DETAILED OPERATION AND MAINTENANCE (O & M) MANUAL FOR FAECAL SLUDGE TREATMENT PLANT AT COX BAZAAR CAMP-18, BANGLADESH

Faecal **S**ludge **T**reatment **P**lant

COX Bazaar, Camp-18, Bangladesh

Capacity – 15 m^3/day

URBAN waters

Consortium for DEWATS Dissemination Society

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1. Background

Faecal sludge management (FSM) is rapidly developing and gaining importance as a non-sewered sanitation alternative. It is one of the economical and sustainable solutions for the sanitation problems of the middle and low economic regions. Establishing faecal sludge treatment plants (FSTPs) is the key element of FSM.

In most of the FSTPs, ease of construction, capital cost, and reuse infrastructure are taken into consideration. At the same time, it is essential that the plant operations and maintenance activities are carried out in an appropriate and timely manner for the productivity and durability of the plant. From past experiences, it has been observed that the performance of the treatment plant directly depends upon how well it is maintained and operated.

This manual is intended for use by the operators/caretakers and maintenance personnel, to facilitate them to carry out the routine specific and critical tasks. It has been prepared to focus on the detailed operation and maintenance related activities that need to be carried out to ensure effective and efficient performance of the infrastructure related to the FSTP at COX Bazaar Camp-18.

Operational tasks refer to the technical service activities required to run the infrastructure, as well as the correct handling and usage of facilities by the users. **Maintenance,** on the other hand, comprises of planned or reactive technical activities, which are needed to keep the system working. Maintenance requires skills, tools and spare parts. This document focuses on the maintenance aspects and only highlights specific operational issues that affect the smooth running and maintenance of systems.

This manual has been developed to provide a better understanding of the 3 W's and 1 H (Where, when, why and How) of Operation and Maintenance of infrastructure for its successful functioning. The 3 W's are specifically:

1. **What** activities need to be carried out and the detailed process description
2. **When** to schedule the activities
3. **Where** to conduct the activities (pertaining to the modules)

1. Objective

The main objective of this manual is to be used as a reference document for the person or entity responsible for the operation and maintenance of the infrastructure to

1. Carry out tasks related to operation and maintenance for the upkeep of the FSTP
1. Transfer knowledge about the functioning of different components of faecal sludge management to operators and users
2. Ensure compliance of faecal sludge treatment system with effluent standards for safe reuse or disposal of treated wastewater
3. Save time and cost by minimizing instances of system breakdowns
4. Ensure long-term-functionality of all the infrastructure components

1. Content

This manual contains operation and maintenance process descriptions for the different components of faecal sludge treatment. It includes guidelines and suggestions on:

1. Brief Introduction of treatment units
2. Regular and periodical operation and maintenance activities
3. Safety rules
4. Activity schedules for operation and maintenance tasks

1. Target Users

This manual has been written for the person(s) responsible for or involved in the upkeep of systems provided. These may include:

1. Engineers and Operators
2. Engineers, planners and other professionals of the Department of Public Health and Education (DPHE)
3. Urban Local Bodies (ULBs).

5. SAFETY MEASURES

This section gives a brief detail about the basic Do's and Don'ts (as shown in Figure 1) in relation to the safety measures which need to be taken while performing the O&M related activities.

1. **General Site Safety**
    1. **Do's**
        1. Be careful and observant at all times
        2. Ensure maintenance holes are suitably covered or supervised when no operation and maintenance activity is being performed.
    2. **Don'ts**
        1. Don't leave open chambers unattended
3. **Personal Safety Precautions**
    4. **Do's**
        1. Wash your hands and disinfect them after completion of tasks. Find a clean space, away from the system, to eat and drink.
        2. Use proper clothing (long-sleeved shirt, long trousers, shoes and gloves, apron, mask) while maintaining the system.
        3. Keep a first aid kit, lime or concentration of chlorine solution, hand wash, hand sanitizer, spare gloves and masks in the vehicle/ treatment plant
        4. Protect any wounds or bruises on the body from getting in contact with wastewater.
        5. Wash clothes, gloves and boots after performing any activity around the treatment modules.
        6. Change into off-duty clothes on completion of desludging. Wash and disinfect the clothes used while desludging before the next use.
        7. Avoid coming in contact with the wastewater.
        8. Keep yourself hydrated when working inside the sludge drying beds.
    5. **Don'ts**
        1. Don't be barefoot or barehanded while handling sludge and performing the O&M activities
        2. Don't eat or drink during work and near to the treatment units.
6. **Proper Disposal of waste**
    7. **Do's**
        1. Put the waste like scum, used gloves, masks and paper towels in suitable garbage bags.
        2. Ensure that the waste from the operation and maintenance tasks are collected at least 10 meters away from any wells or other water bodies so that it doesn't leach into the ground and water.
        3. Ensure that the garbage cannot be ransacked by animals.
        4. Bring the garbage from operation and maintenance tasks to an official collection facility, where it is disposed of safely.
        5. Clean up the spillage. In case there is a spillage, the spill has to be cleaned either by sucking up the spill by the vacuum pump into the tank or if that is not possible to cover it with lime. In case of the lime cover-up is also not possible, then the spill should be washed and the wash water should be directed to a covered drain and chlorine should be sprayed on the spill area.

8. **Don’ts**
    1. Don’t wait longer than necessary to dispose of garbage.
    2. Don’t dispose of garbage at unofficial dumping locations.
    3. Don’t burn garbage to get rid of it.

Figure 1: Safety Precautions

9. LIST OF EQUIPMENT

Sl. No	Equipment Name	Image
1.	Bucket	
2.	Trowel	
3.	Gloves	
4.	Mask	
5.	Shoes (Gumboots)	
6.	Wheel barrow	
7.	Shovel	
8.	Garden Scissors	
9.	Wooden Pole	

Sl. No	**Equipment Name**	**Image**
10	Fishnet mesh	
11.	Measuring tape	
12.	Broom	
13.	Pressure Washer	
14.	Ladder	
15.	Torch	
16.	Rake	
17.	First Aid kit	
18.	Plastic Sheet	

10. OVERVIEW OF TREATMENT PLANT

Nature based treatment technology is adopted while designing the FSTP where maximum gravity flow is maintained wherever possible. The various treatment modules of the FSTP are Anaerobic Stabilization Reactor (ASR), Sludge Drying Beds (SDB), Settler + Anaerobic Filter (ISAF), Horizontal Planted Gravel Filter (HPGF). However, considering the flooding history of the site location the levels of the sludge drying beds and percolate treatment modules have been raised by pumping the faecal sludge from ASR. The by-products like; treated water after HPGF is planned to dispose-off to the canal running beside the treatment system and sludge will be taken to the existing incinerator for further treatment as their regular practice. The total capacity of the treatment plant is 15 m^3/day.

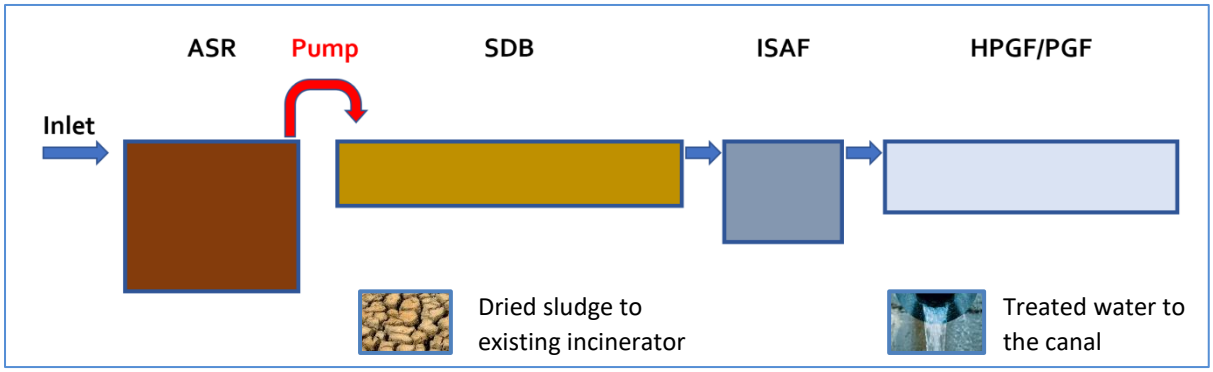


Figure 2: Treatment process flow diagram of the FSTP

In this plant, based on sludge characteristics, location of the treatment unit and end requirements, different combinations of modules are used to achieve desired results. The following are the general steps involved in the treatment process. First unit is an ASR integrated with Screening Chamber which also acts as a receiving station.

1. Layout of the plant

The overall planning of the FSTP at Camp 18 has been done considering the economical aspects and hence the possible existing modules have been used in order to cover the total capacity of the treatment plant.

The total 14 no. of beds along with their percolate collection tanks (2 nos.) have been considered along with the new proposed treatment modules. The proposed new modules are as follows;

1. Anaerobic Stabilization Reactor (ASR) Tank integrated with Screening Chamber
2. 26 nos. of Unplanted Sludge Drying Beds
3. Gazi Tank
4. Integrated Settler + Anaerobic Filter (ISAF)
5. Horizontal Planted Gravel Filter (HPGF) OR PGF

The barrels of the sludge will be taken up to the Screen Chamber with the help of the steps and will be unloaded. The sludge from the Screen Chamber will be allowed to flow in to the ASR respective chambers by unplugging the pipe (by removing the plug).

From the ASR tank, the sludge is proposed to transfer to the beds by using Sludge Pump installed at the outlet chamber of the ASR tank.

The ASR tank has 5 outlets operating through pump which are as follows;

1. Recirculation Arrangement within the ASR tank
2. 2 outlets connected to Existing Drying Beds
3. 2 outlets connected to New Drying Beds

ASR will pump total 15 m3 of sludge daily to 4 numbers of Sludge Drying Beds (either to existing beds or to new beds)

The percolates from the Existing Sludge Drying Beds (Total 16 nos.; 14 existing + 2 new) will be collected in the existing Percolate Collection Chambers and will be pumped to the Gazi Tank installed near ISAF. The purpose of having Gazi Tank is to regulate the flow of percolates travelling to ISAF tank.

However, the percolates from the New Sludge Drying Beds (Total 24 nos,) will be travelled through gravity to the ISAF tank. Further the effluent from ISAF will be connected to HPGF/PGF after which the treated effluent will be disposed-off to the canal running nearby. The dried sludge is proposed to transfer to existing incinerator unit as their regular practice for further treatment.

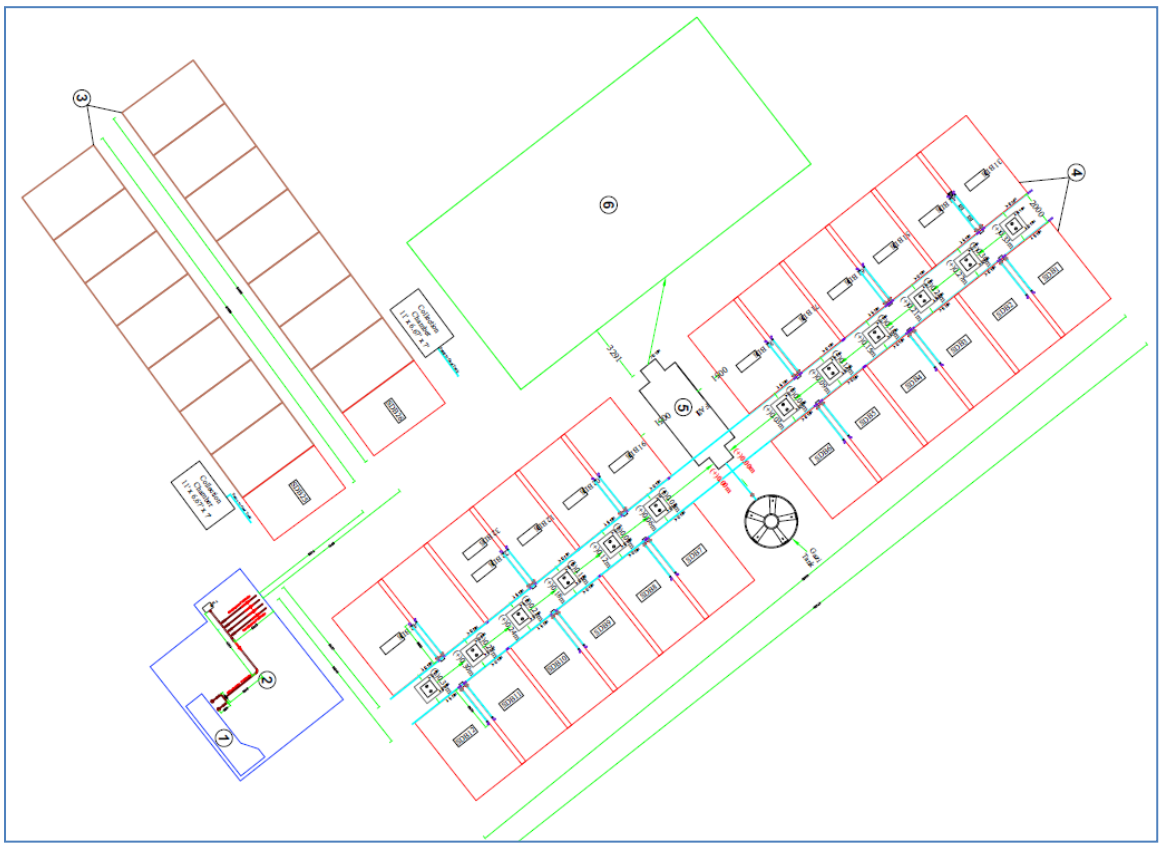
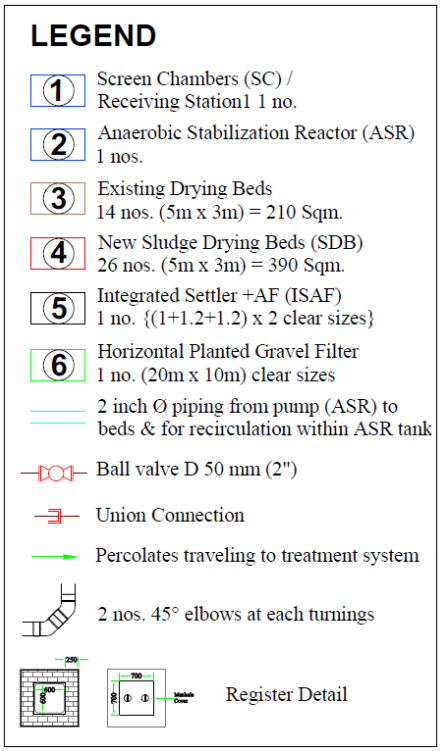
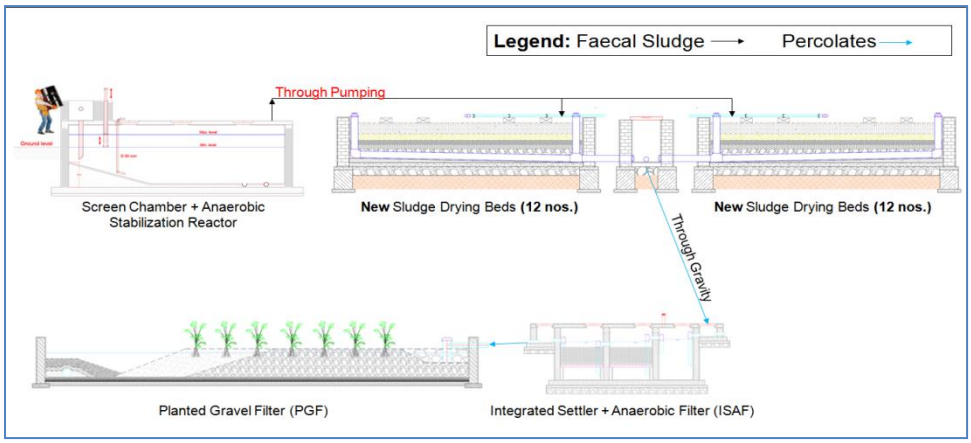


Figure 3: Layout of the FSTP



1. Hydraulic Profiles of the plant



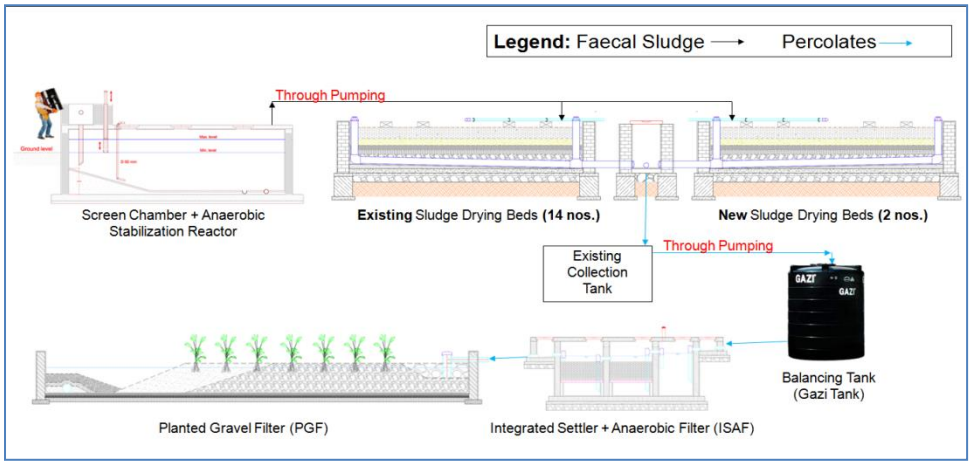


Figure 4: Hydraulic profiles

2. Screening Chamber/Receiving Station

The screening is a basin to trap large solids (rags, paper, plastics, and metals) using different size screens and for settling of grits (sand, gravel, cinder). The screens are provided with parallel bars vertically or horizontally with a specific opening size. The solids collected in this chamber removed regularly and disposed safely.

Figure 5: Existing Screening Arrangement

3. Anaerobic Stabilization Reactor (ASR)

The screened faecal sludge goes to ASR. It is two chambered reactor where anaerobic biodegradation of readily degradable organics present in the FS takes place. Along with degradation, main treatment processes occurs in the ASR are homogenization of fresh and digested FS and stabilization. Stabilized FS dewaters quickly on the Sludge Drying Bed. The outlet discharge pump is used for creating a turbulence in the reactor.

4. Sludge Drying Beds (solid liquid separation)

An **Unplanted Sludge Drying Bed (UPDB) or Sludge Drying Bed (SDB)** is a simple, permeable bed filled with several drainage layers that, when loaded with sludge, collects percolated leachate and allows the sludge to dry by percolation and evaporation. Approximately 50% to 80% of the sludge volume drains off as liquid or evaporates.

Unplanted sludge drying beds need to be desludged before fresh sludge is applied. Drying beds are relatively easy to construct and simple to maintain, although large surface areas and man- or mechanical power is required for regular desludging.

The percolate still contains pathogens and needs to be collected for treatment or controlled reuse.

Figure 6: Existing Sludge Drying Bed

5. Liquid (percolate) Treatment

First unit of the liquid treatment is a **Settler**, an underground tank through which domestic wastewater flows for basic treatment. Settling and anaerobic processes reduce solids and organics, but the treatment efficiency is only moderate. Pathogens and nutrients are barely removed. Settler can be used as primary treatment, prior to secondary or even tertiary treatment.

The next integrated unit of the liquid treatment is **Anaerobic Filter (AF)** where biological degradation takes place without oxygen. Organics (BOD & COD) are reduced in this closed and underground unit with baffle and filter media. In order to remove the odour and colour and to enrich the wastewater with oxygen it is necessary to allow the wastewater to pass

through aerobic treatment. **Planted Gravel Filter (PGF)** is made of planted filter materials consisting of graded gravel and the flow direction is horizontal. The main plants used in this filter bed are Canna Indica (local name: *Kolaboti Plant*), Reed juncus, Papyrus and Phragmites. The plant selection is mainly based on their ability to grow in wastewater and have their roots spread wide. PGF also aims in reducing the nutrients such as Nitrogen, Phosphorous and Potassium present in wastewater.

6. Incinerator

5. Operation and Maintenance aspects

1. Tasks to be performed and coordinated before the feeding of faecal sludge

The treatment plant is designed to handle only faecal sludge and not chemical or industrial waste of any kind. To ensure that the FSTP runs at its full capacity without adversely impacting the performance of the plant in the long run, it is essential to perform some checks and coordination activities

The following activities need to be performed FSTP before the desludging operator disposes of the faecal sludge in the feeding tank.

1. Co-ordination with the desludging operator. Collecting data about the source of faecal sludge
2. Collection of faecal sludge sample monthly and testing its required parameters.

Figure 7: Persons holding barrel of emptied FS

1. Sludge disposal through barrels

The persons carrying barrels of faecal sludge follow the way to the receiving station i.e., screening chamber with the help of staircase. Standing on theplatform, the barrels of faecal sludge will be discharged into the ASR tank through screens.

2. O&M Activities at FSTP

1. Anaerobic Stabilization Reactor (ASR)

It is a closed unit with two compartments separated by a baffle wall having receiving station (screening chamber) on the top. The faecal sludge poured in to the ASR tank will be pumped to SDBs by using submersible sludge pump fixed in the outlet chamber. In order to ensure that the sludge does not get settled in the tank a recirculation arrangement has been provided within the tank.

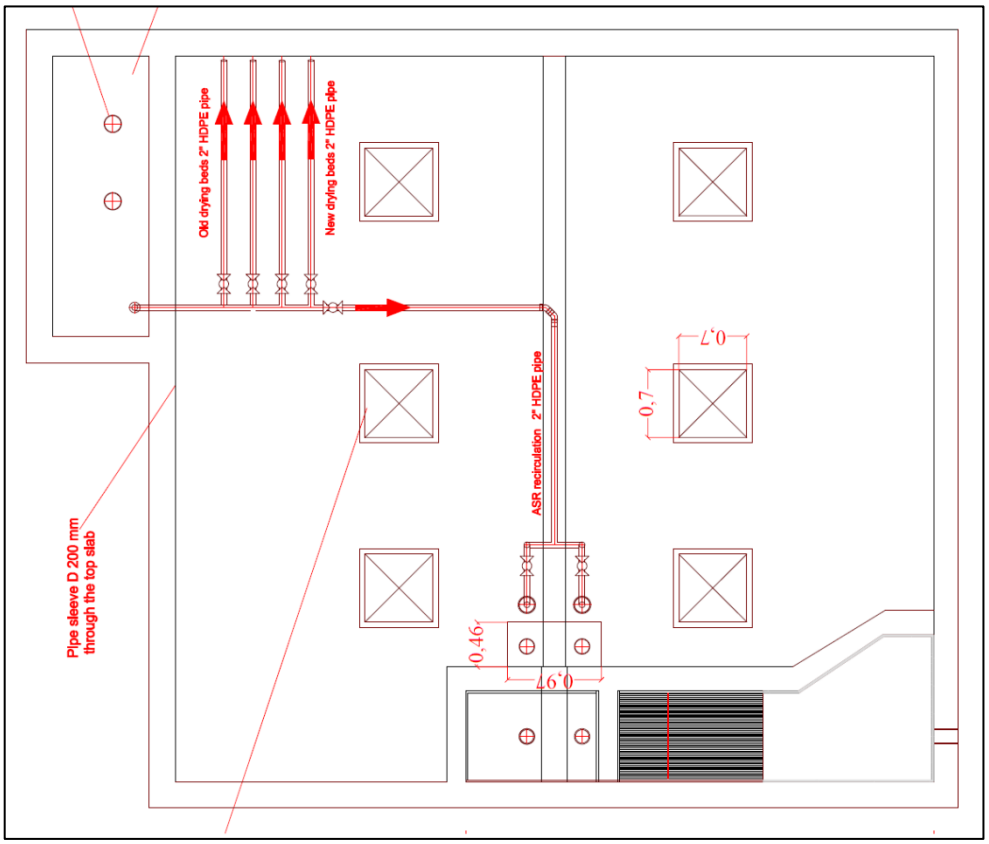


Figure 8: Image showing ASR Recirculation arrangement

In order to ensure the required retention time, the two chambers shall be operated alternately. Meaning;

1. On one day the right chamber will be filled and the left chamber will be desludged.
2. On the next day the left chamber shall be filled and right chamber will be desludged.

With pulling the Closing Pipe exactly 15m^3 will be taken from one chamber only!

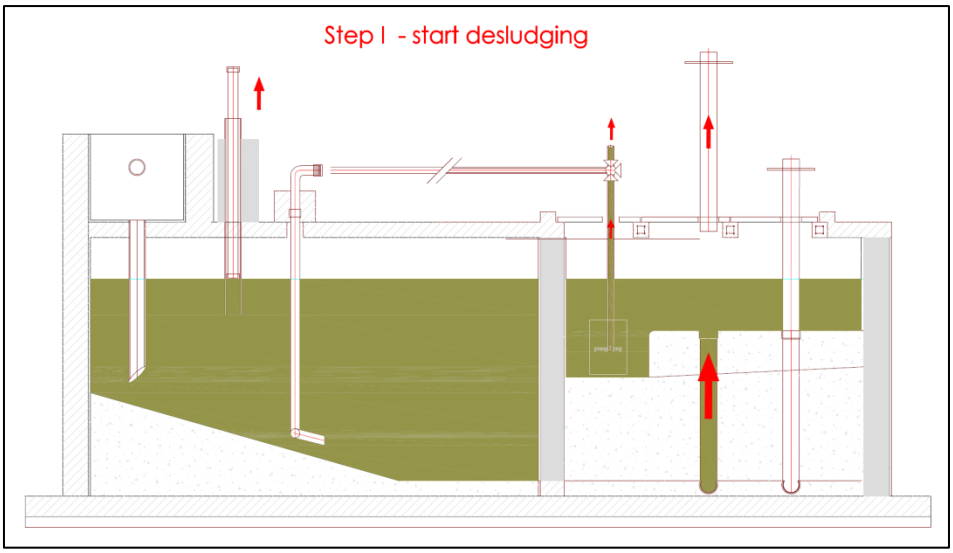


Figure 9: Image showing ASR Desludging Arrangement

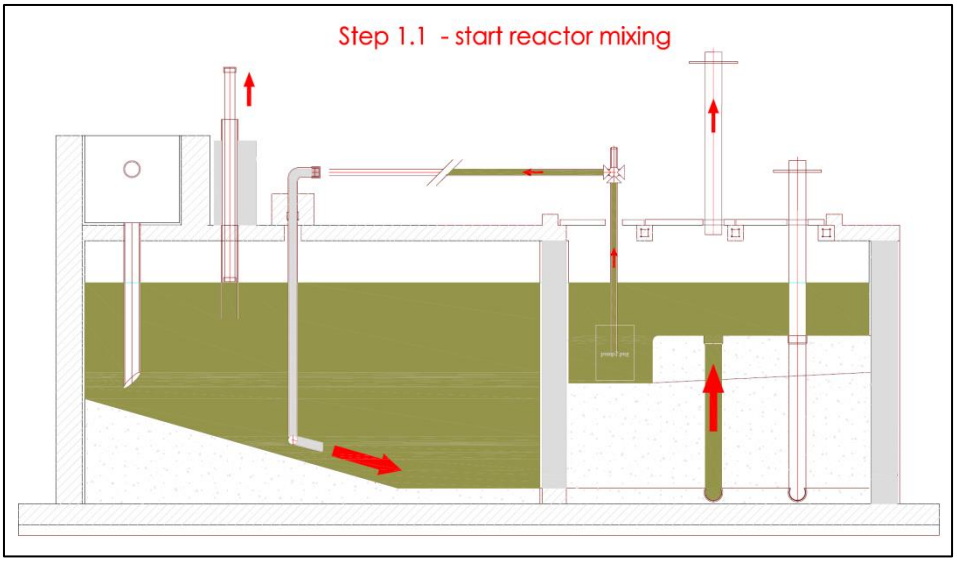


Figure 10: Image showing ASR Mixing (Recirculation) Arrangement

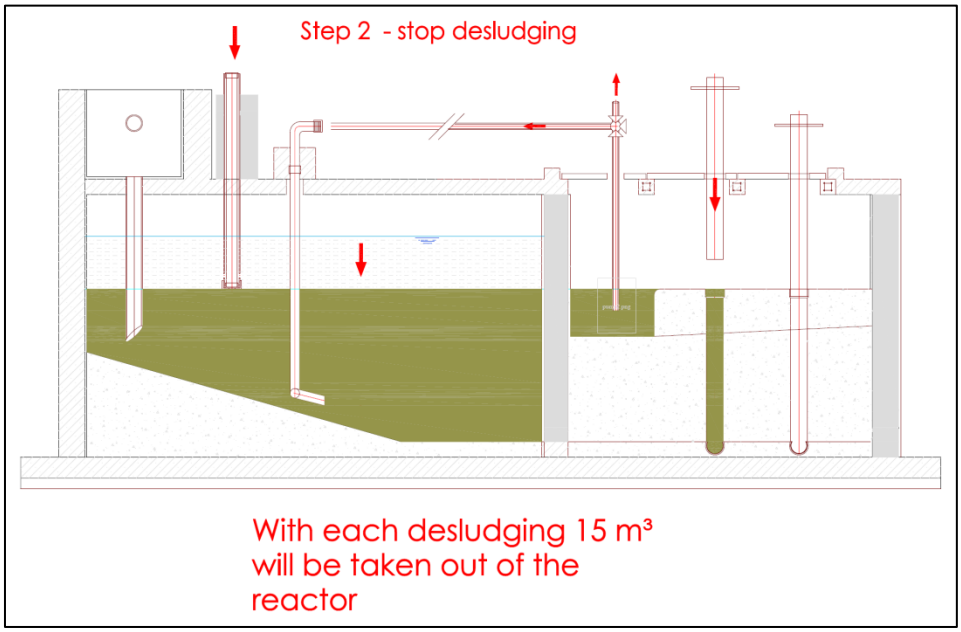


Figure 11: Image showing - When to Stop Desludging at ASR Tank

1. Sludge Drying Bed (SDB)

The faecal sludge is applied to SDBs. While the sludge is drying, the percolate flows to the Liquid (percolate) Treatment modules. If any solid waste comes with FS and spread over the bed, it has to be removed manually by wooden pole etc. The sludge has to be removed manually after specific time frame mentioned in the SDB feeding cycle. Then it has to send for incineration as the regular treatment process. As there is a risk of the presence of helminths and pathogens, the operator

should wear respiratory protection and gloves along with protective clothing. Dead leaves, debris and other trash on the surface of SDB have to be removed periodically.

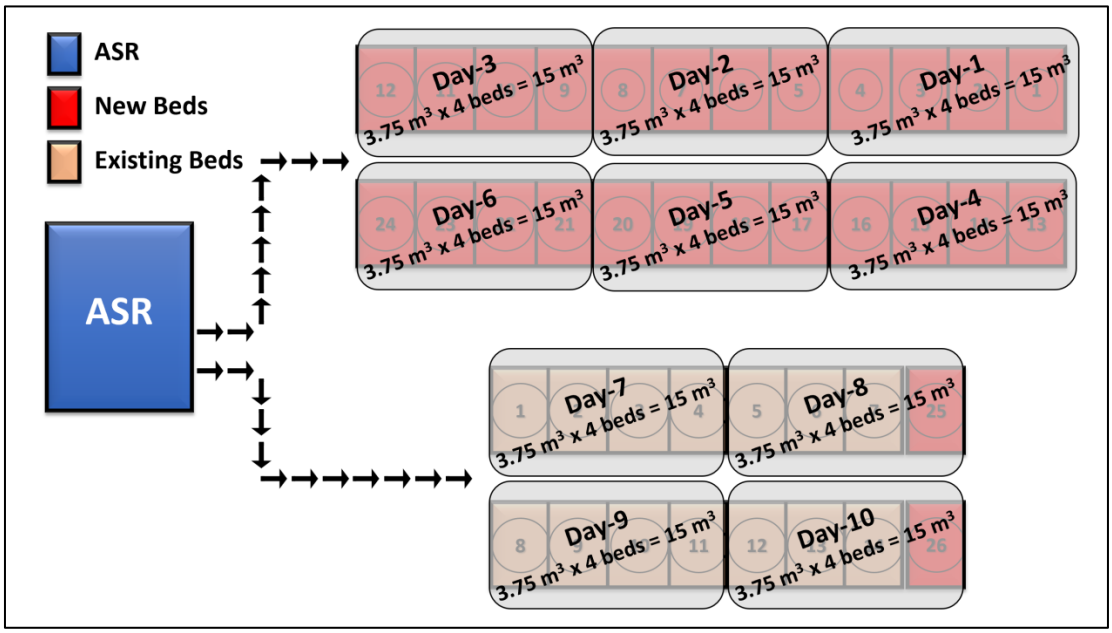


Figure 12: Image showing – SDB Feeding and Frequency

2. Gazi Tank (Balancing Tank)

A readymade HDPE tank called 'Gazi Tank' is proposed to be located near ISAF tank. The main intention of having this tank is to collect the percolates from the existing sludge drying beds and transfer it to the ISAF and further for treatment. The Gazi Tank will be acting as a balancing tank which will avoid the sudden load and turbulence to ISAF by regulating a steady flow with the help of a valve.

Figure 13: Gazi Tank

3. Integrated Settler and Anaerobic Filter (ISAF)

It is a closed unit with one chamber of Settler and two chambers of AF separated by a baffle wall. Settler chamber is meant for sedimentation of easily settleable particles. AF has a Filter media which is placed inside both the chambers. The sludge will get accumulate at the bottom of the ISAF unit which has to be removed periodically and discharged into the SDB. The sludge level has to be checked once in every 3 years and if found excess (like more than 300mm) will need to be desludged.

4. Horizontal Planted Gravel Filter (PGF)

The PGF adds oxygen to the water coming out of ISAF and reduces the organics content further by filtration and biological process. This module does not require any external operation as the flow works by gravity. Dead leaves, debris and other trash on the surface of PGF have to be removed periodically.

2. Data collection

Data needs to be collected about various aspects of the plant functioning in order to monitor the kind of sludge coming into the plant, spot any issues in the plant and improve efficiency.

1. Incoming Sludge logbook

The Faecal Sludge Treatment Plant is designed to treat only domestic sludge. So utmost care should be taken to avoid receiving any industrial sludge which is harmful to the biological treatment system. One of the methods of verifying the sludge characteristics by understanding its source and thus certain data must be regularly collected for records (and analysis if needed).

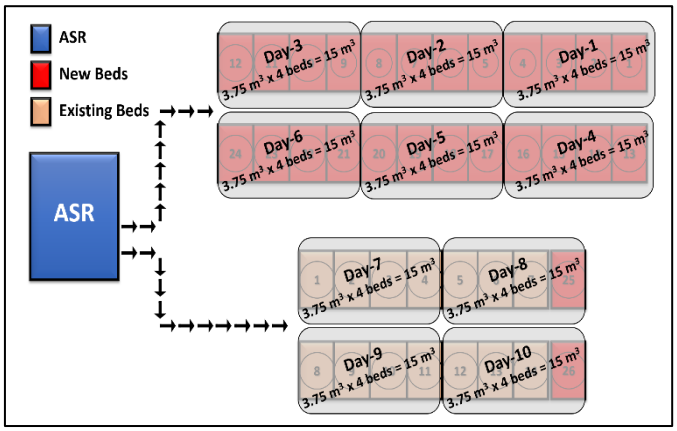
A daily logbook for the incoming sludge including load volume, no. of barrels and discharge time gives insight on the feed rate of the sludge into the FSTP and can give valuable insight on operation details.

1. Drying time in SDB

Currently, the SDBs are designed to have 10 days of resting period in between the alternate loadings. The daily faecal sludge quantity of 15 m^3 is allowed to be fed on total 4 no. of beds by opening the respective valves. Each bed (measuring 5m x 3m) will be loaded until the sludge reaches to its maximum height of 250mm with which one bed will have a faecal sludge volume of 3.75 m^3. Likewise, total 4 beds will have 15 m^3 of faecal sludge.

Further, same pattern will be followed to feed rest of the beds. This pattern will also be followed to the 14 existing beds by which a total of 10 days resting period can be achieved.

After loading 15 m^3 of faecal sludge to 4 beds will be left idle for 10 days without loading for the purpose of drying and the dried sludge is removed and further treated or incinerated.



2. Dried Sludge Analysis

Dried sludge samples should be removed from beds (as per SDB cycle mentioned in the Figure 24 and given to a laboratory for complete chemical and biological analysis. This is important to assure the well-functioning of the FSTP and to ensure the safety of the product when discharged or reused.

3. Effluent water analysis

A sampling of effluent should be done on a regular basis and given to a laboratory for complete chemical and biological analysis to assure the well-functioning of the FSTP and to ensure that the water quality is acceptable for discharge.

Note: A provision has to be made in the budget of O&M plan for quality analysis of FS, treated water and dried sludge (once in a month at-least).

6. Detailed Operation and Maintenance Tasks

3. Feeding of Faecal Sludge and screen chamber

Location	At the inlet of the Screening Chamber (Receiving Station)
Personnel Required	De-sludging operators and FSTP operator
Procedure	1. The desludging operator carrying barrel of faecal sludge should climb up the staircase provided next to the Screening Chamber-cum-ASR tank. 2. The desludging operators will simply lift the barrel and pour in to the screening chamber (receiving station). 3. The FSTP operator needs to observe the sludge flow inside the screening chamber. 4. The FSTP operator needs to ensure that **Closing Pipe** of ASR chamber 2 is closed while feeding chamber 1 and vice versa. 5. The FSTP operator needs to remove the **Overflow Pipe** to release the pooling sludge water. 6. The FSTP operator needs to remove the settled grit if needed and replace the **Overflow Pipe**. 7. The desludging operators needs to take out the barrel with care to avoid spillage of sludge. 8. A sample has to be collected 9. Collect the solids accumulated at bar screens using a rake and transfer them into a plastic/steel tray. Care should be taken to prevent spilling of the solids outside the chamber. 10. Once the accumulated solids have been removed the bar screen has to be cleaned using water and a broom. 11. The collected solids have to be dried by keeping the plastic tray in sunlight till the end of the day and then weighed on the weighing machine. The readings must go into the log book, and the amount of solid waste coming in must be monitored.

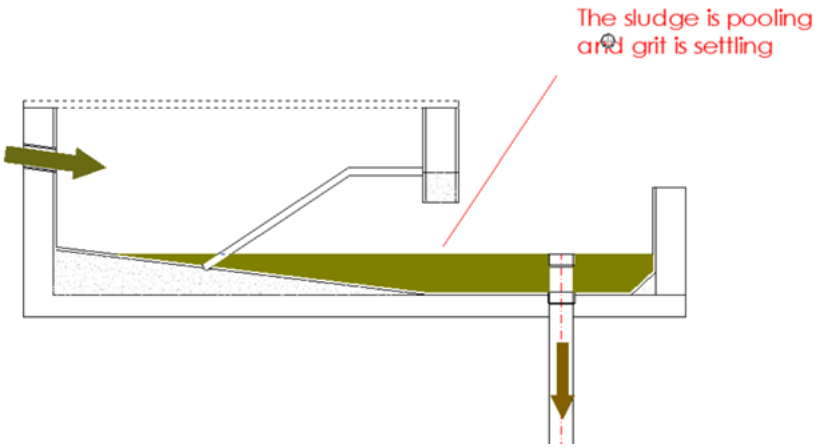


Figure 14 Off loading

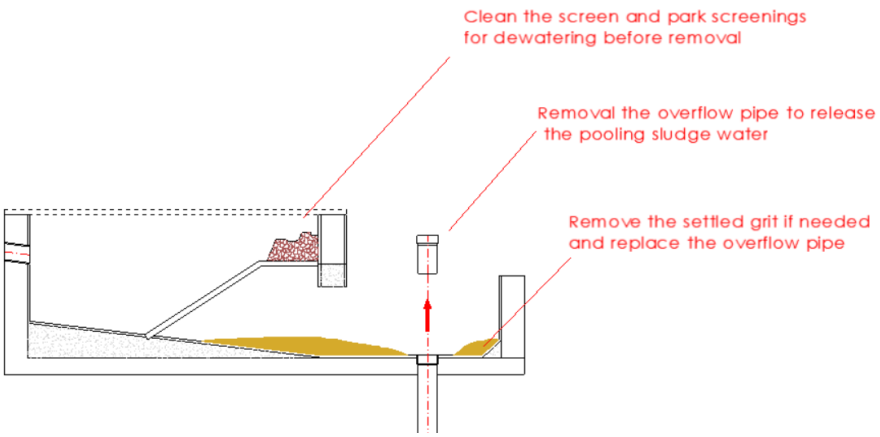


Figure 15 Cleaning

Figure 16 Removing solid waste from the screens with a trowel

Precautions	Make sure that the desludging operators carefully climb up the staircase with loaded barrel to avoid any incidences. The barrel has to be carefully and properly unloaded in to the receiving station only to avoid spillage of sludge. Make sure that both the **Closing Pipe** of Chamber 1 & 2 are closed after unloading of barrels. The solid waste collected should be safely disposed as per Municipal Solid waste management protocol.
Equipment Required	For de-sludging operators: Gloves, mask, boots. For FSTP operator: Gloves, mask, boots, apron, Broom, rake, plastic tray, plastic bin, gloves, mask, apron, trowel.
Documentation	The following data needs to be collected here: Source of faecal sludge, Preliminary chemical characteristics, Observation (colour and odour) and reading for the Imhoff cone test.

1. Weighing of Solid Waste

Location	Next to Screening Chamber
Personnel Required	FSTP Operator

Figure 17: Weighing the solid waste

Procedure	1. After cleaning the screening chamber, weight of the collected solid waste needs to be measured for each load of faecal sludge or at-least at the end of the day. 2. Use the weighing machine along with a plastic tray. 3. Fill the collected waste onto the tray and note down the reading shown in kilograms. 4. Post weighing transfer the solids into the plastic bin for further disposal or need to be handed over to the municipal solid waste once in every week at-least.
Precautions	The FSTP operator should wear gloves while handling the solid waste.
Equipment Required	Weighing machine, plastic tray, gloves, and apron.

1. Flow Regulation of digested sludge from ASR to the Sludge Drying Beds

Location	Outlet of Anaerobic Stabilization Reactor (ASR)
Personnel Required	FSTP Operator
Procedure	1. Step 1 - Desludging 1. If the 'Level Indicator' is up, then FSTP Operator has to pull up the 'Closing Pipe' of the chamber to be emptied.

2. Check the valves of the drying beds.
3. Turn three-way-valve towards drying beds.
4. Switch on pump. (With each desludging 15 m3 will be taken out of the ASR.)

Step 1.1 - Reactor mixing

Only require once in a week for 15 minutes or on demand

5. If 'Level Indicator' is up, FSTP Operator has to pull up the 'Closing Pipe'
6. Turn the three-way-valve to 'Mixing Pipe'
7. Switch on pump for 15 minutes.

2. Step 2 - Stop Desludging
   1. If no sludge is coming anymore and pump has stopped
   2. Replace the 'Closing Pipe' to the closing position.
3. The sludge feeding from ASR tank to the SDBs must be filled to the 25cm mark in the SDB, however in order to ensure and maintain the exact height of the sludge an overflow cut-out have been provided in the intermediate walls to spill over the excess sludge from one bed to the other.

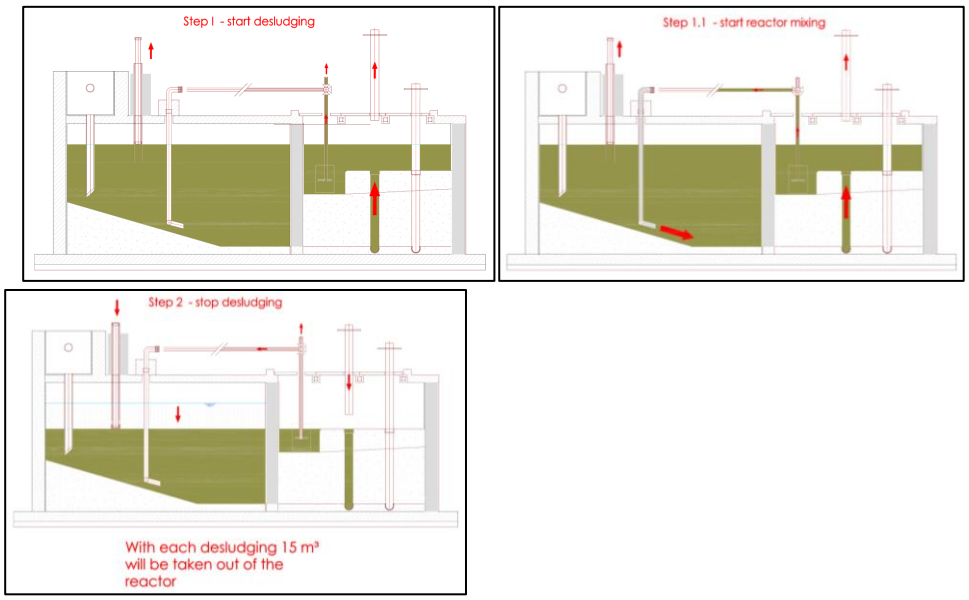


Figure 18 Steps of the operational activities at ASR

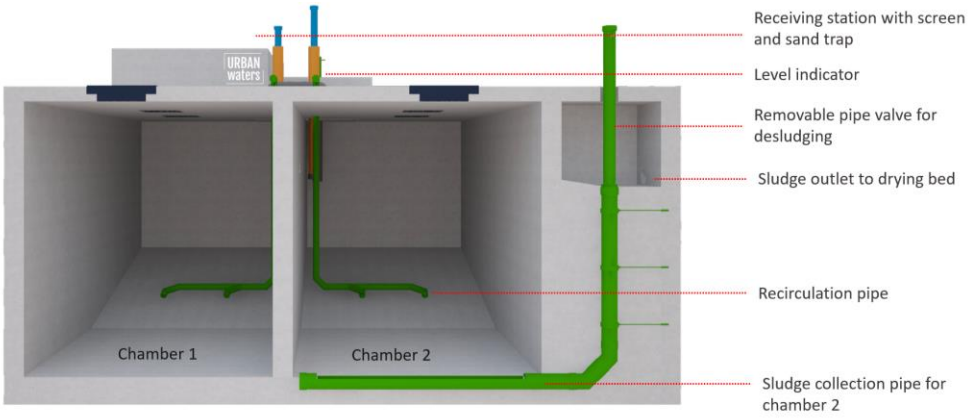


Figure 19 Cross Section of ASR

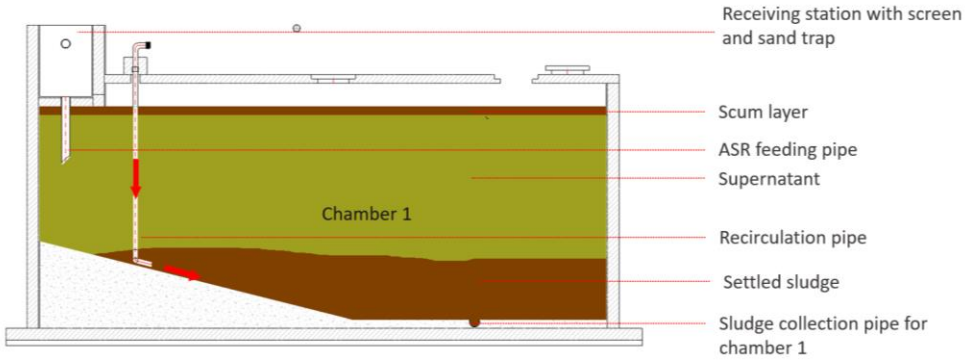


Figure 20 Cross section of ASR

Precautions	1. Make sure the three-way-valve is directed properly. 2. FSTP Operator has to ensure that the respective valves are properly open for the beds to be loaded before starting the pump. 3. Make sure there are no leakages in between ASR & SDB feeding. 4. One single pumping from ASR will discharge total 15m^3 of sludge which will be loaded to 4 no. of beds, each bed taking 3.75m^3 of sludge (i.e., L=5m x W=3m x H=0.25m).
Equipment Required	Mask, gloves.

1. Removal of dried sludge from the Sludge Drying Bed

Location	Sludge Drying Bed
Personnel Required	FSTP Operator

Figure 21: Removal of dry sludge

Procedure	1. When the sludge is visibly dry and the underlying sand layer is visible through the cracks in the dried sludge perform the following steps. 2. Remove the dry sludge by hand wearing gloves, tap it to remove excess sand and collect it in a plastic bowl and transfer it to a wheel barrow. 3. Dump the dried sludge from wheel barrow into the area dedicated for further process. 4. Get the wheel barrow back to the drying bed. 5. Perform steps 2, 3 and 4 until the bed is completely emptied.
Precautions	1. Make sure the person entering the beds during peak sunshine hours is wearing protective clothing. 2. Risk of dehydration: Kindly do not stay in the bed for more time. Keep taking breaks, or limit the working hours inside the beds to before sunrise. 3. Any repair works to be undertaken during off-sunshine hours.
Equipment Required	Gloves, mask, apron, wheel barrow, plastic bowl

1. SDB feeding cycle (Sludge Loading Resting Matrix)

At any given point of time, feeding of the FS will be carried out to the four beds (daily). Daily FS feeding in the designated bed should be conducted. Whereas; Figure 7 explains about SDB feeding cycle for continuous feeding.

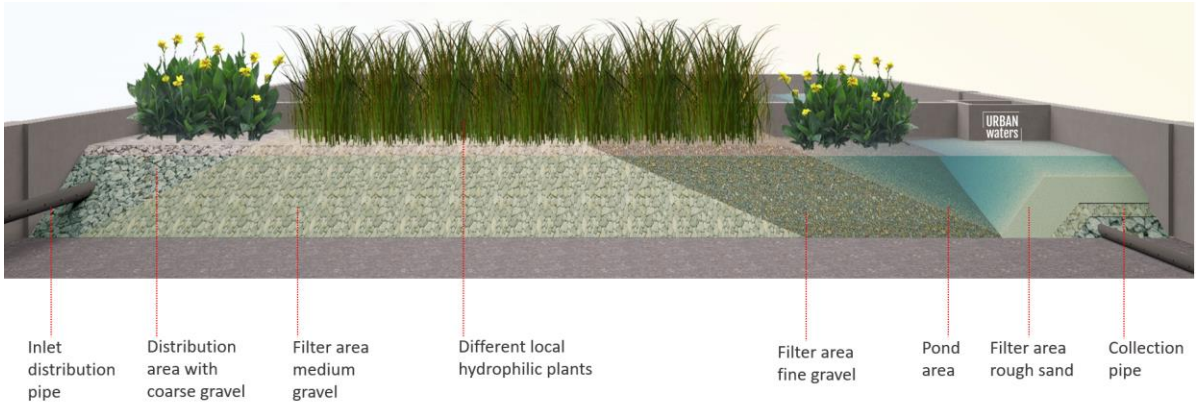


Figure 22 Cross section of PGF

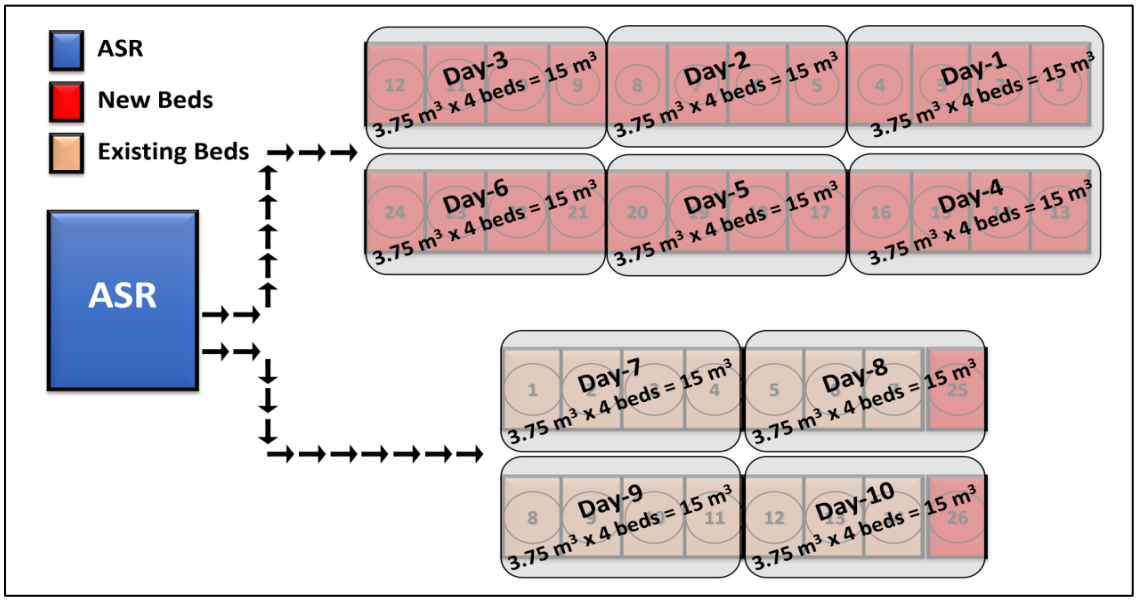


Figure 23: Image showing – SDB Feeding and Frequency

Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7	Day-8	Day-9	Day-10
NB 1-4									
	NB 5-8								
		NB 9-12							
			NB 13-16						
				NB 17-20					
					NB 21-24				
						NB 25-EB 3			
							EB 4-7		
								EB 8-11	
									EB 12-NB 26
									NB 1-4
Day-11	**Day-12**	**Day-13**	**Day-14**	**Day-15**	**Day-16**	**Day-17**	**Day-18**	**Day-19**	**Day-20**
NB 1-4									
NB 5-8	NB 5-8								
	NB 9-12	NB 9-12							
		NB 13-16	NB 13-16						
			NB 17-20	NB 17-20					
				NB 21-24	NB 21-24				
					NB 25-EB 3	NB 25-EB 3			
						EB 4-7	EB 4-7		
							EB 8-11	EB 8-11	
								EB 12-NB 26	EB 12-NB 26
									NB 1-4

NB =	New Beds
EB =	Existing Beds
	Sludge Loading / Feeding to bed
	Removing Dried Sludge and making bed ready to take new loads

Figure 24: SDB feeding cycle (Sludge Loading Resting Matrix)

2. Maintenance Task 1

Note: - In general it is recommended to replace with new filter material, however, one can choose to remove the existing filter material, wash and restore it.

3. Gazi Tank (Balancing Tank)

Location	Installed near ISAF inlet
Personnel Required	FSTP Operator

Procedure	1. This 5000 litre capacity Gazi tank will be receiving percolates from the existing sludge drying beds through pumping. 2. The FSTP operator needs to open the valve at Gazi tank to transfer percolates to ISAF for further treatment daily and hence to check the level of percolates in the Gazi tank at least daily. 3. Considering the capacity of the liquid treatment plant i.e., ISAF+PGF it is recommended to allow just half of the capacity of the Gazi tank i.e., 2500-3000 litres of percolates per day.
Precautions	1. Make sure that the valve is closed all the time before operating. 2. Make sure that the valve is opened in such a way that it should not create any turbulence. 3. Make sure that the operator checks level daily and operate the valve daily without fail to avoid flooding of Gazi Tank.
Equipment Required	Gloves, mask, apron

Maintenance Task 1- Replacing of filter material

Table 1: Replacing of filter materials in the PDB

Where	Sludge drying bed
When	After 5 years of operation (or as per need)

Why	1. To avoid clogging of percolate down the treatment system 2. To ensure the design treatment efficiency to the effluent quality
	Take out all the sludge if any remaining Remove the sand layer from the bed using shovels The sand removed should be transported and disposed of safely The sand used for replacing filter media should be free from silt and clay; if the clay is present then sand must be washed and used. Once ensuring the sand is free from silt and clay, it should be placed on the drying beds
Equipment	Shovel, Plastic sheet, brush
Precautions	The safety rules mentioned in **SAFETY MEASURES** must be followed while performing the above tasks. Stay hydrated before performing any task inside the sludge drying beds

Maintenance Task 2- Covering the beds during rainy season

The beds should be covered by plastic sheet during the occurrence of rain. This task is very much essential for the bed in idle state, the idle bed must be covered during rain. This task is to prevent an entry of rainwater (moisture) into the sludge which is in the process of drying. Other time than rain occurrence, the beds should be kept open so as to get consistent sun light.

1. Integrated Settler Anaerobic Filter (ISAF)

The percolate from the Sludge Drying Bed is further subjected to treatment in Integrated Settler Anaerobic Filter (ISAF). The ISAF is provided with 1 chamber Settler and 2 chambered Anaerobic Filters. The easily settleable solids get settled in Settler whereas wastewater flows through the filter, particles are trapped and organic matter is decomposed by the biomass that is attached to the filter material.

ISAF applications are designed and dimensioned in such a way that treated water meets requirements stipulated in environmental laws and regulations. ISAF is based on the principle of low-maintenance since most important parts of the system work without energy inputs and cannot be switched off intentionally.

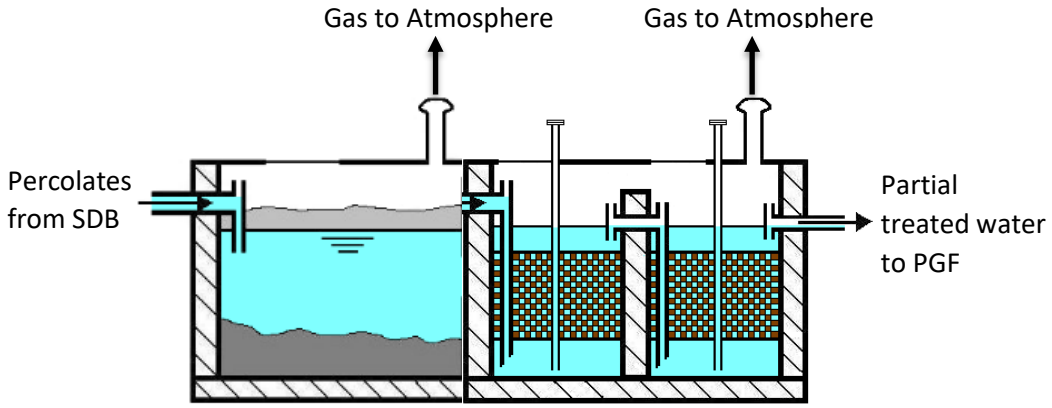


Figure 25: Cross section of ISAF

1. Operational Tasks

Operational Task 1- Ensure free flow of water

Figure 26: Ensuring free wastewater flow

Table 2: Ensuring free wastewater flow

Where	Inlets and outlets of all modules
When	Once in 15 days
Why	1. To identify possible obstructions in pipes and ISAF module. 2. To allow the required free flow of wastewater through the entire system (AF module). 3. To identify possible damages or leakages.
How	1. Open the maintenance hole cover at the inlet and outlet of ISAF module. 2. Check if the wastewater has its usual flow (compare with what was observed in earlier inspections). 3. If no or slow flow is observed, check for obstructions caused by solid materials, floating materials or depositions. Remove obstruction if any. 4. Any, using steel wire in the sewer system and a long steel sieve to remove floating material 5. Place maintenance hole covers back over the maintenance hole.

Equipment	Steel wire, long steel sieve
Precautions	Follow the safety rules mentioned in **SAFETY MEASURES** while performing the tasks Water flushing should be done only after cleaning and opening the outlet of the inspection chamber Pipes of short length should be cleaned using L-brush and normal brush

Operational Task 2- Ensuring functionality of the vent pipes

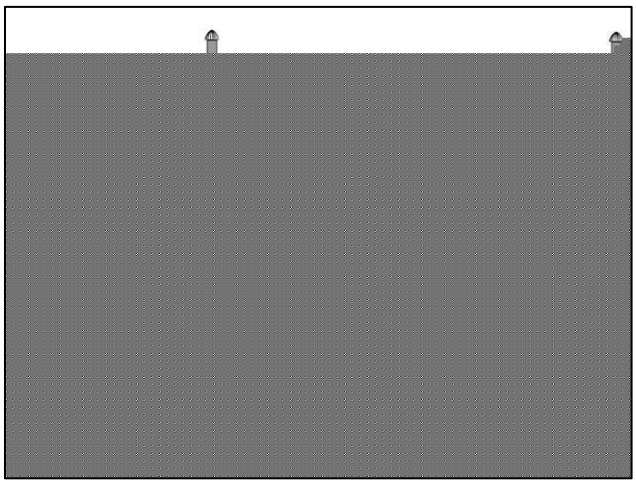


Figure 27: Ensuring functionality of vent pipes

Table 3:Ensuring functionality of the vent pipe

Where	Vent pipe in ISAF
When	Once in a month
Why	To avoid bad odour around the system.
How	Look for damages on the outside of the vent pipe Check for blockages in the vent pipe by either looking through it, tapping it with a stick and judging if it is free from the emanating sound or through other suitable methods Remove any blockages found using an L-brush. If you notice any damage, please contact your service provider for a replacement.
Equipment	L brush
Precautions	Replace the vent pipe cap back after clearing the blockages

Operational Task 3- Check sludge level

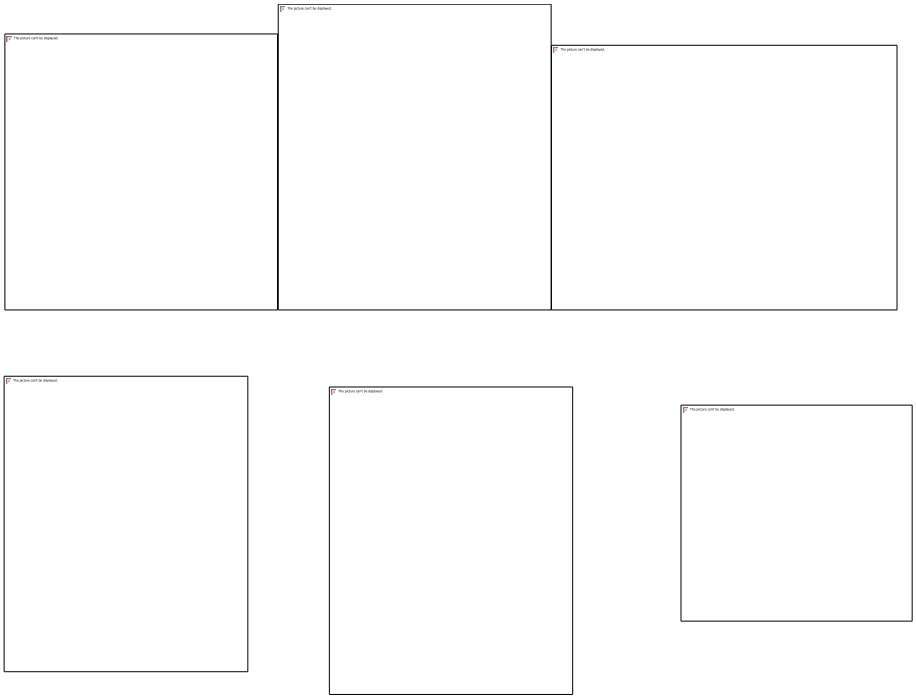


Figure 28: Process for checking the sludge level

Table 4:Check sludge level

Where	Chambers of ISAF
When	Once in 6 months
Why	1. To provide the required retention time for new sludge and wastewater in the components. 2. To ensure separation of water and solids in settler.
How	1. Open the maintenance hole covers 2. Take a clean long stick or a scale. Around the stick, a white cloth has to be wrapped. 3. Insert the cloth wrapped stick vertically and slowly into the inlet and outlet of the settler chamber until it touches the base of the module. 4. Take the stick out slowly and look at the level of sludge mark on the wrapped cloth 5. If the mark of the sludge is higher than 50 cm (which means that the sludge level in the chamber is higher than 50 cm), desludging has to be carried out according to the degree of solidification. 6. In AF chamber Insert the cloth wrapped stick through desludging pipe 7. Close the maintenance hole using the maintenance hole cover.
Equipment	long stick/scale, white cloth
Precautions	Follow the safety rules mentioned in **SAFETY MEASURES** while performing

	the tasks After the sludge measurement, discard the cloth.

1. Maintenance Tasks

Maintenance Task 1 – Desludging of the Settler and Anaerobic Filter

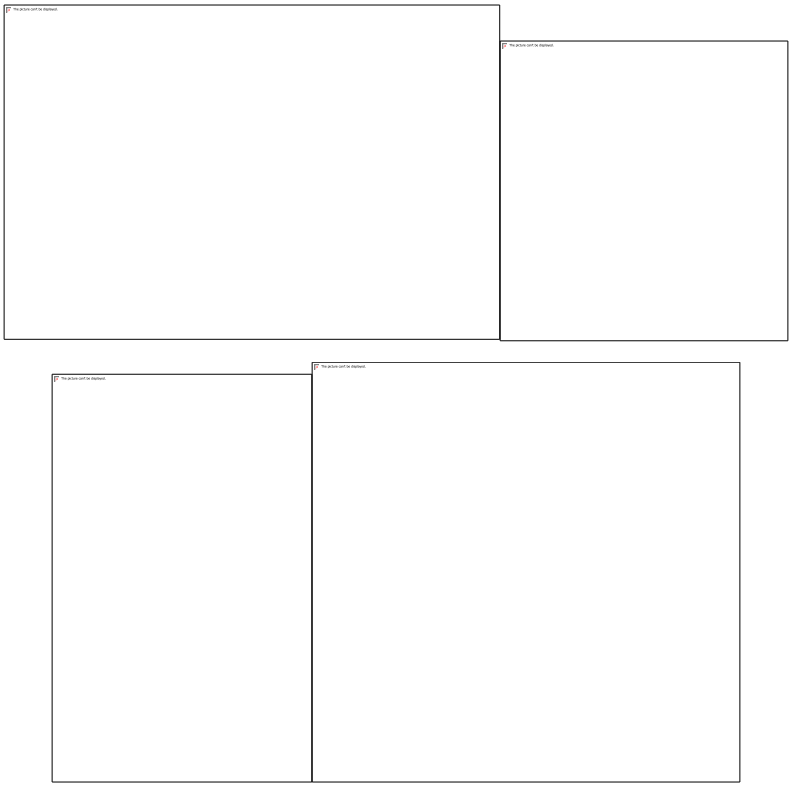


Figure 29: Desludging Process of AF

Table 5:Desludging of the Anaerobic Filter

Where	All maintenance hole covers in ISAF
When	Once in 6 months/whenever necessary
Why	1. To avoid solidification of sludge. 2. To provide required retention time for wastewater flowing through the components
How	1. Open the maintenance hole covers of the chamber 2. Measure the sludge level. (**Refer 1**). 3. Remove excess (more than 50 cm) sludge from the chambers using the desludging equipment.

	4. Leave around 15 cm of sludge in each chamber to ensure the continuous treatment of wastewater. 5. Chambers with less sludge can be inoculated with desludged sludge using sludge pump with hosepipe placed. 6. In AF chamber remove the excess sludge through the desludging pipe 7. Place the maintenance hole cover back over the maintenance hole.
Equipment	Desludging Pump, L-shovel, Straight shovel, Trowel, Personal Protective equipment
Precautions	Follow the safety rules mentioned in **SAFETY MEASURES** while performing the tasks Agitate the sludge adequately with available water to assure the pumping process faster. 3. Avoid pumping at the last bit (10cm from a base slab) of the sludge at the bottom as it contains big stones and other solid waste, which will spoil the pump. This has to be removed by other means such as a customized rake or spade that reaches the bottom of the chamber easily. Access inside the tank is strictly prohibited. In the worst-case scenario, aerate the chamber by leaving it open for some time. Clean the maximum portion of the sludge from outside mechanically and then consider entering. But entry into the chamber is best avoided.

Maintenance Task 2- Cleaning of filter materials at Anaerobic Filter

Note: - In general it is recommended to replace the filter media, however, if one chooses to wash filter media and reuse the same following are the guidelines.

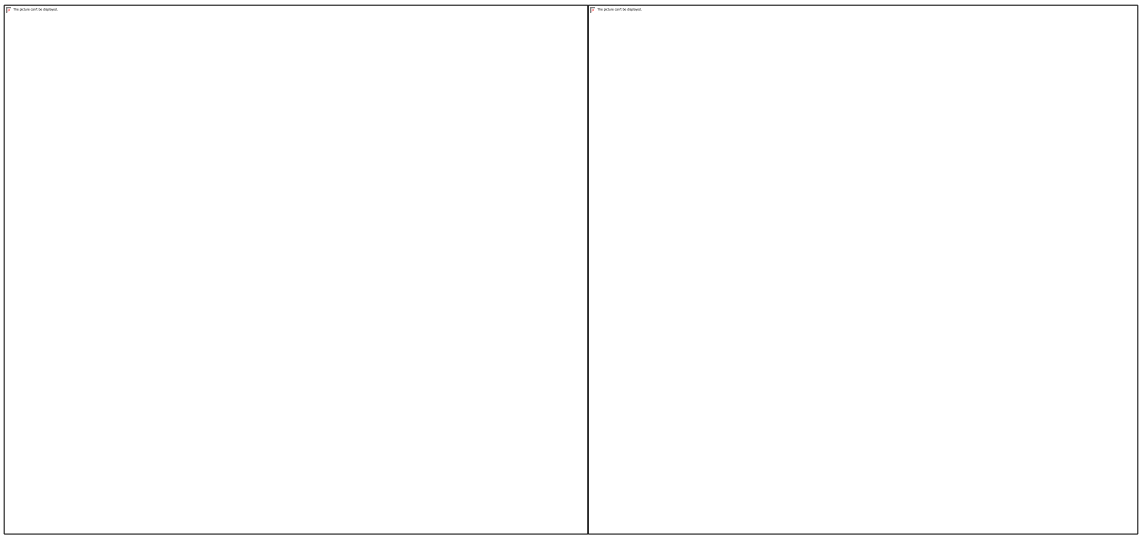


Figure 30: Cleaning of filter materials at Anaerobic Filter

Table 6:Cleaning of filter materials at Anaerobic Filter

Where	All the chambers of Anaerobic Filter
When	Once in 5 years
Why	1. To avoid a large quantity of sludge accumulation in AF 2. To retaliate the design treatment efficiency to the effluent quality. 3. To avoid clogging of wastewater through the treatment system.
How	1. Open the maintenance hole covers of the AF 2. Using a Pump, force water above the filter materials through jetting action. 3. Meanwhile, use a sludge pump to dewater the filter chamber through the desludging pipe 4. Repeat the steps 3 or 4 times till you pump out clear water. 5. Place the maintenance hole cover back over the maintenance hole.
Equipment	Desludging Pump, L-shovel, Straight shovel, Trowel, Personal Protective Equipment, Hose pipe, pressure washer
Precautions	Follow the safety rules mentioned in **SAFETY MEASURES** while performing the tasks Stop the wastewater inflow by plugging the inlet or by bypassing it.

1. Horizontal PGF

The Horizontal PGF is a shallow tank filled with graded gravel or pebbles, and wide rooted plants are planted in this gravel filter. The treatment mechanisms are biological conversion, physical filtration, and chemical adsorption. Plants commonly used in HPGF are *Canas indica*, *Typha latifolia*, *Phragmites Karka*, *Cyperus papyrus* etc. The plant selection is mainly based on their ability to grow on wastewater and have their roots go deep and spread wide. Plants transport oxygen via their roots into the ground.

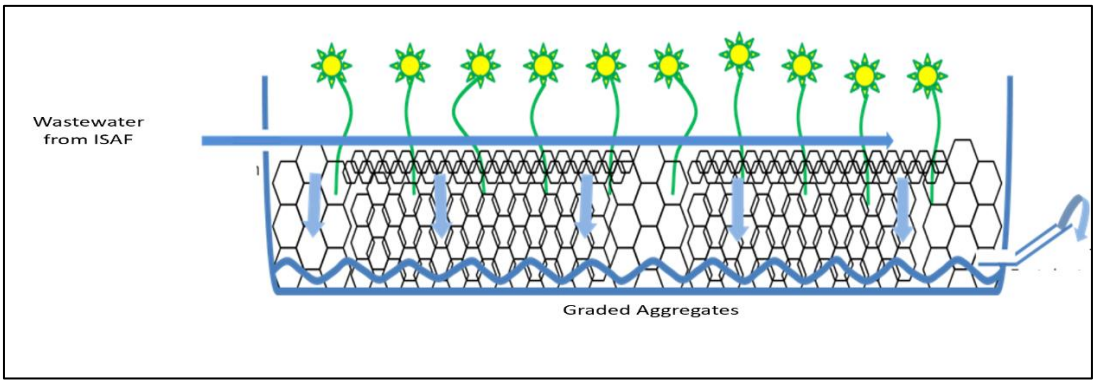


Figure 31: Horizontal PGF

1. Operation Tasks

Operation Task 1- Check for swivel pipe

Table 7:Swivel pipe level checking in HPGF

Where	Horizontal PGF - Outlet of HPGF.
When	Once in a month or, in the following cases 1. The water level is observed above the upper surface of the filter material (coarse aggregates) 2. There is dampness observed in the filter material 3. There is no plant growth 4. There is excess mosquito growth
Why	1. To ensure proper treatment of wastewater 2. To avoid odour
How	1. Open the maintenance hole cover of the outlet chamber. 2. Check if the swivel pipe top is at 60 cm from the bottom of the outlet chamber. 3. If the swivel pipe is not at the desired level, lower or raise it until the top of the swivel pipe is 60 cm from the bottom of the outlet chamber. 4. If there is no water flow from the top of the swivel pipe, check for leakage at the swivel pipe joint at the bottom.
Equipment	Measuring tape, Gloves
Precautions	Follow the safety rules mentioned in **SAFETY MEASURES** while performing the tasks

1. Maintenance Tasks

Maintenance Task 1 - Weed removal and trimming of plants.

Figure 32: Picture showing trimming of plants in HPGF

Table 8: Weed removal and trimming of plants

Where	Horizontal PGF.
When	Once in a month or when there is excess growth of plants
Why	6. To avoid rotting of dead leaf litter in the horizontal PGF. 7. To avoid clogging of filter material in the horizontal PGF. 8. To maintain the cleanliness and to increase aesthetics near the treatment module 9. To avoid blockages of sunlight.
How	1. Check for the presence of dead leaf litter or/and weed inside the horizontal PGF. 2. If the dead leaf litter or other litter is present, remove it manually or using an appropriate tool. 3. If plants in HPGF have grown excessively and are blocking the sunlight, trim them.
Equipment	Garden Scissors, Gum boots, Sickle
Precautions	4. Ensure there are no rodents/snakes/spiders/ants present in the HPGF. 5. Operators should follow the safety rules before performing the tasks mentioned in **SAFETY MEASURES**

Maintenance Task 2 Cleaning of distribution channel

There are chances that the solids/grit may accumulate in the distribution channel of PGF which needs to clean manually.

1. General Tasks

1. Operational Task

The cleaning and removing of debris, solid waste and dirt (if any available) within and around each of the units of the FSTP. Also, cleaning of entire FSTP premises, landscaping, watering to the plants is continuous process on the daily basis.

2. Maintenance Task

Maintenance Task 1- Checking and replacement of broken pipes

Table 9: Pipe damage checking

Where	All units
When	Once in a month
Why	6. To avoid performance decrease of the unit 7. To avoid clogging 8. To avoid smell 9. To ensure the continuation of the treatment process.

How	1. Check for any damaged/broken pipes. This can be visually identified with any leakages or smell. 2. If there are any pipes broken bring this to the notice of the supervisor or whoever in charge. 3. Replace the damaged pipe with a new pipe of the same diameter and specification. 4. Follow the drawings in fixing important pipes.
Precautions	Follow the safety rules mentioned in **SAFETY MEASURES** while performing the tasks Follow the guidelines provided by the vendor

Maintenance Task 2- Checking and fixing of a damaged structure

Table 10:Structure damage checking

Where	All units
When	Once in a month
Why	7. To avoid performance decrease of the unit 8. To avoid clogging 9. To avoid smell 10. To ensure the continuation of the treatment process.
How	1. Check for any damaged structure. This can be visually identified with any leakages or smell. 2. If there are any structures damaged bring this notice to the supervisor or whoever in charge. 3. Repair the damaged structure as per specification. 4. Follow the drawings for better understanding.
Precautions	Follow the safety rules mentioned in SAFETY MEASURES while performing the tasks 6. Follow the guidelines provided by the vendor

1. Occupational Health and Safety

This section lists down the safety requirements that need to be strictly adhered to for personal safety and precautions that need to be taken within the FSTP premises. All the operational and maintenance tasks in the FSTP have to be performed in a safe and efficient manner with the utmost regard for the health and safety of the employees and the public. Safety is an integral part of everyone's duties and responsibilities.

1. Personal Safety

1. The plant operator and all labourers should take precautions because a large number of coliform groups, various kinds of pathogens, and egg parasites exist in sewage. The plant operator and all the labourers should strive to maintain good health by taking care of the following:
    1. Wear a clean uniform, work boots, face mask, and gloves.
    2. Wash hands and disinfect them after work and before having a meal
    3. Bath if possible after work.
    4. Do not enter the offices and lounges wearing dirty clothes.
    5. Take vaccinations against tetanus, leptospirosis fever and so on, if necessary
2. Consuming liquor during working hours is strictly prohibited.
3. When additional light is required while working on the treatment plant premises, Operator shall use a battery-powered flashlight, or an approved properly guarded electrical extension light. Do not use an open flame light such as a match, torch, or cigarette lighter.
4. Wearing sandals or open-toe shoes in the treatment plant premises is discouraged, especially when handling tools or entering the treatment module or areas where weeds and debris can hide glass or sharp objects.
5. Wear rubber boots or leather shoes shall be worn in areas where contact is possible with biological organisms found in faecal sludge.
6. Confined spaces including treatment modules, maintenance hole or any space that is below ground level or has inadequate ventilation, has the potential for containing deadly gases. Prior to entering any confined space clean the confined space off sludge and keep the cover slab on for a minimum of 1 hour.
7. Do not enter a confined space without proper equipment or rescue personnel standing by under any circumstances
8. Ensure rubber gloves are long enough to come well above the wrist, leaving no gap between the glove and coat or shirtsleeve.
9. Wear safety shoes whenever there is danger of dropping tools or materials on the feet.
10. The use of a gas mask for necessary respiratory protection (while entering any of the treatment modules) is important.

1. Site Precautions

1. 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.

2. Junk parts removed from the treatment module should be disposed of in a proper manner.
3. Spare parts used in the operation of the faecal sludge 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 to be used.
4. Do not allow paper and other lighter combustible materials to accumulate in the treatment plant premises to prevent them from getting into the treatment modules and causing a fire.
5. Do not store flammable liquids such as gasoline and diesel fuel in the treatment plant premises where they may cause a fire or leak onto the floor causing hazardous working conditions.
6. Pay strict adherence to “No smoking” signs.
7. Do not accumulate oily rags and papers as they can spontaneously combust under the proper conditions.
8. Consider the size and weight of an object before attempting to lift or move the object. Do not lift any materials that cannot be handled comfortably. If necessary, take assistance or wait until assistance is available.
9. When carrying objects near treatment modules take extra care to avoid falling in the tanks or dropping objects into the tanks.
10. Employees should use tools suitable for the job in progress and only those in good condition.
11. Hoses, extension cords and ropes not in use should not be left where operating personnel might trip over them and possibly fall into a tank.
12. Indoor areas shall have adequate lighting.
13. Use carbon dioxide or halon compressed gas extinguishers to control fires.

1. Medical emergency/ First Aid

In the case of sudden onset of a medical condition characterized by acute symptoms of sufficient severity such that the absence of medical attention could reasonably be expected to result in: placing the patient’s health in serious jeopardy, serious impairment to bodily functions or serious dysfunction of any bodily organ or part.

The following steps need to be followed while administering first aid

1. Keep the victims lying down
2. Examine the victim- look for serious bleeding, lack of breathing and poisoning.
3. Keep the victim warm.

4. Send someone to call a physician or ambulance.
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. If there is a crowd, keep it away from the victim.
8. Ensure the victim is comfortable.
9. Don't allow the victim to see his injury.
10. Give artificial respiration if required.

First Aid: The First Aid toolkit should contain the following items. Unnecessary and out of date items should not be placed in the first aid box.

First Aid Box

1. Band-aid, scissors, cotton
2. Adhesive plasters of assorted sizes
3. Disinfection lotions/powder
4. Eyewash cup
5. Unused sealed twin blade razor
6. Cotton Gauze
7. Crepe Bandages
8. Analgesic (ointment/cream/gel/spray)
9. Anti-allergic medicine
10. Antacid

14. EMERGENCY RESPONSE PROCEDURES

Improperly treated faecal sludge carries infections bacteria, viruses, parasites and toxic chemicals. Human contact with raw or improperly treated sewage can lead to serious health problems. If the FSTP works as designed then there is a reduced risk to public health or environment, however, during emergencies, there can be increased risks. The purpose of this section is to minimize the potentially damaging effects of spills, valve failure, leakages in the system. This section details out the types and level of emergencies and the specific responses for each. These are usually out of the ordinary event and not part of the day-to-day operations of the FSTP.

Emergencies that can occur at the FSTP

1. Spillage from the barrels/unloading activity
2. Valve breakdown
3. Overflow from any treatment module

These have been detailed out in the following section:

1. Spillage from barrels

Table 11: Spillage from barrels

What may be the cause?	Leaking barrels, mishandling of barrels or closing barrel lid improperly.
How could this happen?	4. Leakage from broken / cracked barrels. 5. Spillage due to falling by stumbling. 6. Spillage from the lid due to lose or improper closing.
Emergency Response	7. A desludging persons should collect the spilling faecal sludge in a plastic pan and should change the barrel. 8. It is very important for the desludging person to carefully walk and climb the stairs to avoid any incidence of falling. 9. Desludging persons have to ensure that the lid of the barrel is properly closed before taking it to the FSTP.

1. Valve breakdown

Table 12: Valve breakdown

What may be the cause?	Failure of outlet valve (three-way-valve) OR valves at SDB inlets OR wrong operations of the valve.
How could this happen?	10. Failure of the valve may happen due to solid waste/debris stuck at the valve's opening. 11. Damage to the valve may happen due to the wrong operations of the valve by the operator and turning the valves in the wrong direction forcefully.
Emergency Response	12. If sludge has spilled near the valve, clean the spilled sludge performing the following steps. 13. Pour soil over the sludge. Leave it for at least 2 hours. 14. Using the shovel collect all the soil mixed with sludge in a plastic bowl. 15. Dispose of this sludge in the SDB. 16. Repair or replace the valve if necessary

1. Overflow from any treatment module

Table 13: Overflow from treatment module

What may be the cause?	The module outlet or the inlet of the next downstream module is clogged.
How could this happen?	This can happen due to excessively accumulated scum or sludge as well as

	debris blocking the pipes or modules. Crushed or frozen modules or damage in the pipes connecting various modules or excessive inflow of water into the module due to flooding may as well be responsible for this kind of issue.
Emergency Response	17. Stop the flow into the module immediately if any. 18. Clear the blockage in the pipes using the iron bar and pumped water. Insert the iron bar in the outlet pipe of the module and force the pumped water 19. Check if any debris is stuck in between the outlet of the module and inlet of the downstream module. If found, try to push it to the next module using the iron bar and collect the debris from the inlet of the downstream module. 20. Check for damage/crushing of pipe. If found immediately report it to the person in-charge.

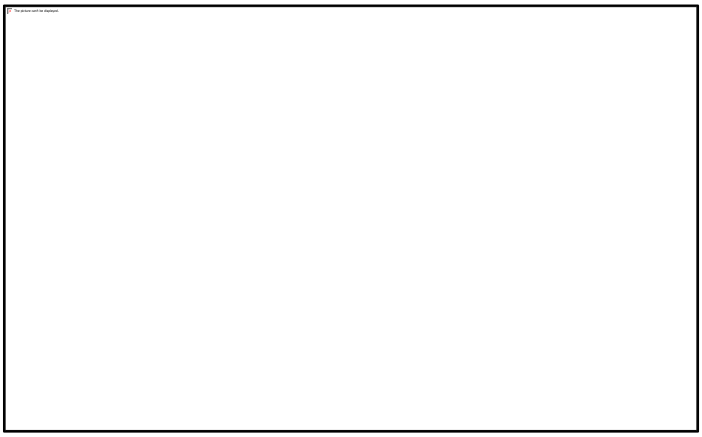


Figure 33: Wastewater Overflow

1. High sludge level in ISAF chambers

Table 14: High sludge level in ISAF chambers

What may be the cause?	Due to solids moving in large volumes from SDB modules.
How could this happen?	Overloading of SDB or gaps in filter media of SDB enabling more solids to travel along with percolate.
Emergency Response	21. Perform 6.4 of the maintenance task section. 22. Check for gaps in filter media of SDB

1. Solids moving into HPGF from ISAF

Table 15: Solids moving into HPGF from AF

What may be the cause?	High level of solids in ISAF chambers or high rate of flow in ISAF.

How could this happen?	23.	Due to high inflow rate into ISAF from SDB solids in the ISAF chambers may move with the water into the HPGF
	24.	Not desludging the ISAF chambers on time as prescribed in the maintenance plan
Emergency Response	25.	Perform 6.4 of the maintenance task section.

1. Emergencies by Symptoms of the System

These emergencies are usually the result of inappropriate operations like excessive inflow to the system, improper desludging, but can also be symptoms of external influences like earthquakes, Tsunami, heavy rain.

1. No or very little wastewater inflow to a module

Table 16: Less water flow

What may be the cause?	The module inlet or the previous upstream module is clogged.
How could this happen?	This can happen due to garbage being entered into the system, excessive accumulated scum or sludge as well as debris blocking the pipes or modules. Crushed or frozen modules/pipes may also be responsible for this kind of issue.
Emergency Response	Check if wastewater is produced at the sources. Check the inlet pipe for obstructions.

2. Bad odour emanating from one or more modules

Table 17: Odour problem

What may be the cause?	The vent pipe may be damaged or blocked and therefore releasing biogas and odour in a noticeable way. Accumulated scum or garbage may also release a bad smell.
How could this happen?	This can happen due to garbage being entered into the system or excessively accumulated scum. External influences may damage the vent pipes. Birds, insects or other things may obstruct the vent pipes.
Emergency Response	To solve issues with bad odour, perform the task “Ensuring functionality of the Vent pipes” at all the modules. Check with the end-users if harmful chemicals have been released into the system. Additionally, perform the following tasks depending on the type of module (If the source of the odour cannot be located it may be necessary to perform all tasks in this list)

2. Externalities and force majeure

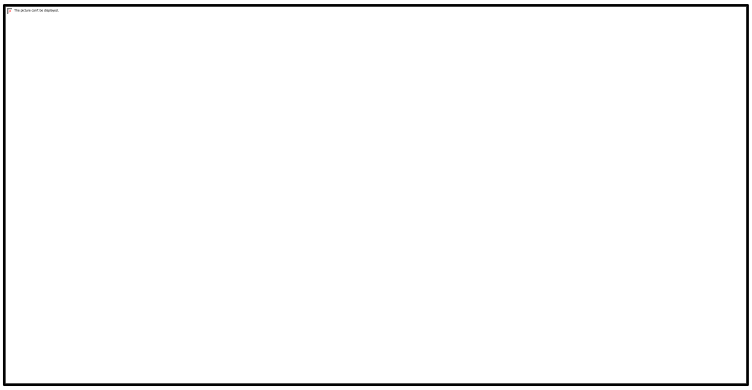


Figure 34: Natural Emergency

Table 18: Externalities and force majeure

What may be the cause?	Storms and other external influences can damage the pipes and the system itself or clog parts of the system with debris.
How could this happen?	This may happen due to debris carried by stormwater in the premises of the FSTP. Also, uncovered treatment modules allow some debris into the module.
Emergency Response	Clear debris by performing the following tasks: 1. Around the surroundings: Check for litter and dead leaves, weeding. 2. Ensure that the maintenance hole covers are intact and cover the maintenance hole. Check the sewer system and the physical/visual appearance of systems for any structural damage by ensuring free Wastewater flow and if any damages found to rectify the same. Also, do the task “Ensuring functionality of the Vent pipes” for all the modules. If the system cannot be put into an operational condition, contact the service provider.

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