constructed.

However, the priority ranking defined in this document and basing solely on the FS demand was not exactly followed. Investments in FSTPs were frequently driven by fundings in water supply projects, with marginal share for FSTPs.

As a result, many TPs are oversized. Hence, to improve the investment strategy, it is recommended to:

- Update the National Faecal Sludge Assessment for Small Towns, which is already 6 years old and not considering the latest population survey.
- Orientate investments according to the demand, via preliminary feasibility studies. Further implementation (detailed design, construction, etc.) shall not be automatic and depend on the results of the feasibility study results.

1.2 Update of the National Faecal Sludge Demand Assessment

1.2.1 Key Principles

This updated document shall be updated using and taking in account:

- The same type of simplified method used in 2013 to estimate the FS production and the demand for collection, transport and treatment services.
- Available FS collection and transport data (rates) from existing TPs, in order to calibrate the estimate method.
- Population growth rates shall base on the analysis of recent growth rates.
- Particular care should be made to not overestimate any forecasted growth rate (population, collection, OSS types).
- Horizons for the demand estimates shall be as follows:
    - Current demand (e.g. 2020)
    - Forecasts for about +10 years (e.g. 2030).
    - Forecasts for about +20 years (e.g. 2040).

- Results of the baseline survey of existing TPs ([7], including WWTPs co-treating WW and FS) and of the future TP monitoring results.
- Transport distances for the definition of the clusters (= service areas):
    - Immediate service area shall be defined as being within about 30km transport distance to the TP (roundtrip).
    - For areas with roundtrip distances beyond 70 to 80 km, no FS shall be considered for the TP, except cases to be justified.
- A GIS to process and map the data and results.

Deviations from these principles are authorized if they can be justified.

1.2.2 Outputs (checklist)

1. **Report:**
    a. Methodology
    b. Assessment results (tables, maps and comments)
    c. Priority ranking
    d. Risk assessment via identification of minimum demand criterion(a)
    e. Annexes with detailed calculation results (tables) and maps

2. **GIS data set:**
    a. Administrative boundaries with population forecasts.
    b. Other base data used for the forecasts (water supply service levels, OSS service level, etc.).
    c. Existing and planned TPs with:
        i. Link to the corresponding cluster (via TP/cluster IDs).
        ii. Cluster data (demand forecasts).
        iii. Data of existing TPs (capacities, operator, etc.)
    d. Clusters (service area of a TP) with link to the corresponding TP.
    e. Transport distances and/or durations for each TP (contour lines and raster data).

1.3 Feasibility Studies

1.3.1 Prerequisites

Feasibilities studies should be implemented for clusters identified within the updated National Faecal Sludge Demand Assessment.

The feasibility study for an FSTP should be combined or included to TSPs[1], as it was more or less the case for the Apac TSP.

It does not require to have previously secured the funds required for the FSTP construction and the O&M financing. This can and shall be addressed in a later step and based on the feasibility study results.

[1] The TSP can be implemented at a later stage if it can be justified.

1.3.2 Clarification of Responsibilities

The feasibility study shall clarify the responsibilities for further Project implementation steps:

Tab. 1-1: Feasibility study: clarification of responsibilities

Responsibilities	Actors
Financing	*optional (only if information is already available at this stage)*
Project owner	? (DWD, WSDF, local government, private, etc.)
Land ownership	?
Facility ownership	?
Technical design	? (public organisation? private company?)
Construction	? (public organisation? private company?)
Construction supervision	? (public organisation? private company?)
O&M	?

1.3.3 Demand Assessment

The demand refers here to the real demand for FS collection and transport services, i.e. customers that are able and willing to pay for these services.

The methodology for the demand assessment has to be refined compared to the simplified method recommended for the update of the national assessment. Moreover, it should not anticipate positive results of demand creation measures that might be defined within the TSPs, in order to not overestimate the demand (in particular for households).

1.3.3.1 Targeted Customers and Service Area

The methodology foresees to estimate more accurately the demand, but only for the most probable customers, which are:

- **Institutions and commercial customers** (schools, hospitals, public toilets, etc.),
- Optionally[2], households: only septic tank users (only those which can be estimated accurately[3]),

[2] Because they usually represent only a small share of the probable customers their estimate but requires large survey efforts.
[3] Based or derived from field surveys.

These customers are located within service areas defined as follows:

- **Immediate service area** (nr1): within about 30km roundtrip distance to the TP.
- **Intermediate service area** (nr2): within about 30 to 50km roundtrip distance to the TP.
- **Distant service area** (nr3): within about 50 to 80km roundtrip distance to the TP.
- For areas with roundtrip distances beyond 80 km, no FS shall be considered for the TP, except cases to be justified.

Data regarding the origin of the sludge collected in small towns is scarce, but it clearly shows that households represents only a negligible share of the customers (maximum 5 to 10%), while customers with commercial activities have a share of 5 to 20% and institutions have a share of 70 to 90%.

1.3.3.2 Horizon of the Estimate

In order to simplify the estimate and not overestimate the first investment, it is recommended to estimate the served population (among the *most probable customers*) for:

- the **current situation** (at the time of the feasibility study),
- rounded up to maximum +10%,
- which can then be considered as short-term estimate.

Land, where the facility is to be built, shall of course consider a more extended design horizon (see §1.3.4).

1.3.3.3 Field Surveys

The served population shall be estimated via:

- Field surveys.
- Alternatively available monitoring data (e.g. databases from the Ministry of Education and Sports), but only if their quality and comprehensiveness can be justified[4].

The field surveys shall be made according to the following principles:

- Use of survey forms (or questionnaires) is mandatory.
- Survey forms can be analogue or digital, but the collected data must be entered into a digital database and a GIS.
- Collected data have to be cleaned before being processed.
- Minimum data to be collected for each potential customer:
    - Name and miscellaneous contact data
    - Location (for GIS)
    - Type (school, hospital, etc.)
    - Number of OSS users.
    - OSS: type and volume (FS storage volume)

[4] The time to be spent for field surveys is often lower than the time to be spent to control the quality and comprehensiveness of available data. Thus it is always recommended to rather foresee a complete field survey, which can then be used by other public administrations to update existing database(s).

- Layout sketch with location of OSS facilities.
- FS collection records as far as available.

1.3.3.4 Estimate of Sludge Production

If reliable[5] data on local specific sludge production are available, they should be used but their plausibility has to be demonstrated by comparing them to literature values[6].

However, usually no reliable data is available and following sludge production rate[7] should be used as the ***normal average production rate:* 100 l/c/a**.
The estimate for the cluster is as follows:

$$FS_{prod,cluster} = \frac{n_{users,OSS} \times fs_{prod,spec}}{1000} = \frac{n_{users,OSS}}{10}$$

with:

$FS_{prod,cluster}$ = sludge production within the cluster by the most probable customers (in m³/a)
$n_{users,OSS}$ = number of users for each OSS facility of the most probable customers (in capita)
$fs_{prod,spec}$ = specific annual sludge production (in l/c/a)

Remark:
It is always very difficult to estimate the sludge production because it depends on many factors, in particular the retention time[8]. Low retention times increase the specific sludge production (per capita and per annum) mainly because they reduce the time allowed to digestion. High retention times occur where high user/stance ratios are to be found. They can be estimated by dividing the estimated sludge produced by users with the sludge retention capacity of the OSS facility.

$$RT_{OSS} = \frac{ssc_{OSS} \times 1000}{n_{users} \times fs_{prod,spec}}$$

with:

RT_{OSS} = *retention time (in years)*
n_{users} = *number of OSS facility users (in capita)*
$fs_{prod,spec}$ = *specific annual sludge production (in l/c/a)*
ssc_{OSS} = *sludge storage capacity of the OSS facility (in m³)*

Retention times of less than 1 year, which can involve higher sludge production rates:

- *shall not be considered for the FSTP planning and design,*
- *but shall be mitigated with urgent OSS facility extension works resulting in higher sludge retention capacity, which then frequently also allow reducing user/stance ratios to conform values.*

[5] Sludge collection/delivery records collected during field surveys are usually only indicative and not very reliable.
[6] typically between 30 and 200 l/c/a depending on the context
[7] This rate is a reliable average value for septic tanks or pit latrines with retention times of at least 1 to 2 years.
[8] Time between two desludging of a pit or septic tank (FS collection)

1.3.3.5 Estimate of FS Volumes Collected, Transported and Treated

Not all the FS produced is collected, transported and treated. The main limiting factors are:

- the type of OSS facilities,
- the distance to the FSTP.

For the estimate of the design value to be used for the technical design of the FSTP first investment stage, following criteria are recommended. Alternative methods can be implemented if their use can be justified.

- Type of OSS facilities[9]:
  - Unlined pits: 0% of the sludge produced is collected, transported and treated.
  - Septic tanks and lined pits: depends on the distance to the FSTP.
- Distance to the FSTP: introduction of correction factors
  - Immediate service area: 70 to 90%
  - Intermediate service area: 60 to 80%
  - Distant service area: 50 to 70%

The estimate for the cluster is as follows:

$$FS_{coll,cluster} = \sum_{serv.a.} f_{coll,serv.a.} \times \frac{n_{users,OSS,serv.a.} \times fs_{prod,spec}}{1000}$$

$$FS_{coll,cluster} = \sum_{serv.a.} f_{coll,serv.a.} \times \frac{n_{users,OSS,serv.a.}}{10}$$

with:

$FS_{coll,cluster}$ = annual FS volume collected, transported and treated within the cluster by the most probable customers (in m³/a)

$f_{coll,serv.a.}$ = collection factor for each service area, i.e. share of sludge collected, transported and treated (in %)

$n_{users,OSS,serv.a.}$ = number of users for each OSS facility of the most probable customers for each service area (in capita)

$fs_{prod,spec}$ = specific annual sludge production (in l/c/a)

[9] Only existing OSS facilities shall be considered except if short term investments on OSS facilities are clearly secured (within next 3 years) or ongoing.

1.3.4 FSTP Site Selection

1.3.4.1 Surface Area Requirements

The minimum surface area requirement shall be deduced from the demand assessment and following diagram.

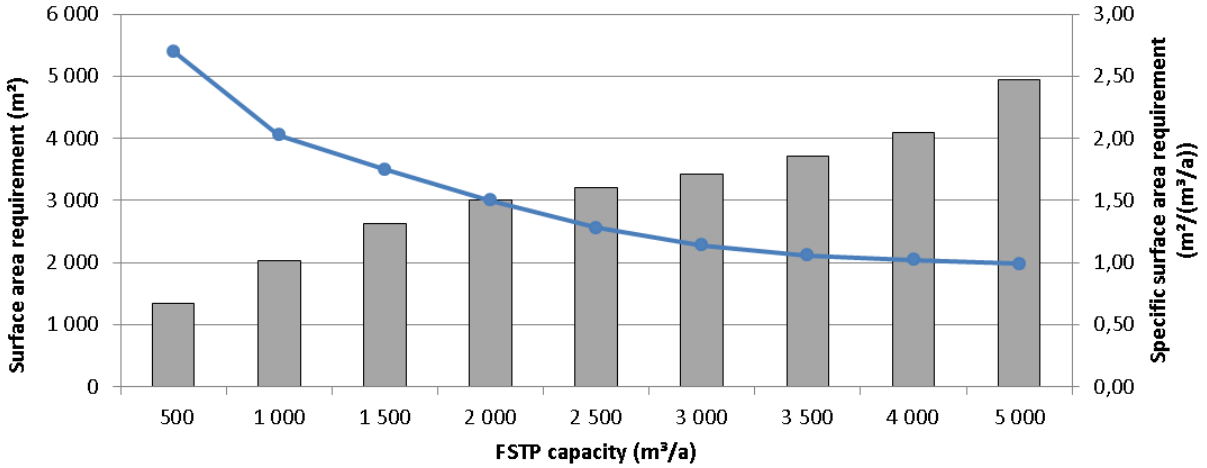


Fig. 1-1: Site surface requirement vs. FSTP capacity

It should be noted that it assumes:

- a compact design for ideal topographical conditions,
- 100% capacity extension,
- 50% safety factor to account for more inadequate site topographies.

As required, these estimates can be refined based on layout sketches adapted to the local specificities.

Following figure illustrates with the example of Apac FSTP the positive impact of compact designs on surface area requirement, which then eases the site identification.

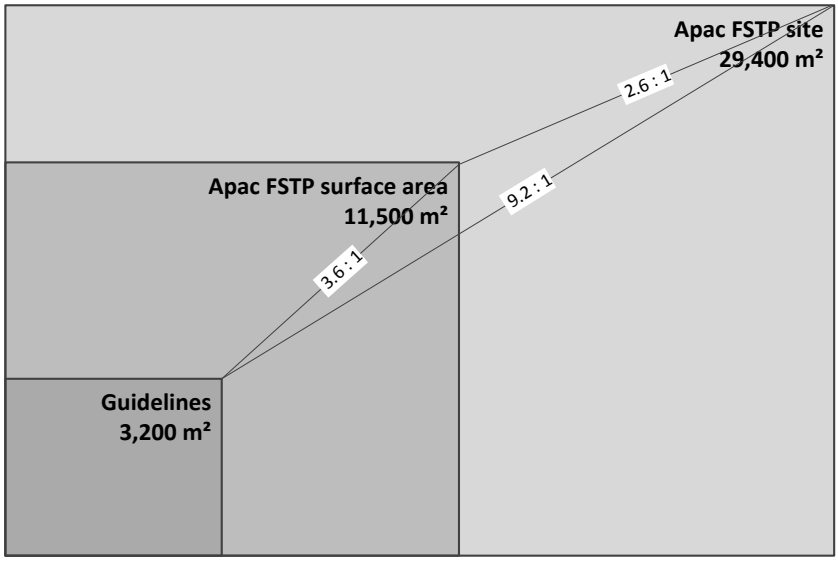


Fig. 1-2: Apac FSTP example: surface area comparison

1.3.4.2 Identification of Appropriate Sites

Following table summarizes and sorts the key criteria to be considered for the selection of appropriate sites.

Tab. 1-2: FSTP site identification criteria

Nr	Criteria	Purposes and remarks	Priority / Preference
1	Proximity to most probable FSTP customers	- Reduce transport costs for the customers (See categories of service areas and impact on FS collection and transport costs)	1
2	"Connectability" by gravity to future town centre sewers	(in case of future combined WW/FSTP) - Allows feasibility	1
3	Proximity to future town centre sewers	- Reduces capital and O&M costs	1
4	Availability of stream	- for effluent discharge and dilution - for stormwater discharge (See also "Free surface water point")	1
5	Availability of piped water[10] (borehole, surface pump)	- FSTP start-up (plants watering, FS dilution) - FSTP maintenance (plants watering, flushing of dumping work and feeding pipe) - Storage of water (elevated water tank)	1
6	Availability of piped water (public supply network)		2
7	Availability of free surface water point	- FSTP start-up (plants watering with water can, FS dilution with vacuum truck) - FSTP maintenance (plants watering with water can)	2
8	Minimal geotechnical conditions	Poor geotechnical conditions involve high site preparation costs (e.g. land reclaimed on swamps like Lubigi FSTP)	3
9	Sloping topography	Sufficient level difference minimizes earthworks	3
10	Availability of electricity	Borehole pump (see "piped water" criterion) Not required for other mandatory purpose	4
11	Recycling opportunity for the effluent in agriculture	Within the FSTP site or offsite Is usually not an issue	4
12	Recycling opportunity for the biosolid in agriculture		4

[10] The purpose does not require the water to be potable but available in sufficient quantities (depending on the FSTP capacity, but up to a few m³/d)

Remark:
In case a WWTP already exists within the targeted service areas, the co-treatment should always be first priority. However, its feasibility has to be established:

- *Is the WWTP capacity sufficient? Or does it require to extend its capacity?*
- *Will the co-treatment endanger the WW treatment process?*
- *Can FS be directly co-treated with WW? Or is it more relevant to previously dewater it?*

Inappropriate sites that are clearly not meeting the criteria should not be considered and further investigated. A maximum number of 3 sites should be considered, but a single site can be sufficient if it is meeting the criteria and obviously the optimum.

In addition, key principles to consider are as follows:

- The centrality of the sites with regard to the targeted FSTP is a key considering the:
    - very high impact of transport on the costs for the customers.
    - usually involved high costs of other infrastructures extension (roads, water, etc.), in terms of investment as well as O&M costs.
- Future conversion to a combined WW/FSTP shall always be considered and is an additional advantage of central sites, located near the town centre (most dense and relevant urban area).
- Even though it is necessary to consider area for possible extensions (either WWTP or a combined WW/FSTP), planners should not always unnecessarily constraint themselves when identifying sites, because:
    - They should focus on an immediate solution that is maximising the immediate benefits.
    - The demand evolution at long term is very difficult to predict in such context.
    - As required, depending on the long term context evolution:
        - More compact technologies will be applicable in the future.
        - And/or a new site can be chosen and financed with the decommissioning and sale of the initial site.
- Proximity to residents is not an issue, because there is no nuisance (odour, insects) to be expected, even on the FSTP site itself.
- As required, impacts of different site locations have to be priced (transport costs, site preparation, infrastructure extension, etc.) in order to enable a sound and fair site identification and later comparison.
- The planner should consult with the local government and relevant stakeholders, particularly in order to prevent social issues, but it shall keep the lead and act on behalf of the Project Owner.

Remark:
Land acquisition costs should normally not be considered because:

- *Land is not a common asset to be amortized, and its value is even supposed to increase with the GDP.*
- *The extra costs of more central and appropriate sites are usually anyway negligible compared to:*

- *The involved extra cost on the FS transport.*
- *The investment cost for the construction of the FSTP.*

1.3.4.3 Selection Criteria for the Most Appropriate Sites

If 2 or 3 identified sites have been selected, their comparison is to be made based on the site identification criteria (see preceding table).

It is mandatory that within the feasibility study, neighbouring residents are well and positively informed in order to prevent and mitigate social issues:

- They must believe that the planned FSTP is not going to be a nuisance.
- They should ideally even believe that it can be an opportunity for them (e.g. if they themselves benefit from infrastructures extensions that are required for the FSTP (water, road, etc.), etc.).

The selected site should be formally secured as soon as possible:

- The purpose of the selected land in the physical development plans should ideally be modified accordingly.
  - Physical development plans usually don't include areas for FSTPs.
  - If a site is already defined, it will probably not have been defined considering all aspects formulated in the Guidelines. Thus the Planner should critically analyse it and propose the most adequate alternatives.
- The planner should indicate and schedule the required steps in accordance with the case and the regulatory requirements.

Remark: it is recommended to avoid the implementation of formal resettlement action plans by targeting unconstructed areas, negotiating the land owner and discussing with the local residents.

1.3.5 Preliminary Cost Estimate

Investment and O&M costs, but also FS collection and transport costs have to be estimated.

1.3.5.1 FSTP Investment Costs

The investments costs required for the construction of the FSTP shall be approximately estimated, following at least following cost breakdown and basing on specific costs derived from the most reliable sources:

- Site preparation
- FSTP construction:
  - General and misc. works
  - Dewatering facility
  - Leachate treatment facility
- Extension of other infrastructures for the FSTP

1.3.5.2 FSTP Annual O&M Costs

- Personnel costs
- Other operation expenditures
- Maintenance costs as a percentage of investment costs

1.3.5.3 FS Collection and Transport Costs

These costs shall be estimated approximately for each *most probable customer* surveyed in order to estimate the sum for all the customers. These estimates are required to allow the:

- To allow the comparison and selection of the most adequate FSTP site (see example in the following subsection).
- To check the feasibility in terms of ability and willingness to pay (to be refined within the detailed design phase).

1.3.5.4 Example of the Impact of the Site Selection on FS Collection and Transport Costs

Following figure shows the impact of the distance between the customers and the treatment plant (assuming a single trip by a vacuum truck doing about 20 trips per months):

- Even within the immediate service areas, costs can double.
- Costs are more or less doubling from the immediate to the distance service area.

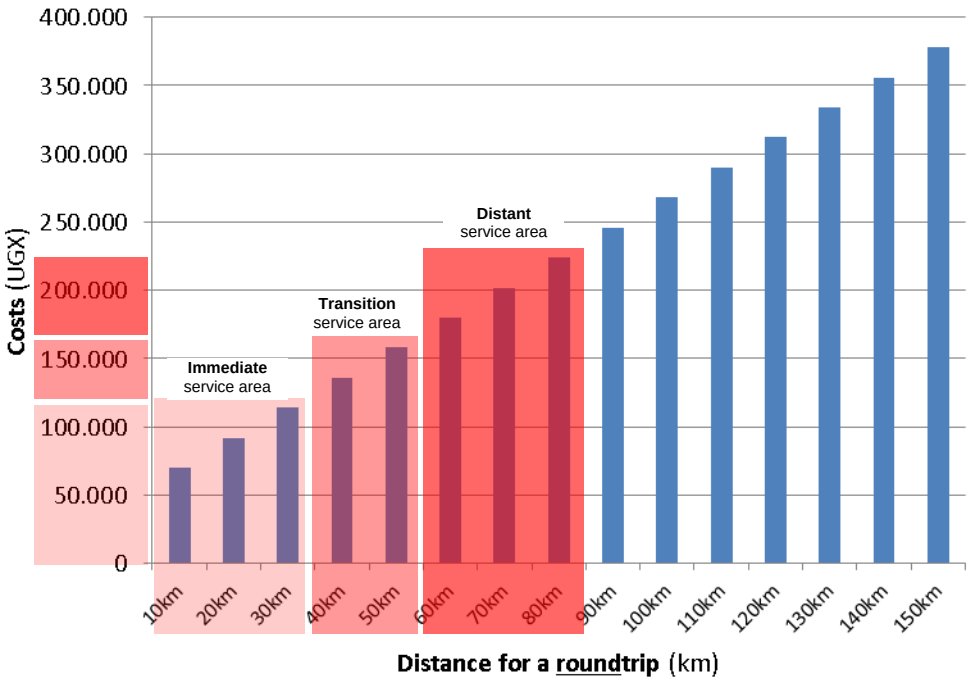


Fig. 1-3: FS emptying costs[11] Vs. Roundtrip distance

[11] Assuming a single trip by a vacuum truck with an average level of activity of about 20 trips per month.

To assess the impact of the site selected for Apac FSTP of the FS collection and transport costs, these costs were estimated for each of the potential customers and for:

1. The selected FSTP site (10 km away from town centre)
2. A more central and adequate site

The comparison of the collection and transport costs between both sites is illustrated by the following tables.

Tab. 1-3: Impact of the site selection on FS collection and transport costs (Apac FSTP)

Volume dumped to FSTP	m³/a	Additional transport costs UGX/a	Additional transport costs UGX/ 20a
Short term - Lower estimate	200 m³	5.100.000	102.000.000
Short term - Higher estimate	800 m³	20.200.000	404.000.000
Design capacity review - Lower estimate	2.800 m³	70.400.000	1.408.000.000
Design capacity review - Higher estimate	4.200 m³	105.600.000	2.112.000.000

Tab. 1-4: Impact of the site selection on costs (Apac FSTP)

Cost items	Site near town	Selected site
Land acquisition	30 Mio UGX	10 Mio UGX
FSTP construction	870 Mio UGX	870 Mio UGX
FS collection and transport costs		≈ 1,900 Mio UGX[1]
Total	900 Mio UGX	≈ 2,900 Mio UGX

[1] Volume collected and transported assuming a high estimate, in line with the design capacity

It clearly appears that the **financial impact in Apac** due to the selected site is massive with about **+200% additional costs**. They are **equivalent to the financing needs for the construction of 2 other similar FSTPs**.

These additional costs have to be borne by the FS Emptier customers, i.e. the OSS users, whose abilities and willingness to pay are already known to be an issue.

Hence before looking for complex subsidies schemes for FS emptying services, project owners shall always rather first make sure to invest in the most adequate FSTP sites, which lower the emptying costs.

1.3.6 Feasibility Study Outputs (checklist)

The outputs of the feasibility studies shall consist of:

1. **Report:**
    a. Background (e.g. reference to updated National Faecal Sludge Demand Assessment)
    b. Clear split of responsibilities
    c. Appraisal results of demand for FS treatment and FSTP capacity
    d. Site identification and selection
    e. Cost estimates
    f. How to secure the site? Steps and schedule.
    g. Annexes with detailed results (tables and maps)
2. **GIS data set:**
    a. Administrative boundaries with population forecasts.
    b. Surveyed most probable customers including all related collected data.
    c. Other relevant base data (free surface waters and streams, water supply network, roads, etc.).
    d. Site identified and site selected (polygon layer)
    e. Transport distances and/or durations for each identified site (contour lines and raster data).
    f. Service areas for each identified site:
        i. Immediate
        ii. Intermediate
        iii. Distant

Remark: considering the impact of inappropriate feasibilities studies, ***it is recommended to always involve adequate international expertise****.*

2. DETAILED DESIGN

2.1 Prerequisites

- Feasibility study (see section 1.3).
- Funding scheme is set and funding is secured including O&M.

2.2 Preliminary Investigations

2.2.1 Review of Demand Assessment

If the demand assessment has not been continuously kept updated by local actors, the Designer shall update the demand assessment implemented during the Feasibility Study.

The objective is to make sure that the most updated and thus correct FSTP capacity is considered for the design.

2.2.2 Geotechnical Investigations

- Consistency:
  - Trial pit(s) (1 to 3 nr)
  - Depth: about 2 m
  - Photo documentation and visual inspection by experienced personnel.

- Primary objectives:
  - Assess the rockiness of the soil
  - Assess the presence of groundwater horizon and if yes, the water table level

- Final objectives:
  - Confirm the technical feasibility of the planned construction works.
  - Optimize the technical design of the planned construction works:
    - Avoid rock excavation, which require expensive mechanical equipment.
    - Avoid construction under the water table:
      - Too expensive
      - Can disturb the FSTP operation
  - Estimate more accurately the investment costs of the planned construction works

The requirements are on purpose not high, because the experience shows that it is usually sufficient.

Nevertheless, if the soil quality is obviously dubious (swampy area, high organic content, etc.), then more advanced investigations shall be implemented in order to refine as required the requirements on construction works:

- At least laboratory analysis of trial pit samples (sieve analysis, Atterberg limits, natural moisture content, hydrometer analysis, specific gravity test, organic matter content, California bearing ratio, soil classification)
- If required, also complement or replace trial pits with hand augering (minimum 60mm diameter, usually down to 5m m depth), includin: photo documentation, borehole logs, samples, laboratory analysis.

2.2.3 Topographical Survey

A comprehensive topographical survey shall always be implemented and its results shall consist in a digital drawing dwg format (i.e. digital "computer-aided design" format) including:

- A digital elevation model (DEM) with all required break lines
- Contour lines for at least 50cm level difference
- All surveyed objects, cleanly classified in layers:
  - Buildings, trees, hedges, fences, roads, channels, culverts, swamp, etc.
  - Discharge stream with water level and date of measurement
  - Trial pits and/or other geotechnical investigation
  - Any other relevant object.

2.3 Selection of Treatment Options

2.3.1 Overview of Treatment Steps

Faecal sludge is delivered and dumped at the FSTP by FS emptiers. It is delivered in liquid form, with between 97 and 99% water content (DSC between 1 to 3%).

The first and **key treatment step is to dewater the faecal sludge**, i.e. extract most of the water in order to get a solid material, which will be called "biosolid" in these Guidelines.

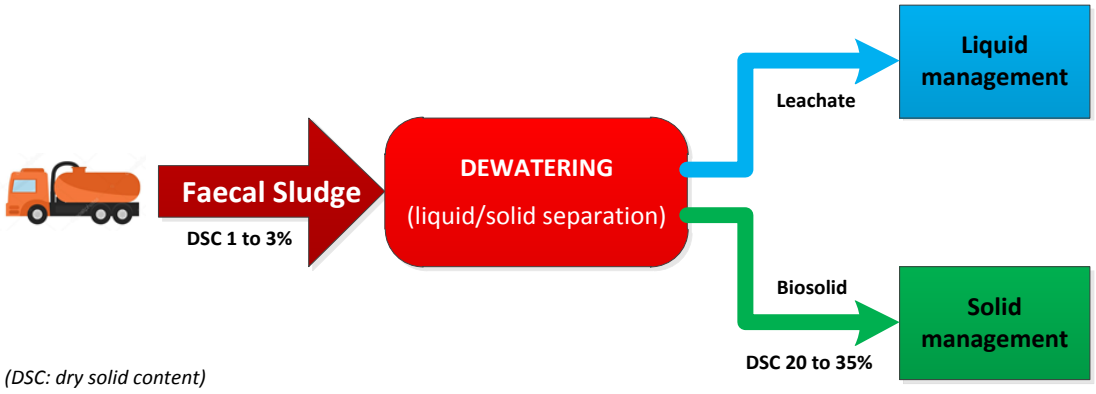


Fig. 2-1: Overview of FS Treatment Steps

Effluent and biosolids have to be recycled as much as possible and previously treated as required. Hereafter, liquid and solid "management" refers to recycling and possible previous treatment.

2.3.2 Dewatering

The scope of these Guidelines basically solely includes planted drying beds, because it is the dewatering process of:

- the pilot FSTP of Apac
- most of the existing FSTPs of small towns

Alternatively, project owners can decide to implement unplanted drying beds but there are fundamental differences to the benefit of PDBs for small FSTPs, which are summarized in the following table.

Tab. 2-1: Differences between PDBs and UnPDBs

Nr	PDB	UnPDB
Interval between two bed feedings[12]	**1 week**	**4 weeks**
Biosolid production	**Every 5 to 10 years**	**Every 4 weeks**
Operation require-ments	**Little**: Only the plants care	**Important**: Bed desludging before each feeding (every 4 weeks)
Specific treatment capacity	**Higher** (smaller feeding intervals)	**Lower** (higher feeding intervals)

Fig. 2-2: UnPDB desludging

UnPBD are usually only relevant in following cases:

- High FSTP capacities, and then necessarily combined with a preliminary FS thickening ("sedimentation tanks", e.g. Lubigi FSTP).
- Onsite dewatering of Waste Stabilization Pond sludge, because it is produced at very large intervals (at maximum annually, but usually between 2 and 5 years)

Furthermore, for PDBs, biosolid is only produced when the bed is full, i.e. after 5 to 10 years, which means that for medium size PDBs with about 5 to 10 beds, FS is produced more or less annually after an initial filling period.

[12] Average and approximate values

UnPBDs produce biosolid almost continuously, which might be advantageous in case of recycling as a fuel (briquettes). However, the latter is usually not economically sustainable, in particular for small FSTPs.

Remark:
Co-composting of undewatered FS is in theory possible but not implemented because the high liquid content of FS does not allow to constantly and easily achieve the required conditions required to enable the composting process.

2.3.3 Biosolid Treatment and/or Recycling

PDB biosolid is to be ideally recycled **in agriculture as fertilizer or soil amendment**. The possible additional treatment requirements shall depend on the agricultural recycling practice (see §2.7).

Remark: recycling in agriculture is the most appropriate because alternative options are more disadvantageous, as shown below:

- *Co-composting the biosolid:*
  - *It is a complex process, which requires stable and specific conditions (particularly moisture content, C/N ratio, aeration).*
  - *It requires an external co-composting material (bulky vegetal material).*
- *Recycle it as fuel (briquettes, i.e. FS-char):*
  - *Despite fully granted and thus hardly sustainable financing, FS-char remains more expensive than other agro-chars and at least 2 to 3 times more expensive than charcoal (see following table).*
  - *Ugandan FS-char energy potential covers only 0.03% of the current charcoal production ([10]).*
  - *Energy and CO_2 emission balance is not necessarily positive because using FS-char would need to import more chemical fertilizer, which requires high energy consumption and CO_2 emission.*

Tab. 2-2: Charcoal and biochar characteristics

Fuel type	Price per kg	Calorific value	Price per 100MJ	Price per equiv kwh
	EUR	MJ/kg	EUR/100MJ	EUR ct/kwh
Charcoal	0.21	29.8	0.70	2.5
Agro-Char Green Heat	0.32	21.7	1.47	5.3
Agro-Char Briketi	0.25	21.5	1.18	4.2
FS-Char Water for People	0.32	18.3	1.74	6.3
FS-Char Sanivation	2.64	20.1	13.13	47.3
FS-Char Capida	0.42	20.0	2.09	7.5

(Source: derived from [9])

2.3.4 Liquid Treatment and Recycling

Following figure summarizes the recommended PDB leachate management options.

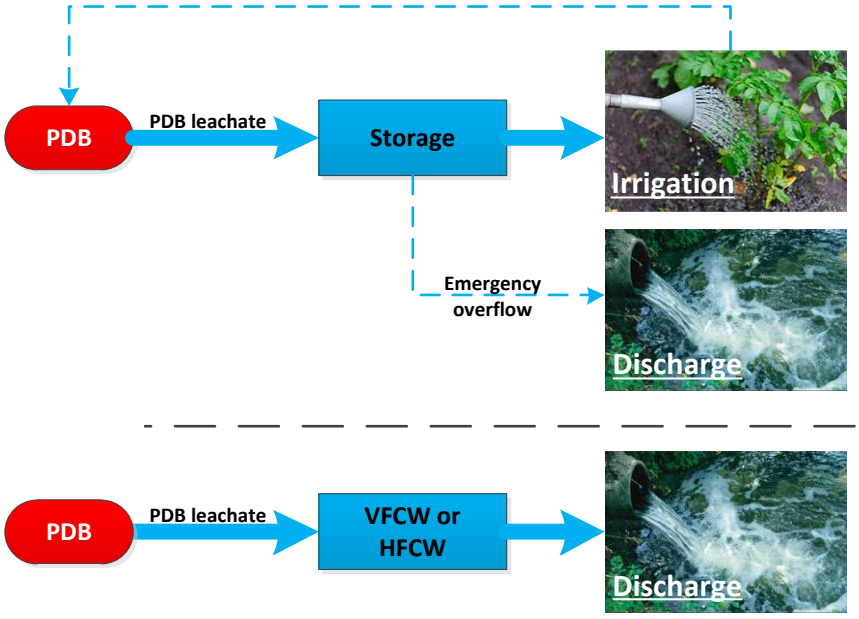


Fig. 2-3: Leachate management options

It is recommended to basically **recycle the leachate in agriculture via irrigation**, thus valuing the water and the nutrient content (particularly nitrogen). It must be noticed that in case of low FS deliveries, it is possible to irrigate the PDB plants, which can be particularly relevant during dry seasons.

Discharge into a stream or swamp must be the last resort option. In such case, an additional treatment before discharge can be foreseen. Following treatment options are recommended as the most suitable:

- Vertical flow constructed wetland (VFCW)
- Horizontal flow constructed wetland (HFCW)

If the topography provides sufficient level difference, VFCW shall be favoured because:

- clogging issues can more easily handled,
- the same civil works type as for the PDB can be used, thus simplifying the construction.

Remark:
Waste stabilization ponds are not recommended for dedicated[13] FSTPs, because of the generally low hydraulic load and their high fluctuations, which do not allow meeting the water balance criterion[14] and providing satisfactory and stable conditions for the algae development. Exceptions can be tolerated if measures are foreseen to maintain the algal activity. These measures should, however, be defined by international experts.

[13] But waste stabilization ponds are the most relevant option in case of combined FSTP and WWTP.
[14] The inflow must be sufficient to compensate the evaporation.

2.4 Hydraulic Profile

The Guidelines emphasize the need to adequately take levels into considerations for the design, because level errors are too frequent and their impact can be high.

- Existing ground levels (see DEM and topographical investigations)
- Planned FSTP levels.

Hence, it is mandatory to design an adequate hydraulic profile by following key principles presented below:

- Design has to **start from the more distant downstream point** towards upstream: highest expected water level of the discharge stream (emergency or permanent discharge point).
- It has to include and consider all level loss between and within works:
  - Pipe slopes
  - Overflow heights
  - FS dumping height
  - Etc.
- It has to highlight the existing ground levels and the planned levels.
- It has to be adapted to optimize the earthworks (including pumping prevention, considering the general financing constraints).

Stormwater has to be considered at this stage in order to not unnecessarily "overdesign" expensive stormwater channels, but rather optimize the terrain planning with earthworks and implement for instance small dams, ditches, etc., including the plantation of grass, vetiver (in case of high slopes), hedges, trees, etc.

2.5 FS Dumping Area and Pre-Treatment

The dumping area shall consist of:

- An access ramp for FS collection and transport vehicles, if the topography requires it. The maximum slope is 15%. For slopes above 6 to 8%, the ramp and dumping bay should be made of reinforced concrete.
- A dumping and storage work with:
  - a dumping height allowing the expected FS collection and transport vehicles to dump FS by gravity (outlet pipe level > dumping point level),
  - a **storage volume allowing** to feed each PDB bed with batches that are covering each bed with **15 to 25 cm FS height** in order to:
    - flood the whole bed,
    - well distribute FS over the whole surface area and
    - allow an air renewal within the filter media (plug effect).
  - a flushing channel (U-from DN100),
  - benching of 10%,
  - a mobile screen basket to:
    - prevent clogging of the feeding pipeline.
    - minimize the solid waste accumulation in the beds.
  - a ruler to read the volume of liquid in the dumping work.

- An elevated water tank with following characteristics:
  - For:
    - storage of water (to be able to flush and also overcome possible water cuts)
    - flushing of dumping work and feeding pipeline
    - dilution of FS during start-up phases
    - adequate batch feeding of the PDB
  - With recommended:
    - 2 to 3m elevation compared to the dumping and storage work outlet invert level,
    - a tank with:
      - about 2m³ storage volume
      - a float valve at its inlet
      - a DN80 or DN100 overflow and flushing pipe at its outlet
- A small and simple covered storage area to dry the screening before their disposal.

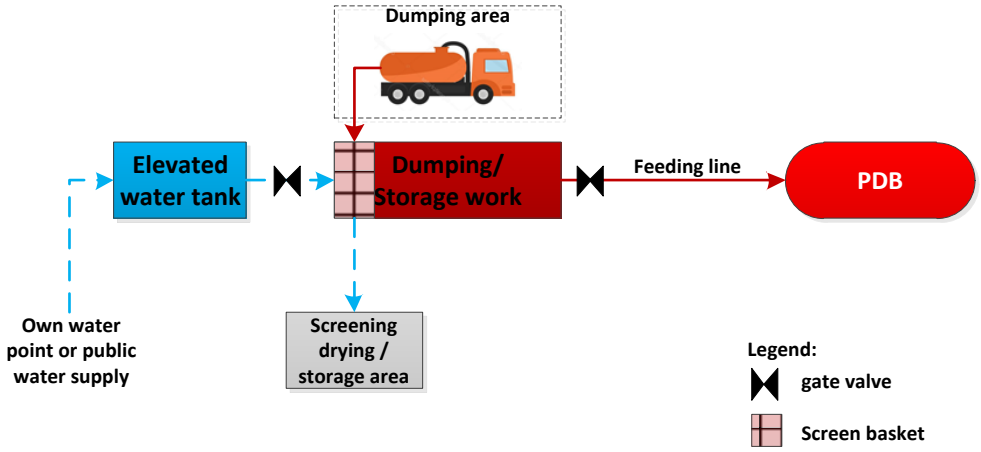


Fig. 2-4: FS Dumping Area and Pre-Treatment

Following pictures illustrates an acceptable example (Apac FSTP).

Fig. 2-5: FS Dumping Area and Pre-Treatment: Apac example

The screenings shall be dewatered in the screening basket and transferred to the covered storage area (see section 2.7.2). Sufficiently dried screenings do not represent a major health hazard, but it is usually not relevant or possible to recycle them. Thus, it is recommended to incinerate them with a low-cost incinerator (Monfort mark 8 or similar).

But considering the very low screening production of the FSTPs:

- It is not relevant to construct a dedicated incinerator at the FSTP site.
- The screening must be transferred to the nearest incinerator, which should be available at a health centre or even a large school.

Remark:
In case of very small FSTPs, or more generally when it is not necessarily worth or possible to invest much, FS can be dumped directly into the a PDB bed, either with a mobile screen basket (see Apac FSTP example for 3 beds). A screen basket is not even mandatory. The beds might get filled up slightly faster (depending on the average solid waste content of FS) and the produced biosolid has to be sieved (but even with a screen basket, biosolid might have to be sieved before recycling).

Fig. 2-6: FS Dumping Area and Pre-Treatment: direct dumping with mobile screen basket

2.6 Dewatering: Planted Drying Beds

2.6.1 Total Surface Area

The beds total surface area can be estimated as follows[15]:

$$PDB_{areal,tot} = \frac{L_{hyd,a} \times C_{TS}}{LR_{TS,a,max}} = \frac{L_{TS,a}}{LR_{TS,a,max}}$$

with:
$PDB_{area,tot}$ = total required bed surface area (in m²)
$L_{hyd,a}$ = annual FS load (in m³/a)
C_{TS} = average total solid concentration (in kg_{TS}/m^3)
$L_{TS,a}$ = maximum annual total solid loading rate (in $kg_{TS}/m^2/a$)
$LR_{TS,a,max}$ = maximum annual total solid loading rate (in $kg_{TS}/m^2/a$)

Usually no reliable and representative TS concentration figures are available. The designer shall then use the following figures:

$$PDB_{areal,tot} = \frac{L_{hyd,a} \times 30}{250} = L_{hyd,a} \times 0{,}12$$

Remark:
Assuming an average FS feeding interval of 1 week, the resulting average weekly sludge height would then be about 16 cm, which is in line with the acceptable range of 10 to 20 cm for a bed feeding event.

2.6.2 Multiple Beds

The PDB treatment process requires:
- a batch FS feeding of the PDB bed(s),
- with sludge application heights ranging between 10 and 20cm[16].

Furthermore, it must be considered that:
- FS deliveries are usually discontinuous, with sometimes:
  - days or even weeks between two deliveries,
  - small volumes (2 to 3 m³, for a single stance OSS facility).
- Vacuum truck capacities usually range between 3 and 5 m³ (typically about 4m³).

Therefore, the designer shall foresee to separate the PDB into multiple independent beds:
- The designer shall use the same surface area for all beds in order to simplify the construction and the operation (and indirectly the costs).
- The higher is the number of independent beds, the best can be the operation:
  - Bed availability and instant FSTP capacity. For example at an FSTP with 120 m² of PDB, with the same volume of 4m³ FS:

[15] In case very unusual peaks of FS deliveries can really not be avoided and have to be foreseen, the designer shall design the total surface area for these peaks, by using the hydraulic criterion (see §6.4.3.1 on maximum instant capacities).
[16] Higher values up to 25 or 30cm can exceptionally be tolerated during the operation of the plant (for a limited number of feeding events that have to be sufficiently spaced).

        - Feeding a bed of 25m² makes 20% of the bed unavailable for 1 week on average until it can accept sludge again.
        - Feeding a bed of 40m² makes 33% bed unavailable for 1 week on average until it can accept sludge again.
    - Lower risks in case of issue on a bed (clogging or plant wilting)
- Larger beds require a larger dumping and storage area.
- The surface area of an independent bed shall be as follows:
    - Minimum: 20 m²
    - **Standard: 25 m²**
    - Maximum: 40 m²
- Some beds, but not all, can share the same drainage system in order to maintain a minimum operating capacity in case of issue on one drainage system.

2.6.3 Beds Arrangement

The beds of the first PDBs were designed in Uganda as separate structures, because they were meant to be built in ferrocement, which is much cheaper than reinforced concrete. However, they were finally built with reinforced concrete because the required workmanship is not available.

Therefore, it is recommended to rather **design joining structures, i.e. joined boxes**, which also allow a higher compactness.

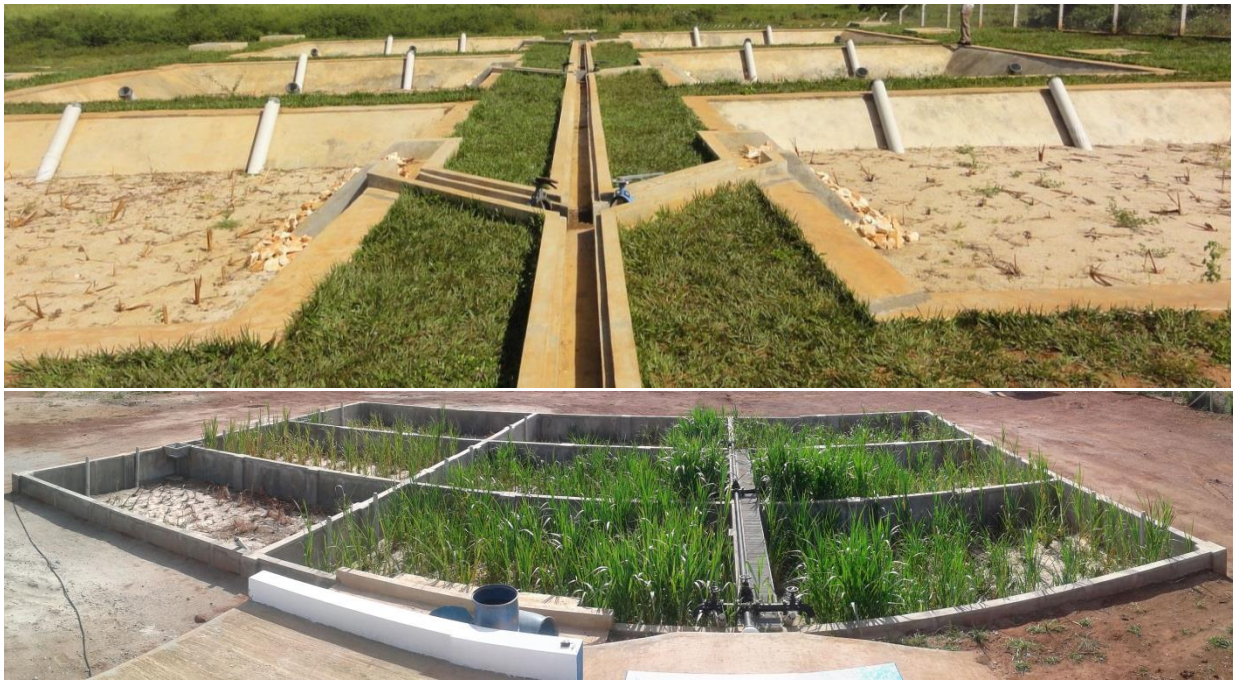


Fig. 2-7: PDB beds construction (on top, separate beds; on bottom, joining beds, i.e. boxes)

2.6.4 Bed Feeding System

It must be possible to select the bed to be fed with a system consisting of a feeding line and valves (assuming a central dumping and storage work).

PDB built as joined boxes shall be equipped with a feeding pipeline and gate valves, as illustrated by the following example.

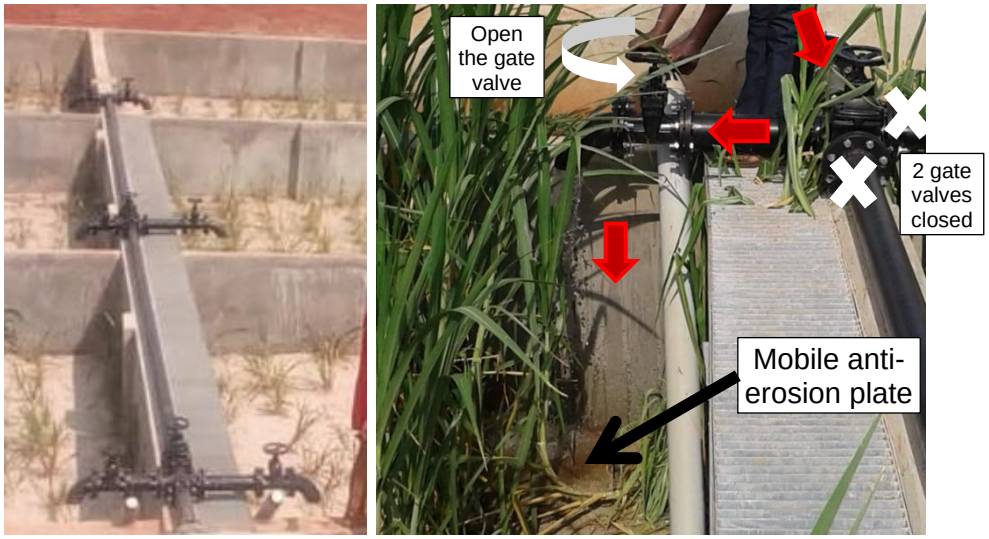


Fig. 2-8: PDB feeding system

- Pipeline and gate valves:
  - The diameter should be DN100 or DN80. Larger diameters do not improve the clogging prevention, but are much more expensive. A screen is mandatory to prevent clogging (see §2.5).
  - The feeding line should have a positive slope of between 5 and 10 ‰[17], in order to allow a complete emptying.
  - The pipeline has to be fixed onto the separation wall. There is hardly pressure expected (0.1bar) and the purpose of the fixing system is rather to set and guarantee the targeted pipe slope.
  - The piping system must be flanged, thus also allowing easy mounting/dismounting for maintenance purpose.
- An anti-erosion plate has to be installed at the top of the bed surface:
  - It has to be mobile, in order to:
    - be regularly raised above the top surface, because biosolid will be constantly accumulating up to the bed top.
    - be always able to improve its position.
- The feeding point (i.e. gates valves and anti-erosion plates) should be located near the bed corners.
- A footbridge is required to access all gate valves:
  - A narrow bridge of 40cm width is sufficient.
  - Larger bridges are unnecessarily and would hinder the plant growth.

[17] ‰ means “per thousand” and not “per cent” (10‰ is equal to 1%).
‰ is the standard unit for sewer works, because the slopes can be low (1 or 2‰) and require high accuracy.

2.6.5 Bed Design

2.6.5.1 Standard Cross-Section

Following figure shows the standard cross-section of a bed:

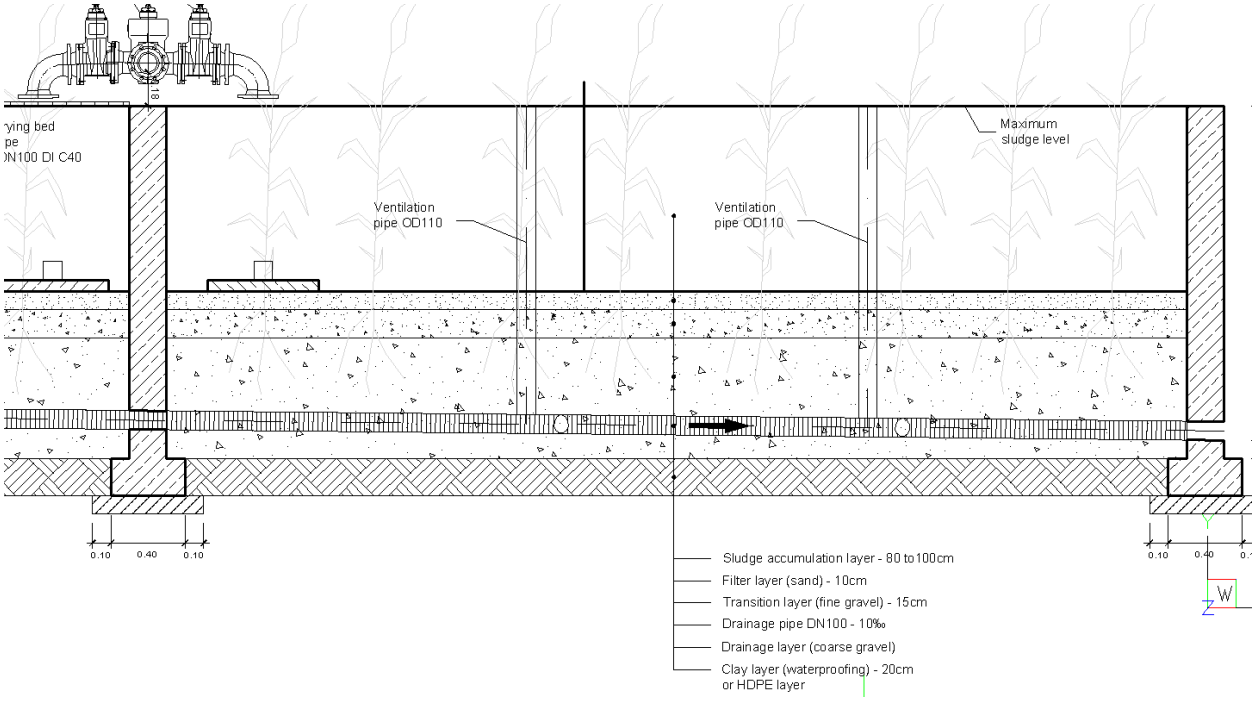


Fig. 2-9: PDB standard cross-section

2.6.5.2 Civil Works

Walls can be made of:

- Reinforced concrete
- Concrete block masonry
- Clay block masonry

The watertightness of the bed bottom can be achieved with:

- clay if it is locally available,
- an HDPE layer.

The current practice of mortar or concrete filling for pipe sealing at the connection to PDB outer walls is considered as sufficiently watertight for the purpose.

Remark:
In case of an HDPE layer, it is sufficient to lay it horizontally just below and until the wall foundations. Welding of layers, which requires expensive equipment and skilled workers that are usually only available in Kampala, is not mandatory and can be replaced by layer overlapping of at least 50cm

2.6.5.3 Filter Body

Great attention should be given to filter media because it can have high impacts, e.g. serious bed clogging, which would require the complete filter media replacement as well as the bed re- start-up.

It shall be made of three layers: from top to bottom

1. Filter layer: sand that filters and thus dewater the FS (low grain sizes)
2. Transition layer: fine gravel that guarantees the mechanical filter stability
3. Drainage layer: coarse gravel, with high permeability to drain the liquid phase

The use of geotextile is forbidden since it could progressively clog. The grain size distributions of each layer are crucial to guarantee the filter function and stability. Therefore, it shall follow the Terzaghi rules. The design criteria for the PDB filter body are summarized by the following table:

Tab. 2-3: PDB filter body characteristics

Layer	Type	Layer thicknesses	Grain size range (mm)	Grain size distribution	Filter stability
Filter	Sand	10 cm	0.2 – 1.5	$4 \leq \frac{d_{60,tran}}{d_{10,fil}} \leq 5$ $80\ \mu m \leq d_{3,fil}$	$\frac{d_{15,tran}}{d_{85,fil}} \leq 5$
Transition	Fine gravel	15 cm	3 – 2	-	$5 \leq \frac{d_{50,dra}}{d_{50,tran}} \leq 10$
Drainage	Coarse gravel	≥ 50 cm	20 – 60	-	

(Source: derived from [12] and [13])

With:

***d_{xx}**: grain size for which xx % of the mass is below that grain size*
***fil**: filter layer*
***tran**: transition layer*
***dra**: drainage layer*

The thickness of the drainage layer depends on the bed dimension and the drainage system arrangement because:

- The drainage layer bottom shall be 10cm below the lowest invert level of the drainage system.
- The top of the drainage layer has to be about 25 cm above the highest level of the top of the drainage system, bearing in mind that the layer levels of all beds shall be identical. Lower values are not recommended because roots could damage the drainage pipes.

Following figure shows an example of possible grain size distribution of the transition layer for the given filter and drainage layer grain size distributions:

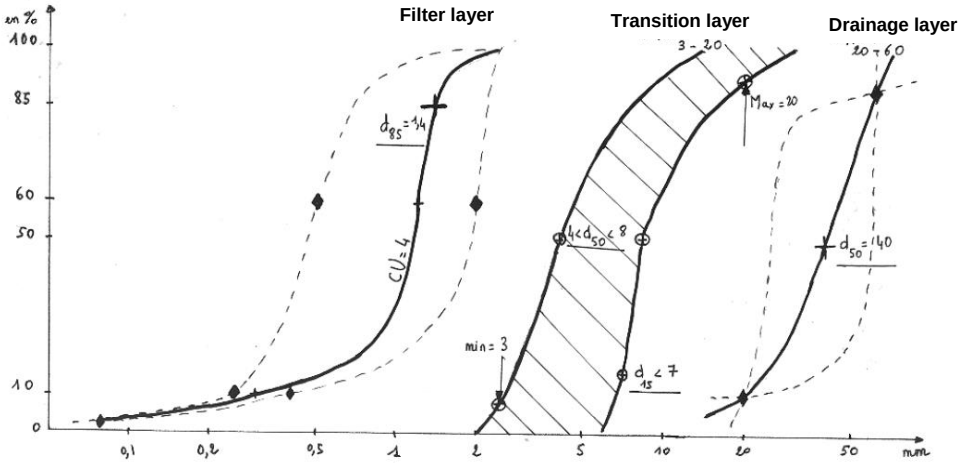


Fig. 2-10: Grain size distributions: example

2.6.5.4 Drainage System

Remark: Drainage pipe or system refers hereafter to a pipeline with perforations. Wastewater pipes without perforations are referred to as sewer pipes.

A drainage system shall be installed at the bottom of the filter body. It shall collect and evacuate the leachate by gravity out of the PDB.

The drainage system shall have the following characteristics:

- Drainage pipe density of 35 to 45 m/100m² of filter.
- Pipe diameter OD110 (DN100).
- Slope:
  - Minimum = 5 ‰
  - Standard = 10 ‰[18]
- Perforation rate: > 50 cm²/m of pipe (see following guidelines).

Since no industrial drainage pipe is produced and easily available in Uganda at reasonable costs, locally produced sewer pipes (see §0) shall be perforated, in accordance with the following criteria:

- Slots shall be cut perpendicularly to the pipe.
- Slots to be cut alternatively at the top and at the bottom of the pipe, in order to not reduce too much its structural stability.
- Various geometries are possible but the designer the minimum perforation rate shall be achieved:
  - Slot width: 1.5mm +-0.2mm.
  - Slot length: 60mm +- 20mm
  - Slot spacing (between slot axis): 25 mm +-5mm.

[18] ‰ means “per thousand” and not “per cent” (10‰ is equal to 1%).
‰ is the standard unit for sewer works, because the slopes can be low (1 or 2‰) and it requires high accuracy.

It is allowed that more than one bed shares the same drainage system, but there shall always be a minimum of 2 independent drainage systems, in order to maintain a minimum treatment capacity even if one of the systems cannot operate (maintenance, clogging, etc.).

Pipe shall not connect together with T-pieces but with Y-pieces aligned towards the flow direction.

2.6.5.5 Outlet Chambers

Each drainage system shall discharge into an outlet chamber (PDB outlet chambers). The outlet chamber shall be designed to allow temporary PDB impounding, with the mounting of a vertical pipe combined to a 90° bend (impounding piping set).

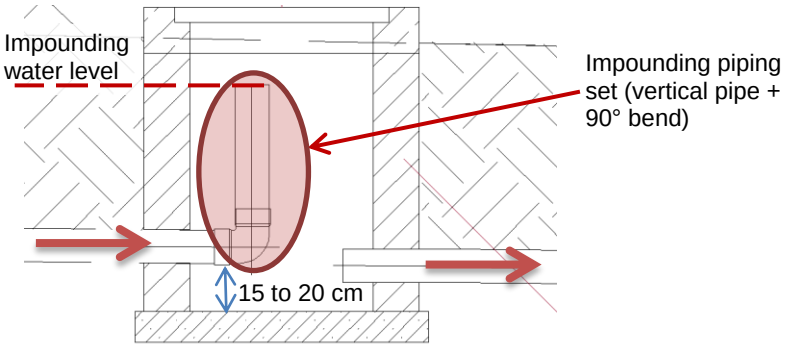


Fig. 2-11: PDB outlet chamber

Chambers shall not be unnecessarily oversized. For outlet chambers where vertical pipes have to be sometimes mounted and dismounted:

- Depth below ground < 1 m: 60cm diameter or width.
- Depth below ground > 1 m: 80cm diameter or width.

2.6.5.6 Ventilation System

Pipe ventilation already occurs via the drainage pipe outlet, but has to be improved with ventilation pipes. Therefore, the drainage system end pipes shall be extended with unperforated pipes up to the bed wall edge, as illustrated by the following figure.

Fig. 2-12: Ventilation pipes

A perforated cap shall be installed at the end of the vertical vent pipes in order to avoid that objects falls into them and blocks the drainage system.

These ventilation pipes can also be used for cleaning and unclogging purpose (via the pipe end). Moreover, each *main* line of a drainage system, i.e. straight drainage pipeline from a bed outlet, shall end at its upstream part with a 45° bend, as illustrated by the following figure. Hence, it is possible to much better clean or even unclog the main from both this sides as well as the bed outlet side, with very basic tools (e.g. ∅ 6mm reinforcement bar with towel).

Fig. 2-13: Drainage system: cleaning and unclogging pipe end

2.6.5.7 Plants

Plants have to be planted at the top of the bed surface. They play the **key role** to continuously and in the long term **ensure the bed permeability**, which allows the FSTP operator to re-feed a bed without previously desludging it.

Biosolid will accumulate slowly and progressively. The accumulation rate will mainly depend on the annual loading rate applied. Therefore, it is required to foresee a freeboard of about 1m. Assuming that the bed is fully loaded, it can fill up in theory within 5 to 10 years.

Locally available plants are mandatory:

1. **Elephant grass** is recommended wherever available. It has proven its appropriateness and it seems widely available in Uganda.
2. In case it is not available within about 50km from the FSTP, papyrus or antelope grass are to be considered as alternatives.

Plant shootings shall have

- a 15 to 20 cm stem
- roots with at least 2 nodes.

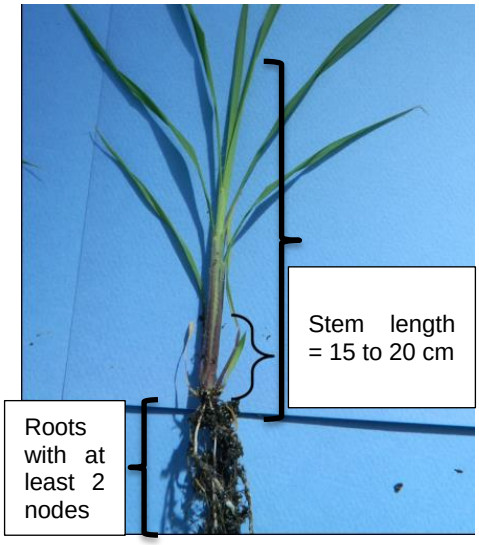


Fig. 2-14: Elephant grass shootings to be planted

The planting arrangement shall be as illustrating by the following sketch. A planting density of 9 shoots per m² is recommended:

- It allows the most convenient layout
- It ensures optimal plant growth and thus avoids clogging risks

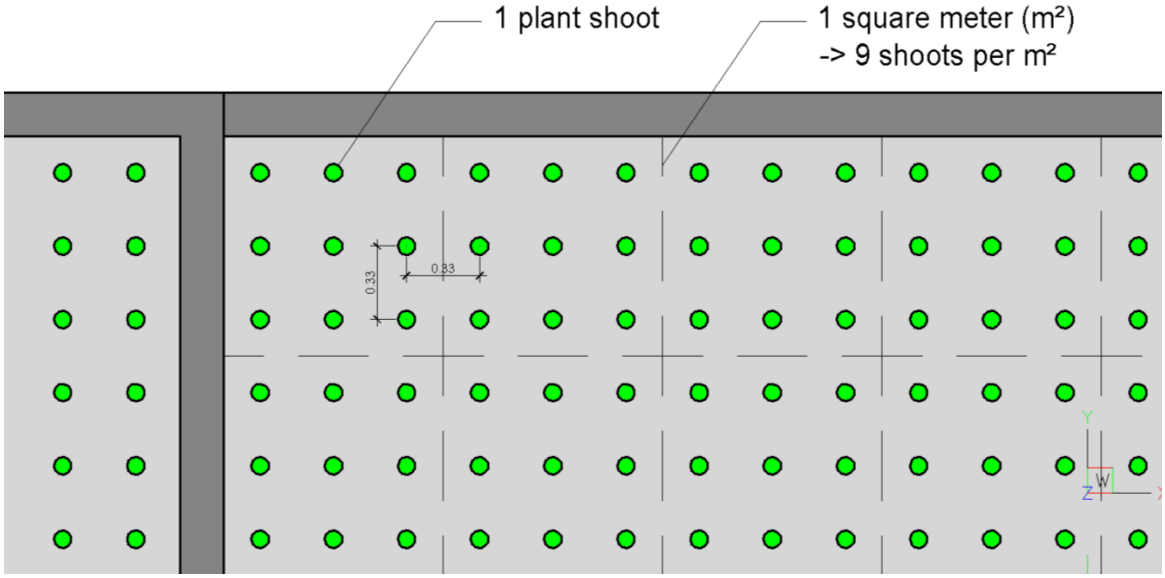


Fig. 2-15: PDB planting arrangement

2.6.6 Sewer System

2.6.6.1 Design Principles

Considering that the leachate is similar to filtered wastewater with reasonably low TS content, blockages risks are very low and it is thus:

- Not required to foresee an inspection chamber at each pipeline direction changes.
- But:
    - There should not be 2 directions changes following each other, without inspection chamber.
    - A direction change without inspection chamber should consist of a single piece bend of not more than 45° (2 x 22.5° is not allowed).
    - There should be an inspection chamber at the outlet of each independent drainage system.

Furthermore, the designer shall follow these key principles:

- Pipelines:
    - The higher the filling ratio is, the better is the pipe self-cleansing efficiency (i.e. small pipes are better and even cheaper): do not unnecessarily oversize the sewer lines.
    - DN100 is the minimum diameter (same as the drainage system) and is usually sufficient except for the total outflow of very large plants.
    - Depths of maximum about 1m should be targeted. Depths higher than 2m should be avoided: they usually result from inappropriate hydraulic profiles and/or general FSTP altitude settings, and unnecessarily involve high costs.
    - Material:
        - Since gravity sewer pipes are not industrially produced in Uganda for diameter below DN200, the designer should foresee the use of uPVC pressure water supply pipes PN6 equipped with rubber joints
        - These PN6 uPVC pipes have an SDR 33, which is usually equivalent to an SN 8 (sewer pipes are available in SN2 to SN16, with SN4 or SN8 as the usual values).
        - HDPE pressure pipe are not appropriate and not recommended, because they are flexible and cannot guarantee a sufficiently accurate slope. Moreover, pipe connections are more complicated and expensive.
- Inspection chambers:
    - The chamber wall edges shall be between 20 and 30 cm above ground level in order to avoid surface storm-water inflows and to always keep the chamber easily visible even.
    - Covers shall be as light as possible, in order to be removed by 1 or maximum 2 persons.
    - Chambers shall not be unnecessarily oversized (they usually don't need to cater for man entrance ("manhole")):
        - Depth below ground < 1 m: 30 to 40 cm diameter or width.
        - Depth below ground > 1 m: 60cm diameter or width.
    - Current practice of mortar or concrete filling for pipe sealing at chamber connections is considered as sufficiently watertight for the purpose.

2.6.6.2 Detailed Design Criteria

The sewer system shall be designed according to the following design criteria:

- Design flow: $Q_{design,sewer}$ = 1 l/s per 100 m² of PDB
- Sewer pipe filling ratio at $Q_{design,sewer}$: ≤ 80%
- Tractive tension at $Q_{design,sewer}$: τ > 1 N/m²
- Minimum slope: 5 ‰[19]

2.7 Biosolid Treatment and/or Recycling

2.7.1 Biosolid Production Cycles

Biosolid will accumulate slowly on the PDB beds surface. When a bed is full, the accumulated biosolid has to be removed from it.

It is assumed that the FSTP Utility will organise the sludge deliveries such that all beds are not be filled at the same time but with approximately regular intervals. This will allow to have similar biosolid storage durations, which is important for an optimal management of health exposure risks related to biosolid recycling. A minimum interval of 6 months is recommended (ideally 12 months).

It is possible to decommission a filled bed at the start of a dry season in order to let the biosolid dry for some weeks within the bed before its removal. Health exposure risks during the manual removal works can thus be reduced, even though drying should be more efficient under a storage area because it allows heap turning and better evapotranspiration.

Partial and progressive biosolid removal during the dry season is also possible in order to take advantage of the sludge storage area as well as the storage area within the bed.

2.7.2 Covered Storage Area

The designer shall foresee a storage area that is sufficient for the storage of the biosolid resulting from the emptying of a single bed. For usual FSTP capacities and arrangements (2 to 10 beds), it will allow a storage period of at least 6 to 12 months.

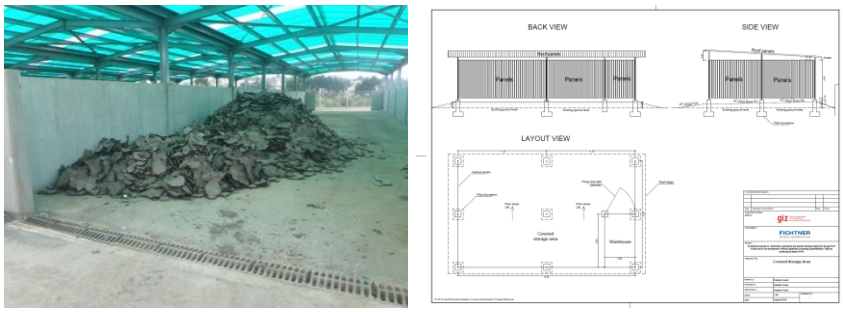


Fig. 2-16: Covered biosolid storage area examples

[19] Except cases to be justified. This slope is the minimum recommended in order to take in account the low workmanship and accuracy with regard to pipe laying of local contractors. ‰ means “per thousand” and not “per cent” (10‰ is equal to 1%).

Design principles:

- Generally, the storage area arrangement shall be designed in order to take into account and optimize the:
  - offloading
  - storage
  - loading
- Considering the high DSC of the removed biosolid (≥ 25%), the storage area does not necessarily need to be paved with concrete or asphalt (e.g. murram is sufficient).
- Walls:
  - Adequate walls shall be foreseen in order to prevent direct rain and surface runoff interrupting the drying process (thus the hygienization process) and in order to ease the storage.
  - Walls don't necessarily need to be made of concrete. Cheaper and more flexible solution can be implemented (e.g. same panels as those for the roofing).
  - The storage area can be combined and use wall(s) of other constructed works (PDB or operation building).
- Roofing:
  - The existing roofing steel structures are too frequently unnecessarily oversized.
  - The use of transparent polycarbonate roofing can improve the drying process but is not mandatory.
  - The storage of biosolid does not involve a more corrosive ambient atmosphere.
  - Corrugated galvanized iron panels are usually sufficient.
- This covered area can also be used to store the small screenings volumes produced, before the disposal.
- No odour nuisance is expected.

It is not relevant at this stage to assess the demand from farmers for biosolids. It shall be addressed in due time before biosolids are removed from the first bed.

2.7.3 Health Exposure Risks

2.7.3.1 Exposure Scenarii

Two health exposure scenarii are to be considered (WHO Guidelines [11]) and require different pathogen reduction targets:

- **Restricted biosolid recycling in agriculture**:
  - health exposed groups are mainly fieldworkers
  - scenario of involuntary soil ingestion
  - pathogen reduction target of 6 logs in case of labour-intensive recycling (5 logs in case of highly mechanised recycling method).
- **Unrestricted biosolid recycling in agriculture**:
  - health exposed groups are mainly crop produce consumers
  - scenario of raw crop consumption
  - pathogen reduction target of 8 to 9 logs

We'll refer hereafter to this target for pathogen reduction as hygienization. E.Coli is chosen as a proxy because it is much easier and cheaper to monitor than other pathogens like for example helminth eggs.

2.7.3.2 Exposure Risk Management

The targeted log reduction can be achieved via adequate exposure control measures which are not necessarily limited to treatment measures. The main measures are summarized in the following table.

Tab. 2-4: Biosolid recycling: log reductions

Control measure	Log reduction	Comments
Treatment		
Planted Drying Bed	2-3	
Before application		
Die-off by storage 6-12 month	6	Depends on temperature and moisture content
Die-off by storage 1 month	1-5	
Application - Harvesting		
Biosolids buried/worked into soil	1	During or immediately after application
1-month withholding before harvest	n.a.	Significant effects after 2 weeks. Application occurs anyway much before harvest.
Post-harvest		
1-month withholding before consumption	4-6	Dry and hot weather, even 0.5 log/d
Produce washed with water	1	
Produce washed with water + detergent	1-2	
Produce disinfection	2	
Produce peeling	2	
Produce cooking	6-7	

(Source: WHO guidelines [11])

In case of **restricted recycling** (exposure for fieldworkers), achieving a 6 log reduction requires

- the PDB treatment (2 to 3 log reduction),
- an additional covered storage period that is sufficient to achieve a 3 to 4 log reduction.

In the case of **unrestricted[20] recycling** (exposure for produce consumers), several combinations are possible to achieve a 8 to 9 log reduction. The FSTP will already allow it even with storage durations shorter than 6 to 12 months.

- PDB treatment: 2 to 3 log reduction
- Covered storage period of 6 to 12 months: 6 log reduction

[20] Unrestricted recycling scenario does not apply if biosolids are used for fields where non-food crops are grown (cotton, trees, etc.)

Several combinations of exposure control options are possible. Following options fulfil the requirements for both restricted and unrestricted recycling:

- *Option 1:* total of 6+1+1+1=9 log reduction ≥ 8 to 9 log reduction
  - PDB treatment and short storage period: 6 log reduction
  - Biosolid buried into soil: 1 log reduction
  - At least 1-month withholding before harvest: 1 log reduction
  - Produce washed with water: 1 log reduction
  - Produce eventually eaten raw.
- *Option 2:* total of 6+1+2=9 log reduction ≥ 8 to 9 log reduction
  - PDB treatment and short storage period: 6 log reduction
  - At least 1-month withholding before harvest: 1 log reduction
  - Produce peeling: 2 log reduction
  - Produce eventually eaten raw.
- *Option 3:* total of 6+1+6=13 log reduction ≥ 8 to 9 log reduction
  - PDB treatment and short storage period: 6 log reduction
  - At least 1-month withholding before harvest: 1 log reduction
  - Produce cooking: 6 log reduction
  - Produce eventually eaten cooked.
- ***Etc.***

2.7.3.3 Verification Monitoring

In both exposure scenarii, a **"verification monitoring" is required**. Its objectives will be to verify the E.Coli content and the log reduction, thus compliance with the targets related to health exposure risks.

The verification level regarding E. Coli after treatment can be derived from the WHO guidelines ([11]) and would be about **10^5 cfu/g_{DS}**.

The above-presented control measure combinations further illustrate the very low health risks.

It is important to be aware in mind that **these targets guarantee a very high health protection level**, i.e. very low health risks. Following quick facts helps to better illustrate it:

- The targets ensure a maximum loss of 10^{-6} DALY loss per person and per year, which could be a theoretical loss via illness of only 32 seconds per person and per year.
- In the EU:
  - Meat preparation: E. Coli < 5.10^3 cfu/g
  - Ready-to-eat vegetables: E. Coli < 10^3 cfu/g
- In France:
  - Raw milk cheese: E. Coli < 10^4 cfu/g
  - Raw milk and rind washed cheese: E. Coli < 10^5 cfu/g

2.7.4 Environmental Exposure Risks

The major environmental risk of biosolid application in agriculture might be nitrogen overloads, which can involve eutrophication issues. Therefore, the biosolid should not involve an annual total nitrogen application rate of more than 350 kg/ha, including other nitrogen sources (manure, urea, PDB leachate, etc.).

Remark: Biosolids produced in small towns won't include high heavy metals contents because no treated faecal sludge should originate from large and heavy industries (steel processing, etc.) in the targeted small towns.

To estimate the nitrogen load, a nitrogen content of about 3% of DS can be considered. It results in maximum annual biosolid loading rates ranging between 20 and 40 t/ha/a.

To better control nitrogen losses in the environment through surface runoff with rainfalls, it is recommended that the farmer bury or work the biosolid into the soil.

2.8 Liquid Treatment and/or Recycling

Two options are possible (by order of priority; see section 2.3.4):

1. Storage before recycling, including emergency discharge into a stream or swamp
2. No recycling and direct discharge into a stream or swamp

2.8.1 Leachate Storage before Recycling

It is recommended to foresee a minimum storage volume for the leachate resulting from the feeding of all beds during a week. This volume can be approximately estimated as follows:

$$V_{leac,sto} \geq \frac{L_{hyd,a}}{52} \times R_{leach}$$

with:

$V_{leach,sto}$ = leachate storage volume (in m³)
$L_{hyd,a}$ = annual FS load (in m³/a)
R_{leach} = leachate production rate

The leachate production rate usually varies between 40 and 60%. An average value of 50% can be used if no more reliable reference value is available.

For example, assuming an annual loading rate of 1,000 m³/a, a PDB total surface area of 120 m² divided in 5 beds of 24m², the required minimum leachate storage volume would be about 10 m³.

Other design principles:

- It is recommended to physically separate the total storage volume in at least 2 storage areas, in order to ease and optimize the operation.

- The storage system can be constructed as:
  - Ponds fully lined with HDPE layer (clay is not appropriate in case of hydraulic load fluctuations that might involve long periods without leachate production, because shrinkage and cracks might appear).
  - Masonry chamber with inner cement mortar lining
  - Reinforced concrete.
- The water depth should be ≥ 1m in order to avoid excessive evaporation (which contradicts the recycling target).
- Piping systems, either mobile or fixed, should allow the operator to select the storage unit to be fed as well as to use storage volumes in parallel or in series.
- The storage system should be equipped with an emergency overflow connected to a discharge line into a stream or swamp.
- Leachate can be recycled for the PDB watering or the FS dilution during the plant start-up.
- The operator should be aware that high salinity values could be an issue even though experience has for example proven that elephant grass of PDB beds can accept leachate.

2.8.2 Health Exposure Risks

2.8.2.1 Exposure Scenarii

Similarly to biosolid recycling, two health exposure scenarii are to be considered ([11]) and require different pathogen reduction targets:

- **Restricted leachate recycling in agriculture**:
  - health exposed groups are mainly fieldworkers
  - scenario of involuntary soil ingestion
  - pathogen reduction target of 4 logs (labour intensive recycling)
- **Unrestricted leachate recycling in agriculture**:
  - health exposed groups are mainly crop produce consumers
  - scenario of raw crop consumption
  - pathogen reduction target of 6 to 7 logs

2.8.2.2 Exposure Risk Management

The targeted log reduction can be achieved via adequate exposure control measures which are not necessarily limited to treatment measures. The main measures are summarized in the following table.

Tab. 2-5: Leachate recycling: log reductions

Control measure	Log reduction	Comments
Before application		
Treatment	1-6	e.g. single-stage CW or PDB allow 2 to 3 log reduction
Die-off by storage 1 week	1.5-2	Marais' equation (1974) basing on temperature and duration
Application - Harvesting		
Localized (drip) irrigation (low-growing crops)	2	
Localized (drip) irrigation (high-growing crops)	4	
Withholding before harvest (after irrigation)	0.5-2 per day	Depending on climate (temperature, sun, humidity, etc.)
Post-harvest		
Produce washed with water	1	
Produce washed with water + detergent	1-2	
Produce disinfection	2	
Produce peeling	2	
Produce cooking	6-7	

(Source: WHO guidelines [11])

In case of **restricted recycling** (exposure for fieldworkers), achieving a 4 log reduction requires

- the PDB treatment: 2 to 3 log reduction,
- the storage period of 1 week: 1.5 to 2 log reduction.

In the case of unrestricted[21] recycling (exposure for produce consumers), several combinations are possible to achieve a 6 to 7 log reduction. Following options fulfil the requirements for both restricted and unrestricted recycling:

- *Option 1*: total of 4+3=7 log reduction ≤ 4 log reduction
  - PDB treatment and storage period: 4 log reduction
  - Withholding period of 6 days before harvest: 3 log reduction
  - Produce eventually eaten raw.
- *Option 2*: total of 4+3=7 log reduction ≤ 4 log reduction
  - PDB treatment and storage period: 4 log reduction
  - Withholding period of 2 sunny and hot days, before harvest: 3 log reduction
  - Produce eventually eaten raw.
- *Option 3*: total of 4+6=10 log reduction ≤ 4 log reduction
  - PDB treatment and storage period: 4 log reduction
  - Produce cooking: 6 log reduction
  - Produce eventually eaten cooked.
- ***Etc.***

[21] Unrestricted recycling scenario does not apply if biosolids are used for fields where non-food crops are grown (cotton, trees, etc.)

2.8.2.3 Verification Monitoring

In both scenarii, a **"verification monitoring" is required**. Its objectives will be to verify the E.Coli content and the log reduction, thus compliance with the targets related to health exposure risks.

The verification level regarding E. Coli after treatment can be derived from the WHO guidelines ([11]) and would be about **10^5 cfu/100 ml**. This exposure control targets ensure very low health risks, similarly to biosolid recycling (see §2.8.2.3).

2.8.3 Environmental Exposure Risks

Similarly to the biosolid recycling, the major environmental risk of leachate irrigation in agriculture might be nitrogen overloads, which can involve eutrophication issues. Therefore, the biosolid should not involve an annual total nitrogen application rate of more than 350 kg/ha, including other nitrogen sources (manure, urea, biosolids, etc.).

The environmental impact of the irrigation with leachate will be negligible as long as large nitrogen loads from other nitrogen sources are not applied in addition to the same soil. To highlight the low nitrogen exposure risk, it must be noted that:

- To highlight the low nitrogen exposure risk, it must be noted that
  - The average **nitrogen load** of leachate from PDBs treating ***1,000 m³/a*** *FS*, is **equivalent to the raw wastewater load from only about *20 PE*** (i.e. only 0,2 kg/d).
  - Urine,w hich has a much higher nitrogen concentration (ranging between 5,000 and 10,000 mg/l), is sometimes used in diluted form to irrigate and fertilize (with dilution ratio of 1:3 to 1:10 (500 to 3,333 mg/l)).
- Similarly, the average COD or BOD loads of leachate from PDBs treating *1,000 m³/a FS*, is equivalent to the raw wastewater loads from only about *5 PE* (i.e. only 0,4 kg_{COD}/d and 0,2 kg_{BOD}/d). Hence, the environmental impact from COD and BOD loads is negligible.

Assuming that the irrigation provides a nitrogen application rate of 350 kg/ha via leachate irrigation, the resulting annual hydraulic load would be about 200 to 300 mm/a, which is not negligible irrigation contribution, in particular in area with low rainfall and limited availability of irrigation water.

2.8.4 Direct Discharge with additional Treatment

2.8.4.1 Scope of Application

Discharge into a stream or swamp must be the last resort option. In such case, an additional treatment before discharge can be foreseen.

2.8.4.2 Vertical Flow Constructed Wetland

The main design principles are summarized below:

- Surface area: same as one bed of the PDB.

- Freeboard: 30 cm
- Filter body: same as PDB but with a filter layer thickness of 30 cm.
- A dedicated batch feeding system is not necessary. It will automatically result from the batch feeding of the PDB, even though it will be smoothened.
- Drainage and ventilation system: same as for the PDB.

2.8.4.3 Horizontal Flow Constructed Wetland

The main design principles are summarized below:

- Surface area: same as one bed of the PDB.
- Depth: 50 to 60cm
- Width/Length ratio: 1:2
- Bottom slope: 5‰
- Filter body: same sand as for the filter layer of the PDB.
- Entrance and outlet material: same fine gravel as for the transition layer of the PDB.
- It does not require an upstream sedimentation chamber.

2.9 Water Supply

2.9.1 Objectives

Water supply is essential to operate the plant:

- Watering the plants:
  - Start-up of the plant (PDB bed and CW): watering the plants.
  - In case of dry season and no FS deliveries, to maintain them in good condition.
- Preventive pipe flushing
- Cleaning

The provision of piped drinking water is possible but not mandatory, in particular if no public water supply network exist in the near surrounding of the FSTP (within a few hundred meters).

2.9.2 Options

Available relevant options have to be compared and are basically the following:

1. Public water supply network
2. New borehole or well (typically onsite), equipped e.g. with a solar pump.
3. Others, as far as available and relevant:
   a. Surface water.
   b. Water source

Electricity supply to the FSTP is not mandatory except if it is required for its water supply. Options for the provision of electricity shall also be considered. The selection of the water supply option shall base on a brief technical and financial comparison (including O&M costs).

Remark:
Rain-water harvesting can be foreseen at the operation but will only discontinuously provide negligible volumes that can only be used for cleaning purposes requiring small volumes.

2.10 Miscellaneous Works

2.10.1 Operation Building

In Uganda, theft risks are usually too high to leave FSTPs without attendance. Therefore and because the targeted FSTPs are small, it is recommended to combine the watchmen housing with the operation building.

The following layout view illustrates an example for a treatment capacity of 1,000 m³/a or higher. It consists in:

- A small office with a kitchen corner
- A room with a bed
- A bathroom with a shower and WC, communicating with the room
- A warehouse and workshop: to store and repair tools.

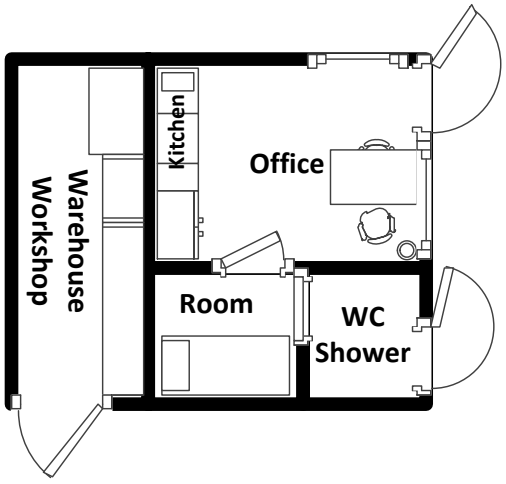


Fig. 2-17: FSTP standard operation building ($L_{hyd,a}$ = 1,000 m³/a)

Lower capacities FSTPs should be foreseen with smaller operation buildings (even a simple watchmen room with toilets). Generally, operation buildings should not be oversized since they would represent a too large share of the investment costs.

The toilet should be a pour-flush WC, since water shall be available for the FSTP operation. The produced wastewater can be treated with:

- a septic tank connected to a soak pit[22].
- a single lined leach pit[23].

2.10.2 Safety Measures

The site shall be fenced to prevent:

- Intruder for their safety
- Thefts

[22] Compendium of Sanitation Systems and Technologies, EAWAG, 2014, page 31
[23] Compendium of Sanitation Systems and Technologies, EAWAG, 2014, page 68-69

2.11 FSTP Layout Arrangement

Following figures show a compact FSTP arrangement for different treatment capacities.

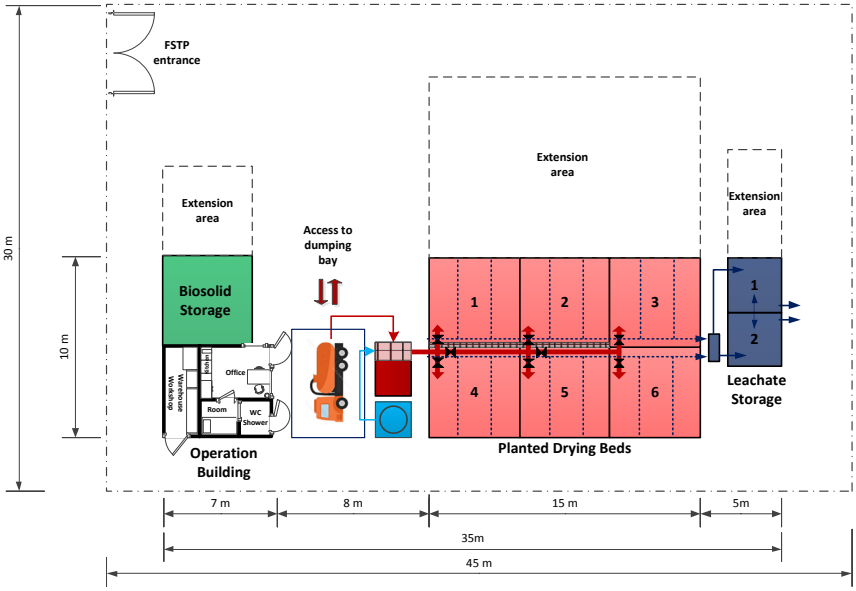


Fig. 2-18: FSTP standard arrangement: $L_{hyd,a}$ = 1,000 m³/a

Fig. 2-19: FSTP standard arrangement: Lhyd,a = 3,500 m³/a

<u>Remark</u>: The extension areas and more generally the unconstructed areas can be used for the application of biosolids and/or leachate recycling since it is also recommended to implement onsite agricultural activity to generate revenues and value the acquired land.

2.12 Costing

2.12.1 Objectives

The purpose of costing is to:

1. Keep the necessary total cost as low as possible (looking for the financially cheapest solution).
2. Ensure that all costs including O&M costs are sustainably financed.

2.12.2 Cost Estimates

Cost information is essential for proper planning, budgeting and implementation of sustainable FSTPs.

The different components of the costs, which are required for the construction and sustainable provision of the FSTP service during its lifetime, include:

- Initial investment costs: capital invested in constructing or rehabilitating the FSTP.
- Re-investment costs: expenditures on asset renewal depending on asset lifetime. Estimated lifetimes are given here:
  - PVC pipes: 30 to 50 a
  - Civil works and misc.: 30 to 50 a
  - Mechanical works[24]: 10 a
  - Electromechanical works: 5 to 10 a
- Residual asset values: values, used for a financing modelling for assets with lifetime that are not expired at the end of the modelling period.
- Annual operation costs:
  - *Personnel costs*: considering the small size of the FSTPs, they have to be detailed (staff type, number, costs, full/part-time, etc.), because it is a key parameter to reduce the costs.
  - *Other operation costs*: electricity, water, etc., estimated based on consumptions.
- Annual maintenance costs: expenditure on works implemented to maintain the facility in sufficient condition as long as possible. Estimates are proportional to the investment works:
  - PVC pipes and earthworks: 0.25%
  - Civil works and misc.: 1.00 %
  - Mechanical works[25]: 3.00%
  - Electromechanical works: 5.00%
- Financing costs: as far as relevant and provided by the Project Owner.
- Service delegation costs: as far as relevant, costs of the delegation of the service to a private company. The service to be delegated is to be defined by the Project Owner (operation? O&M? O&M and reinvestment? etc.). The costs refer here to the profit related to the provided service and the risks taken by this company.

[24] Pipes above ground, gate valves, screen, significant steel works
[25] Pipes above ground, gate valves, screen, significant steel works

Cost estimates should:

- Be sufficiently detailed to guarantee an accuracy of +-15%
- Be based on current market prices.
- Be estimated in strong currencies (EUR or USD) and if required in UGX.
- Include an amount for contingencies.

2.12.3 Option Comparison

The following key principles apply:

- Cost efficiency is given when the technical requirements are met sustainably at the lowest price. Options might be considered and compared to achieve this.
- Only relevant options have to be considered and compared. It might happen in designs that no comparison is relevant and required.
- The Guidelines already define rather precisely the treatment processes and option comparisons would thus rather concern only parts of the FSTP, e.g.:
    - Water supply (public water network extension vs. borehole? Solar borehole pump vs. public electricity network extension).
    - General altitude of the planned works (earthworks, ramp, etc.)
    - Etc.
- The financial comparison shall always consider all costs, i.e. not only the investment costs.
- The level of detail of the financial comparison shall be defined to be sufficient for the comparison sake (it also applies to the cost estimate). Hence it will usually not need a fully detailed net present value calculation.

2.12.4 Financial Analysis

Costs estimates shall be made as per section 2.12.2. Net present values shall be calculated based on these estimates (excluding the land acquisition costs) and according to the following principles:

- Calculation period of 20 to 30 years, including residual values.
- Use of a strong currency (EUR or USD).
- Annual cost increase rates: real inflation (i.e. not the monetary inflation) applicable to the planned costs.
- Annual discount rate (usually 3%).
- Annual volumes of sludge treated: a sensitivity analysis shall be made with 3 scenarii of volumes:
    - High estimate: 100 % of the design capacity
    - Intermediate estimate: 50 % of the design capacity
    - Low estimate: 20 % of the design capacity

Together with the NPV calculation to be modelled with annual steps, the designer shall establish a cash flow model by including annual revenues generated through the commercialization of recycling products as far as applicable and depending on the market prices:

- Biosolid

- Leachate
- Fodder (quarterly harvest of PDB and CW)
- Crops or trees (if onsite production[26]).

Specific service costs can be deduced for the 3 scenarii by dividing the NPV by the annual sludge volumes. Considering the uncertainty on the annual volumes of FS treated, it is not relevant to discount these volumes for the financial calculation.

Implementing the same calculation for the NPV but subtracted by the revenues from the commercialization of recycling products (average over the calculation period as well as annual evolution) will show the theoretical average specific net treatment costs for the 3 scenarii.

Charging FS Emptiers, thus indirectly their customers, with a dumping fee:

- Is usually not sufficient to fill the financing gap.
- Increases the existing gap between FS Emptying tariffs and the ability and willingness to pay, thus increasing the access to FS emptying services, which is already a major issue.
- Negatively affects the quality and relevance of the sludge delivery monitoring (see §7.1.2.2).

In any case, these specific treatment costs should be compared with the affordability and willingness to pay of the targeted end customers (see §1.3.3.1). This comparison shall highlight for the worst of the 3 scenarii (low volume of FS treated):

- Subsidizing needs for the sustainable financing and O&M of the FSTP.
- The impact on the access to FS emptying services.

Remark: it is recommended to previously make sure to have maximized cost savings (see §1.3.5, etc.) in order to minimize the subsidy needs.

In Uganda, like in similar contexts in developing countries, subsidies are usually eventually required to ensure the sustainable financing and O&M of the FSTP. The Project Owner shall indicate:

- what costs will be subsidized
- the origin of the subsidies
- a form of guarantee (budget, etc.).

[26] Either by the operator or delegated to a farmer.

2.13 Detailed Design Outputs (checklist)

1. **Report**
   a. Background (e.g. reference to updated National Faecal Sludge Demand Assessment and Feasibility Study)
   b. Results of appraisal update of demand for FS treatment and FSTP capacity
   c. Variants descriptions (if relevant)
   d. Brief design descriptions
   e. Cost estimates

2. **Annexes**
   a. Preliminary investigation results
   b. Design calculations
   c. Miscellaneous

3. **Drawings:**
   a. Overview map showing at least:
      i. the location of the planned TP
      ii. the targeted customers
      iii. transport distance contour lines (service areas if available)
   b. General layout showing:
      i. All planned works including
      ii. Discharge point
      iii. Roads
      iv. Landscaping works
   c. Hydraulic profile
   d. Layout view(s) and cross-sections of each work.
   e. Construction details as far as required.

4. **GIS data set** (update of Feasibility study, see §0)
   a. Administrative boundaries with population forecasts.
   b. Surveyed most probable customers including all related collected data.
   c. Other relevant base data (free surface waters and streams, water supply network, roads, etc.).
   d. Site identified and site selected (polygon layer)
   e. Transport distances and/or durations for each identified site (contour lines and raster data).
   f. Service areas for each identified site:
      i. Immediate
      ii. Intermediate
      iii. Distant

Remark: considering the results of the baseline study ([14]), ***it is recommended to always involve adequate international expertise for the detailed design****.*

3. AUTHORIZATIONS

3.1 Ongoing Regulation Revisions

A revised National Environment Act has been issued in May and replaces the former version of 1995. All depending sub-regulations are currently being revised, in particular following regulations via statutory instruments:

- Environment and Social Impact Assessment (SI No. 13/1998)
- Audit (SI No. 12/2006)
- Standards for Discharge of Effluent into Water or on Land (SI No. 5/1999)
- Waste Management (SI No. 52/1999)

Furthermore, a Consultancy is currently addressing the ***development of a National Standard for the treatment of faecal sludge for safe recycling and/or disposal***.

3.2 Current Requirements for Authorization Applications

The requirements for authorization requirements are current as follows. In case of modification, the Project Owners shall consider the requirements of the revised regulations.

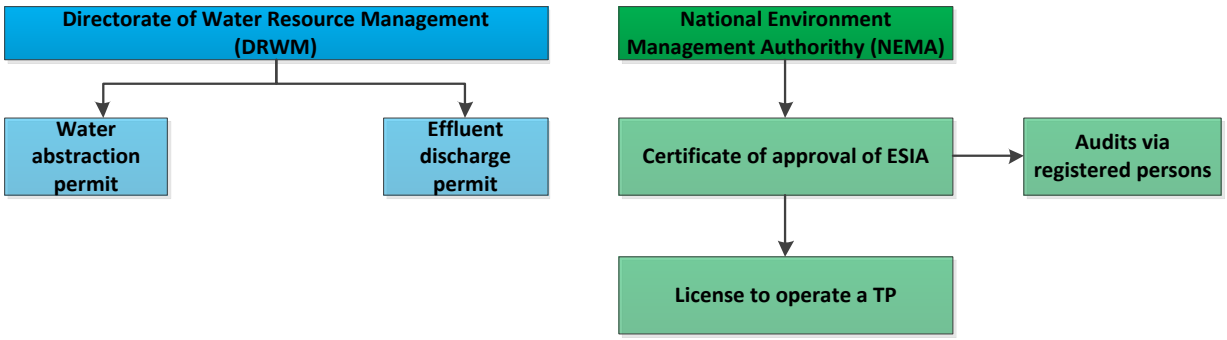


Fig. 3-1: Current authorization requirements[27]

- Effluent discharge permits are required for the leachate, even if it is recycled.
- Biosolids are not clearly subject to permits or requirements.

The permits and the certificate can define additional operation and monitoring conditions that are not included in the regulations, e.g. regarding effluent self-monitoring.

In 2019 only about 1/4 of the treatment plants have a discharge permit.

[27] Water abstraction permits are only applicable if water is produced onsite

It is very important to note that the requirements are the same for any size of FSTP and any effluent discharge environment. This principle is much more stringent than in industrialized countries, where small facilities benefit from lower requirements than larger ones, in terms of effluent standards/removal as well as permits. The objective is to achieve cost efficiency and allow sustainable costs for even small TPs.

E.g. in EU countries, following categories exist for WWTPs, with gradual increasing requirements:

1. Small TPs or OSS: < 12 kg_{BOD5}/d (< 200 PE):
2. Small TPs: 12 to 120 kg_{BOD5}/d (200 to 2,000 PE)
3. Small to medium to large TPs:
    a. 120 to 600 kg_{BOD5}/d (2,000 to 10,000 PE)
    b. 600 to 9,000 kg_{BOD5}/d (10,000 to 150,000 PE)
    c. >9,000 kg_{BOD5}/d (> 150,000 PE)

4. CONSTRUCTION

4.1 Construction Works Implementation

The case of construction works implemented by the Project Owner is not considered here but is possible, particularly for small FSTPs.

The Guidelines only address the usual case of construction works implemented by a private company through public procurement procedures.

The Design and/or Project Owner shall consider the applicable public procurement regulations, in particular the thresholds on the value of the construction works for the procurement method, sin it usually defines the level of complexity.

For instance, according to the Guidelines issued the 3rd March 2014 in Uganda, following thresholds have to be considered:

- > 500 Mio UGX: Open bidding
- 200 to 500 Mio UGX: Restricted bidding
- 10 to 200 Mio UGX: Request for quotation
- < 10 Mio UGX: Micro procurement

4.2 Contractors and their Low Capacities

Only **local construction companies** will be interested for the targeted construction works. The Project Owner must bear in mind that these capacities have **very low capacities**:

- Very low **human resources** (managerial) capacities, involving:
  - Managerial
  - Overseers (supervisors)
- Very low **financial resources** capacities:

The very low resources typically involve:

- Issues to understand and handle a construction contract.
- Issues to cost-efficiently organize the construction activities.

The resources and capacities of local construction companies cannot significantly improve within the next 5 or even 10 years.

On the other hand, contract documents are too often poorly defining the tendered works, which contributes to:

- Inadequate financial bids that can lead contractor into financial stress situation.
- A certain laxity in the contract implementation.

To tackle this issue, it is therefore very important to invest efforts in all activities that can prevent possible issues resulting from the very low capacities of local construction companies:

- The design and tendering documentation.
- During the procurement process to prevent misunderstandings.
- The construction supervision.

4.3 Procurement

4.3.1 Documentation for Tendering or Request for Quotation (RFQ)

4.3.1.1 Content

The Project Owner should tender in accordance with the applicable regulation and include at least the following documents:

- Bidding Procedures:
  - Instruction to bidders.
  - Evaluation and Qualification criteria (in case of tendering).
- Conditions of Contract.
- Detailed BoQ.
- Technical Specifications.
- Drawings.
- Detailed tentative work schedule.

The Guidelines should ideally be complemented with a standard set of tender documents.

4.3.1.2 BoQ

The BoQ shall be sufficiently and uniformly detailed, taking into consideration:

- The later measurement implications: the more items there are the more control efforts will be required during the construction supervision.
- Risks related to the use of too few items: the more items there are the more flexible is the Client and the less risk is taken.
- Deriving from local habits is possible but it is to make sure that local contractors notice it when preparing their bids.

The BoQ can base on the Civil Engineering Standard Method of Measurement (CESMM) of the Institution of Civil Engineers (ICE), but should not totally follow it since some of its principles are not the most adequate for the targeted construction works. E.g.:

- Not enough categories for small diameter and depths of pipeworks.
- No filter body items.
- Etc.

4.3.1.3 Technical Specifications

The technical specifications and the standards set in the tender documents should reasonably meet the real specifications and standards of the products and works that can **really** be supplied by the local contractors.

Unrealistic standards shall create issues during the construction supervision:

- Many bidders won't notice the standard difference or simply ignore it
- It potentially creates a competition distortion between bidders during the tendering process (those pricing the tendered standards vs. those pricing their lower usual standard).
- The later construction of underpriced items will be problematic.

The designer and Project Owner can, of course, try to raise the local standards, but this should be done with the greatest care, with requests of:

- Unit price calculations at the evaluation stage, in order to clarify item prices that are obviously too low.
- Work method statements.

It is very important that the bidders indicate the products that they commit to provide and fill the requested data-sheet form(s). This shall mainly concern industrially produced material:

- Sewer pipes
- Flanged piping (feeding pipeline)
- Gate valves
- HDPE liner
- Provider and origin of the filter body material (sand, fine grave and coarse grave).

4.3.1.4 Detailed Tentative Work Schedule.

This is important to compensate the lack of organizational capacity of local contractors. It shall be realistic and sufficient detailed to actually provide a light form of organizational program for the Contractor.

It shall show the:

- Milestones
- Control of key levels
- Testing activities (bed permeability, watertightness, etc.).
- Independent activities: what activity can only start after what other activity? E.g.
    - Drainage pipe laying of the PDB can only start after the provision with the provision of drainage material.
    - Work construction should always start from downstream (in particular sewer pipe laying).
    - Etc.
- Identification of the critical paths

4.3.1.5 Planting and FSTP Start-Up

It is not recommended to include the PDB (and CW) planting and the FSTP start-up in the construction contract, because:

- Local contractors are usually not willing and not able to implement it.
- It binds the contractor for a period of about 3 months.
- Local contractors are not able to assume the risk of failures through clogging and/or plant wilting, which would require to replace plants and/or filter bodies and restart the start-up process.

Hence, it is recommended that the FSTP Utility takes over the facility and implements the planting works and eventually the start-up process. A dedicated budget should be foreseen for that purpose:

- Planting
- Possible promotional subsidies for pit emptying in order to ensure FS deliveries
- Water required for the FS dilution

4.3.2 Bidders Evaluation

As indicated earlier, it is very important to ensure that the financial bids meet the required technical specifications (see §4.3.1.3).

4.3.3 Contract Award

There isn't yet enough positive experience of contract implementation to implement a lump sum contract.

It is recommended to foresee a conventional **unit price contract**, in order to allow more flexibility to the Client in particular regarding the quantities. Usually variations up to 25% are allowed without requiring the revision of the unit price.

4.4 Construction Supervision

It is recommended that the Engineer in charge of the construction supervision is also responsible for the tender document elaboration, in order to guarantee consistency and better efficiency.

4.4.1 Quality Management Principles

4.4.1.1 Preliminary Validations and Activities

Delays during the construction works are much more expensive than before their start. Therefore, it is recommended to not start the works before following is submitted to and validated by the construction supervisor:

- All construction or shop drawings and calculations.

- Grain size analysis results of the proposed filter body materials.
- Provision of an automatic optical horizontal level (professional and calibrated equipment, 1.5mm accuracy at 30m), available at full time onsite.
- Installation by a topographic surveyor of the first physical marks required for the planned works (corners, etc.). The marks can be made of reinforcement bars (6 or 8 mm) with warning tapes.

It is assumed that all main required method statements will be already clarified during the tender phase.

4.4.1.2 Communication

The communications are too often too formal (with only letters in hardcopies tolerated), thus contract actors are often limiting the use of written communication to the minimum and increasing the use of telephone or “mobile texting” communication.

It is recommended to revise these habits in order to extend the use of written communication, which is the only relevant type for control purpose and in case of litigation with regard to the contract implementation.

Following communication rules are recommended:

- Contractual and financial topics: *wide list of diffusion*
  - Letters with handwritten signature and stamp.
  - Considering the frequent large distance between Clients, Construction supervisor and Client, good quality scans can be sent via emails but with email receipt.
- Technical topics: *wide list of diffusion*
  - Emails.
  - Including scanned handwritten documents sent by email:
    - Pictures
    - Minutes of site inspection meeting
    - Site instructions
    - Control measurement results
    - Etc.
- Agreements of little importance (no or little impact in case of problem): *peer to peer communication*
  - Telephone
  - Mobile texting

4.4.1.3 Digital Filing System

When selecting a company to delegate construction supervision services, companies certified and applying ISO 9000 family standards for (Quality management) shall always be prioritized even if they are more expensive, because it is a good investment.

In any case, the construction supervisor has to keep a structure digital filing system. This is currently not or hardly the case with among local service providers (either public or private), and only with international companies.

All digital data shall be:

- Filed in an adequate and well-structured filing system by the construction supervisor.
- Safe backups of the filed files shall be made regularly (at least weekly).

This includes:

- Contractual data (main contract, addenda, claims, etc.)
- Correspondence (emails, letter)
- Reporting and minutes (inception, monthly or quarterly, minutes of meetings, final)
- Drawings, design calculations, method statements
- Control measurements
- Invoices and budget control
- Work schedules
- Test results, inspection results
- As-built documentation
- Classified pictures (at least by date)

4.4.2 Priorities of the Quality Management

Considering the current gap in terms of quality management, it is worth highlighting here the priorities for the construction supervision:

Particular care has to be given to following potential issues, with high risks. The impact of mistakes in pipe and works levels will eventually depend on the error and the work element concerned.

Tab. 4-1: Construction – Main risks

No.	Issue concerns:	Risk	Impact
1	Pipe and works **levels**	High	Low to High
2	Slope, perforation rate, density of **drainage pipes**	High	High (bed clogging)
3	**Grain sizes** of the filter media	High	High (bed clogging)
4	**Plant** shoots' and start-up	High	High (bed clogging)

4.4.2.1 Levels (altitudes) of Pipes and Works

For example, the topography was not sufficiently planned and controlled while setting the general levels of the Apac FSTP.

The construction did not start with the most downstream elements and the levels "as constructed" of the first works built were such that the effluent discharge pipeline had to be extended for more than 100m in order to be able to drain out by gravity the effluent to a discharge point.

Luckily, the site was large enough and the topography within the site allowed to compensate this error without requiring to exit the site limits and to negotiate for rights of easement with neighbours.

Therefore, we remind here key principles:

- All level controls have to be doubled:
  - The Contractor controls
  - The construction supervisor cross-checked (the construction supervisor basically has to distrust the contractor).
- Before starting the first works:
  - The Contractors has to control that the planned and existing levels are matching with the design. The construction supervisor has also to control it itself.
  - Always start the construction with the most downstream works (discharge point, leachate storage).
  - Installation by a topographic surveyor of the first physical marks required for the planned works (corners, etc.). The marks can be made of reinforcement bars (6 or 8 mm) with warning tapes.
  - Control the installed marks and levels.
- Before starting new works, along with the implementation of the construction works:
  - Installation of physical marks required for the planned works (corners, etc.).
  - Control the installed marks and levels.
- For the constructed works:
  - Control the levels.
- Do not authorize to resume the construction of works that would make difficult the control or the correction of built works that were not previously controlled. E.g. do not authorize start with:
  - The PDB wall construction if base levels were not previously controlled.
  - The PDB drainage layer installation if the PDB walls are not controlled.
  - Etc.

4.4.2.2 Drainage pipes: Slope, Perforation Rate and Density

If the drainage pipes are not adequately built, they can clog, which will require important correction works that will involve decommissioning beds and reducing the FSTP capacity during long period of at least 3 months.

Hence, it is essential to prevent such clogging issues and we remind here key principles:

- Before installation of the drainage pipe, control the adequacy of pipe and in particular the perforations.
- Pipes shall be laid on drainage material. Do not allow to lay pipes on support systems and fill afterwards until pipe level, because it is a sufficient compaction below the pipe becomes hardly possible.
- After laying the pipes:
  - Control the pipe orientation, including Y-connection fittings.
  - Control the pipe routings.
  - Control the pipe slopes.

4.4.2.3 Grain Sizes of Filter Body Layers

If the grain sizes of the installed 3 filter body layers (filter, transition and drainage) are not compliant with the requirements, it can involve a clogging of beds, which will require important correction works that will involve to decommission beds and reduce the FSTP capacity during long period of at least 3 months.

Hence, it is essential to prevent such clogging issues and we remind here key principles:

- Before the start of the construction works, the contractor has to submit grain size analysis for approval (see §4.4.1.1).
- Material delivered without receipt signed by the quarry producing it and indicating the material type as well as the date and hour of delivery shall not be accepted.
- The Construction Supervisor shall sample and make analysis of the material delivered at the construction site before authorizing its installation into the PDB.
    - At least 1 sample for each of the 3 layers
    - At least 1 sample for each delivery day of material.
    - The Construction Supervisor shall take more samples if the material delivered is visually different enough to have doubts, more samples shall be taken.
    - Care shall be taken to take homogeneous samples.
- The Project Owner shall:
    - not rely on the contractor,
    - but directly finance the sample transport and analysis (or via its construction supervisor),
    - select public laboratories.
- If and as long as analysis results reveal invalid material:
    - It shall not be allowed for installation and disposed offsite or reused onsite.
    - It shall be replaced by material that will have to be also analysed approval.
    - It shall be financed indirectly financed via the construction contracts with predefined penalties.

4.4.2.4 Plant Shoots and Start-Up

This is recommended to not be part of the Contractor's tasks (see 4.3.1.5 and 6.4.2)

4.4.3 Defect Notification Period (DNP)

The Contract has to clearly define the limit of responsibility of the Contractor during the DNP. It cannot be held liable or clogging during the DNP since the planting and start-up has to be implemented by the FSTP Utility, except if its responsibility can be demonstrated.

To prevent any clogging risk and discussion during the DNP, it is very important to successfully implement all the required tests before the start of the DNP, in particular those related to the grain size of the PDB filter bodies and the drainage systems.

5. HANDOVER AND AGREEMENTS

5.1 Land and Facility Ownership

Following scenarii have been identified as the most probable in the current context:

Tab. 5-1: Land and facility ownership scenarii

Scenario	Ownership	Phase 1: Project Implementation	Phase 2: FSTP Operation
MWE	Land	Local Government or MWE	Local Government or MWE
	Facility	MWE	MWE
NWSC	Land	NWSC	NWSC
	Facility	NWSC	NWSC
Private company	Land	Private company (Project Owner)	Private company (Project Owner)
	Facility	Private company (Project Owner)	Private company (Project Owner)

5.2 FSTP Operation

FSTPs are in a grey zone, at the interface with many actors, and no clear mandates. E.g. NWSC is clearly responsible for the “provision of water supply and sewerage services”, but not for FS treatment services. Nevertheless, it operates TPs where FS and WW are co-treated as well as dedicated FSTPs.

According to the practice and public policy, the public organisations that can be considered for the operation of FSTPs are:

- Umbrella Organisations: (MWE)
  - Deconcentrated actor that is depending on the Urban Water Supply and Sewerage Department of DWD (MWE).
  - Operating water schemes and support local water supply and sanitation services.
  - Usually in charge of very small towns or urban centres.

- NWSC:
  - Parastatal utility.
  - Operating water production and supply networks, WWTPs and FSTPs.
  - Usually in charge of small to large towns.

Formal mandates to operate a particular FSTP is given to these organisations via a gazetting process.

5.3 FSTP Handover

If the Project Owner (or developer) is not the FSTP Utility, the facility will have to be handed over to the future Utility operating.

It is proposed that the Utility takes over the facility at the start of the DNP (see §4.3.1.5), after an inspection of the FSTP, which aims at assessing the functionality of the facility.

5.4 Agreement "FSTP Utility / Pit Emptier / Local Government"

5.4.1 Agreement Form and Force

The current policy of Ugandan public organisations does not allow them to sign legally binding agreements with pit emptiers but to sign simple MoU.

To enforce as much as possible a non-legally binding document require a deeper commitment from all the parties, which is more risky and will require more efforts but will be more sustainable if it can be achieved.

5.4.2 Parties

The parties of the MoU shall be the:

- FSTP Utility.
- FS emptier(s).
- Local government.

5.4.3 Objectives of the Agreement

The immediate purpose of the MoU is to clarify the roles and responsibilities of each Party with regard to "*FS emptying and FS dumping at the FSTP*".

However, the following objectives are targeted and to be addressed:

- Create an enabling environment for the private sector to improve the service in terms of quality and tariffs for the customers:
  - Public support for promotion and marketing activities
  - Ensure fair, equal and stable conditions for all FS emptiers
  - Limit the administrative requirements to the strict minimum
  - Fair and for all equitable regulation enforcement
- Regulate the tariffs:
  - fair tariffs for service providers
  - fair and equal tariffs for all customers
- Create demand through:
  - Public support to promotion and marketing of FS emptying services
  - Better information on customer rights and fair tariffs
  - Fair and for all equitable regulation enforcement
- Improve the FSTP operation and monitoring:
  - Optimize the treatment capacity at any time of the year (optimize the availability of the plant for pit emptiers and their customers) through efficient dumping scheduling, variable dumping fees and efficient monitoring
  - Reduce the operating costs through optimized operation

    - Increase the revenues through resource recovery
- Sustain the FSM implementation:
    - Implement relevant monitoring activities
    - Implement cross controls/assessments of activates
    - Regularly assess the implementation of the MoU agreements
    - Regularly assess the need for MoU improvements/adaptations.

5.5 Agreement “FSTP Utility / Farmer(s)”

Similarly, it is recommended for the FSTP Utility to look for agreements with farmers in order to commercialize the biosolids or even the leachate.

6. OPERATION & MAINTENANCE

6.1 Staff Requirements and Responsibilities

6.1.1 Staff Requirements

Considering the very intermittent sludge deliveries but the need to always ensure the facility safety against theft, it is recommended to foresee the following staff:

1. **Plant attendant and main operator** (named hereafter *Plant attendant*)
   - Full time
   - Level 1 qualification
2. **FSTP responsible and supervisor** (named hereafter *Supervisor*)
   - Part-time
   - Level 2 to level 3 qualification

More staff members are not required to implement a cost-efficient O&M of the plant (this will usually be critical enough to be sustainably financed).

Remark:
If the theft risk is low enough, then following it is recommended to only foresee one person:

1. *FSTP responsible and main operator: part-time*
   - *Part-time.*
   - *Level 2 to level 3 qualification.*

Following table shows the differences in terms of responsibility between the two staff members. The Supervisor can be himself supervised by a superior, who will be in charge of controlling his/her performance and the resources (to some extent).

Tab. 6-1: Staff: Qualification description (responsibility)

Qualification description (responsibility)	Plant Attendant	Supervisor
Responsibility	Specific duties and tasks	FSTP global performance Include. subordinate performance
Complexity of tasks	Simple	Simple and sometimes complex
Subordinates	None	Yes
Supervisor	Yes	Yes
Financial and physical resources control	None	Moderate control

6.1.2 Remuneration

It is recommended to remunerate the staff members according to their performance.

Recycling via onsite agriculture might represent an interesting incentive potential for the Plant Attendant.

6.1.3 Duties and Tasks

The Supervisor should be able to implement all tasks of the Plant Attendant and train him accordingly. The main duties and the related tasks are summarized in the following table, which is also used for the establishment of the SOPs.

Tab. 6-2: O&M duties and tasks

No.	Duties and tasks	Plant Attendant	Supervisor	Frequency
A	***Administrative tasks and monitoring***			
A.1	Monitoring of climate data	X		Daily
A.2	Monitoring of all onsite activities	X		Daily
A.3	Control and analysis of onsite monitoring		X	Weekly
A.4	Control the plant attendant performance		X	≥ Weekly
B	***Organize FS deliveries***			
B.1	Actively coordinate the scheduling of FS deliveries		X	As required
B.2	Receive and schedule FS delivery requests		X	As required
C	***Receive FS and feed beds***			
C.1	Pit emptier reception[28]	X		At FS delivery
C.2	Prepare FS dumping[29]	X		At FS delivery
C.3	Control and direct FS dumping[30]	X		At FS delivery
C.4	Prepare and proceed to bed feeding	X		At FS delivery
C.4	Screening removal and disposal onsite	X		< next dumping
C.5	Screening disposal offsite		X	≥ Annually
D	***Biosolid management***			
D.1	Monitor the biosolid storage	X	X	As required
D.2	Control that biosolids can't be and aren't re-humidified	X	X	As required
D.3	Commercialize the biosolids	X	X	As required
D.4	Control the collection by the customer of the sold biosolid	X	X	As required
E	***Leachate management***			
E.1	Control selection and use of storage units	X		At FS delivery
E.2	Commercialize the leachate		X	As required
E.3	Control the collection by the customer of the stored leachate	X		As required
E.4	Monitor the leachate storage	X		At FS delivery
F	***PDB bed desludging and recommissioning***			
F.1	Harvest the plants	X		As required
F.2	Desludge	X		As required
F.3	Control the filter body material		X	As required
F.4	Organize the replacement of the filter body material[31]		X	As required
F.5	Bed planting	X		As required
F.6	Organize the bed start-up and control dilution rates		X	As required
F.7	Onsite watering and plant care	X		Daily
G	***Preventive maintenance and inspections***			

[28] Collect the payment receipt of the pit emptier customer
[29] Prepare pre-treatment work and PDB feeding line, direct pit emptier for FS dumping
[30] Including "Charge excessive screening" and "Refuse FS"
[31] Via a subcontractor

No.	Duties and tasks	Plant Attendant	Supervisor	Frequency
G.1	Control and take care of plants (watering, harvest, etc.)	X		Daily
G.2	Harvest the plants	X		Quarterly
G.3	Flush PDB feeding pipeline with water	X		≥ Monthly
G.5	Control tools	X		Monthly
G.4	Control functionality of valves	X		Annually
G.4	Service valves	X		Acc. manufacturer
G.6	Control pump[32]	X		Annually
G.6	Service pump	-[33]		Acc. manufacturer
G.7	General visual inspection	X		Daily
G.8	General site cleaning	X		Regularly
H	***Curative maintenance***			
H.1	Repair tools	X		As required
H.2	Repair valves	X		As required
H.3	Repair/Replace pump (borehole pump or mobile pump)	-[34]		As required
H.4	Unblock pipes	X		As required
H.5	Unclog beds (see ***F***)	X	X	As required
H.6	Misc. unpredictable	X	X	As required
I	***Onsite recycling of biosolids/leachate (optional[35])***			
I.1	Implement the onsite recycling of biosolids/leachate	X		Acc. crop / §2.7, 2.8
I.2	Control the onsite recycling of biosolids/leachate		X	Acc. crop / §2.7, 2.8
I.3	Crop harvesting	X		Acc. crop / §2.7, 2.8
I.4	Crop commercialization		X	Acc. crop / §2.7, 2.8
J	***Occupational health and safety requirements (OHS)***			
J.1	Use personal safety equipment	X		As required
J.2	Comply with other OHS guidelines	X		As required

6.2 Training

6.2.1 Training of Trainers

Training sessions were implemented during the Apac FSTP project. The objective was to train trainers (called national referents), who were supposed to remain closely involved with the practical operation of existing FSTPs.

6.2.2 Assessment and Training Package

In addition, to further develop and sustain human resources for O&M, an Assessment and Training Package (ATP) is currently developed for FSTP operators, on behalf of GIZ for the Directorate of Industrial Training (DIT), under the Business, Technical, Vocational Education and Training (BTVET) Act (2009).

[32] Borehole pump or mobile pump
[33] By an electromechanical expert
[34] By an electromechanical expert
[35] Only if the FSTP operator recycles itself the biosolids and leachate onsite

The ATP can be used by any training provider and/or those who wish to present themselves for Occupational Assessment and Certification.

This ATP will contain 3 parts, namely:

1. Job profile
2. Training modules
3. Assessment instruments[36]

6.3 Standard Operation Procedures

Templates of Standard Operation Procedures (SOPs) are given in Annex. They follow the main operation duties and tasks defined in section 6.1.3 and include Occupational Health and Safety (OHS) Guidelines.

6.4 Key O&M Duties and Tasks

Even though SOPs and OHS already provide detailed information, the lessons learnt from the treatment baseline study show that it is important to emphasize on some key principles of the operation, which are presented in the following sections.

6.4.1 PDB Planting

See §2.6.5.7.

6.4.2 PDB Start-Up

6.4.2.1 Principles

After planting, the plants need to be acclimatized and then fed with a gradual FS load increase. Following figure illustrates indicative durations for these 2 phases.

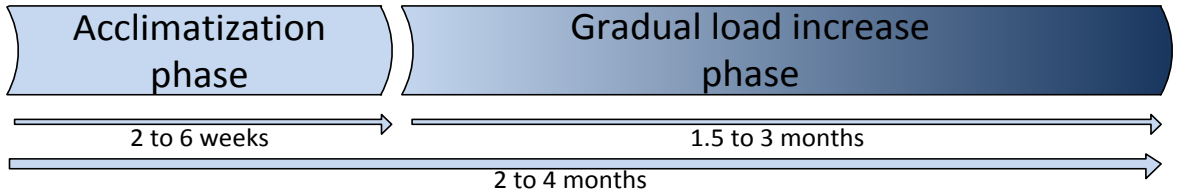


Fig. 6-1: FSTP start-up duration

During the acclimatization phase, it is recommended to:

- not apply very diluted FS (maximum 25% dilution rate),
- alternatively, use small dung or compost quantities at each shoot and water.

The experiences in Apac have proven that the acclimatization phase can be shortened to a few weeks only.

[36] Assessment (evaluation) of qualification acquired by the trainees

6.4.2.2 Example

The table below shows an example of start-up successfully implemented at the Apac FSTP:

Tab. 6-3: PDB start-up program and monitoring at Apac FSTP in 2019

Week no.	PDB bed no.								
	1	2	3	4	5	6	7	8	9
19	-	-	-	50%	50%	-	50%	50%	-
21	25%	25%	25%	25%	25%	25%	25%	25%	25%
23	25%	50%	25%	50%	50%	50%	50%	50%	50%
25	100%	100%	100%	100%	100%	30%	100%	30%	30%
27	-	-	40%	100%	-	-	-	-	100%
28	100%	100%	100%	100%	-	-	100%	100%	100%
29	100%	100%	100%	100%	100%	100%	100%	100%	100%

The indicated dilution rates represent the share of FS volume in the total volume (25% dilution rate signifies 25% of FS and 75% of water). The operator will also have to increase the dilution rate in case of very thick and fresh FS (indicators are brown colour, smell, higher DSC).

The dilution does not need to be accurate like in a laboratory. It requires the operator to be green-thumbed and have a good feeling of the plants evolution according to the loads. It is thus very important that it is always the same person(s) who implement a start-up.

The watering and/or diluted FS feeding should be adapted depending on the plant condition. Warning indicators are:

- Trends in the plants' condition (over days or a week)
- Yellowish colour
- Wilting (dryer and harder leaves)

Such decision are clearly illustrated by the preceding table with dilution rates reduction or longer resting periods depending on the plants status of each bed.

6.4.2.3 How to dilute?

To dilute, it is recommended to:

1. Dilute in the dumping work and with water available onsite (only FS is to be delivered).
2. Dilute offsite: if the FS collection vehicle allows to read the tank level (e.g. gauge).
    - Collect FS until the required level is reached.
    - Complement with water (e.g. from the nearest swamp).

6.4.2.4 Start-Up Failures

The following picture shows a drying bed, where plants are not grown up and even wilting.

Fig. 6-2: Mayuge FSTP – Wilted plants and weeds invasion

6.4.3 Organizing and Programming FS Deliveries

6.4.3.1 Fluctuating Instant Treatment Capacity

The capacity of the treatment plant varies according to the availability of the PDB. The maximum instant capacity of the FSTP is available if all beds are ready to be fed with FS.

For example, assuming 6 beds of 20 m² and an application depth 15 cm, the maximum instant capacity would be about 18 m³/d. This is to be compared with the 1,000 m^3_{FS}/a, thus 3.8 m³/d on average (5 days/week).

This will, however, involve that the FSTP cannot accept FS until the end of the dewatering period is over. This dewatering period will depend on:

- The FS characteristics
- The dewatering of each bed status before the FS feeding
- The climate during the following days or weeks.

As the following figure suggests it, the evapotranspiration and the rainfall vary in Uganda depending on the location, which might impact the dewatering performance variations along the year.

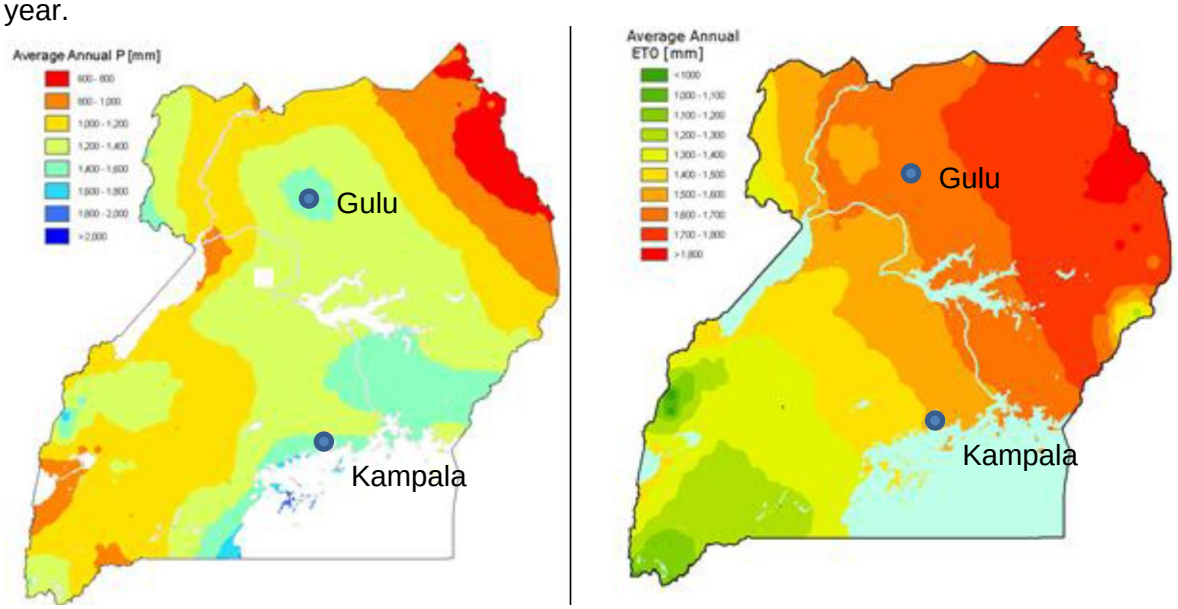


Fig. 6-3: Rainfall (left) and Evaporation (right) Maps of Uganda

(Source: National Water Resource Assessment of Uganda, 2012)

However, these data are not sufficient to predict these variations. It would require an empirical approach basing on representative monitoring data (FS deliveries and climate data) of FSTPs across the country.

6.4.3.2 Understanding the Challenge

The challenge for the FSTP Utility is that its FSTP capacity always meets the demand for FS treatment.

As previously indicated, the TP capacity fluctuates depending on the previously FS delivered and the climate. But the FS deliveries also fluctuate along the year.

Hence, as shown by the following figure, there can then be periods of the year with a gap between the TP capacity and the demand for FS treatment.

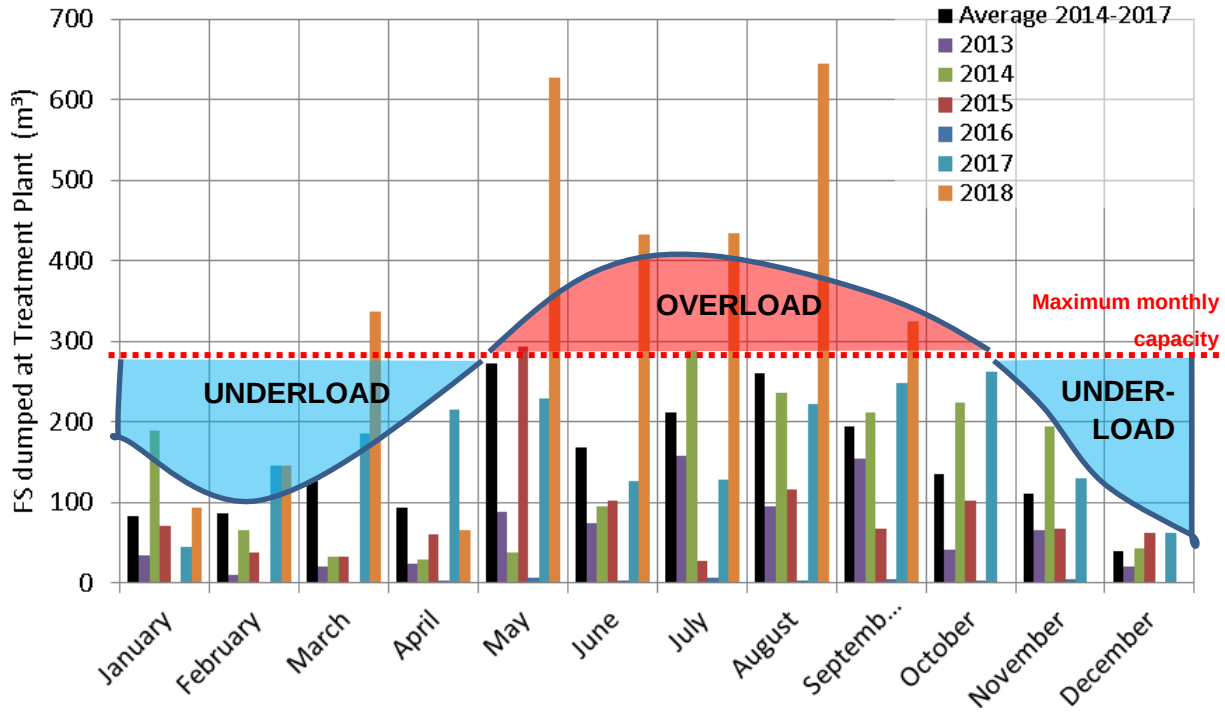


Fig. 6-4: Gulu: Monthly FS Volumes Dumped between 2013 and 2018

(Source: derived from NWSC dumping billing records, 09/2018)

It shows the case of Gulu, but this is typical to small towns, with usually higher demand during the rainy season or after school fee payment.

But these demand fluctuations can be to some extent regulated in order to avoid overloads and underloads, thus optimizing the distribution along the year of the FS deliveries and the FSTP utilization.

In the case of Gulu, the underload volume potential (blue areas) can more or less compensate the overload volumes (red area).

6.4.3.3 Overload Impacts

To clarify the high impact of overload, we refer to the existing TP of Ntungamo. It clearly shows the only problem: "**bed clogging**". The following, additional, statements are illustrated by the pictures shown below:

- Plants, which are meant to guarantee the permeability of the bed hardly exists. It can be noted that the bed with the most number of plants is not clogged.
- Some beds are so clogged, that the accumulation of liquid sludge involves anaerobic activity on the top of the beds.
- The same issue affects the vertical flow constructed wetland (picture on bottom right), which should normally not be prone to clogging, since solid loads are low. There are no more plants and grass is even slowly invading the surface.

Fig. 6-5: Ntungamo FSTP: bed overloading and clogging (2018)

In such case, the only solution is to desludge, remove the filter, transition and drainage layers, control the drainage pipes, reinstall a new filter body, replant the beds and restart the beds.

This will require significant efforts and at least 3 to 6 months before the beds can be fed again.

6.4.3.4 Coordination by the FSTP Utility

Hence, it has been shown the importance to not overload the FSTPs through better regulation of the dumpings. In order to achieve it, it is recommended that the **FSTP Utility coordinates the FS deliveries with the targeted customers**, whose number is limited enough to allow this coordination.

Even if it is not possible to precisely program all FS deliveries a few weeks or even months in advance, the minimum objective is that these customers call the FSTP Utility to request for treatment availability 1 or 2 weeks before the intending FS delivery.

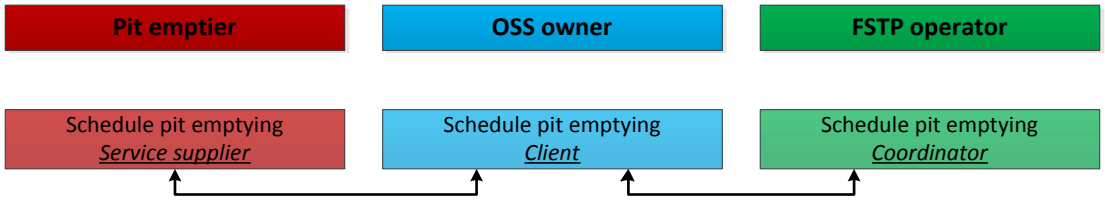


Fig. 6-6: Procedure for organizing and programming FS deliveries

7. MONITORING

7.1 Objectives and Principles

7.1.1 Objectives

The objectives of the monitoring are to collect data that will be used to:

1. Control the activities and assess the performance of the treatment plant.
2. Value the collected data in order to improve the O&M and the designs.
3. Control the compliance with the regulations.

7.1.2 Principles

Principles are derived from the treatment plant baseline study[37] of 2019, which has shown insufficient monitoring and data availability among the sector stakeholders.

Therefore, the following principles are recommended. The SOPs given in Annex are of course compliant with these recommendations.

7.1.2.1 Digital Tabular Data

Hardcopies are a very adequate format data recorded at the treatment plant by lower-skilled staff. But eventually data have to be available in digital and tabular form in order to allow their analysis and use.

7.1.2.2 Clean and High-Quality Data

The value of data is **not** the amount of data but their cleanliness and quality. “Dirty datasets” consist of wrong and/or incomplete data.

Dirty dataset are useless and can even be dangerous become their analysis will involve erroneous results, which can have later negative impacts.

Example: FS dumping records are frequently incomplete because some Utilities charge a dumping fee involving collusion risks thus non-recorded dumping and/or because of inconsistent monitoring. This underestimate can result in the planning of undersized treatment facilities, inadequate treatment facilities, etc.

Hence it is mandatory to include quality management measures (data cleaning) during the data production (monitoring), in order to ensure a sufficient quality.

- Give clear responsibilities along the monitoring chain, including explicit tasks of data controlling and cleaning.
- The earliest control and cleaning measures occur, the more efficient they are, because information gets lost along the monitoring chain.
- To be able to certify the quality of the data, it is required to:
    - Foresee controls and cleaning at different stages.
    - Collect data that allows cross-checking (same information but from at least 2 sources).

[37] [14]

  - Implement real and exhaustive random controls as required.
  - Implement controls of the data control and cleaning tasks.
- Raise interest and understanding of monitoring:
  - Interest for monitoring is basically the lowest at an early stage of the chain because the staff usually doesn't understand why they have to record data.
  - The staff in charge of the data analysis (rather at the end of the monitoring chain) shall be given the overall responsibility because they should understand that it is in their interest to analyse clean data: they shall generate interest and understanding along the monitoring chain.

7.1.2.3 Data Transparency and Availability

It is recommended that the MWE makes the Sector stakeholders to readily avail monitoring data, in order to allow their monitoring activities at national scale and foster the cooperation, which will help to define measures that will improve the service delivery for the Ugandan population.

It is recommended to enforce but also to make understand that and how monitoring can help them.

For example, it can help:

- To positively illustrate the provided services (m^3 of FS treated, m^3 or tons of biosolids valued, etc.).
- To identify and highlight real cases that are efficient, good, etc.
- Etc.

7.1.2.4 Online Monitoring

During the past year many mobile applications and webservers were developed and used in various fields to allow decentralized data entries and collection in developing countries.

- It definitely allows generating and availing a lot of data, which shall fill a current important gap ([14]).
- But it allows only limited online data analysis and usually only limited quantities of data (much less than what is required for all objectives of the monitoring). Therefore, it cannot and should not be the only monitoring tool.
- Moreover, these software hardly include data control and cleaning tools, which require more complex and extended programming.

In conclusion, online monitoring can foster and complement offline and decentralized data monitoring, however, it cannot and should not replace it. It will generate data but focus has to be given to offline and decentralized data monitoring (see SOPs), which will allow to meet all formulated monitoring principles.

For the case of the targeted treatment plants, it is recommended to:

- Not use mobile applications, because:
  - There is no need to enter data in the field and a webserver (or equivalent).
  - Data entry is much less convenient and efficient than with a laptop or desktop computer.

- Supervisors should be the ones to enter the data and they should have a desktop or laptop computer.
- Stepwise develop a webserver, which could initially base on the existing UPMIS server.

7.1.3 Types of Monitoring

The monitoring can be divided into two categories:

- Self-monitoring:
  - Implemented by the Utility
  - For all objectives (no. 1, 2 and 3)
- External monitoring:
  - Implemented by external Authorities
  - For objective no. 3

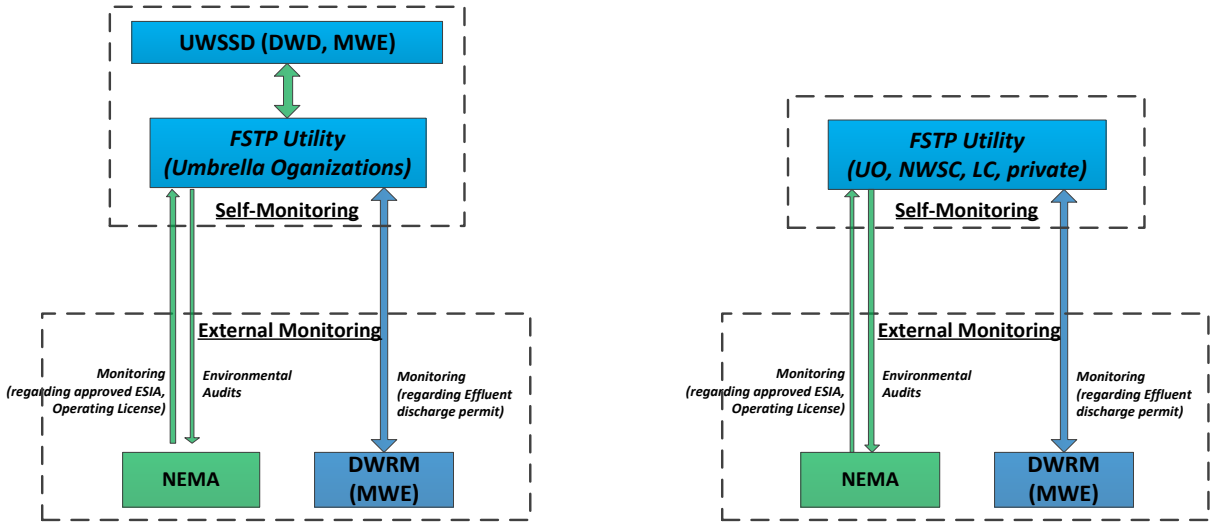


Fig. 7-1: Monitoring types (right: general cases; left: UO is the Utility)

The Guidelines focuses on “Self-Monitoring” and not on “External Monitoring” because the latter results from legal and regulatory requirements.

7.2 Self-Monitoring by the FSTP Utility

7.2.1 Standard Operating Procedures for Monitoring

All guidelines for data monitoring are given in detail in the SOPs (see in Annex). Following sections only provides additional and more general information.

7.2.2 Quality Management Procedures and Staff Performance

7.2.2.1 Data Recording

The data to be monitored must take into consideration the limited skills of the Plant Attendant, while collecting a minimum of data. Hence the **monitoring templates shall be simple and clear**, e.g. requiring for him to:

- Record as much as possible “numbers or crosses”, instead of long text. This will also ease the further processing of the data.
- Of course, only foresee “paper” records (analogue records)

The recorded data will have to:

- controlled and cleaned by the Supervisor,
- entered digitally in an excel file.

The Supervisor shall use the same excel files used to print out the monitoring books of the Plant Attendant.

The **data control and cleaning shall be a key task of the supervisor** and shall consist of:

- Plausibility of the data recorded by hand by the Plant Attendant (incl. cross-checking with other data like pit emptier receipts)
- Correct the data as required, after consultation of the Plant Attendant

It is recommended that the supervisor implements these tasks monthly in order to prevent that:

- The Plant attendant forgets information.
- Have a regular control of the FSTP activities.
- Improve the data entering (an annual frequency would involve a large data amount, which cannot allow to maintain good data quality).

At the end of the year, the Supervisor shall:

- Compile the monthly excel files (data) into a single excel tab and
- Proceed to basic data process:
  - Monthly averages and diagram showing evolutions
  - Annual sums
- Provide relevant comments to abnormal data.

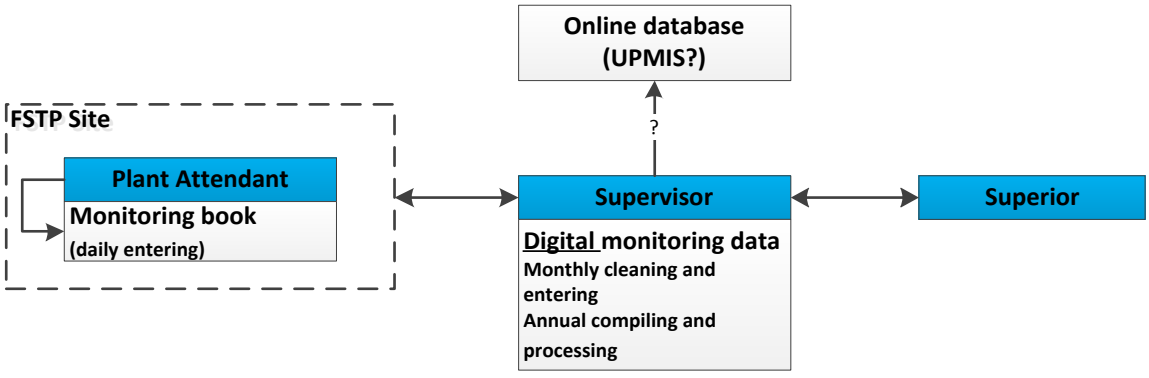


Fig. 7-2: Self-monitoring and quality management

7.2.2.2 Staff Performance Indicators

To assess the performance of the **Plant Attendant**:

- Are all data recorded?
- Number of corrections required.
- Inadequate O&M events (e.g. wrong bed fed, followed by a clogging or plant wilting).

To assess the performance of the **Supervisor**:

- Are all the data digitally entered?
- Are the data digitally entered supplied on time to its superior:
  - Monthly files
  - Annual files
- Are the digital data supplied to its superior clean?
- Are the comments provided for to abnormal data relevant?
- The Supervisor should also be liable to the FSTP performance, to the extent of the resources made available to him and its responsibilities.

It is recommended to foresee relevant incentive remunerations based on these indicators and others. This should be designed with the greatest care, i.e. consider possible strategies that employees can use to distort the incentive rules.

7.2.3 Climate Data

Climate data are very important to the objective no. 2, improve the O&M and the designs, because it will allow to better understand the reactions to the climate variations regarding:

- Dewatering capacity
- Plant growth

It is recommended to measure:

- Temperature
- Rainfall
- Hygrometry (if possible)

For more details about the equipment and its installation, please refer to the Annex.

7.2.3.1 Temperature

The Operator has to measure daily the maximum and minimum temperature each day. The average of both values will be the average day temperature.

Digital (electronic) thermometer should be avoided because of the power need and the usual poor quality of the equipment. See following pictures of appropriate thermometers:

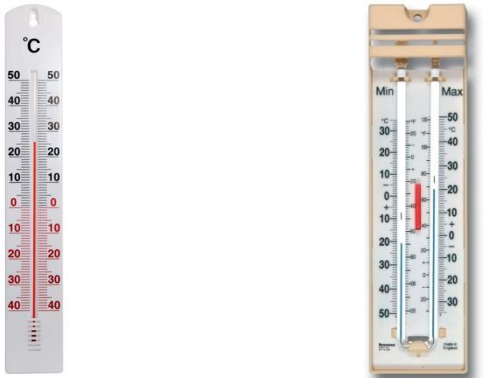


Fig. 7-3: Thermometer (left: normal; right: with min and max records)

- If the thermometer is a normal thermometer, the Operator shall read the temperature at fixed times, when the temperatures are the lowest and highest:
  - At about 6:00: minimum
  - At about 18:00: maximum

- If the thermometer records the minimum and maximum, the Operator shall:
  - read the measurement during the day, between the times when the temperatures are the lowest and highest, and
  - immediately reset the min/max measurement, so that the thermometer is ready for the next measurement (the reset method depends on the thermometer).
  - The reading will provide the maximum of the previous day and the minimum of the current day (reading day). The recording has to be made accordingly.

7.2.3.2 Hygrometry

- Hygrometer measure the air humidity in %.
- Since the hygrometer and the thermometer are to be installed next to each other, it is recommended to read the measurement at the same time.

7.2.3.3 Rainfall

- Rainfall should be read daily at a fixed time.
- After the reading, the fallen water has to be removed from the gauge in order to be ready for the next measurement day.
- For example, the following figure shows a rainfall of about 15mm.

Fig. 7-4: Rain gauge reading

7.3 Operation Indicators

Remark: Regulatory indicators are per definition in accordance with current regulations (see Chapter 3), which are currently under revision.

Considering the current gaps, it is recommended to first focus on indicator measuring the implementation of the monitoring activities:

- At Utility level (see SOPs)
- Between the MWE (or other Authorities) and the Utilities.

The Ministry should get every year all digital monitoring data and an O&M monitoring report with:

- Basic operation indicators.
- A general analysis of monitoring data: annual and monthly figures, sludge application rates, relevant comparisons (e.g. with capacity), etc.
- Information on all particular events: breakdowns, issues, etc.

The operation indicators should comprise by order of priority:

- First priority:
  - FS volumes delivered at the FSTP: daily, weekly, monthly and annually.
  - Sludge application rates (volumes on drying beds): weekly, monthly and annually.
- Second priority:
  - FS origin and type.
  - Climate data: daily, weekly, monthly and annually.
- Third priority:
  - O&M costs by categories (staff, etc.): monthly and annually
  - Valued quantities of biosolids and/or leachate.
  - Revenues: monthly and annually
  - Accidents records (see OHS guidelines under SOP).

8. ANNEXES

Annex 1: Standard Design Calculations

Annex 2: Standard Operating Procedures (Templates)

Annex 3: Monitoring Forms (Templates)

Annex 4: Meteorological Monitoring Equipment

Annex 1

Standard Design Calculations

Description		Unit	Standard Capacities								
Loads	**Annual hydraulic load**	**m³/a**	**500**	**1.000**	**1.500**	**2.000**	**2.500**	**3.000**	**3.500**	**4.000**	**5.000**
	Average weekly hydraulic load	m³/wk	10	19	29	38	48	58	67	77	96
	Average daily hydraulic load (5d/wk)	m³/d	2	4	6	8	10	12	13	15	19
	TS concentration	g/l	30	30	30	30	30	30	30	30	30
	Annual TS load	kg/a	15.000	30.000	45.000	60.000	75.000	90.000	105.000	120.000	150.000
Beds	Maximum TS loading rate	kg/m²/a	250	250	250	250	250	250	250	250	250
	Minimum total surface area	m²	60	120	180	240	300	360	420	480	600
	Total surface area	**m²**	**60**	**120**	**184**	**240**	**300**	**360**	**420**	**480**	**608**
	No. of beds	**nr**	**2**	**6**	**8**	**12**	**12**	**12**	**12**	**12**	**16**
	Nr of bed rows	nr	1	2	2	3	3	3	3	3	4
	Nr of beds in a row	nr	2	3	4	4	4	4	4	4	4
	Bed surface area	m²	30	20	23	20	25	30	35	40	38
	Bed with	m	5,5	4,5	4,8	4,5	5,0	5,5	5,9	6,3	6,2
	Bed length	m	5,5	4,5	4,8	4,5	5,0	5,5	5,9	6,3	6,2
Leachate	Nr of drainage systems	nr	1	2	2	3	3	3	3	3	4
	Dumping work storage volume	m³	6,0	4,0	4,6	4,0	5,0	6,0	7,0	8,0	7,6
	Leachate production rate	-	50%	50%	50%	50%	50%	50%	50%	50%	50%
	Annual leachate production	m³/a	250	500	750	1.000	1.250	1.500	1.750	2.000	2.500
	Average weekly leachate production	m³/wk	4,8	9,6	14,4	19,2	24,0	28,8	33,7	38,5	48,1
	Minimum storage volume	m³	4,8	9,6	14,4	19,2	24,0	28,8	33,7	38,5	48,1
	Storage units	nr	2	2	2	3	3	3	3	3	4
	Storage depth	m	1,5	1,5	1,5	1,5	1,8	2,0	2,0	2,0	2,0
	Storage length and width	m	1,7	3,5	5,0	4,4	4,5	4,8	5,7	6,5	6,0
	Storage volume	m³	5,1	10,5	15,0	19,8	24,3	28,8	34,2	39,0	48,0
Biosolids	Accumulation depth in each bed	m	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8
	Minimum storage volume	m³	24	16	18,4	16	20	24	28	32	30
	Storage length	m	5,5	4,5	4,8	4,5	5,0	5,5	5,9	6,3	6,2
	Storage width	m	5,5	4,5	4,8	4,5	5,0	5,5	5,9	6,3	6,2
	Storage surface area	m²	30	20	23	20	25	30	35	40	38
	Storage average heigth	m	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8
FSTP Site Surface Area	Site width (without extension)	m	30,0	30,0	35,0	40,0	41,5	43,0	45,0	47,5	55,0
	Site length (without extension)	m	30,0	45,0	50,0	50,0	51,5	53,0	55,0	57,5	60,0
	Site surface area (without extension)	m²	900	1.350	1.750	2.000	2.137	2.279	2.475	2.731	3.300
	Safety factor (future extension)	-	50%	50%	50%	50%	50%	50%	50%	50%	50%
	Total site surface area	m²	1.350	2.025	2.625	3.000	3.206	3.419	3.713	4.097	4.950
	Total site specific surface area	m²/(m³/a)	2,70	2,03	1,75	1,50	1,28	1,14	1,06	1,02	0,99

Annex 2

Standard Operating Procedures (Templates)

Facility type	**Faecal Sludge Treatment Plant (FSTP)**
Location	**Apac**

Document Description

Number	**-**
Title	**Occupational Health and Safety Guidelines**
Targeted Staff	**Plant attendant, supervisor**

Scope and responsibilities

No.	Tasks	Plant Attendant	Supervi-sor	Frequency
C.1	Pit emptier reception	X		At FS delivery
C.2	Prepare FS dumping	X		At FS delivery
C.3	Control and direct FS dumping	X		At FS delivery
C.4	Prepare and proceed to bed feeding	X		At FS delivery
C.4	Screening removal and disposal onsite	X		< next dumping
C.5	Screening disposal offsite		X	≥ Annually

Issue and Revision Record

No.	Date	Author(s)	Checker	Description
1	**__.__._20__**			**Initial version**

Read by

No.	Name	Title	Signature	Date
1				**__.__._20__**

1. What are the main hazards?

a) Infection by pathogens via skin contact

Pathogens can infect and then sometimes transmit diseases to humans. Main pathogen categories at the treatment plant are the following:

- Helminths eggs
- Bacteria and viruses

Impacts:

- Diseases from helminths can be particularly serious.
- Diseases from bacteria or virus infections can have little impact but in some cases also high impacts.

In the case of the targeted small treatment plants, the main infection route is the **skin contact** with:

- Raw faecal sludge: infection risk is the highest (highest pathogen doses).
- Biosolid (dewatered faecal sludge of planted drying beds): infection risk can negligible too high, depending on the length of the resting period as well as on the temperature and moisture of the biosolid during its resting period (doses are diminishing).
- Leachate: infection risk is low.

In addition, infections can occur via indirect contact with one of these pathogen carriers, if they have infected elements, with which the skin can get in contact: this can typically the case of the soil.

Other infection risks and routes (inhalation, etc.) are negligible for the targeted treatment plants.

Remarks on the pathogens categories and control measures:

- Helminth eggs are very resistant and can survive several months under mild and wet conditions. But they are well reduced through filtering or sedimentation treatment methods because of their large size. This is why they are mainly present in raw faecal sludge, they can disappear in the biosolids if the resting period and conditions are adequate and they are non-present in the leachate.
- Bacteria and viruses are usually dying within a few weeks.
- Hot and dry conditions are the best to reduce both types of pathogens (via die-off).

b) Accidents followed by injuries

There may be injuries by:

- Slips and falls on wet surfaces.
- Falls from/into high/deep works of the treatment plant.
- Tools (sharp, heavy, etc.).

These risks and their impacts vary depending on the treatment plant and their works.

c) General assessment of hazards and impacts

Considering the rather low operation activities related to these small treatment plants, the risks are low. **Risk control measures should not be unnecessarily overdesigned**.

2. What are the persons at risk?

Persons who are the most exposed to the previously described hazards are:

- Plant Attendant: high exposure
- FS emptiers: high exposure
- Supervisor and occasional treatment plant visitors: low exposure

3. Responsibilities

Utility in charge of the operation of the treatment plant (Employer):

- The employer shall appoint only competent personnel as supervisors, who shall be responsible for the safety of those under his or her supervision.
- The plant attendant shall require a supervisor to observe and enforce all safety rules.
- The employer shall provide adequate equipment, tools, and protective devices, and insist upon their proper use and maintenance.
- The employer, or designated representative, shall fully investigate all serious accidents and take remedial steps to prevent repetition of similar accidents wherever possible.
- The employer shall be responsible for safety records and shall be responsible for completing safety inspections and maintaining records to reflect findings and corrective actions taken.
- The employer shall require employees to use suitable tools and equipment in order that they may perform their work in a safe manner.
- The employer shall require employees to be instructed in safe methods of performing their work.

Supervisor:

- Supervisors are at all times responsible for the execution of the work in a safe manner and for the job performance of all personnel under their direction.
- Supervisors will be held accountable for all accidents and employee actions unless investigation indicates the actions were due to conditions beyond the supervisor's control.
- Supervisors shall instruct all new employees on the reporting of all accidents and the prompt receipt of first aid.
- Supervisors shall be responsible for the training and instruction of new employees and of employees transferred to their supervision.
- Supervisors shall fully understand and comply with the safety rules. They shall also ensure that safety rules are understood by the operators under their supervision.
- Supervisors shall insist on employees observing these safety rules of this document and shall use disciplinary measures, if necessary, to obtain compliance.
- Supervisors shall be responsible for the proper use of safety devices and equipment by the employees under their supervision.
- Supervisors shall be responsible for the regular inspection of all tools and equipment, including employees personal tools used while working under their supervision.
- Supervisors shall ensure no duties are assigned to an individual who is unqualified or incapable of completing those duties safely.
- Before leaving a job, the supervisor shall see that the site is left in as safe a condition as possible. The supervisor shall arrange adequate warning of any condition that might endanger other employees, the general public, or inspectors.

Plant Attendant:

- It is the definite responsibility of the Plant Attendant to so perform assigned duties while at work to assure:
  - Safety for self;
  - Safety for fellow employees;
  - Protection for the other persons onsite;
  - Protection for company property.
- It is the responsibility of the Plant Attendant to report to the Supervisor in charge all unsafe conditions or acts witnessed on the job.
- When the Plant Attendant is requested to perform duties under unsafe conditions, the Plant Attendant should not perform those duties without first notifying the Supervisor in charge of the unsafe conditions.
- It is the responsibility of management to verify that the Plant Attendant is acquainted with the principles of first aid as soon as possible.
- It is the responsibility of the Plant Attendant to attend all safety meetings possible and to take an active part in safety work.
- It is the responsibility of the Plant Attendant to know and understand the safety rules of this document, which will apply to the work being performed.

4. Location of this Document

These Guidelines must be printed out and be located at the treatment plant and filed into a binder, in order to be accessible at any time to any employee at the treatment plant.

These Guidelines must be read and fully understood by the Supervisor and the Plant Attendant.

5. Exposure control measures

a) Vaccination

The Employer should ensure that the Plant attendant and the supervisor are vaccinated for:

- Diphteria, Tetanus, Polio
- Hepatitis A

b) Deworming (Preventive chemotherapy)

- Deworming can be done once a year but is not mandatory (usually with mebendazole or albendazole pills).
- It is rather recommended to pay attention to possible symptoms and if any doubt arises, then seek immediately a physician. Possible symptoms:
  - Abnormal fatigue (anaemia)
  - Stomach ache (intestinal pains inflammation and damages)
  - Etc.

c) Define and ensure separation of clean and dirty surfaces / objects

- Dirty surfaces / objects are carrying high pathogen numbers, which might infect you and the infection might cause you a disease.
- It is very important to define surfaces / objects, which are and shall remain "dirty" (this is unavoidable and normal), as well as surfaces / objects, which are and shall remain "clean". For example, eat in designated areas, which you are sure that they are really clean.
- Furthermore, it is important to avoid that dirty objects (e.g. tools in frequent direct contact with sludge) contaminate clean surfaces / objects. Therefore ensure areas for storage of clean and contaminated equipment and personal effects are segregated (separate from eating facilities, and other clean areas).

d) Handwashing*: minimize exposure time and risks*

Hand washing does not prevent the skin contact but it is essential to ***minimize the exposure time*** and it also <u>minimizes the spreading of pathogens</u> with your dirty hands touching surfaces / objects which should remain clean.

- **Wash hands thoroughly with soap and water**
  - <u>Before</u>:
    - Eating and drinking.
    - Before and after using the bathroom.
    - Getting in contact with "clean surfaces" (incl. shaking hands).
  - <u>After contact</u> with:
    - Raw sludge
    - Biosolids
    - Leachate
    - "Dirty" surfaces".

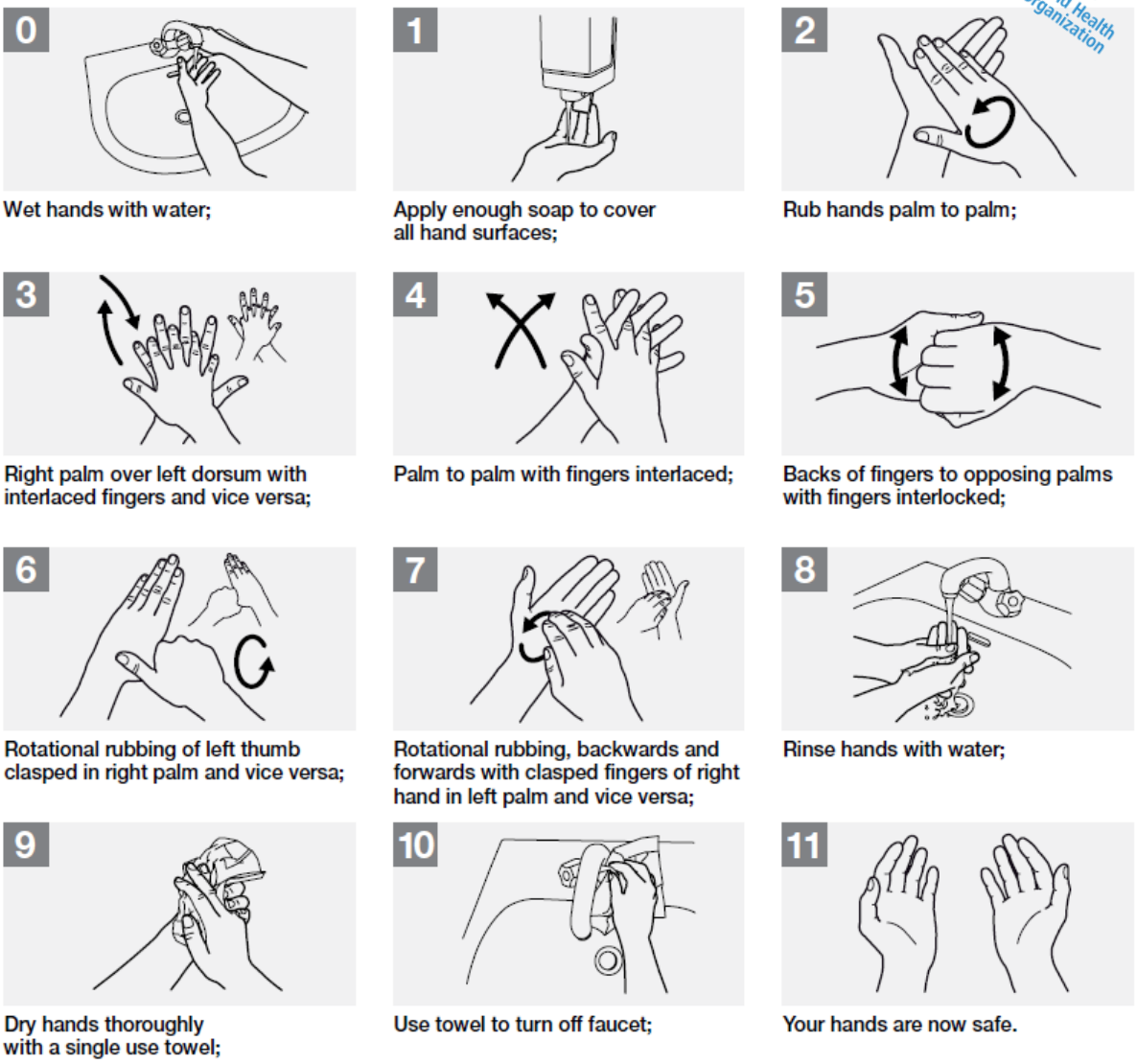
Bear in mind that the raw sludge has the highest concentration of pathogens and can represents high doses.

- **Hand washing or hand rubbing?**
  - In any case, hand washing is adequate and soap is usually the most accessible product.
  - Hand rubbing with an antiseptic can provide more efficiency, but if you have soiled hands, then hand rubbing is not sufficient, because the visible dirt has to be removed with water before the hand rubbing.

- **How to wash hands with soap?** Soap and its alternatives to hand washing: solid (left) and liquid/foamy (middle) soap and liquid detergent (right).

Duration of the entire procedure: 40-60 seconds

World Health Organization



Note that it is recommended to close the tap using the towel in order to avoid a recontamination (because you have previously opened it with your unwashed hands). If you don't have a towel, then use some other clean object/surface, which might not expose you.

- **How to hand rub?** Usual hand rubbing products are antiseptic liquids or alternatively ash.

e) Personal Protective Equipment (PPE): minimize skin contact (exposure risks)

Use barriers between your skin and the sludge / biosolids in case of potential contact:

- Hands:
  - Wear **liquid repellent gloves**.
  - Keep short nails to improve the impact of the handwashing.
- Feet:
  - Wear gumboots if you have to step into sludge, biosolids or leachate.
  - Wear of sandals or open toe shoes is prohibited in order to minimize the exposure risk via foots.
- Eyes:
  - Considering the low exposure risks and impact, goggles are not mandatory. Instead, following alternative preventive measures are recommended.
  - When dumping sludge or opening the flow with a gate valve, particularly at the start of the flow:
    - Do not approach too much

        - Don’t direct your eyes to the expected splashing point or hide your eyes.
- Rest of the body:
    - Wear work clothes.
    - The use of overalls or overcoats is not mandatory. It is the cleanliness of the clothes, which is important. The Plant Attendant must have at least 2 sets of work clothes, which have to be used alternatively and only for work at the treatment plant.

Adequately segregate your PPE from clean areas and clean it frequently in order to avoid contamination of clean surfaces/objects:

- The Plant Attendant must have:
    - Specific footwear and clothes for the work, and which can get dirty
    - Other footwear and clothes off the work.
- The Plant Attendant must remove contaminated PPE (gloves, footwear and clothes) after completion of a job
- The Plant Attendant must clean the PPE as soon as it becomes dirty and change it or them for clean PPE.
- The Plant Attendant must wash at work before changing into clean clothes and footwear.

f) Biosolid handling

- At the treatment plant site, biosolids can only be handled without protection equipment if the analysis of a representative sample shows that it is safe.
- In all other cases:
    - Use gumboots, gloves and adequate clothes to avoid any contact with the biosolids

g) Accident and injury prevention

- Wear a safety vest if a FS emptier delivers sludge very late and it has become dark. In other cases, the very low risks do not justify the use of a safety vest.
- Risks of falling objects are very low or inexistent. Therefore, it is basically not necessary to wear a safety helmet and safety shoes, which might rather hinder the Plant attendant and increase accident risks.
- Before commencing any work that may be hazardous, care should be taken to establish a safe procedure. Where more than one worker is engaged in the same job, all of them shall be concerned and understand the procedures to be followed to prevent endangerment to self or other personnel on the job. Under no circumstances shall safety be sacrificed for speed.
- Worker(s) shall always place themselves in a safe and secure position. The care exercised by others shall not be relied upon for one’s own protection.
- No guard shall be removed from any machine or piece of equipment except to perform required maintenance.
- Housekeeping:
    - Materials and supplies used at a plant site should be stored in a neat and orderly manner at the site to prevent them from falling off of shelves or else.
    - Junk parts removed from a piece of equipment should be disposed of in a proper manner.

    - Spare parts used in the operation of a treatment plant should be kept in a neat and orderly manner with the item labelled to indicate on what piece of equipment the spare part is used.
    - The treatment plant premises shall be sufficiently maintained to maintain a safe access to any part of the treatment plant as required for its O&M.
- Reporting hazardous conditions:
    - When an employee observes a hazardous condition that may cause injury or property damage, the employee shall report it promptly to a proper authority and when necessary, guard it.
    - An employee who receives a report of a hazardous condition, either from the general public or another employee, shall immediately refer this information to the person or utility responsible for such matters.

6. First Aid

a) Skin contact

- In case of skin contact with faecal sludge or biosolids:
    - Thoroughly cleanse all exposed surfaces with soap and water.
    - Use antiseptic to disinfect.
- In case biosolids contact eyes, flush eyes thoroughly, but gently.
- In case of massive skin contact (not simple splashes), wound contact or of eye contact, immediately seek medication attention.

b) Accident and small injury

- In case of small wounds:
    - cleanse thoroughly with water and disinfect with antiseptic,
    - install a bandage (hands must have been previously washed),
    - Seek medication attention immediately.
    - Inform your Supervisor.
- In case of small contusion, sprain, etc., which is hindering you:
    - Seek medication attention immediately.
    - Inform your Supervisor.
    - If you can't move and should be transported, don't try to move by your own means but call/request transportation assistance.

c) Accident and serious injuries

As already indicated, risks are low, but in case of serious injuries, knowing what not to do in an emergency is just as important as knowing what to do. The original injury may be magnified by the wrong kind of treatment or mishandling.

If a victim must be transported, ensure that methods described in a standard first aid text are used. With neck or back injuries, particularly, serious damage may occur by improperly transporting the victim. If possible, the victim should remain at the site where the injury occurred until a physician arrives, rather than risk an increase to the injury through mishandling.

1. Keep the victim lying down.
2. Examine the victim - look for serious bleeding, lack of breathing, and poisoning.
3. Keep the victim warm.
4. Call a physician or ambulance (or send someone to)
5. Remain calm. Do not be rushed into moving the victim unless absolutely necessary.
6. Never give an unconscious victim anything to eat or drink.
7. Keep the crowd away from the victim.
8. Ensure the victim is comfortable and cheerful.
9. Don’t allow the victim see his injury.

7. Health Impact Reporting and Monitoring

a) Reporting

Report in detail to your Supervisor in all following cases:

- Serious skin contacts (wound contact or of eye contact)
- Disease symptoms:
    - cramping stomach pains, diarrhoea, vomiting
    - yellowing of the skin
    - symptoms of breathlessness, chest tightness and wheezing
    - redness and pain of the eyes
    - skin rash and/or pain
    - etc. (any unusual symptom identified by the employee)
- Injuries resulting from accidents
- Medical diagnostics
- Medical leave periods

b) Monitoring

The Supervisor shall digitally compile and analyse all the reported facts and events, in order to be able to:

- provide an annual brief on the topic,
- improve the OHS guidelines as required.

Facility type	**Faecal Sludge Treatment Plant (FSTP)**
Location	**Apac**

SOP Description

Number	**A.1-2**
Title	**Administrative Tasks and Monitoring**
Targeted Staff	**Plant attendant**

Scope and responsibilities

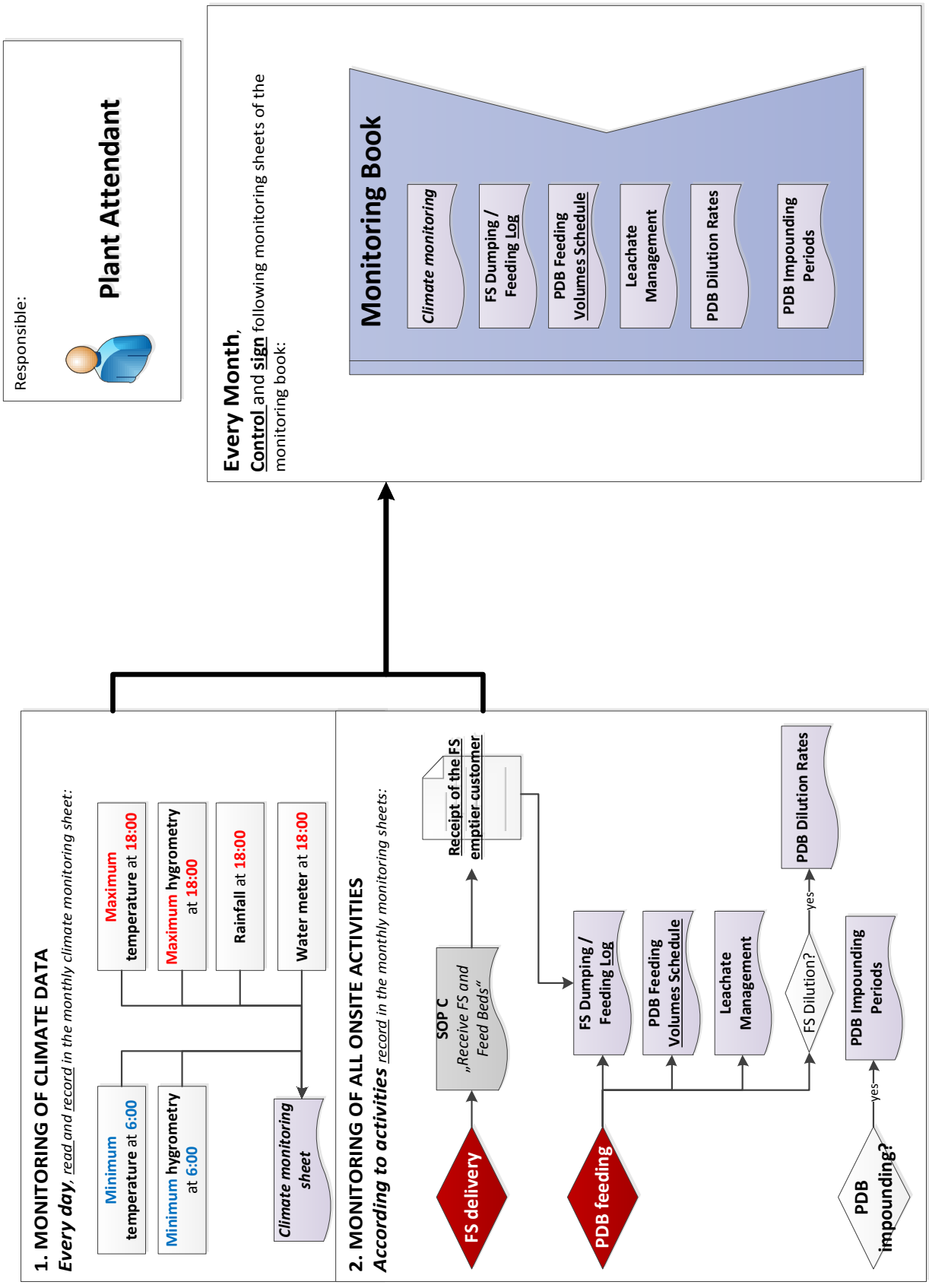
No.	Tasks	Plant Attendant	Supervi-sor	Frequency
A.1	Monitoring of climate data	X		Daily
A.2	Monitoring of all onsite activities	X		Daily

Issue and Revision Record

No.	Date	Author(s)	Checker	Description
1	**__.__._20__**			**Initial version**

Read by

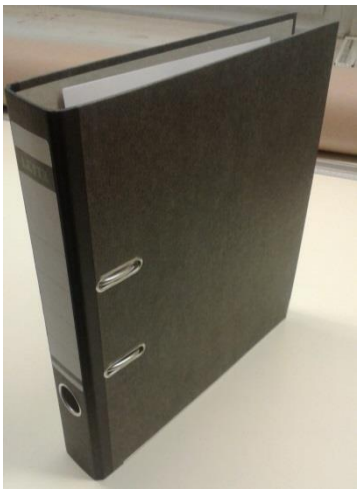
No.	Name	Title	Signature	Date
1				**__.__._20__**


Responsible:
Plant Attendant
Every Month,
Control and sign following monitoring sheets of the monitoring book:
Monitoring Book
Climate monitoring
FS Dumping / Feeding Log
PDB Feeding Volumes Schedule
Leachate Management
PDB Dilution Rates
PDB Impounding Periods
1. MONITORING OF CLIMATE DATA
Every day, read and record in the monthly climate monitoring sheet:
Minimum temperature at 6:00
Minimum hygrometry at 6:00
Maximum temperature at 18:00
Maximum hygrometry at 18:00
Rainfall at 18:00
Water meter at 18:00
Climate monitoring sheet
2. MONITORING OF ALL ONSITE ACTIVITIES
According to activities record in the monthly monitoring sheets:
FS delivery
SOP C „Receive FS and Feed Beds"
Receipt of the FS emptier customer
PDB feeding
FS Dumping / Feeding Log
PDB Feeding Volumes Schedule
Leachate Management
FS Dilution?
yes
PDB Dilution Rates
PDB impounding?
yes
PDB Impounding Periods

Procedure

Preliminary remark

The “monitoring book” or “monitoring binder” consists of the hardcopies of the monitoring tables, with handwritten values.



These hardcopies must remain at the FSTP in case of internal (within the Utility in charge of the O&M of the treatment plant) or external control (governmental Authorithies, e.g. MWE , etc.).

It is very important to number the drying beds (and effluent management facilities as far as required) and that everybody knows and uses the same numbering system. If not, all the monitoring work will be jeopardized and even worthless.

1. Monitoring of Climate Data

a) Read the temperature

Read daily the maximum and minimum temperature. The average of both values will be the average day temperature.

Digital (electronic) thermometer should be avoided because of the power need and the usual poor quality of the equipment. See following pictures of appropriate thermometers:

Simple thermometer :

Thermom. recording min and max:

- If the thermometer is a normal thermometer, read the temperature at fixed times, when the temperatures are the lowest and highest:
  - At about 6:00: minimum
  - At about 18:00: maximum

- If the thermometer records the minimum and maximum, the Operator shall:
  - read the measurement during the day, between the times when the temperatures are the lowest and highest, and

- immediately reset the min/max measurement, so that the thermometer is ready for the next measurement (the reset method depends on the thermometer).
- The reading will provide the maximum of the previous day and the minimum of the current day (reading day). The recording has to be made accordingly.

b) Read the hygrometry

- Read daily the hygrometry on the hygrometer. Hygrometers are measuring the air humidity in %.
- Since the hygrometer and the thermometer are to be installed next each other, it is recommended to read the measurement at the same time. Hence, read the temperature at fixed times, when the temperatures are the lowest and highest:
  - At about 6:00: minimum
  - At about 18:00: maximum

c) Read the rainfall

- Rainfall should be read daily with the rain gauge. It is recommended to read it at the same time as the temperature, i.e. at 18:00.
- After the reading, the water fallen into the rain gauge has to be removed from the gauge in order be ready for the next measurement day.
- For example, this rain gauge picture shows a rainfall of about 15mm.

d) Read operation measurement data:

- Read daily the water meter.
- Any other operation data, according the treatment plant type (e.g. electricity meter)

e) After each reading, immediately write the value in the record book (or monitoring book). See table example below:

FSTP Apac — Originator (name, date, signature): _____

Climate and misc. — Checker (name, date, signature): _____

Year: **2019**

Month	Date	Day	T°C min	T°C max	T°C ave	Hygr am	Hygr pm	Hygr ave	Rainfall	Waterme ter inde	Watermet. Consumpti ion	Comment
January	01	Tue	17	29	23	52%	1%	26%	0	134,0	0,8	
January	02	Wed	18	30	24	67%	2%	34%	0	135,0	1,0	
January	03	Thu	16	32	24	59%	25%	42%	0	135,0	0,0	
January	04	Fri	18	30	24	70%	10%	40%	5	135,3	0,3	
January	05	Sa	17	32	25	86%	8%	47%	0	135,7	0,4	

- Year, month, date and day: it is your supervisor's task to prepare and provide blank hardcopies of the climate monitoring table, with ideally already entered year, month, date and day.
- Temperature:
  - T°C min: minimum temperature (e.g. read at 6:00). Unit is °C (Celsius) and NOT °F (Fahrenheit).

  - T°C max: maximum temperature (e.g. read at 18:00). Unit is °C (Celsius) and NOT °F (Fahrenheit).
  - T°C ave: average temperature. Do not enter it. It is only meant for your supervisor.
- Hygrometry:
  - Hygr am: hygrometry in the morning, when you read the minimum temperature (e.g. read at 6:00). Unit is %. For example: for 85%, enter 85.
  - Hygr pm: hygrometry in the afternoon, when you read the maximum temperature (e.g. read at 18:00). Unit is %. For example: for 85%, enter 85.
  - Hygr ave: average hygrometry. Do not enter it. It is only meant for your supervisor.
- Rainfall: enter the rainfall read at the rain gauge. Unit is mm (millimetre).
- Watermeter: enter the value read at the water meter of your piped water supply system (either public water supply network or own water production system). Unit is m³ (cubic metre).
- Watermeter consumption: Do not enter it. It is only meant for your supervisor.
- Comment: use the comment field in case of unusual event that will help to later understand the entered values. For example in case of water leakage (unusual high water meter readings, etc.).

f) Each month, control and sign the climate monitoring sheet (1 sheet per month), with your entered values. You (the plant attendant) are the originator.

FSTP Apac — Originator (name, date, signature): _____

Climate and misc. — Checker (name, date, signature): _____

Year: **2019**

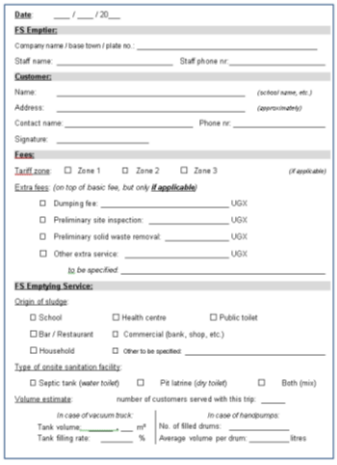
1	2	3
4	5	6
7	8	9

Month	Date	Day	T°C min	T°C max	T°C ave	Hygr am	Hygr pm	Hygr ave	Rainfall	Watermeter inde	Watermet. Consumption	Comment
January	01	Tue	17	29	23	52%	1%	26%	0	134,0	0,8	

2. Monitoring of all onsite activities

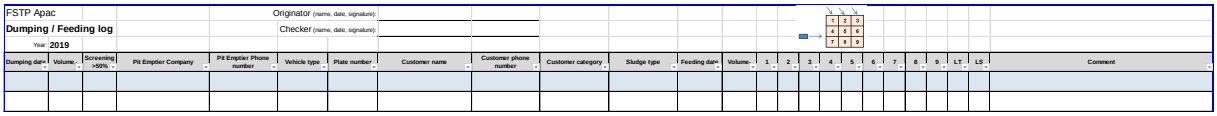
a) Pit Emptier Customers' Receipts

- Receive and annotate the receipts according to SOP "C-Receive FS and Feed Beds".
- All receipts have to be immediately filed in binders and sorted by date (newest receipts are to be filed above oldest receipts).


Date ___ / ___ / 20___
FS Emptier:
Company name / base town / plate no.: _____
Staff name: _____ Staff phone nr: _____
Customer:
Name: _____ (school name, etc.)
Address: _____ (approximately)
Contact name: _____ Phone nr: _____
Signature: _____
Fees:
Tariff zone: ☐ Zone 1 ☐ Zone 2 ☐ Zone 3 (if applicable)
Extra fees: (on top of basic fee, but only if applicable)
☐ Dumping fee: _____ UGX
☐ Preliminary site inspection: _____ UGX
☐ Preliminary solid waste removal: _____ UGX
☐ Other extra service: _____ UGX
to be specified: _____
FS Emptying Service:
Origin of sludge:
☐ School ☐ Health centre ☐ Public toilet
☐ Bar / Restaurant ☐ Commercial (bank, shop, etc.)
☐ Household ☐ Other to be specified: _____
Type of onsite sanitation facility:
☐ Septic tank (water toilet) ☐ Pit latrine (dry toilet) ☐ Both (mix)
Volume estimate: number of customers served with this trip: _____
In case of vacuum truck: Tank volume: _____ / ___ m³ Tank filling rate: _____ %
In case of handpumps: No. of filled drums: _____ Average volume per drum: _____ litres

b) FS Dumping / Feeding Log

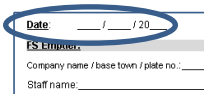
Fill in the fields according to the receipts received from the FS emptiers (see SOP "C-Receive FS and Feed Beds").



FSTP Apac
Dumping / Feeding log
Year: 2019
Originator (name, date, signature):
Checker (name, date, signature):

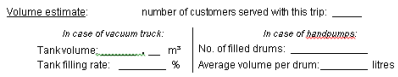
Dumping date	Volume	Screening >50%	Pit Emptier Company	Pit Emptier Phone number	Vehicle type	Plate number	Customer name	Customer phone number	Customer category	Sludge type	Feeding date	Volume	1	2	3	4	5	6	7	8	9	LT	LS	Comment

- Dumping date: date of the sludge delivery and umping at the treatment plant. It is not necessarily the date of the bed feeding, which can occur at the same day, but also at another day.



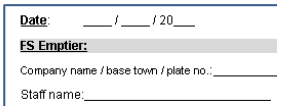
Date: ____ / ____ / 20___
FS Emptier:
Company name / base town / plate no.:____
Staff name:_____

- Volume: Volume measured at the dumping work (use the ruler).
  If no dumping work or else allows that onsite measurement, then use estimate given by the FS emptier and indicated at the bottom of the receipt.



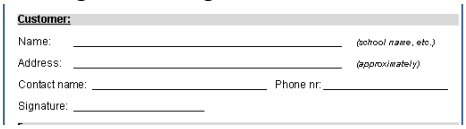
Volume estimate: number of customers served with this trip: _____
In case of vacuum truck: Tank volume:_____, __ m³ Tank filling rate: _____ %
In case of handpumps: No. of filled drums: _____ Average volume per drum:_____ litres

- Screening >50%: Indicate if you have charged the FS emptier with a fee for "high screenings' volume".
- Pit Emptier company: company name of the FS emptier, as indicated on the receipt. Do not enter here the name of the driver of the vehicle.



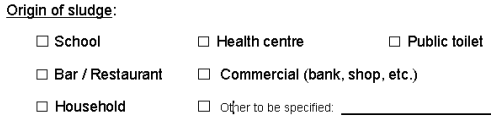
Date: ____ / ____ / 20___
FS Emptier:
Company name / base town / plate no.:_____
Staff name:_____

- Pit Emptier phone number: enter the phone number of the person representing the FS emptier company, as indicated on the receipt.
- Vehicle type: enter
  - Either "***vacuum truck***"
  - Or "***handpump***", if the FS was pumped with handpumps (for example, gulpers or rammers) and transported in drums on a pickup or on a truck.
- Plate number: enter the plate number of the vehicle delivering the sludge.



Customer:
Name: _____ (school name, etc.)
Address: _____ (approximately)
Contact name: _____ Phone nr:_____
Signature: _____

- Customer name: enter the name of the customer of the FS emptier. It is the owner and/or user of the emptied onsite sanitation facility (toilet). What you enter must indirectly designate a location, where the emptied toilet is located. Hence, only enter the name of a person if it is a household and in all other cases enter the name of the institution (school, restaurant, public toilet, etc.). The name that you enter for a particular customer must always be the same: we must not get multiple names for the same customer. This last requirement applies on the long term: never vary the names, even after months or years.
- Customer phone number: enter the phone number of the customer of the FS emptier. It is the owner and/or user of the emptied onsite sanitation facility (toilet).
- Customer category: enter the phone number of the customer of the FS emptier. Do not create new categories, but use the categories of the receipt handed over by the FS emptier.



Origin of sludge:
☐ School ☐ Health centre ☐ Public toilet
☐ Bar / Restaurant ☐ Commercial (bank, shop, etc.)
☐ Household ☐ Other to be specified: _____

- Sludge type: enter the type of the onsite sanitation facility from which the sludge originates. It can be either from a septic tank or from a pit latrine or from a mix of both types (septic tank and pit latrines, if more than a toilet was emptied for the same trip).

Type of onsite sanitation facility:
☐ Septic tank (*water toilet*) ☐ Pit latrine (*dry toilet*) ☐ Both (mix)

- Feeding date: this is the date, when you feed a bed with the particular sludge that was delivered. It is usually the same day as the delivery date, but it can be later if you want to wait for additional sludge or if you want to wait until a bed is ready to accept sludge.
- Volume: enter the volume that has fed a drying bed.

  *It is usually the same as the delivered volume. It can only be more if you have added water: in this case, enter the initial sludge volume **+** the added water volume.*

  Be aware than you can have 1 bed feeding event with 2 different sludge deliveries, if you need 2 deliveries to get sufficient sludge volume to allow a bed feeding.
- No. of fed drying bed no.: when feeding a bed with the delivered sludge, tick the drying bed no. that was fed.
- LT: if applicable, indicate the number of the unit for leachate treatment, which was used.
- LS: if applicable, indicate the number of the unit for leachate storage, which was used.
- Comment: use the comment field in case of unusual event that will help to later understand the entered values.

c) PDB - Feeding volumes schedule

- Fill in the fields according to your bed feeding activities.
- Each numbered column (e.g. 1 to 9 for Apac FSTP) represents a drying bed.
- Enter the volume fed in the right column (fed bed) at the right day.
  - For example: 4.5 m^3 for bed no. 6 on the 2nd of January.
  - You don't need to enter the unit. It has to be always m^3 (cubic metre).
  - The volume that you enter has to be read from at the dumping work before feeding start (use the ruler).
  - If there is no dumping work that allows an onsite reading of the volume, then estimate it based on the estimate on the FS emptier customer receipt handed over by the FS emptier.
  - It should normally never occur, but if you feed the same bed on a single day, then enter the cumulated volume fed that day (the addition of the 2 volumes fed), and enter a comment accordingly.
- Note that you should use this table to schedule future sludge deliveries:
  - Because it clearly shows you the interval period between 2 feedings for the same bed.
  - Use a pencil and a rubber.
  - Enter the scheduled delivery under the field "comment" at the scheduled delivery date. Don't erase that entry.
  - Tick the beds that you intend to use.
  - In case you need to modify the schedule:
    - Erase with the rubber the ticks
    - Cross (and don't erase it) the related comment and indicate cancelled, postponed. etc., so that anybody else reading your book can understand what happened.
    - If postponed, proceed as previously indicated for the newly scheduled date.

FSTP Apac — Originator (name, date, signature):

PDB - Feeding volumes — Checker (name, date, signature):

Year: **2019**

Month	Date	Day	1	2	3	4	5	6	7	8	9	Comment
January	01	Tue										
January	02	Wed										
January	03	Thu										

d) PDB - Dilution rates

- Fill in the fields according to your dilution activities, when feeding drying beds:
  - 75% dilution rate means
  - 100% rate means that you have fed the bed with only water.
- The dilution occurs:
  - Normally only during PDB start-up phases: monitoring is important to better understand and optimize start-up phase.
  - Exceptionally in case very thick or high-strength FS is delivered: monitoring is important to follow-up critical operation activities.
- Comment:
  - Use it to monitor particular status of plants: for example plants that are wilting, or turning yellow. In this case, clearly indicate what bed is concerned by your comment.
  - Indicate the bed re-planting.
  - Use the comment field in case of unusual event that will help to later understand the entered values.
  - Pencil within columns.

FSTP Apac — Originator (name, date, signature):

PDB - Dilution rates — Checker (name, date, signature):

Year: **2019**

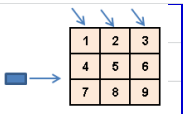
Month	Date	Day	1	2	3	4	5	6	7	8	9	Comment
January	01	Tue										
January	02	Wed										
January	03	Thu										

e) PDB - Impounding periods

- Impounding drying beds means that you have installed a piping system at the drying beds drainage outlet, which is made of a bend + vertical straight pipe. This system raises the invert level of the outlet and thus the water level in the upstream bed.
- It can be used to provide the plants access to water through their roots, for example during the dry season and low dumping activity.
- A bed should not be impounded more than 1 week, in order to avoid anaerobic process in the bed.

- The sludge content rate (or indirectly the dilution rate) must be entered according to your dilution activities when feeding drying beds:
  - 100% rate means that you have fed the bed with only sludge.
  - 75% rate means that there is 75% of sludge and 25% of water.
  - Etc.
- You don't need to write the unit (%): simply indicate the number (e.g. 75 instead of 75%).
- You don't need to always (for each feeding) indicate 100 if you're not adding water: it is only required to enter a value if the rate is <100.

FSTP Apac — Originator (name, date, signature):
PDB - Dilution rates — Checker (name, date, signature):
Year: **2019**

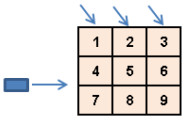


Month	Date	Day	1	2	3	4	5	6	7	8	9	Comment
January	01	Tue										
January	02	Wed										
January	03	Thu										

f) Leachate Management

- LT: tick the number of the unit for leachate treatment, which was used.
  - If applicable.
  - You must tick daily the activated unit, because you can get leachate from natural rainfall at any day, thus not necessarily when you have FS bed feeding events.
- LS: tick the number of the unit for leachate storage, which was used:
  - If applicable.
  - Usually, you will have only one storage unit used by day,
  - but you it can happen that you use more than one (if the previous one is full before end of the FS deliveries/feedings).
  - You must tick daily the activated unit, because you can get leachate from natural rainfall at any day, thus not necessarily when you have FS bed feeding events.
- Comment: use the comment field in case of unusual event that will help to later understand the entered ticks.

FSTP xxx — Originator (name, date, signature):
PDB - Leachate Management — Checker (name, date, signature):
Year: **2019**



Month	Date	Day	LT1	LT2	LT3	LS1	LS2	LS3	Comment
January	01	Tue							
January	02	Wed							
January	03	Thu							

Facility type	**Faecal Sludge Treatment Plant (FSTP)**
Location	**Apac**

SOP Description

Number	**A.3-4**
Title	**Administrative Tasks and Monitoring**
Targeted Staff	**Supervisor**

Scope and responsibilities

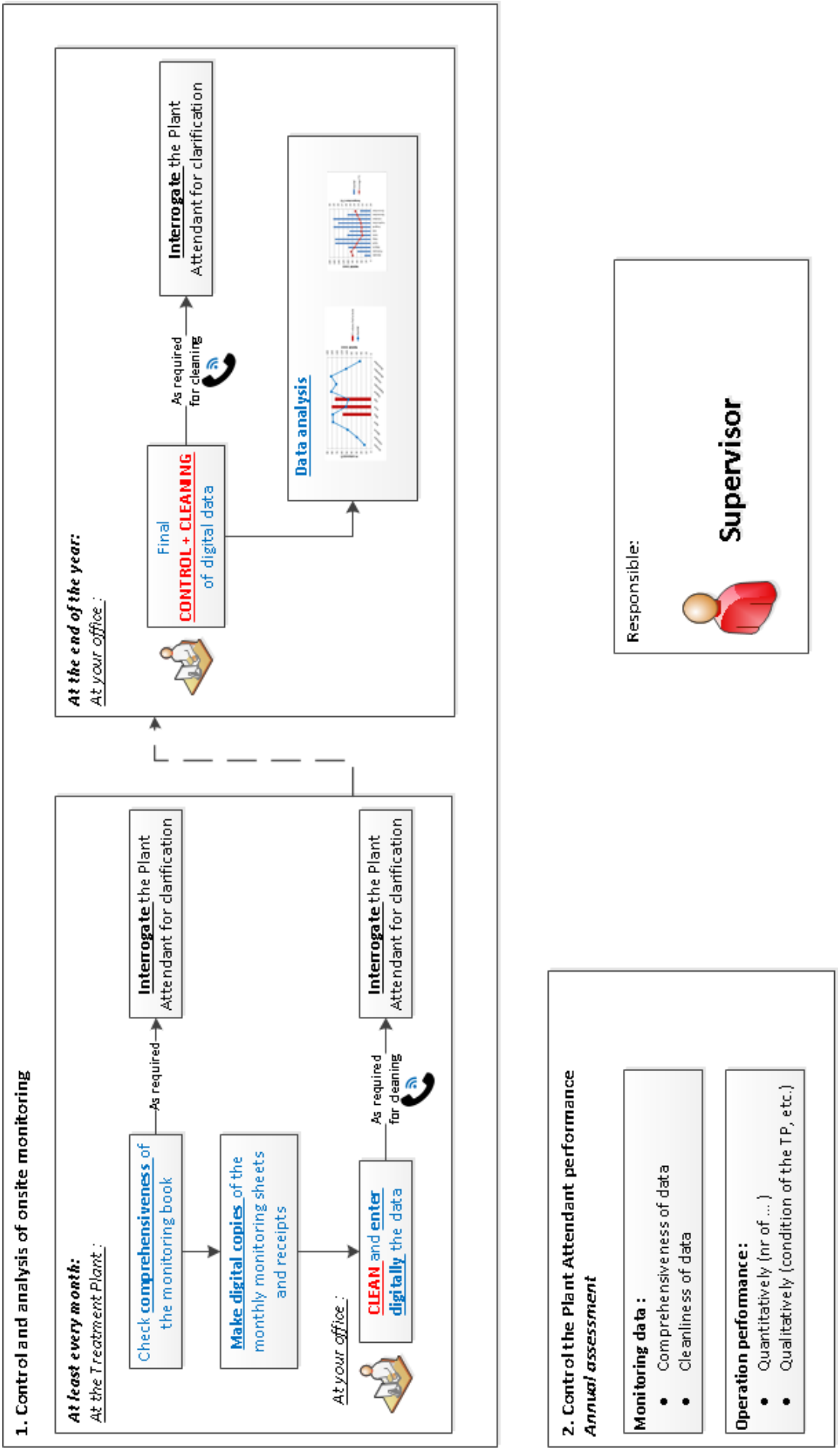
No.	Tasks	Plant Attendant	Supervi-sor	Frequency
A.3	Control and analysis of onsite monitoring		X	Weekly
A.4	Control the plant attendant performance		X	≥ Weekly

Issue and Revision Record

No.	Date	Author(s)	Checker	Description
1	**__.__._20__**			**Initial version**

Read by

No.	Name	Title	Signature	Date
1				**__.__._20__**


1. Control and analysis of onsite monitoring
At least every month:
At the Treatment Plant :
Check comprehensiveness of the monitoring book
As required
Interrogate the Plant Attendant for clarification
Make digital copies of the monthly monitoring sheets and receipts
At your office :
CLEAN and enter digitally the data
As required for cleaning
Interrogate the Plant Attendant for clarification
At the end of the year:
At your office :
Final CONTROL + CLEANING of digital data
As required for cleaning
Interrogate the Plant Attendant for clarification
Data analysis
Responsible:
Supervisor
2. Control the Plant Attendant performance
Annual assessment
Monitoring data :
Comprehensiveness of data
Cleanliness of data
Operation perfomance:
Quantitatively (nr of ...)
Qualitatively (condition of the TP, etc.)

Procedure

1. Control and analysis of onsite monitoring

a) At least every month, control the monitoring book (or binder)

- Make digital copies of all documents (with a smartphone or else):
  - in order to be able to control them at your office,
  - in order to enter the data digitally at your office.
- Check the comprehensiveness of the documents and data:
  - All hardcopies (monthly hardcopies and all receipts) must be previously controlled by the plant attendant and signed by him, before you can control them.
  - Data to be entered daily:
    - Climate data must be entered every day. Briefly check for outlier values, for which you have to immediately ask confirmation.
    - Leachate management data must be entered daily.
  - Receipts:
    - Check if all receipts are in the binders.
    - Check if all receipts in the binders are signed and dated by the plant attendant.
    - For every dumping event in the log file, there must be a customer receipt handed over by the FS emptier, and the contrary/reverse (for every receipt, there is a dumping event).
    - Check if all data (receipts vs. data entered in the monitoring tables) are consistent: all data of the receipts must be entered in the monitoring tables.
    - Data from the receipts might be missing due to FS emptiers (gaps on their customer receipts). The plant attendant must have informed you at these moments and noticed it on the receipts and monitoring table. Check all missing data were previously reported to you. If not, then request as far as required clarification to your plant attendant.
    - Try a last time by phone to get missing information from the customers of the FS emptiers. When you enter digitally the data, describe in comment your last data request effort (phone call to xxx at xxx, etc.).
  - “Dumping / feeding log file” vs. “PDB - Feeding volumes schedules”
    - For every feeding event entered in the “dumping / feeding log file”, there must be a volume entered in the “PDB - Feeding volumes schedules” (and the contrary/reverse).
    - Check if no data is missing
    - Check if the entered data are correct (consistent and plausible):
      - What bed?
      - Volumes?
      - Dates?
      - Etc.
  - “Dumping / feeding log file” vs. “Leachate management”
    - For every feeding event entered in the “dumping / feeding log file”, there must be a volume entered in the “P Leachate management” (and the contrary/reverse).

        - Check if no data is missing
        - Check if the entered data are correct (consistent and plausible)
    - If a bed was recently started up, then you have to know it and there should be dilution data entered in the “PDB - Dilution rates” table.
    - If a bed was recently impounded, then you have to know it and there should be data entered in the “PDB - Impounding periods” table.

b) At least every month, in parallel to the control of the monitoring book (or binder) clean and enter digitally all monitoring data:

- Using the excel template: this will be the digital monitoring book.
- The excel file names must be comprehensive and systematic in order to ease the storage of the files, for example:

  UG302-1_FSTP_Apac_Monitoring_2019-190912-buy.xslx
    - First: short description (FSTP_Apac_Monitoring_2019), indicating the national ID of the treatment plant (UG302-1), the TP name, the year of the monitoring.
    - Then: the date of the last file modification (year (19), followed by month (09) and ended with the date (12), e.g. 12th of September 2019).
    - The short name of the originator (e.g. Mr Buye).
- Control the monitoring data (hardcopies):
    - As previously indicated.
    - Note that the digital data entering will ease some control processes (for example, you can use excel to sum values and easily compare them with other values).
- Clean and enter the data as required:
    - **Complement, correct and enter digitally the data**
    - Data that you will enter must be **clean**, i.e.:
        - No different spelling for the same FS emptier, plate number, customer, phone number, categories, etc.
        - Dates using always the same format
        - Use always the same pre-defined categories (vehicle type, customer, sludge origin).
        - Etc.
    - By interrogating your plant attendant, or the FS emptier customer, or the FS emptier, etc.
    - Clearly indicate the results of your investigation in the digital monitoring book: use the comment fields or sometimes also comments that you can add to excel cells.
    - Make sure that everybody that was not involved in the operation can understand the operation activities with this book.

c) At the end of every year, control and analyse the entered digital monitoring data

- Control:
    - Main control tasks have been implemented when you controlling, cleaning and digitally entering the data.
    - In addition, control following at the scale of a year:
        - Comprehensiveness of data
        - Plausibility of data (outliers, etc.)
- Analysis:
    - General analysis:
        - Basic:
            - Monthly averages and their annual variation.

- Annual averages/sums.
- Comparison of annual FS volumes and climate data.
- Comparison with theoretical treatment plant capacity.

▪ Extended:

- Activity of each FS emptier (monthly averages and their annual variation): shares by company.
- Type of FS emptier: shares by category (vacuum truck, handpump).
- Type of the sludge: shares by category (septic tank, pit latrine, mix).
- Origin of the sludge (customer): shares by category (school, public toilet, etc.).
- Origin of the sludge (location): as far possible with the available data.

o Particular analysis: depending on the particular operation events along the year.

2. Control the plant attendant performance

It is recommended to assess annually the performance of the Plant Attendant and to formally document it in a brief assessment note.

- Comprehensiveness:
  - for each month,
  - count in % the number of data that number of data that are missing for which the plant attendant should have provided and written them, among all data that should have been provided by him.
- Cleanliness of the data:
  - Count the number (and share) of data for which you have to ask the plant attendant for clarification because of its fault.
  - Count the number (and share) of data that could eventually not be cleaned.
- Estimate the general operation performance of the treatment:
  - Quantitative:
    - Number and impact of operation breakdown(s) for which the plant attendant is responsible or partly responsible.
    - Number and impact of clogging events due to inappropriate bed feeding or other actions which for which the plant attendant is the responsible.
    - Number of unjustified absence.
    - Any other non-compliance.
  - Qualitative:
    - Condition of the plants of the drying bed, taking in account the meteorology, and the FS deliveries, and the resources available for the plant attendant (water, etc.).
    - Any other non-compliance.

Facility type	**Faecal Sludge Treatment Plant (FSTP)**
Location	**Apac**

SOP Description

Number	**B**
Title	**Organize FS Deliveries**
Targeted Staff	**Supervisor (and Plant Attendant)**

Scope and responsibilities

No.	Tasks	Plant Attendant	Supervi-sor	Frequency
B.1	Actively coordinate the scheduling of FS deliveries		X	As required
B.2	Receive and schedule FS delivery requests		X	As required

Issue and Revision Record

No.	Date	Author(s)	Checker	Description
1	**__.__._20__**			**Initial version**

Read by

No.	Name	Title	Signature	Date
1				**__.__._20__**

Procedure

1. Actively coordinate the scheduling of FS deliveries

a) Have a contact book of the main potential customers of FS emptying services

- Main potential customers: those who need, can afford and are willing to pay for FS emptying services.
    - Schools
    - Heath centres
    - Etc.
- Contact name, phone number.
- Ideally, have also:
    - The number of onsite sanitation users of each potential customer (e.g. no. of pupils for each school, etc.).
    - The location of the potential customers (and distance to the TP)
    - Ideally “map” the contact book.

b) Actively contact and inform the main potential customers:

- Inform them:
    - Inform them of the need to schedule their FS emptying in order to:
        - Maximize the treatment plant capacity
        - Avoid that the plant cannot accept their sludge.
        - Avoid the “non-scheduled fee” (if your Utility decides to implement such a fee) and its terms and conditions.
    - Give them your contact and the contact of your colleague (plant attendant).
    - Give them the contacts of all FS emptying service suppliers, which are active in the region.
    - Inform them of the need to sign and fill in a payment receipt to their FS emptier.
    - Provide any information that they require regarding the treatment plant and the FS emptying.
- Take into account your cooperation agreement with local authorities, as required.

2. Receive and schedule FS delivery requests

Schedule the FS deliveries together with your plant attendant

- Use the tables “PDB - Feeding volumes schedules”
- see SOP A-2.c

Facility type	**Faecal Sludge Treatment Plant (FSTP)**
Location	**Apac**

SOP Description

Number	**C**
Title	**Receive FS and Feed Beds**
Targeted Staff	**Plant attendant**

Scope and responsibilities

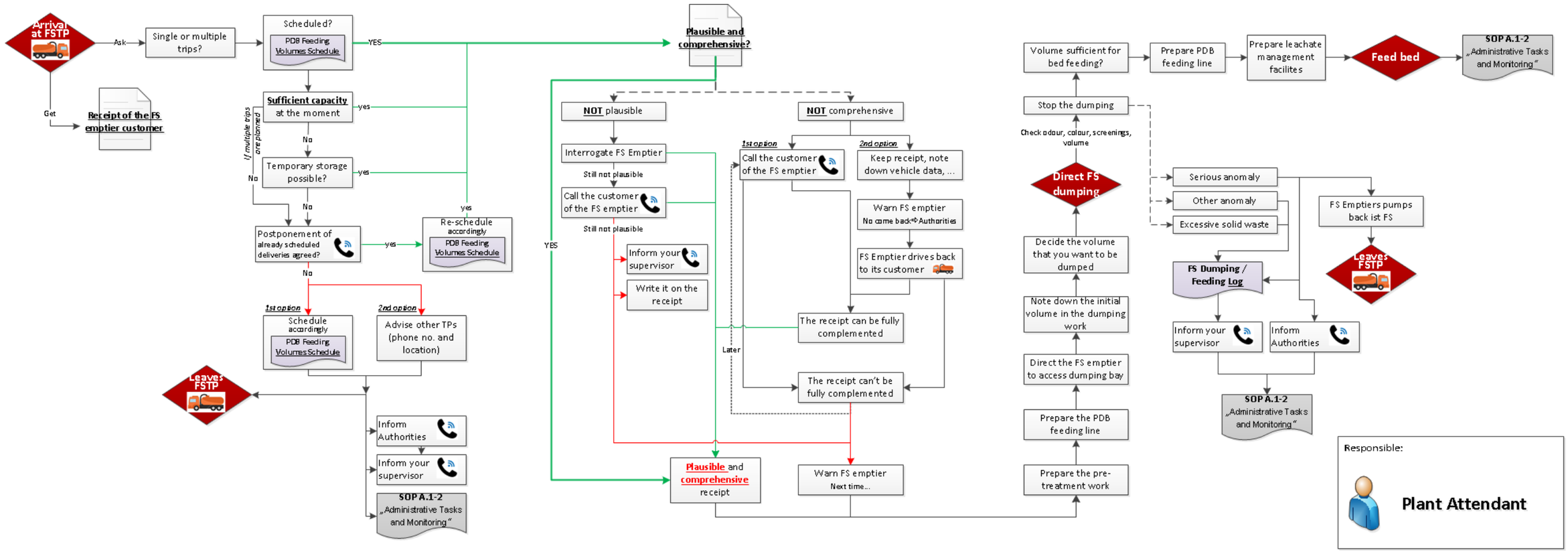
No.	Tasks	Plant Attendant	Supervi-sor	Frequency
C.1	Pit emptier reception	X		At FS delivery
C.2	Prepare FS dumping	X		At FS delivery
C.3	Control and direct FS dumping	X		At FS delivery
C.4	Prepare and proceed to bed feeding	X		At FS delivery
C.4	Screening removal and disposal onsite	X		< next dumping
C.5	Screening disposal offsite		X	≥ Annually

Issue and Revision Record

No.	Date	Author(s)	Checker	Description
1	**__.__._20__**			**Initial version**

Read by

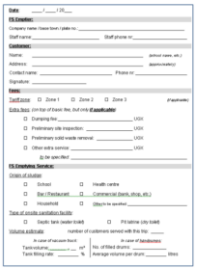
No.	Name	Title	Signature	Date
1				**__.__._20__**


Arrival at FSTP
Ask
Single or multiple trips?
Get
Receipt of the FS emptier customer
Scheduled?
PDB Feeding Volumes Schedule
YES
Sufficient capacity at the moment
yes
No
If multiple trips are planned
Temporary storage possible?
yes
No
No
Postponement of already scheduled deliveries agreed?
yes
Re-schedule accordingly
PDB Feeding Volumes Schedule
No
1st option
Schedule accordingly
PDB Feeding Volumes Schedule
2nd option
Advise other TPs (phone no. and location)
Leaves FSTP
Inform Authorities
Inform your supervisor
SOP A.1-2 „Administrative Tasks and Monitoring"
Plausible and comprehensive?
YES
NOT plausible
Interrogate FS Emptier
Still not plausible
Call the customer of the FS emptier
Still not plausible
Inform your supervisor
Write it on the receipt
Later
Plausible and comprehensive receipt
NOT comprehensive
1st option
Call the customer of the FS emptier
2nd option
Keep receipt, note down vehicle data, ...
Warn FS emptier No come back⇨Authorities
FS Emptier drives back to its customer
The receipt can be fully complemented
The receipt can't be fully complemented
Warn FS emptier Next time...
Volume sufficient for bed feeding?
Prepare PDB feeding line
Prepare leachate management facilites
Feed bed
SOP A.1-2 „Administrative Tasks and Monitoring"
Stop the dumping
Check odour, colour, screenings, volume
Direct FS dumping
Decide the volume that you want to be dumped
Note down the initial volume in the dumping work
Direct the FS emptier to access dumping bay
Prepare the PDB feeding line
Prepare the pre-treatment work
Serious anomaly
Other anomaly
Excessive solid waste
FS Dumping / Feeding Log
Inform your supervisor
Inform Authorities
FS Emptiers pumps back ist FS
Leaves FSTP
SOP A.1-2 „Administrative Tasks and Monitoring"
Responsible:
Plant Attendant

Procedure

1. Pit emptier reception

a) Collect from the FS emptier the payment receipt(s) of its customer(s), when he arrives at the treatment plant.



N.B.: The objective of the receipt is to track the sludge from the pit to the FSTP. This information is important for the better operation of the FSTP and for future design improvements.

b) Ask if the FS emptier intends proceed to multiple trips and if he has multiple customers

If the FS emptier intends to do multiple trips for the same customer:

There should be always 1 receipt per trip, even though most of the information of these receipts will be repetitive.

If the FS emptier delivers sludge from multiple customers:

- There should be always 1 receipt per customer.
- But the number of customers served by the same trip shall be indicated on the receipt.
- The filling rate indicated shall be the filling rate for the sludge of the customer signing the receipt. For example:
    - with the first customer, about 40% of the tank is filled and this figure shall be indicated on its receipt;
    - with the 2nd and last customer, the filling rate of the tank reaches 70%, but the figure to be indicated on its receipt has to be 30% (=70%-40%), which represents the added volume originating from its onsite sanitation facility.

c) Check if the delivered receipt is comprehensive.

All fields have to be filled in, except the "fee" fields which are not necessarily always applicable. If at least one of these "fee" fields is empty, you have to ask confirmation to the FS emptier.

If the receipt is completely written by hand:

This is not a problem, as long as all other requirements described within this SOP are fulfilled and the information can be read.

If data are missing: 1st option

- Immediately have a phone call with the FS emptier customer, get the missing data, and fill in the empty fields on the receipt.
- Clearly mention by writing on the receipt what data were initially missing and how they were complemented.

If data are missing: 2nd option

- The FS emptier can also fill the missing data together with its customer and come back later to the FSTP with a new and fully filled in receipt.
- Before that the truck leaves the FSTP:
    - Keep the initial receipt and note down vehicle information that you can see (plate number, phone no., company name, tank volume, colour, vehicle brand), the name of the FS emptier, his phone number (test it).

  - Inform the FS emptier that if he does not come back delivering the sludge, you will inform Authorities.
- If the FS emptier comes back:
  - Check the new receipt.
  - Keep both receipts (initial and new).
  - Clearly mention by writing on the new receipt that it replaces an incomplete receipt.
- If the FS emptier does not come back the same day:
  - Inform your supervisor.
  - Inform Authorities.

If data are missing and cannot be immediately complemented: with previous two options

- Keep the receipt and clearly mention by writing on the receipt what data were initially missing, how they were complemented and what data are eventually missing.
- Inform the FS emptier that this should be the last time and that next time you shall inform Authorities accordingly.
- Try again later to contact the customer of the FS emptier and get the missing data. If you can't succeed even after a few days, note it down on the receipt and inform your supervisor.

If you doubt the information of the receipt, you can:

- Interrogate the FS emptier.
- Call the pit emptier customer by using the phone no. indicated on the receipt.

If your doubts remain:

- Mention it clearly by writing on the receipt.
- Inform your supervisor.

In any case, eventually proceed with the next step of the procedure.

d) Check if the sludge delivery was scheduled

If it was scheduled, then you should know and be sure that a drying bed (or beds) is (are) ready to accept the sludge.

e) If the sludge delivery was not scheduled check if the sludge delivery can be accepted

- First inform the FS emptier that next time it should be scheduled in order to avoid FSTP capacity bottlenecks.
- If applicable at your FSTP, apply the fee for "non-scheduled FS delivery".
- Check if drying beds are sufficient to accept the sludge.
  - Take into account the already scheduled sludge deliveries: do not accept sludge now, which will prevent you to accept the already scheduled sludge deliveries.
  - Take your temporary storage capacity into consideration (dumping work), but bear in mind that you will need the dumping work for the next scheduled sludge delivery.

If the current plant capacity allows you to accept only a part of the sludge deliveries announced by the FS emptier, then:

- Inform the FS emptier immediately of the volume that you can accept and thus the volumes that you cannot accept now.
- Offer the FS emptier:
  - Later dates for accepting these remaining sludge volumes (as soon as the capacity will be sufficient again). If he accepts, then schedule the sludge deliveries accordingly. Make sure by phone that the customer of the FS emptier agrees on it.

  - Postponement of already scheduled FS deliveries to free capacities “now” is possible but only if all the concerned customer(s), which had already scheduled the FS delivery accept to postpone their sludge. In this case, immediately re-schedule their FS delivery. Bear in mind that postponing the next sludge delivery might impact the following one, etc.
  - If the FS emptier doesn’t accept to postpone the delivery of these remaining sludge volumes, offer him other dumping alternatives in the region.
- Immediately inform Authorities about the situation in order to allow them to make sure that no sludge is dumped wildly into the environment.

If the current plant capacity does not even allow you to accept the sludge delivered now by the FS emptier, then:

- Inform at what date he can deliver it. If he accepts, then schedule the sludge delivery(ies) accordingly. Make sure by phone that the customer of the FS emptier agrees on it.
- Postponement of already scheduled FS deliveries to free capacities “now” is possible but only if all the concerned customer(s), which had already scheduled the FS delivery accept to postpone their sludge. In this case, immediately re-schedule their FS delivery. Bear in mind that postponing the next sludge delivery might impact the following one, etc.
- If the FS emptier doesn’t accept to postpone the delivery of the FS, then offer him other dumping alternatives in the region.
- Immediately inform Authorities about the situation in order to allow them to make sure that no sludge is dumped wildly into the environment.

f) Sign and date the receipt in a corner of it.

g) If the FS is to be dumped now, inform the FS emptier that he has to wait a few minutes until you have prepared the dumping of the FS.

2. Prepare FS dumping

a) Prepare the pre-treatment work

- Check that the FS emptier vehicle can access to the dumping work (no obstacles, etc.)
- Check that the screening basket is free from already dewatered screenings and not more than half full.
  - If dewatered screenings are remaining or if the is more than half full, then transport the screenings to the screening storage are.
  - If you use a mobile screen basket, then request the help of the FS emptier to transport it (as required).

b) Prepare the PDB feeding line

- Close the gate valve(s) in order to retain the dumped FS in the dumping work.

c) Direct the FS emptier to access the dumping bay

- Make sure before the drivers starts manoeuvring his vehicle that he knows <u>how</u> and <u>where</u> to park it.

3. <u>Control and direct the FS dumping</u>

a) Note down the initial volume:

- If you mix the delivered FS with sludge that is already stored in the dumping work, then make sure to have noted down the stored volume by reading the ruler before dumping the delivered FS.

b) Make sure before the FS emptier starts the dumping that it must:

- Start on your order
- Immediately stop on your order
- Dump adequately into the screening basket.

c) During FS dumping, control:

- Proceed with visual and odour control of the FS:
  - Stop it if it has an abnormal colour.
  - Stop it if it has an abnormal odour.
- Proceed with visual control of the screenings
  - If the screening basket is full, stop it.
  - Transport the screenings to the screening storage area.
  - Re-start the FS dumping.
  - Apply a fee for "high screenings' volume" if the screening basket become full before having filled the dumping work with FS, in accordance with the rules set by the Utility in charge of the FSTP.
  - Inform the FS emptier that he should inform his customers to not dump solid waste into their toilets anymore.
- <u>*If there is an abnormal colour or odour*</u>:
  - Interrogate the FS emptier.
  - Call the pit emptier customer by using the phone no. indicated on the receipt.
- <u>*If serious doubts remain about the origin of the FS*</u>:
  - Request the FS emptier to pump it out from the dumping work.
  - Refuse the FS delivered.
  - Report it on the payment receipt handed over by the FS emptier.
  - Immediately inform your supervisor accordingly.
  - Immediately inform the Authorities accordingly.

<u>Remark:</u>
Abnormal FS odours: chemical odours
Normal FS colours:
- *Light to dark brown: fresh FS*
- *Grey to black: digested FS*

Also abnormal: smoke indicating abnormally high temperature

<u>Remark:</u>
Refusing FS is a serious matter and should be exceptional.
In small towns, the main risk is to have inadequate chemicals used to give the FS emptier customer the feeling that it helps to prevent odours and/or diseases. But this risk and its impact are low.
Bear in mind, that if you know the FS emptier enough to be sure to later find him easily, you can accept the FS, but warn him that if the plants of the bed to be fed with its FS should wilt, he will be considered responsible and penalized.

d) Decide on the volume you desire in the dumping work:

- The FS to be dumped should normally fill the dumping work, so that it later allows sludge depth on the bed of at least about 10 cm, but ideally 15 to 25 cm. For example:
  - with a dumping work of 4 m^3
  - and a bed surface area of 25 m^2,
  - you can feed a bed with a sludge depth of: 4 m^3 divided by 25 m^2 = 16 cm.
- Only if the visual inspection of the FS dumped shows that you have to dilute the FS because it is too thick for the FSTP, then do not fill the dumping work in order to later be able to dilute by adding water.

Remark:
This should however be exceptional because the FS thickness required to allow the emptying is equivalent to the FS thickness required by the FSTP (assuming it as has been correctly started up).

e) When you reach the desired volume:

- Stop the dumping:
- If the FS emptier vehicle:
  - is empty, then release the FS emptier.
  - is not empty and you have no more capacities to accept its remaining FS, then release the FS emptier.
  - is not empty and you have capacities to accept its remaining FS, then:
    - Proceed with the next step of the procedure
    - The FS emptier will stay until emptying of the dumping work and you will start again at step no. 2 of this SOP.
- Note down the dumped volume:
  - By reading the ruler.
  - If there was an initial volume, subtract it from your reading in order to only record the dumped FS volume.
- Record all monitoring data related to the dumping event.

4. Prepare and proceed to bed feeding

a) Check if the FS volume retained in the dumping work is sufficient

- The FS to be dumped should normally fill the dumping work, so that it later allows sludge depth on the bed of at least about 10 cm, but ideally 15 to 25 cm.
- If the volume in the dumping work is sufficient to reach at least about 10cm, then proceed with the next step of the procedure.
- If the volume in the dumping work is not sufficient to reach at least about 10cm, then:
  - Either you can decide to wait until the next FS delivery.
  - Or you can decide to add water in order to reach the minimum volume required for the bed feeding.

b) Prepare the PDB feeding line

- The bed to be fed is the bed that you have selected according to your capacities and feeding program.
- Open and close the gate valve(s), which are downstream of the gates vale(s) that are retaining the FS of the dumping work, in order to be ready to feed the bed that you have selected.
- All opened gate valves must be fully open, in order to maximize the flow.

- Check that the anti-erosion plate of the selected bed is not buried too deep in the sludge. If it is too deep raise it (lift it, put below sufficient surrounding dewatered sludge or sand or else, and put the plate back).

c) Prepare the leachate management facilities

- Similarly, if the leachate management facilities require you to select a particular treatment/storage line, then proceed similarly to the PDB in order to be ready for the bed feeding and thus the leachate flow that will follow.

d) Proceed with the bed feeding

- If the FS retained in the dumping work has be stored for a long time, mix it with a rod or else, in order to get an homogeneous liquid (no scum and no sediment set at the bottom must remain).
- Open the gate valve(s) that is (are) retaining the FS in the dumping work.
- All opened gate valves must be fully open, in order to maximize the flow.
- Check that the flow is splashing on the anti-erosion plate in order to minimize the erosion effects. Improve it as deemed required, before the next feeding of this bed.

e) At the end of the bed feeding.

- Open all gate valves
- Record all monitoring data related to the feeding event.

5. Screening removal and disposal onsite

a) Screenings can remain in the screen basket until next use for further dewatering and/or washing by the rain:

- Dewatering of screening is essential to:
  - Reduce the volume of the screenings.
  - Reach sufficient “dryness” in order to allow its later handling and incineration.
  - Speed-up the die-off of pathogens that it might contain.
- Screenings will dewater the best in the basket and under the sun.
- If it is a rainy period, you can put a plate above the basket in order to avoid that screenings are re-wetted. But during rainy period it is also tolerable to transport the screenings to the covered storage area immediately after the FS dumping session.

b) Transport the screening to the storage area

- Transport the screening to the storage area using the basket, if you can have the support of a second person for this short task (transport the basket alone is not recommended since (i) it is heavy and (ii) you won’t be able to avoid your clothes to be dirty and get in touch with the screenings).
- Transport the screening to the storage area using the wheelbarrow or another container that you can handle alone.

c) Sort out the screenings

- After or before transporting the screenings to the storage area, you have to sort out the screenings and separate according to the final recycling/disposal strategy of your FSTP. In no particular strategy exists, then separate as follows:
  - Stones, concrete, ceramics
  - Steel
  - Wood
  - Rest (including mixed materials that cannot be easily separated)

6. Screening disposal offsite

a) Every year or when the storage capacity is over, transport the "Rest" material to the nearest incinerator or landfill site.

a) Every year or when the storage capacity is over, stones, concrete, ceramics, steel, wood can be either recycled or buried onsite.

Alternative disposal/recycling methods can apply if the recycling/disposal strategy of your FSTP is different.

Facility type	**Faecal Sludge Treatment Plant (FSTP)**
Location	**Apac**

SOP Description

Number	**D**
Title	**Biosolid management**
Targeted Staff	**Supervisor and Plant Attendant**

Scope and responsibilities

No.	Tasks	Plant Attendant	Supervi-sor	Frequency
D.1	Monitor the biosolids' storage	X	X	As required
D.2	Control that biosolids can't be and aren't re-humidified	X	X	As required
D.3	Commercialize the biosolids	X	X	As required
D.4	Control the collection by the customer of the sold biosolids	X	X	As required

Issue and Revision Record

No.	Date	Author(s)	Checker	Description
1	**__.__._20__**			**Initial version**

Read by

No.	Name	Title	Signature	Date
1				**__.__._20__**

Procedure

1. Monitor the biosolids' storage

- The Plant attendant is responsible for the monitoring and entering of the data on hardcopies.
- The Supervisor is responsible for the controlling, cleaning and digital conversion of the hardcopy monitoring data
- Biosolids are stored in batches, which are stored as a single or multiple heaps.
- Make sure that each heap can be clearly identified with for example a number, which should be at least the same number as the drying bed from where it originates, in order to **be always able to track its origin**. Hence from the FS emptier customer, to the PDB bed number, to the storage area onsite, to recycling.
- For each batch, have and enter monitoring data:
    - All monitoring data can usually hold on a single A4 sheet.
    - Number of the PDB bed emptied, which fed the storage area.
    - Number and ID(s) of the related heap(s).
    - Volume removed and stored:
        - Estimate it based on the dimensions of the bed (length and width) and the depth of biosolids removed and stored.
        - The volume will be equal to the multiplication of:

          bed length **x** *bed width* **x** *biosolids' depth*

          All values are in metre and the volume in m³ (cubic metre).
    - Date of the removal from the PDB bed and storage to the storage area.
    - Any particular event before removal from the storage area and recycling in agriculture. Always indicate the date and description. Possible events:
        - Accidental re-humidification:
            - Date
            - Description allowing to understand:
                - The reason, thus allowing a later storage improvement measure.
                - The extent of the accident.
        - Sampling and laboratory analysis results.
        - Etc.
    - Date of the removal from the storage area and recycling in agriculture:
        - This can be total (all the batch volume is removed and recycled) but also partial (only a part of the catch is removed and recycled).
        - Indicate the volume removed
        - Indicate if the biosolids is:
            - Sold or given for agriculture (*See SOP for commercialization*).
            - Recycled onsite for agriculture (*See SOP for recycling onsite*).

2. Control that biosolids can't be and aren't re-humidified

- When installing a biosolid heap in the storage area, make sure that it can't be humidified (wetted) by rain or via surface runoff.
- Check after each rain, but not more than daily that no heap was accidentally re-humidified (wetted).
- In case of accidental re-humidification (re-wetting), report it immediately (*see SOP for monitoring of the biosolids' storage*). If you have a smartphone, take pictures and give them to your Supervisor.

3. Commercialize the biosolids

- In case of payment for the acquisition of the biosolids, many payment schemes are possible. The procedure shall result from the selected scheme.
- Biosolids should not be commercialized before:
    - A minimum storage period to be defined (usually a minimum of 6 to 12 months are indicated, but it will depend on the storage conditions).
    - Or laboratory tests show that it complies with the threshold indicated within the National Guidelines for Small FSTPs.
    - Or you implement monitoring measures ensuring a safe handling of the biosolids until their application and a few weeks after it.

4. Control the collection by the customer of the sold biosolid

- Sign 2 identical receipts together with the carrier of the biosolids:
    - One copy is to be kept by the carrier.
    - The other one is to be kept at the treatment plant, filed in the monitoring book (or binder).
- The receipts shall include at least following information:
    - Date of transport
    - Customer name, address, phone number
    - Recycling purpose (what crop(s)?), location
    - Carrier name, phone number
    - Vehicle type, plate number, estimated maximum volume transport capacity (by measuring length and width of the tipper/container, as well as the average biosolds depth within the tipper/container).
    - Estimated volume transported: indicate in detail the estimate method.
- If the biosolid is so dry that it becomes dusty and can fly away during transport, then:
    - The tipper/container has to be covered properly during transport.
    - Or the biosolid has to be sufficiently wetted before the transport (and even loading).

Annex 3

Monitoring Forms (Templates)

Payment Receipt for FS Emptying

Date: ____ / ____ / 20___

FS Emptier:

Company name / base town / plate no.: _____

Staff name: _____ Staff phone nr: _____

Customer:

Name: _____ *(school name, etc.)*

Address: _____ *(approximately)*

Contact name: _____ Phone nr: _____

Signature: _____

Fees:

Tariff zone: ☐ Zone 1 ☐ Zone 2 ☐ Zone 3 *(if applicable)*

Extra fees: *(on top of basic fee, but only **if applicable**)*

- ☐ Dumping fee: _____ UGX
- ☐ Preliminary site inspection: _____ UGX
- ☐ Preliminary solid waste removal: _____ UGX
- ☐ Other extra service: _____ UGX

to be specified: _____

FS Emptying Service:

Origin of sludge:

☐ School ☐ Health centre ☐ Public toilet

☐ Bar / Restaurant ☐ Commercial (bank, shop, etc.)

☐ Household ☐ Other to be specified: _____

Type of onsite sanitation facility:

☐ Septic tank (*water toilet*) ☐ Pit latrine (*dry toilet*) ☐ Both (mix)

Volume estimate: number of customers served with this trip: _____

In case of vacuum truck:	*In case of handpumps:*
Tank volume: _____ . ___ m³	No. of filled drums: _____
Tank filling rate: _____ %	Average volume per drum: _____ litres

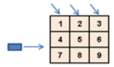
FSTP Apac

Dumping / Feeding log

Year: **2019**

Originator (name, date, signature): ______________________

Checker (name, date, signature): ______________________



Dumping date	Volume$_d$	Screening >50%	Pit Emptier Company	Pit Emptier Phone number	Vehicle type	Plate number	Customer name	Customer phone number	Customer category	Sludge type	Feeding date	Volume$_f$	1	2	3	4	5	6	7	8	9	LT	LS	Comment

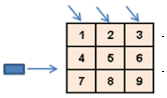
FSTP Apac

Climate and misc.

Year: **2019**

Originator (name, date, signature): _____

Checker (name, date, signature): _____



Month	Date	Day	T°C min	T°C max	T°C ave	Hygr am	Hygr pm	Hygr ave	Rainfall	Water meter index	Watermet. Consumption	Comment
December	01	Sun										
December	02	Mo										
December	03	Tue										
December	04	Wed										
December	05	Thu										
December	06	Fri										
December	07	Sa										
December	08	Sun										
December	09	Mo										
December	10	Tue										
December	11	Wed										
December	12	Thu										
December	13	Fri										
December	14	Sa										
December	15	Sun										
December	16	Mo										
December	17	Tue										
December	18	Wed										
December	19	Thu										
December	20	Fri										
December	21	Sa										
December	22	Sun										
December	23	Mo										
December	24	Tue										
December	25	Wed										
December	26	Thu										
December	27	Fri										
December	28	Sa										
December	29	Sun										
December	30	Mo										
December	31	Tue										

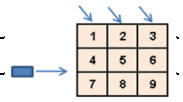
FSTP Apac

PDB - Feeding volumes schedules

Year: **2019**

Originator (name, date, signature): _____

Checker (name, date, signature): _____



Month	Date	Day	1	2	3	4	5	6	7	8	9	Total	Comment
December	01	Sun											
December	02	Mo											
December	03	Tue											
December	04	Wed											
December	05	Thu											
December	06	Fri											
December	07	Sa											
December	08	Sun											
December	09	Mo											
December	10	Tue											
December	11	Wed											
December	12	Thu											
December	13	Fri											
December	14	Sa											
December	15	Sun											
December	16	Mo											
December	17	Tue											
December	18	Wed											
December	19	Thu											
December	20	Fri											
December	21	Sa											
December	22	Sun											
December	23	Mo											
December	24	Tue											
December	25	Wed											
December	26	Thu											
December	27	Fri											
December	28	Sa											
December	29	Sun											
December	30	Mo											
December	31	Tue											

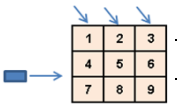
FSTP Apac

PDB - Dilution rates

Year: **2019**

Originator (name, date, signature): _____

Checker (name, date, signature): _____



Month	Date	Day	1	2	3	4	5	6	7	8	9	Comment
December	01	Sun										
December	02	Mo										
December	03	Tue										
December	04	Wed										
December	05	Thu										
December	06	Fri										
December	07	Sa										
December	08	Sun										
December	09	Mo										
December	10	Tue										
December	11	Wed										
December	12	Thu										
December	13	Fri										
December	14	Sa										
December	15	Sun										
December	16	Mo										
December	17	Tue										
December	18	Wed										
December	19	Thu										
December	20	Fri										
December	21	Sa										
December	22	Sun										
December	23	Mo										
December	24	Tue										
December	25	Wed										
December	26	Thu										
December	27	Fri										
December	28	Sa										
December	29	Sun										
December	30	Mo										
December	31	Tue										

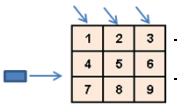
FSTP Apac

PDB - Impounding periods

Year: **2019**

Originator (name, date, signature): _____

Checker (name, date, signature): _____



Month	Date	Day	1	2	3	4	5	6	7	8	9	Comment
December	01	Sun										
December	02	Mo										
December	03	Tue										
December	04	Wed										
December	05	Thu										
December	06	Fri										
December	07	Sa										
December	08	Sun										
December	09	Mo										
December	10	Tue										
December	11	Wed										
December	12	Thu										
December	13	Fri										
December	14	Sa										
December	15	Sun										
December	16	Mo										
December	17	Tue										
December	18	Wed										
December	19	Thu										
December	20	Fri										
December	21	Sa										
December	22	Sun										
December	23	Mo										
December	24	Tue										
December	25	Wed										
December	26	Thu										
December	27	Fri										
December	28	Sa										
December	29	Sun										
December	30	Mo										
December	31	Tue										

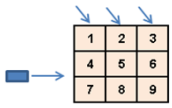
FSTP xxx

PDB - Leachate Management

Year: **2019**

Originator (name, date, signature):

Checker (name, date, signature):



Month	Date	Day	LT1	LT2	LT3	LS1	LS2	LS3	Comment
December	01	Sun							
December	02	Mo							
December	03	Tue							
December	04	Wed							
December	05	Thu							
December	06	Fri							
December	07	Sa							
December	08	Sun							
December	09	Mo							
December	10	Tue							
December	11	Wed							
December	12	Thu							
December	13	Fri							
December	14	Sa							
December	15	Sun							
December	16	Mo							
December	17	Tue							
December	18	Wed							
December	19	Thu							
December	20	Fri							
December	21	Sa							
December	22	Sun							
December	23	Mo							
December	24	Tue							
December	25	Wed							
December	26	Thu							
December	27	Fri							
December	28	Sa							
December	29	Sun							
December	30	Mo							
December	31	Tue							

Annex 4

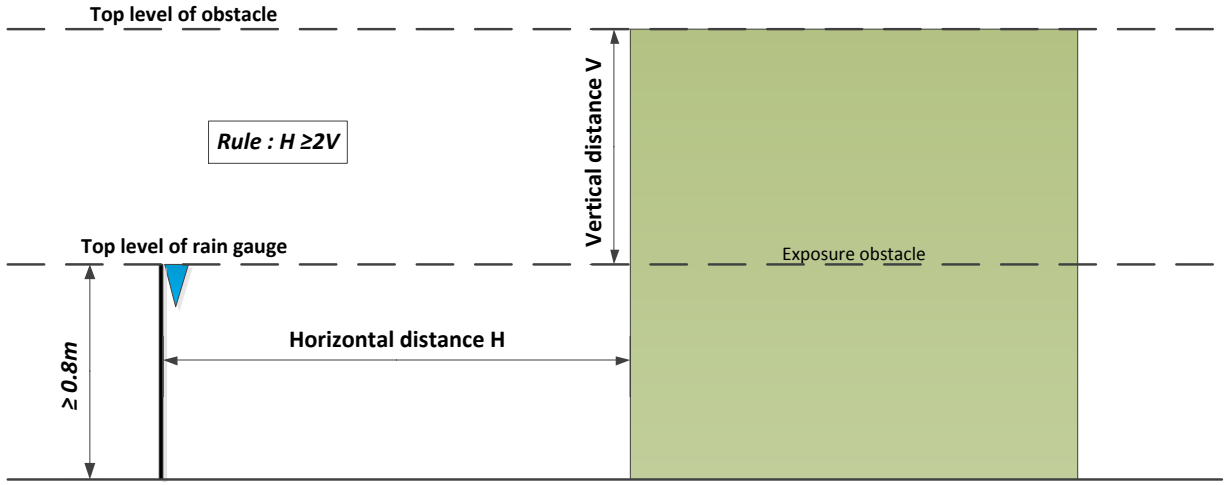
Meteorological Monitoring Equipment

Rain gauge

The location of the rain gauge shall ensure:

- Ease the access
- Exposure to rain at any time
- Not exposed to tampering (e.g. pit emptiers).

Regarding the exposure to rain, following rule is recommended. The distance from obstacles reducing the exposure by windy rain events shall be at least twice as large as the height difference.



An installation example is shown below. Only analogue rain gauges are recommended for better reliability, with IS units (mm).

Alternatively, it can be installed above the shelter the thermometer and hygrometer.

Thermometer and hygrometer

Location of Measurement Devices

Thermometer and hygrometer have ideally to be installed in a shelter that is itself installed at a specific location. The shelter shall:

- avoid measurement interferences with rain, dew and sun.
- allow to measure outdoor ambient air, thus be well aerated,
- ensure easy access,
- not be exposed to tampering (e.g. pit emptiers).

The location of the shelter shall be:

- At 1.5m from ground level
- In a location without shade at any time of the day.

The shelter can be:

- Ideally, a standardized shelter (“Stevenson screen” or equivalent)
- If not, then within a sheltered but open large area, on a wall.

Meteorological Shelter

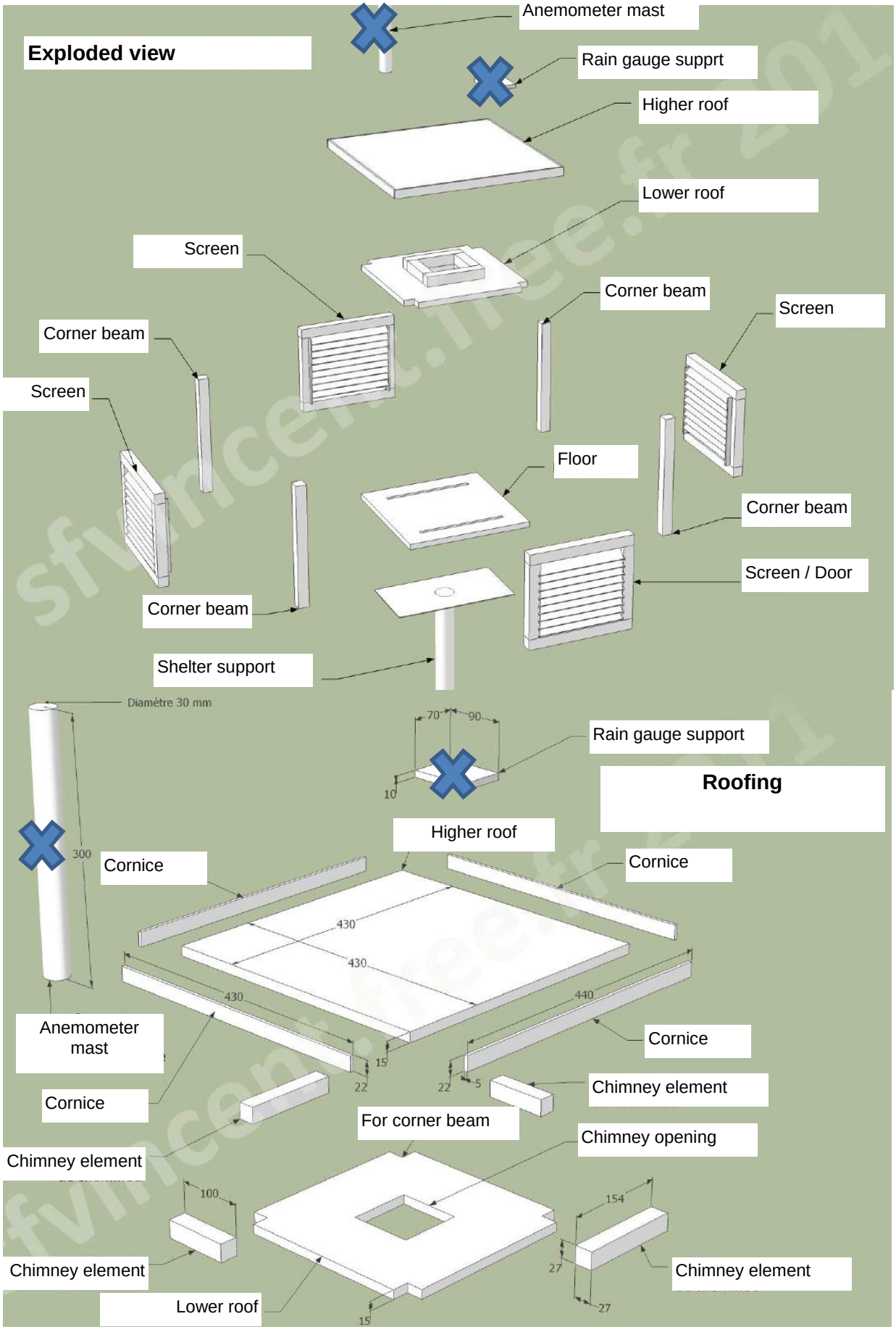
The recommended shelter type is derived from:

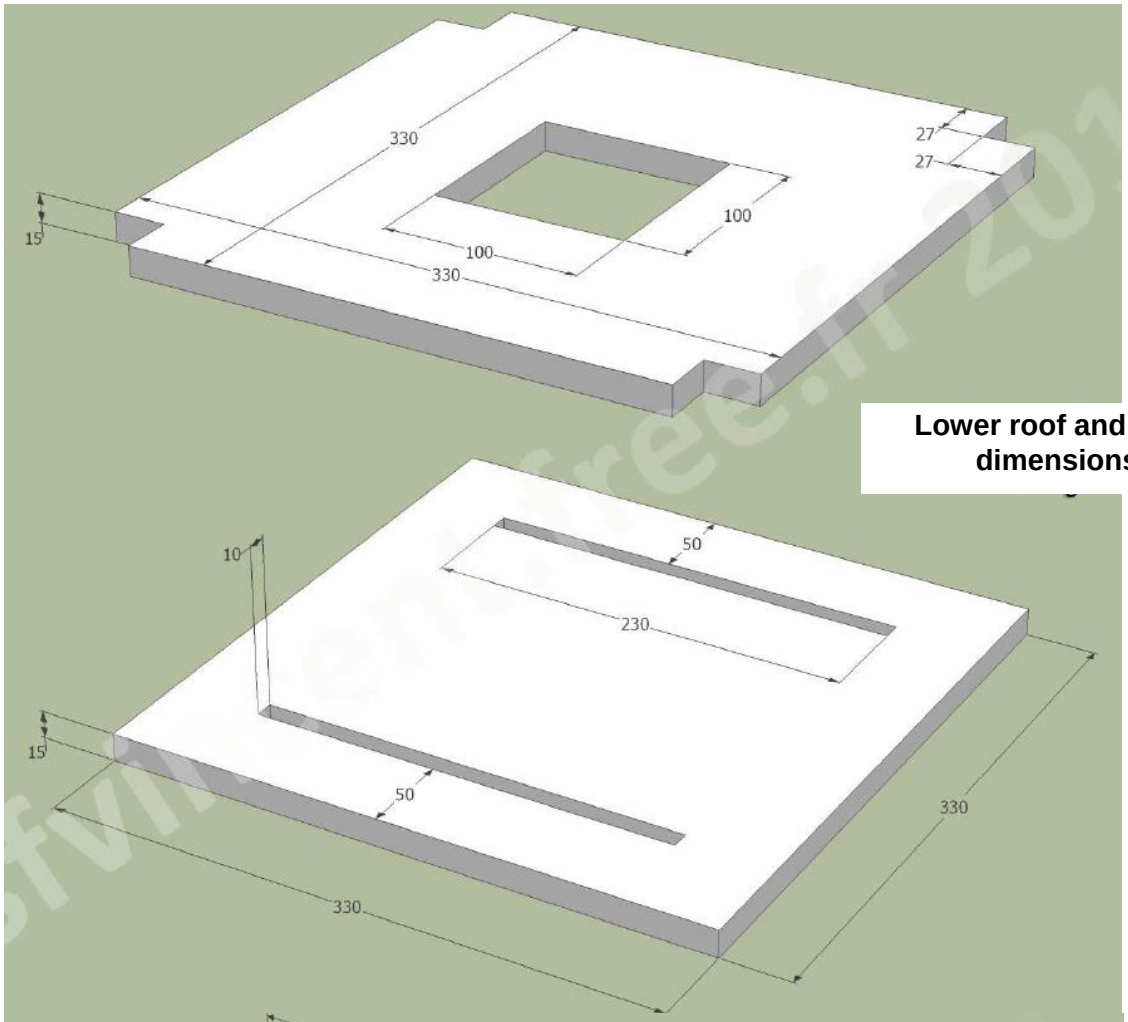
- https://www.station-meteo.com/wp-content/uploads/abri-meteo/plan-abri-meteo-version-2011.pdf and
- http://sfvincent.fr.

All dimensions are given in mm.

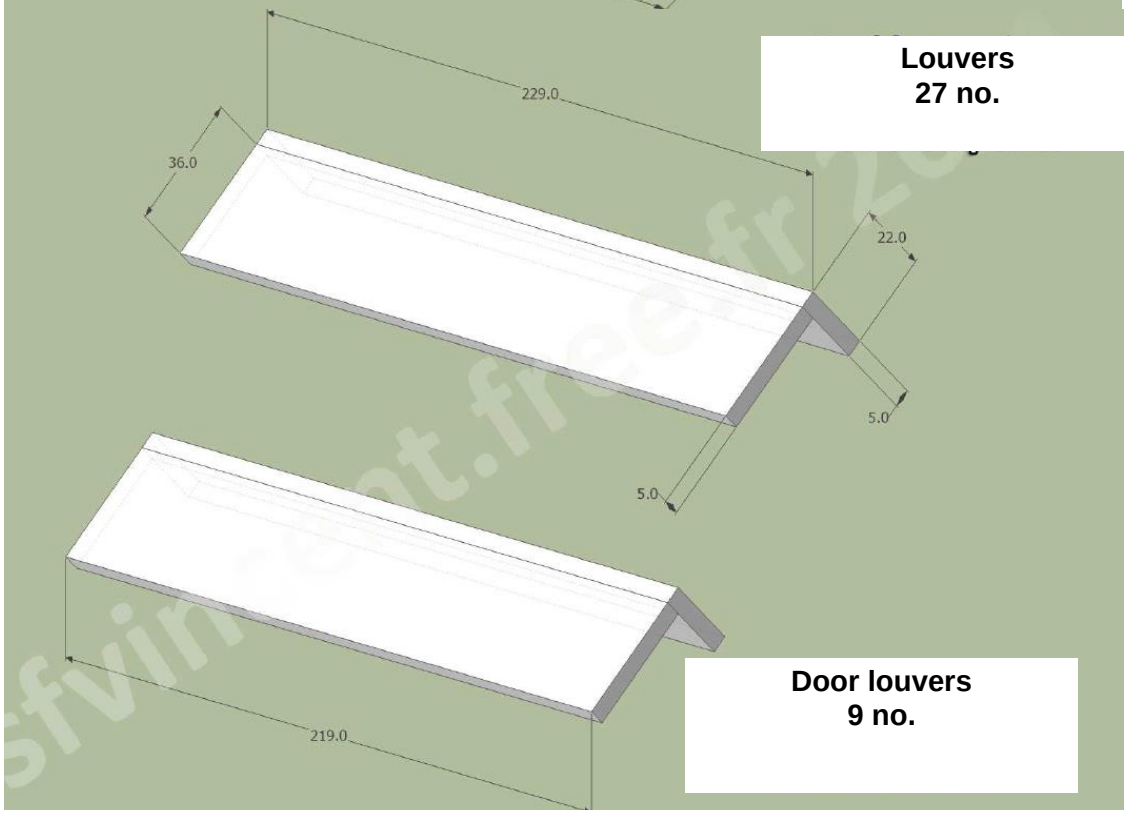
It must be noted that this shelter type incorporates a rain gauge, which is not recommended, and an anemometer, which is not required. Design adaptations shall be made accordingly.

Larger shelter can be built but are not required.


Exploded view
Anemometer mast
Rain gauge supprt
Higher roof
Lower roof
Screen
Corner beam
Screen
Corner beam
Screen
Floor
Corner beam
Screen / Door
Corner beam
Shelter support
Diamètre 30 mm
70
90
10
Rain gauge support
Roofing
Higher roof
300
Cornice
Cornice
430
430
430
440
Cornice
Anemometer mast
15
22
22
5
Chimney element
Cornice
For corner beam
Chimney opening
Chimney element
100
154
27
27
Chimney element
15
Lower roof

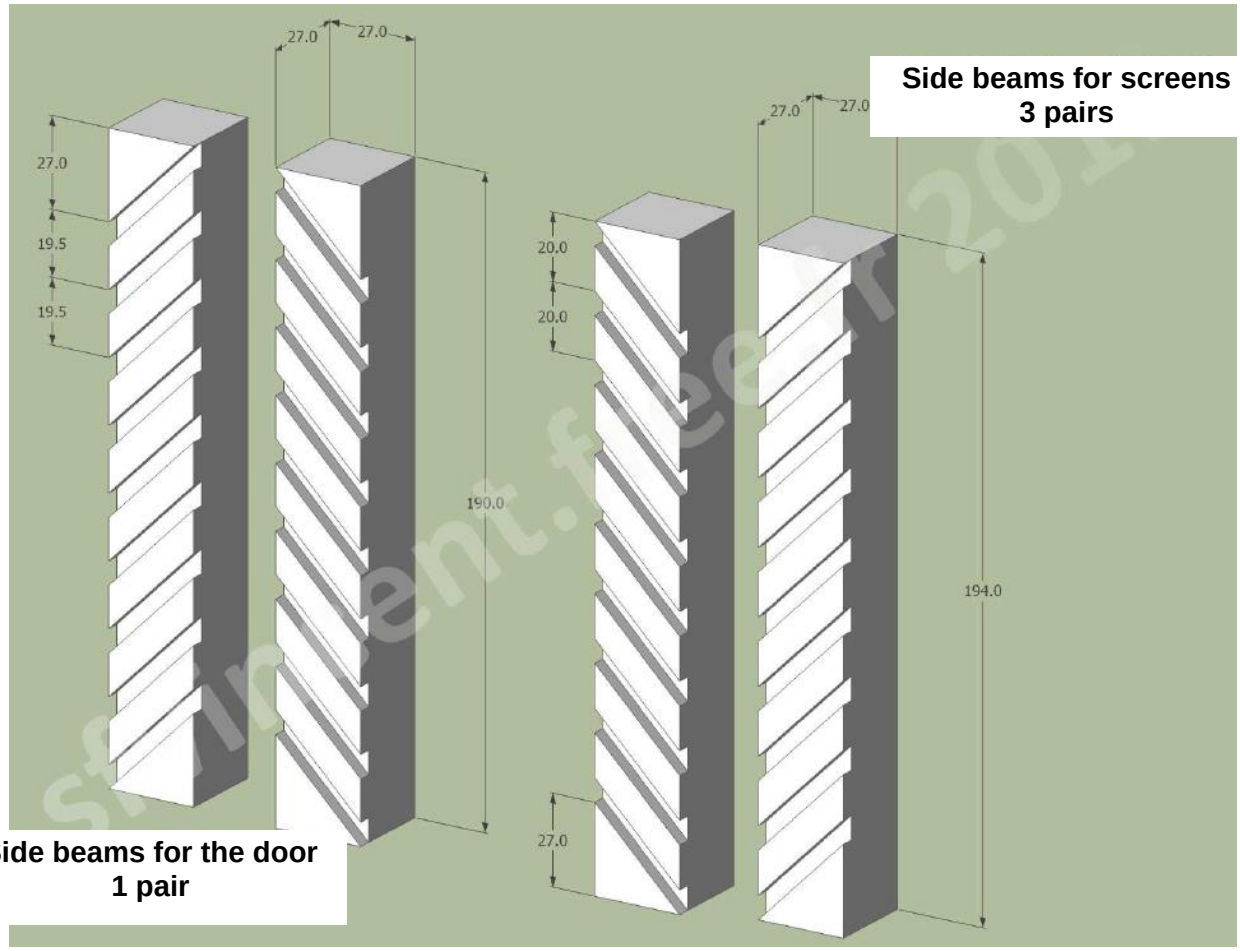


Lower roof and floor dimensions



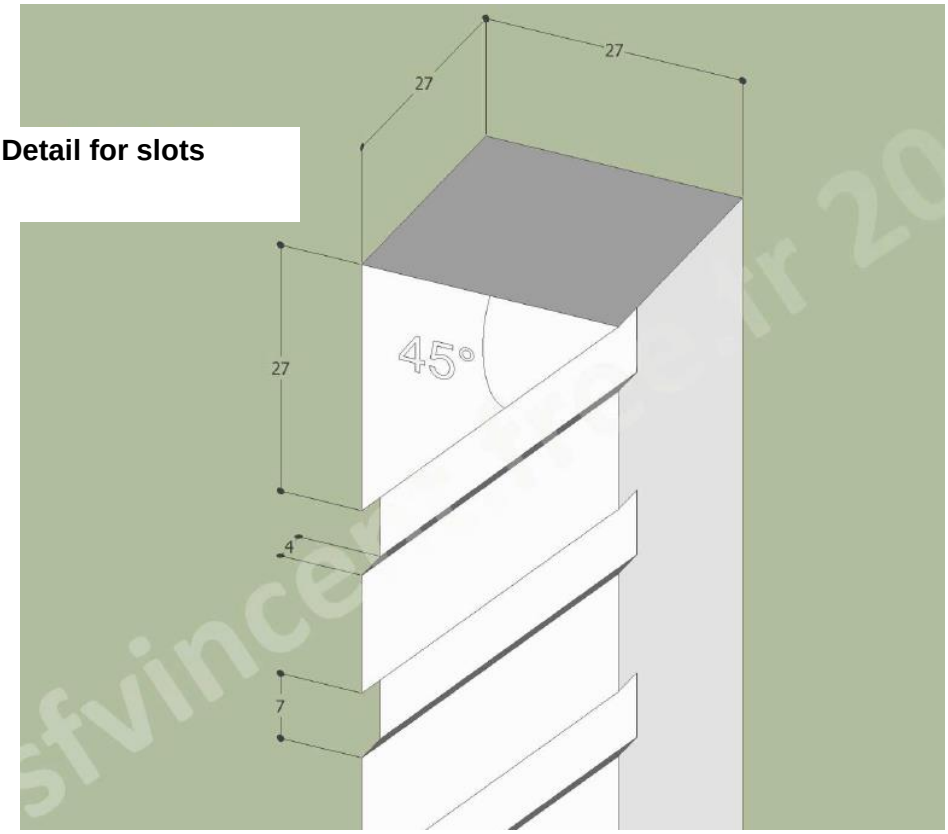
Louvers
27 no.

Door louvers
9 no.

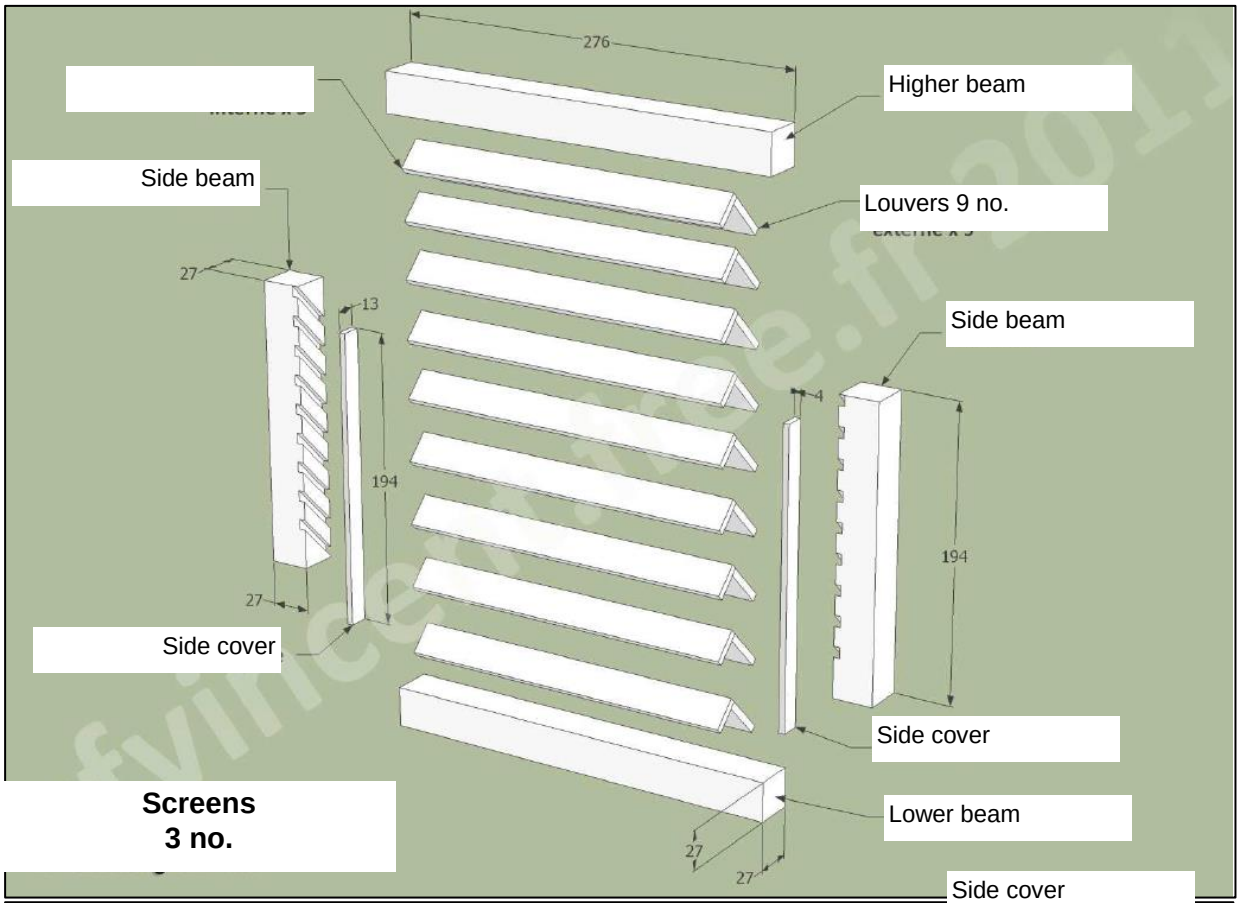


Side beams for screens
3 pairs

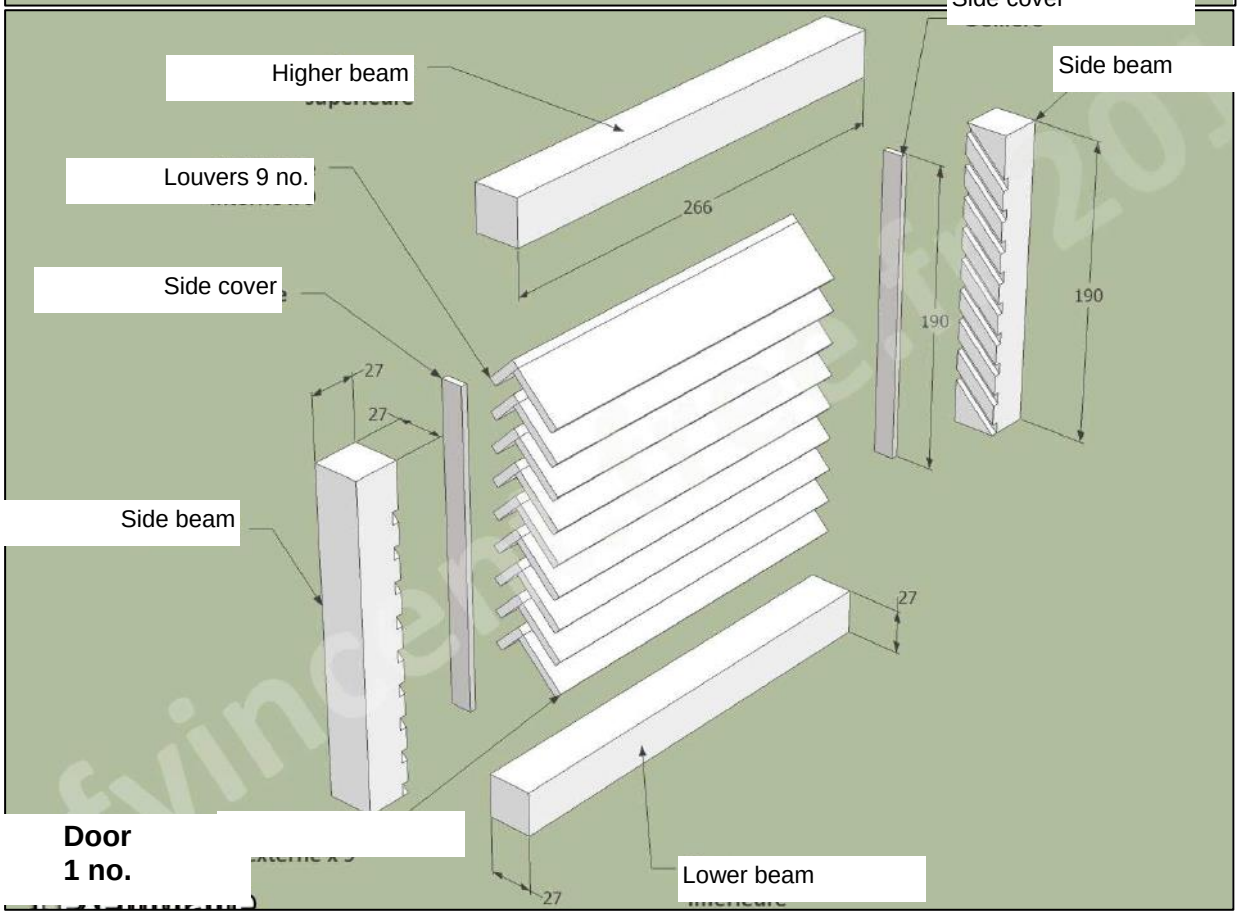
Side beams for the door
1 pair



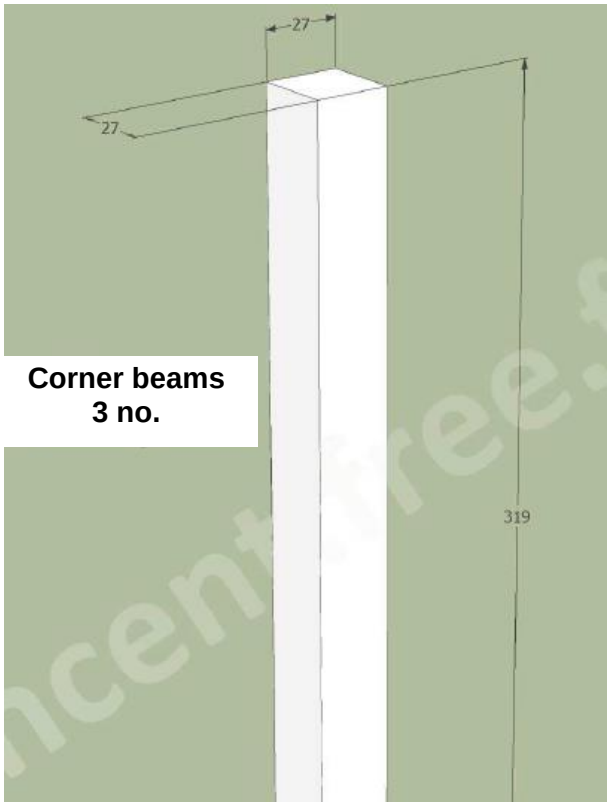
Detail for slots

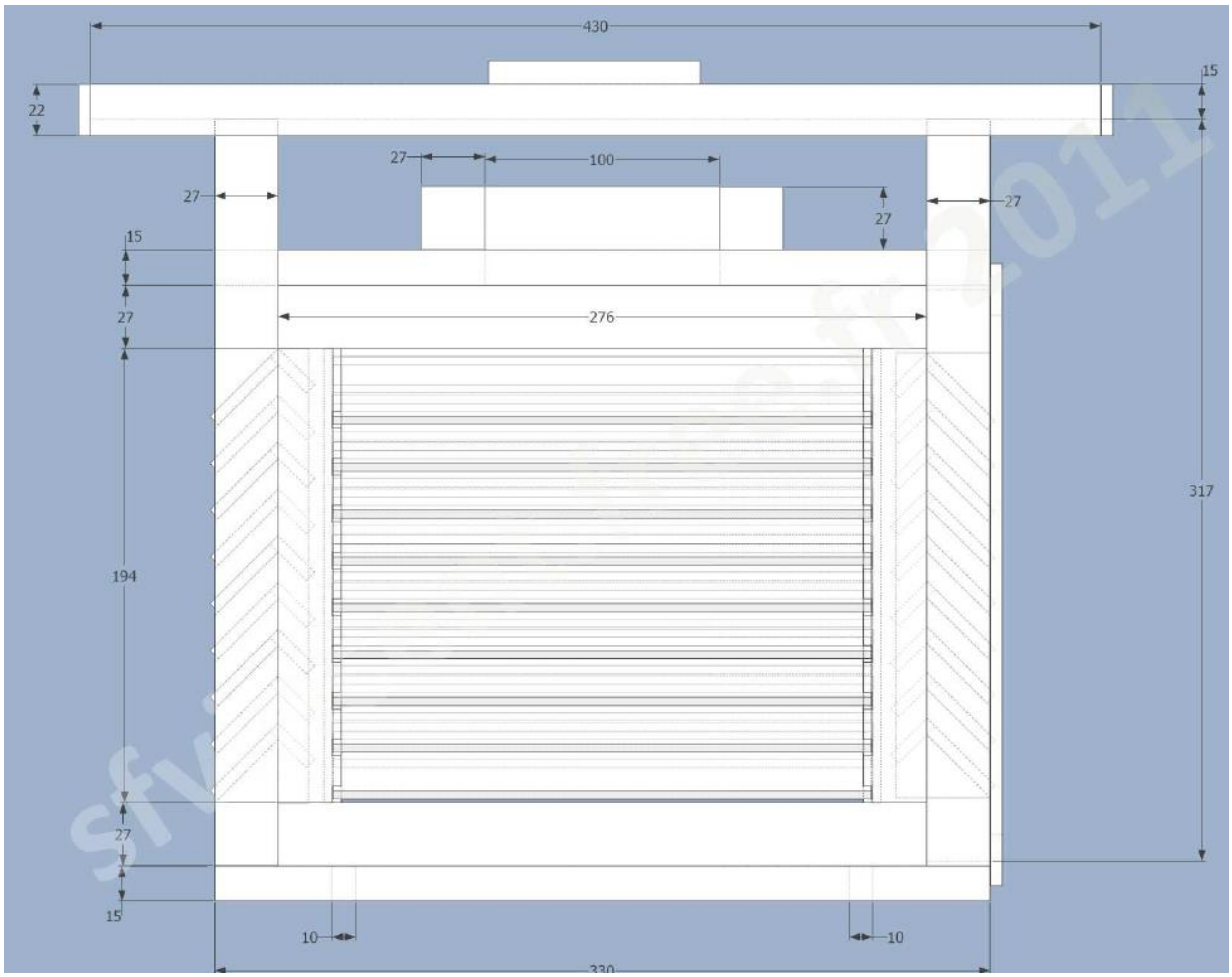


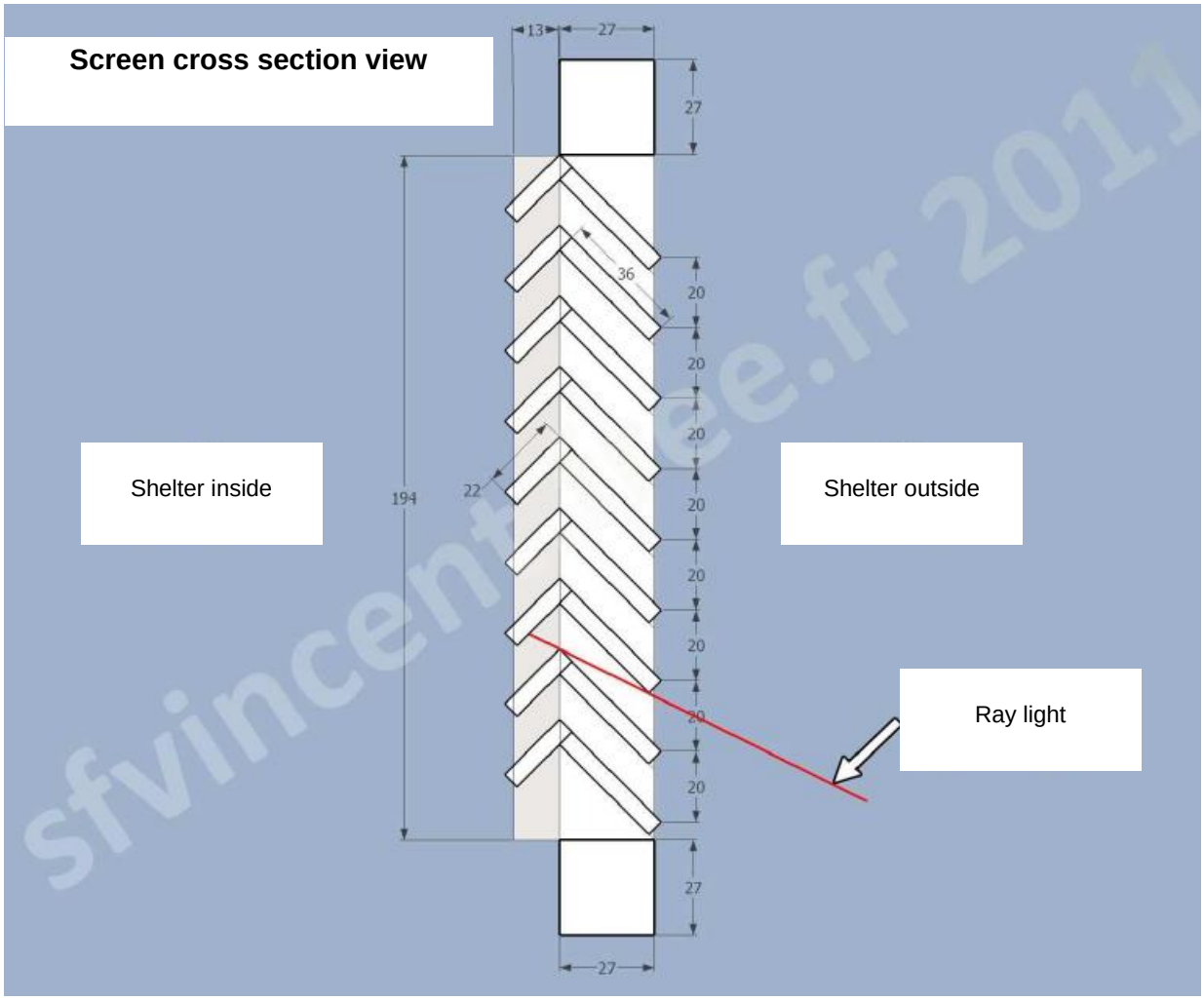
Screens
3 no.



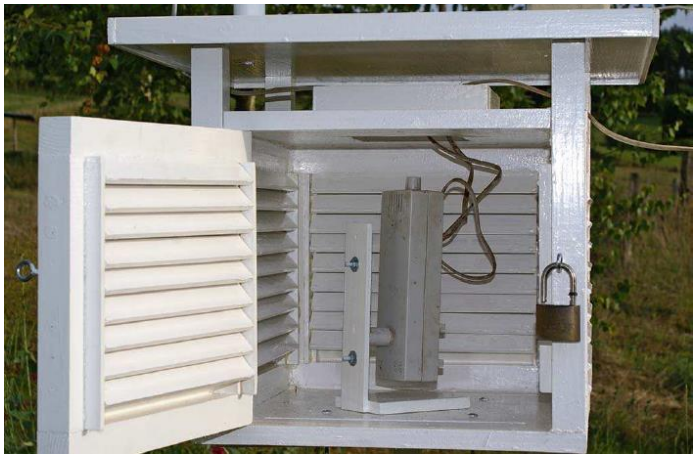
Door
1 no.


27
27
Corner beams
3 no.
319


430
22
15
27
100
27
27
27
15
27
276
317
194
27
15
10
10
330



All parts surfaces have to be painted in white:



The floor should not be plain to further allow aeration and also to avoid damaging the devices in case water should nevertheless enter the shelter.

The shelter should be 1.5m above ground level.