FAECAL SLUDGE AND SEPTAGE MANAGEMENT

AN ADVANCED TRAINING MODULE

PART A - PARTICIPANT KIT

SCBP

Sanitation Capacity Building Platform

National Institute of Urban Affairs

Consortium for DEWATS Dissemination Society

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This document is a compilation of various reference materials and additional reading materials to enhance the understanding of faecal sludge management. This compilation is provided along with the training on advanced faecal sludge management developed and delivered as part of Sanitation capacity building platform.

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The materials in the document are to be read and understood alongside the other resources provided during the training.

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ABOUT SANITATION CAPACITY BUILDING PLATFORM

National Institute of Urban Affairs (NIUA) is a national nodal institute that works closely with the Ministry of Housing and Urban Affairs (MoHUA), Government of India. The Sanitation Capacity Building Platform (SCBP) anchored by NIUA aims to build local capacity for planning, designing and implementing non-sewer decentralized sanitation solutions, with specific focus on Faecal sludge and septage management (FSSM) and waste water.

SCBP is a partnership of various research organizations and non-profit institutions (CPR, BORDA/CDD, CEPT, CSTEP, UMC, CSE, CPR, WASHi, iDECK, Dasara, Ecosan Services Foundation, AIILSG). The platform works in in partnership with national nodal training institutes working for Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and Swachh Bharat Mission (SBM), with universities and research organizations and all stakeholders in the urban sanitation space. SCBP is supported by a grant from the Bill and Melinda Gates Foundation (BMGF).

ABOUT THIS HANDBOOK

The Swachh Bharat Mission has aimed to make India open defecation free by October 2019. The wide prevalence of on-site sanitation system in India necessitates the need to explore safe management of septage along with improved access to toilets. Recognising this, the Government of India has also emphasised septage management in its flagship programme of AMRUT and has also issued policy guidelines on Faecal Sludge and Septage Management (FSSM).

This document is a part of the advanced training module on faecal sludge management for engineers. It provides engineers with a comprehensive understanding on various aspects of FSM such as planning, design of treatment systems, contracts for implementation and O&M, etc.

This document consists of details pertaining to the concept of the training, session plan, objectives and key take aways from each session and lesson plan. The purpose of this document is to faciliatate the resource person in conducting the training program.

ABOUT THE TRAINING MODULE

Day 1, Session 1 Introduction and need for FSM	This session introduces the importance and global need for faecal sludge management to realize public health, environmental, social, and economic benefits.
Day 1, Session 2 Feacal Sludge Management - Over view	This session facilitates understanding of the problems in FSM implementation and also have an idea about tentative solutions to overcome these problems
Day 1, Session 3 Case Studies	This session covers the FSM case studies from around the world and heps to understand the applicability and efficiency of FSM in various scenarios
Day 1, Session 4 Collection and Conveyance of FS	This session introduces the various options for collection and conveyance of faecal slude and enables the participant to calculate the number of trucks for their town/city
Day 1, Session 5 Approach to Feacal Sludge Treatment	This session heps to understand the difference between sewage and faecal sludge and to familiarize with treatment principles, objectives, and outcomes
Day 1, Session 6 Faecal Sludge Treatment Technologies	This session introduces at least five treatment technologies for faecal sludge and to understand the need for combination of treatment technologies
Day 1, Session 7 Planning for FSTP Implementation	This session introduces the process involved in implementing an FSTP different cities and explains various contract methods for implementing FST
Day 1, Session 8 Preparation for feasibility study	This session elaborates the different data collection points and methods for a feasibility study to implement FSM
Day 2 Feasibility Study	This session allows the participants to gain hands on experience in data collection for feasibility study to implement FSM
Day 3, Session 1 Presentation on feasibility study	This session is an activity where the participants prepare and presentation of the data collection during the feasibility sutdy and discuss the scenarios
Day 3, Session 2 Treatment conecpt - Sludge drying	This session hepls to understand the concept and characteristics of sludge drying using planted and unplanted drying beds
Day 3, Session 3 Design of drying beds	This session enanles the participants to carry out preliminary design of the treatment module - Sludge drying and planted sludge drying bed
Day 3, Session 4 Treatment concept - effluent	This session introduces the components of effluent treatment that is required in a faecal sludge treatment plant
Day 3, Session 5 Design of Treatment Systems	This session hepls the participants to put together modules for treatment of faecal sludge to achieve the desired objective
Day 3, Session 6 Operation and Maintenance	This session deals with the various O&M requirements of the technology options discussed during the training
Day 3, Session 7 Components and Review of a DPR	This session elaborates the various components that must be included in an FSTP DPR

Introduction

Non-sewered sanitation is a recent and novice topic in the field of sanitation planning and implementation in India. Though these systems have been existent for quite some time in the country, not much focus was laid on the proper and sustainable treatment of waste generated from such systems. The focus over the years has largely been towards networked or sewerage based sanitation with the focus to connect all household's wastewater sources to a network and provide an end of the pipe treatment. Though such an approach might be at the mainstream of planning, yet the dearth of funds and sustainable operation model has led to very few urban local bodies being sewered. As a result, most ULB still primarily rely on non-networked sanitation such as septic tanks, pits, community cess pits etc. There is not much that has been done or planned for treatment or conveyance of the waste from such systems and their treatment.

However, with the recent changes in the policy and emphasis by civil society, the focus is now also towards safe conveyance and treatment of wastewater generated from such on site sanitation systems. Urban local bodies have been provided mandate and direction by the central and state governments to promote FSM (a major part of non-sewered sanitation). However, the capacities within the ULB or other engineering departments are limited in this field. It is hence the need of the hour to equip the team of these engineers with knowledge and skill to implement effective solutions.

This document is a learning tool for the participants of the training program for government engineers working with the state or local bodies who would be intimately or partly involved in planning and implementing an FSTP.

TRAINING AGENDA

DAY 1

Time	Session name	Session outcomes
0930 -1000	Registration and introduction	Participants introduction and training outcomes and expectations
1000 – 1045	Introduction and need for FSM	Participants understand the concept and need for FSM Participants remember shit flow diagram (SFD) as a tool for assessing sanitation Participants can list the stakeholders involved in FSM
1045 – 1130	Faecal sludge management – Overview	Participants will learn the components of FSM. Participants have an understanding of the problems in FSM implementation and also have an idea about tentative solutions to overcome these problems
1130 – 1145	Tea break	
1145 – 1230	Case studies	Participants are confident of FSM as a solution Participants can remember benefits accrued to the public and ULB due to FSM
1230 – 1300	Collection and conveyance of Faecal sludge	Participants are aware of various options for collection and transport of faecal sludge Particpants are able to estimate the number of vechicles required for desludging.
1300 – 1400	Lunch break	
1400 - 1445	Approach to Faecal sludge treatment	Participants understand the difference between sewage and faecal sludge Participants are familiar with treatment principles, objectives, and outcomes
1445 – 1530	Faecal sludge treatment technologies	Participants are aware and remember at least five treatment technologies Participants understand the need for combination of treatment technologies
1530 – 1545	Tea break	
1545 – 1630	Planning for FSTP implementation	Participants are aware of the process involved in implementing an FSTP for their cities Participants are aware of various contracting methods for FSTP implementation
1630 - 1700	Preparation for feasibility study	Participants are aware of data collection methods for a feasibility study
1700 - 1715	Debriefing on days learning	Participants reinforce their learnings
1715 – 1730	Feedback	Participants co-create the learning environment based on their needs.

DAY 2

Time	Session name	Session outcomes
0930 – 0950	Briefing	Participants are aware of the day's agenda and remember critical data to be collected
0950 – 1100	Travel to site	
1100 – 1300	Data collection in groups	Participants have necessary data for feasibility study
1300 – 1345	Lunch at site	
1345 – 1500	Return travel	
1500 – 1515	Debriefing	Participants learn new perspectives from others/groups
1515 – 1700	Group work	Participants have information for preparing feasibility study

DAY 3

Time	Session name	Session outcomes
0930 -1000	Preparation for Feasibility study	
1000 – 1100	Presentation on Feasibility study	Participants have experience of a feasibility study
1100 – 1130	Treatment concept – Sludge drying (Planted and unplanted drying beds)	Participants understand the concept and characteristics of sludge drying using planted and unplanted drying beds
1130 – 1145	Tea break	
1145 – 1215	Design of sludge drying bed	Participants carry out preliminary design of the treatment module – Sludge drying and planted sludge drying bed
1215 – 1300	Treatment concept – Effluent treatment	Participants can list and understand the components of effluent treatment
1300 – 1400	Lunch break	
1400 – 1500	Design of a treatment system	Participants can put together modules for treatment of faecal sludge to achieve the desired objective
1500 – 1530	O&M of Treatment technologies – sludge drying beds, planted drying beds and Effluent treatment	Participants are aware of th various O&M requirements of the technology options discussed during the training.
1530 – 1545	Tea break	
1545 – 1630	Components and review of DPR	Participants know the various components that must be included in an FSTP DPR Participants posses a framework for assessing an FSTP DPR prepared by external consultant
1630 – 1700	Debriefing	To assess the learning of the participants
1700 – 1715	Feedback	Participants can share their learning experience

DEFINITIONS

Disposal	The return of waste to the environment, ideally in a way that is least harmful to publichealth and the environment.
Excreta	Urine and feces not mixed with any flush water.
Feacal Sludge	Also called sludge. Excreta from an on-site sanitation technology (like a pitlatrine or septic tank) that may also contain used water, anal cleansing materials, and solid waste.
Faecal sludge management	Includes the emptying, transport, treatment, and safe use ordisposal of faecal sludge from an on-site sanitation technology (like a pit latrine or septic tank). Some people also include storage in the definition of faecal sludge Management.
Guidelines	International recommendations to help governments set national standards ordetermine a course of action. Guidelines are not mandatory.
Legislation Treatment	A group of laws or the action of making laws.
Non-sewered system	Also called on-plot or on-site sanitation. A sanitation system in whichexcreta and used water are collected andstored on the location where it is produced. Often, the faecal sludge has to be transported off-site for treatment, use or disposal.
Nutrient	Any substance that is used for growth. Nitrogen (N), phosphorus (P), and Potassium(K) are the main nutrients in agricultural fertilizers.
On-site sanitation	Also called on-plot sanitation or non-sewered system. A sanitation systemin hich excreta and used water are collected and stored or treated on the location where it is generated. Often, the faecal sludge has to be transported off-site for treatment, use or disposal.
On-site sanitation technology	Also known as a latrine. An on-site sanitation technology is made up of the part included in the first two components of a sanitation system: user interface and excreta storage. Excreta is collected and stored where it is produced (for example, pit latrine, septic tank, aqua privy, and non-sewered public toilets). Often, the faecal sludge has to be transported off-site for treatment, use or disposal.
Pathogen	An organism that causes disease.
Policy	A government plan to guide and determine future decisions.
Sanitation	The safe management of human excreta. The main objective is to protect and promote public health by providing a clean environment and breaking the cycle of disease.(5) faecal sludge use or disposal.

Sanitation system

Also called a sanitation chain or sanitation service chain. A collection of technologies and services that deals with human excreta from the time it is generated until it is used or disposed of safely.

A sanitation system includes five components:
(1) user interface
(2) excreta storage
(3) emptying and transporting faecal sludge
(4) faecal sludge treatment and
(5) faecal sludge use or disposal

A sanitation system also includes the management, operation and maintenance required to ensure that the system functions safely and sustainably. The components or functions within the sanitation system may be named differently depending on the local context or organization.

Sewered system

Also called a sewer system, sewerage system, sewers, connecteds anitation, and networked sanitation. A sanitation system that transports wastewater through a pipe network (like a simplified sewer, solids free sewer or conventional sewer) to another location for treatment, use or discharge. This includes centralized systems and decentralized wastewater treatment systems.

Soil amendment

Anything mixed into soil toimprove soil quality and support healthy plantgrowth. Fertilizers and soil conditioners are two types of soil amendments. Fertilizersadd nutrients to the soil that plants need to grow. Soil conditioners improve the physical soil structure.

Use

The use of waste as a beneficial resource.
For example, using treated faecal sludge as asoil conditioner in agriculture.

Watewater

Used water from any combination of domestic, Industrial, commercial or agricultural activities, surface runoff (stormwater), and any sewer inflow (infiltration). Wastewater can be managed onsite or off-site. Wastewater managed off-site is often called sewage.

Day 1 - Session 1

Introduction and need for FSM

This Technical Brief introduces the importance and global need for faecal sludge management to realize public health, environmental, social, and economic benefits.

Great efforts are being made globally to reduce open defecation by building on-site sanitation technologies, like pit latrines and septic tanks. Yet, emptying full on-site sanitation technologies and safely managing the faecal sludge is an essential service that is often neglected. Households and institutions are lacking the knowledge, skills and services to manage the faecal sludge once the technology is full.

2.7 billion people around the world use on-site sanitation technologies that need faecal sludge management services (Strande, Ronteltap & Brdjanovic, 2014). Ideally, on-site sanitation technologies should be emptied in a safe and hygienic manner by well-equipped and protected workers who transport the sludge for treatment, use or disposal. However, in reality, most technologies are either abandoned or emptied using unsafe and unhygienic methods. Sludge is simply dumped by the home, in the street, or in nearby water sources.

Day 1

Session 1

Outcomes

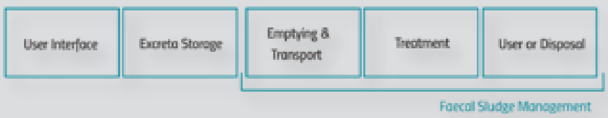
- Participants can list the stakeholders involved in FSM
- Participants understand the concept and need for FSM
- Participants remember shit flow diagram (SFD) as a tool for assessing sanitation

Objectives of the session

- Goals of sanitation
- Sanitation value chain and the issues occurring across it
- Shit flow diagram
- Role of FSM within sanitation
- Financial estimates for centralised v/s FSM system
- Stakeholders in FSM

What is Faecal Sludge Management?

A sanitation system deals with human excreta from the time it is generated until it is used or disposed of safely. Faecal sludge management includes emptying, transportation, treatment, and use or disposal of faecal sludge from an on-site sanitation technology (like a pit latrine or septic tank). It addresses the last three components of a sanitation system.



Faecal sludge management is a relatively new term and field that is gaining rapid acknowledgment in the sanitation sector. The following definitions help explain the scope of faecal sludge management:

Faecal sludge (also called sludge) is excreta from an on-site sanitation technology (like a pitlatrine or septic tank) that may also contain used water, anal cleansing materials, and solid waste. Faecal sludge should not to be confused with wastewater that has been transported through a sewered system.

Excreta is urine and feces that are not mixed with any flush water.

An on-site sanitation technology is made up of the parts included in the first two components of a sanitation system: user interface and excreta storage. Excreta is collected and stored where it is produced (for example, a pit latrine, septic tank, aqua privy, and non-sewered public toilets). Often, the faecal sludge has to be transported off-site for treatment, use or disposal.

Use or Disposal

The following are some options for using or disposing of urine and faeces in ways that are the least harmful to people and the environment:

- Use urine as a fertilizer
- Use treated faecal sludge and source separated urine as a soil amendment in home gardens and agriculture to provide nutrients for plant growth and improve the physical qualities of soil
- Use treated faecal sludge as a soil amendment in: forestry, sod and turf growing, flower growing, landscaping, parks, golf courses, mine reclamation, landfill cover, or erosion control
- Use faecal sludge and source-separated urine as a source of nutrients and water for growing aquatic plants and fish (also known as aquaculture)
- Dispose of faecal sludge by burying in a pit, trench or landfill
- Dispose of source-separated urine into the ground using a soak pit or infiltration trench.
- Use faecal sludge as a source of protein for animal feed (for example, black soldier fly larvae) Use faecal sludge as a source of energy (for example, biogas and solid fuel)

Risk Management

Faecal sludge management aims to reduce the risk of pathogen transmission and environmental contamination through using protective measures. These are actions, often called barriers or the multi-barrier approach, to prevent or eliminate a sanitation-related risk, or reduce it to an acceptable level (WHO, 2016)

The more protective measures that are used, the lower the risk of pathogen transmission and environmental contamination. Faecal sludge management often focuses on treatment as a protective measure to reduce health risks. Yet, it is difficult to check the quality of treated sludge to ensure that it is safe and pathogen-free.

There is always an environmental and health risk. It is therefore important that other health and safety measures are put in place, even when the sludge has been treated.Protective measures can be difficult to put in place. They will be more or less efficient depending on various factors, such as local habits and available resources.

For example, it may be more efficient to focus on covering faecal sludge with soil rather than wearing shoes if farmers work barefoot or if shoes are not available or affordable.

Treatment

The type and level of treatment depends on the final goal for the faecal sludge (how it is to be used or disposed of). There are four different treatment objectives for faecal sludge:

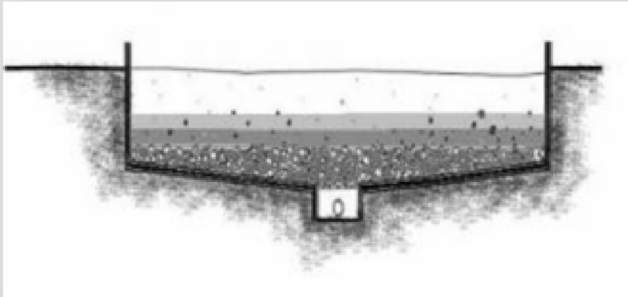
(1) pathogen inactivation,
(2) stabilization,
(3) dewatering, and
(4) nutrient management.

Each treatment objective has associated environmental, health, and logistics impacts.

Treatment technologies available for faecal sludge are in different stages of development:

Established: There is experience in designing and operating the technologies for faecalsludge. For example, drying beds, settling-thickening, and co-composting.
Transferring: Technologies are being adapted from wastewater treatment or another sector.For example, mechanical dewatering, anaerobic digestion, incineration, and thermal drying.

Innovative: Technologies are being researched, developed and piloted. For example, alkaline and ammonia treatment, vermi composting, and black soldier flies for animal protein.



Identify risks and vulnerable groups before identifying and prioritizing protective measures. Generally, people who work with faecal sludge directly (like latrine pit emptiers, compost plant operators, farmers who use faecal sludge as a fertilizer) have a higher risk of getting sick from faecal pathogens than the general public.

The four groups of people exposed to risks include the following:

Workers: People who empty and transport sludge, work at a treatment site or dispose of the sludge

Farmers: People who use faecal sludge to fertilize their fields.
Consumers: People who eat food that has been grown using faecal sludge as a fertilizer.

Local community: People that live in a community near faecal sludge treatment technologies.

Type of Protective Measure		Examples of Protective Measure
Treatment		Inactivate pathogens in faecal sludge (for example,co-composting)
Non-Treatment	Technical	Crop selection: Faecal sludge is applied to only certain crops (for example, non-edible crops)Pause period: Wait a certain period of time before harvesting crops grown with faecal sludge. Restrict access: Place a barrier (like a fence) to stop people from approaching a faecal sludge management area
	Behavioural	Use personal protective equipment when handling faecal sludge (for example, boots, gloves, masks,and protective clothing) Wash hands with soap after handling faecal sludge Use good food hygiene when preparing foods grown with faecal sludge products

Importance of Faecal Sludge Management

Failing to properly manage faecal sludge is directly responsible for adverse effects on public health and the environment worldwide. It is not just enough to build a latrine to ensure good sanitation and protect public health. Without faecal sludge management services, untreated sludge enters the environment and contaminates drinking water sources. This is often the case when latrines are left to overflow or faecal sludge is illegally dumped into the environment.

Excreta is a major source of pathogens – microorganisms such as bacteria, viruses, protozoa and helminths that cause disease. Pathogens in untreated excreta can survive a long time in the environment. They can transmit diseases to people and animals through direct contact and contaminated soil, food, and water.

Diarrhea is one of the leading diseases that cause death and illness. Globally, about 361,000 children die every year from diarrheal diseases linked to poor WASH (Prüss-Ustün et al., 2014). That's about 1,000 children under five every day. For every child that dies from diarrhea, countless others suffer from poor health and lost educational opportunities leading to poverty in adulthood.

In addition to health and environmental benefits, the economic benefits of improved sanitation are also persuasive. Improved sanitation in developing countries typically yields about US$5.50 worth of benefits for every dollar spent (Hutton, 2005).

The benefits of improved sanitation also extend beyond better health and economics. No one wants to live, work or go to school in dirty, smelly, and unsanitary conditions. Improved sanitation also contributes to the general well-being of a population.

The Joint Monitoring Programme (JMP) for water supply and sanitation measures the progress towards achieving the Sanitation Development Goal (SDG) target of ensuring availability and sustainable management of water and sanitation for all by 2030 (Goal 6).

The goal includes the whole sanitation system. This is a move from the Millennium Development Goals (MDGs) that focused on access to improved sanitation. The term faecal sludge management is not directly used in the SDG Goal 6, but it is covered by "safely managed sanitation services". This is defined as excreta that is safely disposed in situ or transported and treated off-site.

Case

Poor Faecal Sludge Management = Open Defecation?

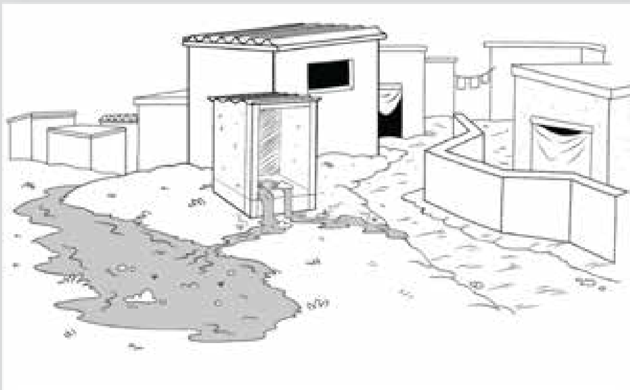
Imagine a town of 5,000 people using pit latrines. Full pits are emptied manually. The untreated sludge is dumped into the nearby river. Is this any different from open defecation?

Dhaka has made a lot of efforts to reduce open defecation. As a result, only 1% of the population still defecates in the open. 79% of people use on-site sanitation technologies and 20% are connected to a sewer. However, all of the faecal sludge from on-site sanitation technologies is disposed of untreated into the environment. It is either dumped around people's homes, into drainage systems, or into water sources.

87.3% of on-site sanitation technologies are left to overflow or abandoned. 11.4% of on-sitesanitation technologies are unsafely emptied.

1.3 % of on-site sanitation technologies are safely emptied, but the faecal sludge is illegally dumped.

Innovative: Technologies are being researched, developed and piloted. For example, alkaline and ammonia treatment, vermi composting, and black soldier flies for animal protein.



Implementation Challenges

Faecal sludge management is an urgent issue in many parts of the world. Unfortunately, it is not that simple and implementers have many challenges. These result from the complexity of the process. There are various stakeholders to involve including the household users, informal and formal private sector, government, non governmental organizations (NGOs) and community-based organizations (CBOs). Some of the key challenges include:

Accessibility: On-site sanitation technologies are not always accessible to emptying services. They can also be located too far from a service provider. It is not worth the cost of transportation or the service provider's time. The roads can also be too narrow and poorly constructed for emptying vehicles. Furthermore, people constructing on-site sanitation technologies often do not take into account the emptying component. It can be difficult to have direct access to the latrine pit or septic tank.

Affordability: Many households cannot afford emptying services. They rely on informal private services to manually empty their on-site sanitation technology. Many manual transport services also cannot afford to take sludge to a treatment site that is located far away. Instead, they choose to dump the untreated sludge close to the on-site sanitation technology and directly into the environment.

Investment: There is a lack of faecal sludge management services because there is a need for investment in construction, operation, and maintenance. Many faecal sludge technologies stop functioning because there is little to no funding available for long-term operation and maintenance.

Policy: Policy makers still focus on sewered systems rather than on-site sanitation, which is often considered a temporary solution. Therefore, not many countries have a policy on faecal sludge management. As a result, faecal sludge management is often unplanned, unreliable, and operated by informal private services.

Legal Frameworks: Laws on faecal sludge management are non-existent or weak. This leads to illegal dumping of untreated sludge into the environment. In countries where there are laws, there have been challenges with enforcing them (Johansson & Kvarnstrom, 2005).

Knowledge and Skills: Compared to wastewater management, faecal sludge management has only recently gained acknowledgment. There is less research and lessons learned in this field. As well, there are few examples of success. There is a gap in knowledge on how to ensure faecal sludge is safe to dispose of or use (Strande et al., 2014).

International Guidelines, National Law and Policy

Over 66% of countries have recognized the human right to sanitation in their constitution or legislation (GLAAS, 2014). Recognizing the human right to sanitation is a good start towards improving access to sanitation. Governments are held accountable by international human rights law. However, to sustain sanitation, governments must also develop national legislation and supporting policy. They must also ensure implementation and enforcement of these laws and policies. This has proved to be a difficult task globally.

One of the reasons for this struggle is because the sanitation system is included in different pieces of legislation. Components of the sanitation system are often spread across environmental protection, public health, construction, and agriculture legislation. This leads to gaps and overlaps in the legislation (Johansson &Kvarnstrom, 2005).

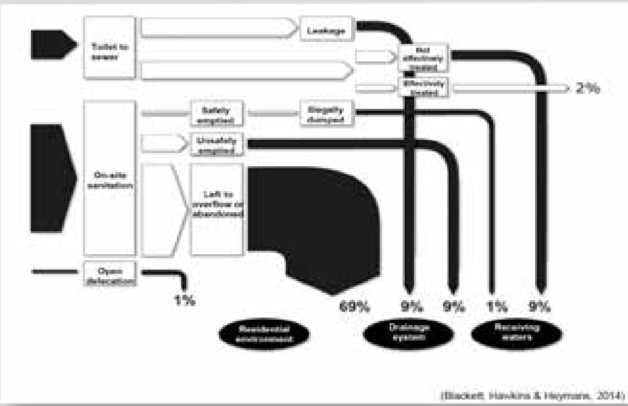
Once the national sanitation laws and policies are established, they need to translate into local action. A government is usually made of different levels. Many governments, for example, are composed of a national, regional and local level government. Legislation and policy must state clearly the roles of the different levels of government, which is not often the case (Johansson & Kvarnstrom, 2005). The lack of delegation, capacity and resources weakens the implementation of legislation and policy.

Questions that need to be clearly answered by national governments include:

Who takes the lead?
Who regulates?
Who monitors?
Who enforces?

The World Health Organization (WHO) released the Guidelines for Safe Use of Wastewater, Excreta and Greywater in 2006. They provide a comprehensive framework for managing health risks associated with using human waste in agriculture and aquaculture. The Guidelines were designed to assist in developing national and international approaches (like policies and legislation). They also provide a framework for national and local decision making to identify and manage health risk. Crucially, the Guidelines recognize that changes in sanitation policy and investment in improvements, be they capital works, operations or behavioural measures, involve multiple actors and take time (WHO, 2016).

The Sanitation Safety Planning Manual was released by the WHO in 2016 to provide practical step-by-step guidance to assist in the implementation of the 2006 Guidelines. The Manual assists users to implement the Guidelines by providing a structure to bring together actors from different sectors to identify health risks in a sanitation system and agree on improvements and regular monitoring. The concepts of coordination and incremental improvement over time are central to the sanitation safety planning approach (WHO, 2016).



2.7 billion people around the world use on-site sanitation technologies that need faecal sludge management services (Strande et al., 2014). The greatest numbers are in Eastern Asia with 1.1 billion people, Southern Asia with 593 million people, and Sub-Saharan Africa with 439 million. These are households and communities using latrines without access to or unable to afford faecal sludge management services.

If present sanitation trends continue, the number of people needing faecal sludge management services will rise to 5 billion people by 2030 (Strande et al., 2014). This number could increase even faster as water scarcity becomes more severe. Sewered systems use a lot of water to flush wastewater to a treatment facility. As water becomes less available, it will become more challenging to flush everything away through sewers. Households will have to use on-site sanitation technologies instead of being linked to a sewered system.

Sewered systems have been constructed in many parts of the world, particularly in high-income countries. However, for many low- and middle-income communities, particularly in developing countries, installing a sewered system is not a feasible option due to the complexity, high cost, and need for a piped water supply. For such communities, on-site sanitation offers a hygienic and affordable solution (Franceys, Pickford & Reed, 1992).

Sanitation planners have come to realize that sewered systems are an inappropriate technology to manage excreta in many parts of low- and middle-income countries. This has led to a shift in sanitation planning. Implementers are now accepting on-site sanitation as an appropriate, sustainable, and affordable solution as long as faecal sludge emptying, transport, treatment and disposal or use services are available and managed correctly (Strande et al., 2014).

On-site sanitation is often considered as a solution in only rural areas. However, on-site sanitation is also very common in urban areas. In fact, one billion people using on-site sanitation live in urban areas (Strande et al., 2014). The wealthy neighbourhoods are often the only parts of a city linked to a sewered system. Governments are often unwilling to invest funds to install a sewered system in lower-income neighbourhoods. This can be for various reasons such as land ownership, affordability and instability. Households in these lower-income neighbourhoods usually have to build their own on-site technology, like a pit latrine or septic tank. When their latrines fill up, they have to manually empty them or pay for an informal emptying service.

Although some neighborhoods have informal services for emptying and transportation, services for treating sludge rarely exist.

Advantages	Limitations
Convenient for households: the excreta is almost immediately removed from their property and is no longer theirs to manage. Easy to control and test: all the excreta is centralized. Well-constructed and maintained sewered systems with wastewater treatment facilities can reduce environmental contamination and protect public health	Resource intensive: a large amount of water is needed year-round High technical skills required High capital cost High operation and maintenance costs If not functioning correctly, can cause significant environmental contami-nation and public health risk

References

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Kitchen

Day 1 - Session 2

Faecal Sludge Management Overview

The process leaders who are designated with the responsibility for planning and implementing a city- wide faecal sludge management (FSM) system often face a complicated situation, characterised by diverse levels of service and a patchwork of uncoordinated and independent stakeholders managing various activities. FSM planning aims to transform such a complex situation into a well-organised and coordinated management framework, which is usually initially expressed in the form of a city sanitation plan or citywide sanitation strategy and later translated into action plans and concrete implementation. This is no easy task as stakeholders have different and even conflicting interests, needs and constraints.

However, it is a crucial task, as urban sanitation planning is the key to sound investment and clear action plans greatly assist in sourcing funding. If donor money is being sought, a detailed plan with a clear strategy will be necessary. The problem with urban sanitation is not only a lack of investment, but also the lack of a plan. FSM planning is about understanding and matching stakeholders' interests, needs and constraints with an appropriate and accepted management scheme and financial mechanisms.

Experience in FSM shows that every solution should be context-specific and integrated. Moreover, experience in Asia demonstrates that any number of approaches can be successful when implemented in conjunction with a comprehensive legal and regulatory framework, clear delineation and appropriate delegation of roles and responsibilities, and dedicated public funding.

In the past, many water and sanitation projects have failed because of the lack of an integrated approach. The development of physical infrastructure is only one component of a functioning FSM program, which also depends upon sustained public sector commitment and funding, effective policies, appropriate implementation and compliance enforcement.

Day 1

Session 2

Outcomes

- Participants will understand the components of FSM
- Participants have an understanding of the problems in FSM implementation and also have an idea about tentative solutions to overcome these problems

Objectives of the session

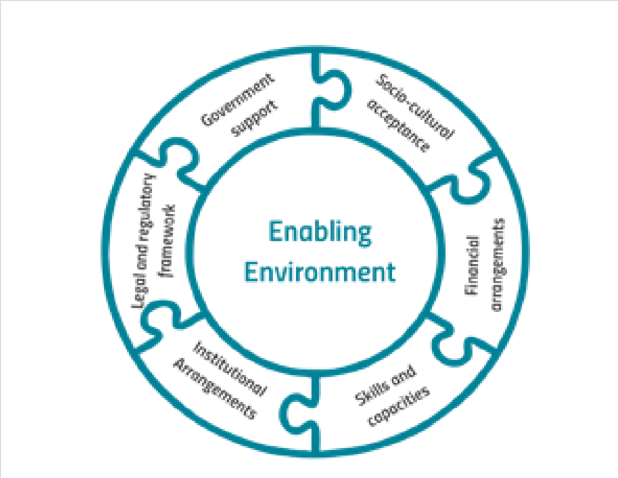
Familiarise the participants with various components of an enabling environment. Introduction to mechanisms to create an enabling environment

Overview

Common reasons for failure are the implementation of infrastructure without consulting the main stakeholders or without planning adequate operation and maintenance (O&M) and financial schemes. Besides lack of institutionalisation of the system, lack of skills, insufficient organisational capacity and lack of cost-recovery mechanisms are also recognised as major factors in failure.

Broadly speaking, it is possible to say that the enabling environment necessary for a functioning FSM system was either not there in the first place, or was not developed as an integral part of the project.

The lack of an enabling environment should not be considered as a reason for not engaging in a city because activities such as planning the O&M, defining roles and responsibilities, and structuring financial instruments for cost recovery can be structured into the project design.
A bit more time and resources invested in the preliminary phase of the project can save a lot of time and money during and after implementation. In addition, a careful assessment of the initial situation and involvement of stakeholders will ensure a more appropriate selection of technical options and also provide insight into the presence (or absent) of the fundamental conditions necessary for an enabling environment.



In order to understand the large variety of potential influences, the enabling conditions are classified into six categories, as shown in the above graphic
1) Government support
2) Legal and regulatory framework
3) Institutional arrangements
4) Skills and capacities
5) Financial arrangements and
6) Socio-cultural acceptance

Government support

Conflicting political priorities and therefore, a lack of explicit political support, is often the initial cause for project failure. Enabling government support includes not only relevant national policy frameworks and sector strategies, but also receptive local authorities and decision- makers.

Legal and regulatory framework

The technical norms and standards that influence the types andlevels of service that are put in place are clearly important. Typical problems include regulatoryinconsistencies, lack of regulations or unrealistic standards. A further issue in many countries isthe poor enforcement of existing regulations. For the legal framework to contribute to the enablingenvironment, it must be transparent, realistic and enforced.

Institutional Arrangements

Public institutions and private actors are integral to an enabling environment and getting the institutional environment right is a key ingredient for the sustainable delivery of sanitation services. This encompasses the correct understanding of roles and responsibilities and capacities of each stakeholder, as wel as their influence and interest inimproving service provision. A potential obstacle may be overlapping mandates between different institutions and ministries.

Skills and capacities

Developing the required skills and capacities at all levels is a key requirement and an issue that can take considerable time to develop. Identifying capacity gaps, particularly at district and municipal level, and then filling the gaps with tailored training courses, on-the-job training, etc. is a prerequisite.

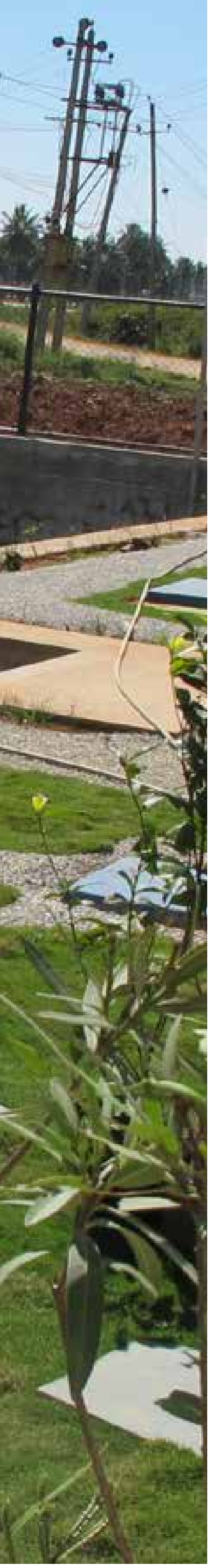
Financial arrangements

Implementing and maintaining environmental sanitation services is costlyand requires an enabling financial environment. Financial contributions and investments are required from users, from government agencies and from the private sector.

Socio-cultural acceptance

Achieving socio-cultural acceptance depends on matching each aspect of the proposed sanitation system as closely as possible to the users' preferences. Failure to ensure that the implemented solution is socio-culturally embedded is one of the most common reasons for past project failure. If these aspects are absent, conditions for an enabling environment should be created before going any further into implementation and need to be addressed as part of the initial stage of the planning process.


STABILISATION TANK

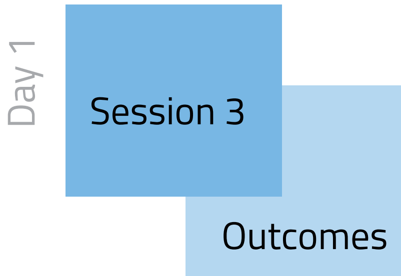


Day 1 - Session 3

Case Studies

Case studies hold prime importance as they provide excellent learnings and helps us understand the operational difficulties while constructing and running an FSTP.

This section provides the case study of Devanahalli along with the treatment concept, the efficiency of the treatment plant and the lessons learnt from it.



- Participants will understand the components of FSM
- Participants have an understanding of the problems in FSM implementation and also have an idea about tentative solutions to overcome these problems

Objectives of the session

Case study on FSM at Devanahalli, Leh, Unnao and Senegal
Explanation of 3 types of sludge treatment methods

Devanahalli: A Case Study

The challenge of providing good sanitation infrastructure to India's 1.2 billion people is well known, with 64% of the population (Census of India, 2011) not having access to improved sanitation services1. This is almost twice the global average. Only 36% of ~67 million urban households in India are connected to a piped sewer system. Of these households, 44% use septic tanks or pit latrines and a further 8% use public toilets or dry latrines2. This indicates that almost 35 million urban households in India depend on onsite sanitation systems (OSS); however, there are no faecal sludge management (FSM) programs or dedicated faecal sludge treatment facilities in the country (NUSP, 2008).

The Swachh Bharat Mission was launched in 2014, where they pledged to construct 12 crore toilets for rural India among many other goals for improving overall sanitation in India. Through this programme we aim to be an open defecation free country by 2020, however, it is important that we take a step back to look at sanitation as a whole and how it fares with this mission as a whole. These toilets, most of which are being constructed in rural, semi-urban or peri-urban areas are built with an on-site sanitation systems, which need emptying once in every 2-3 years according to CPHEEO manuals. Peri-urban settlements in India are generally unplanned and haphazard which present accessibility challenges for the design and construction of networked sewer systems.

Other barriers such as unavailability of funds and insufficient water supply have resulted in low coverage of networked sewer systems in urban and peri-urban India. Thus, it is not unreasonable to assume the on-site sanitation systems will continue to serve as an important link in the sanitation value chain for the foreseeable future in most households in rural, semi-urban and peri-urban households.

These on-site sanitation systems require emptying when they fill and this service is provided by cesspool vehicle operators who pump out the sludge. This sludge is usually disposed illegally and insanitarily in fields, storm drains or other water bodies, that is, in the surrounding environment to contaminate the air, water and soil without any treatment. This is an environmental hazard which will potentially increase in size, which makes it imperative for us to address the problem from the root, that is, the containment of the faecal sludge to the end, which is treatment and reuse or disposal.

This pilot project aimed to introduce an integrated decentralized faecal sludge management system in Devanahalli and assess its effectiveness in addressing the sanitation needs of the town. The faecal sludge management system also provided for resource recovery options (soil conditioner and nutrient-rich water) and aimed to explore the suitability of such a system which could be replicated in other towns and cities across India.

Parameter	Networked Sewer System	Decentralized FSM System
Water Supply	Needs to be >100 lpcd for self-cleansing of system	No such requirement
Installation Cost4	High	Relatively Low
Construction	Protracted and disruptive	Quick and less disruptive
Topography of site	Challenges faced in hilly terrain	No such constraint
Level of planning of settlement	Difficult to install in unplanned settlements	No such constraint
Degree of O&M5	High	Comparatively low
Value recovery	End product is generally discharged into the environment	End product can be reused onsite
Source: Intellecap and CDD Society		

Methodology

This illustrative case study was written with the idea of sharing CDD's Society's experience during this pilot. The intention was to bring to light the processes involved, challenges faced and lessons learnt during this project which was a pilot Faecal Sludge Treatment Plant designed and built by CDD Society.

Selection of location

For the purpose of this pilot project fringe towns in the vicinity of the Bengaluru metropolitan area – Anekal, Devanahalli, Nelamangala and Magadi - were considered for installing a town-level faecal sludge management system. The town selected were studied across parameters, such as the towns' population, its growth rate, availability of water, presence of underground drainage systems, awareness and implementation of sanitation safety plan, presence of desludging service providers and prospective users of the final product of the treatment facility.

Devanahalli was shortlisted among the four due to its strategic location with respect to Bangalore. Since the town is where the Kempegowda International Airport is located, the growth rate it faces would be unusually high. The town's current population also made it a suitable beneficiary for the pilot faecal sludge treatment plant.

Devanahalli gets a water supply lesser than 70 litres of water per capita per day, which makes it unsuitable for an underground drainage system which mandates a minimum of 100 LPCD of water for smooth operation and treatment of sewage.

A Sanitation Safety Plan had already been prepared for Devanahalli as per World Health Organization guidelines, which also showed the intent of the Urban Local Body officials towards the existing sanitation situation. They were aware of the down sides of improper disposal of raw faecal sludge, and in fact were already experimenting with make-shift solutions to treat raw sludge. A study of the impact of municipal waste on public health by a partner, Biome Solutions (a design firm focused on ecology, architecture and water) gave us insights that allowed the conception of a pilot, which could be more than an isolated faecal sludge management solution and would explore the viability of an integrated waste management system that would include human waste and municipal solid waste.The proximity of agricultural fields to the town provided for an easily accessible user base for the re-use of the end product.

Parameter	Anekal	Devanahalli	Nelamangala	Magadi
Population Growth	High	Medium	Very High	Low
Water Supply	Low	Low	Low	Medium
UGD Coverage	Present	Absent	Absent	Partial
Sanitation Safety Plan	Absent	Present	Absent	Absent
Partners	Present	Present	Absent	Absent
Desludging Facility	Present	Present	Present	Present
No. of users for end product	Low	High	Low	Low

Source: Census of India, Intellecap and CDD Research

Devanahalli: Before the Initiative

The town Devanahalli is 36 km away from the heart of the Bangalore and it is houses the Kempegowda International Airport. Thus, it is the town of choice to tap into for Bengaluru's growth, but the town has suffered considerable setbacks from the withdrawal of a few prominent IT companies due to Devanahalli's persistent water problems.Devanahalli has a population of roughly 28,000 as per the 2011 Census. The town's population has grown by 32 % over the last decade, driven mainly by the growth expansion of Bangalore city and the construction of the Kempegowda International Airport. Although originally a village that is still surrounded by farmland, commerce and services are now the dominant occupations for the people of Devanhalli.The topography of Devanahalli is largely plain s, with occasional small elevation. The town depends entirely on groundwater for its water supply. Municipal water supply is estimated to be 1.76 MLD; there are also numerous private bore-wells.

Existing Sanitation Situation in Devanahalli

Devanahalli Town Municipal Corporation (TMC) does not have an underground drainage (UGD) system. Most of the households in the town depend on pit latrines or septic tanks for containment of faecal sludge.

Particulars	Details
Total Population	28,000
Number of Households (HHs)	6,500
Pits/Septic Tanks	> 4,000
Pit size	3 – 5 rings
Average frequency of cleaning pits	2 – 5 years
Community toilets	3

Source: Devanahalli TMC

The TMC owns one desludging truck with a capacity of 4,000 litres. On an average, the TMC truck desludges 4 septic tanks/pit latrines per week. Apart from the TMC, there are also 3local private agencies that provide desludging services. It is estimated that 4,000 – 5,000 litres of faecal sludge is desludged daily from Devanahalli. The faecal sludge is either transported to a farm to be mixed with soil, or is dumped at a remote location.

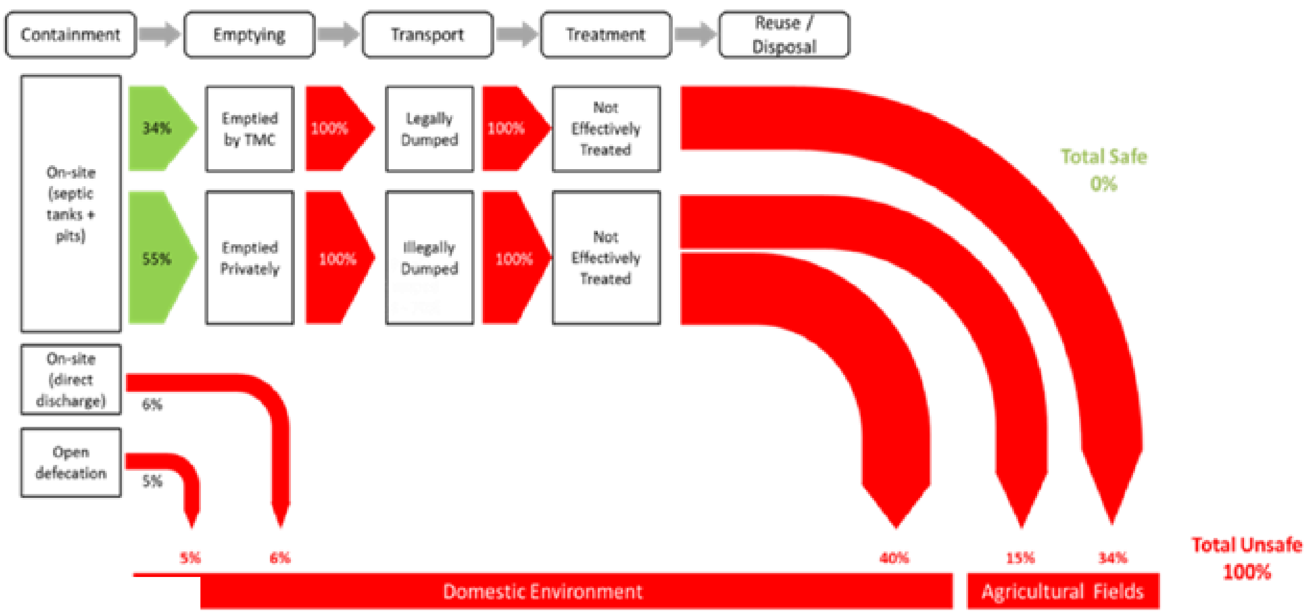
These on-site sanitation systems require emptying when they fill and this service is provided by cesspool vehicle operators who pump out the sludge. This sludge is usually disposed illegally and insanitarily in fields, storm drains or other water bodies, that is, in the surrounding environment to contaminate the air, water and soil without any treatment. This is an environmental hazard which will potentially increase in size, which makes it imperative for us to address the problem from the root, that is, the containment of the faecal sludge to the end, which is treatment and reuse or disposal.

Containment

The prevalence of open defecation in Devanahalli is quite low at 5%.Over 90% of the population uses pit latrines and/or septic tanks, with the rest discharging its sewage directly into the storm-water drains that line the streets of Devanahalli.

Transport

Pit latrines need to be desludged every 2 to 5 years depending on their size. The TMC desludging vehicle services 4septic tanks/pits weekly on an average and the charges for the operations are Rs. 1,200 to Rs.1,500 depending on the size of the septic tank/pit latrine and complexity of the procedure. Private service-providers also charge a similar amount per servicing. As per the Devanahalli TMC estimates and interactions with local private desludging operators,out of the total faecal desludging operations undertaken in Devanahalli, roughly 40% are carried out by the TMC and 60% by private operators.



Treatment and Reuse

Currently, some of the faecal sludge in Devanahalli is being reused in agriculture by supplying it to a grape farm where it is allowed to dry out in a large trench and then mixed with soil to be used as manure in the grape plantation and other farms where ragi is grown. There is no specific 'treatment' carried out. However, the current process addresses the hazard from faecal sludge to some extent. The TMC ensures that any OSS it desludges gets channelized through this route However, it has been observed that private service providers often dispose the faecal sludge in a remote location, away from the human settlements in Devanahalli.

Before the plant was established, some treatment was provided to faecal sludge, but the method used lacked scientific backing, was not scalable. The land arrangement for drying faecal sludge was informal, which increased dependency of the TMC on farmers' land. Only ~30% of the total amount desludged daily in the town was being supplied to the drying pit.This method involved a high degree of human contact with untreated faecal sludge – both at the time of dumping in the pit and while applying to farms, which posed a health hazard to the handlers in-spite of them taking adequate precautions. The effectiveness of this system was also compromised during the monsoon season resulting in protracted drying times and increased pathogen activity.

Considering that Devanahalli would be dependent on on-site sanitation systems for the near foreseeable future, it is important for a treatment which is sustainable in the long run. With this background, CDD Society worked towards providing a solution for faecal sludge management of the town through a system which is easy to maintain, operate and finance in the future. The work was funded by a grant by Bill and Melinda Gates Foundation which enabled the construction and operation of a pilot Faecal Sludge Treatment Plant for a year, with the support of Town Municipal Council, Devanahalli.

Establishing the Faecal SludgeManagement System

There were many approaches that could be taken for treatment of faecal sludge, but the approach best for Devanahalli was decided on the basis of the local constraints and conditions such as the below:

- Lack of continuous electricity supply
- Limited availability of land with the TMC
- Simplicity of technology
- Ability of system to handle increasing amount of faecal sludge and provide useful end products and perform year round
- Ability of the system to mitigate health hazards of handling faecal sludge
- Ability of the system to minimize any negative environmental impact

Keeping these in mind, passive methods of faecal sludge treatment through methods such as waste stabilization ponds, anaerobic pre-treatment, sludge drying beds, composting with municipal organic refuse, and constructed wetlands were considered for Devanahalli. The DEWATS system which is a combination of the above components was also considered.

After comparing different approaches that could be taken and the availability of capital and expertise, CDD decided to install a treatment plant based on the principle of their DEWATS system in Devanahalli. To validate the application of DEWATS and understand its treatment efficiency, CDD had setup a smaller pilot treatment plant at CASS and conducted research on the separation and stabilization methodology for faecal sludge treatment.

The pilot model sought to validate the treatment capacity and duration of treatment for the faecal sludge treatment facility. The faecal sludge treatment plantin Devanahalli uses various treatment principles. Descriptions of the modules used and the parameters compared are given in the following section. The plant was built over an area of 650 m2designed to treat 5000 L of incoming faecal sludge every day.

Co-composting

This refers to composting of two or more raw materials together. Organic materials such as animal manure, saw-dust, wood chips, bark, slaughterhouse waste, sludge or solid residues from food and beverage industries are typically used for co-composting. In the case of Devanahalli, municipal solid waste (MSW) will be used along with faecal sludge for co-composting.

Co-composting results in pathogen inactivation and the output is a good soil conditioner. This also helps to kill helminth eggs as the temperature of the compost mounds increase due to exothermic metabolic activity of bacteria. Faecal sludge has a high moisture and nitrogen content while biodegradable solid waste is high in organic carbon and has good bulking properties (i.e. it allows air to flow and circulate). By combining the two, the benefits of each can be used to optimize the process and the output.

The setting up of the plant alone was not sufficient for ensuring implementation of FSM in the town, it was backed with awareness drives stressing on the proper construction of toilets, conversion of insanitary toilets to sanitary toilets and proper use of toilets. The desludging service providers play a key role in the system, hence a major step was training them and helpers from TMC who operate and maintain the FSTP under CDD's supervision. Elected members of the urban local body and its employs also received training and awareness regarding implementation of FSM and also, how policy and governance can impact the successful implementation of an effective and sustainable FSM system.

Operation and Maintenance

The plant operates on no electricity and doesn't consist of any machinery. This was intentionally designed to cope with the lack of steady electricity supply and for ease of maintenance and operation by semi-skilled labour. The operation of the plant ensures minimal contact with raw sludge, minimal labour and is cost effective owing to the complete absence of any inputs apart from the faecal sludge itself. CDD Society has been training and supervising personnel from TMC for operating the plant since the beginning. The training not just includes instruction on how to run the plant, but also the importance of wearing protective gear and following protocol for the operators' own health and safety. The lack of inputs also make the operation of the plant much more cost effective as compared to any regular sewage treatment plant.

Financing FSM in Devanahalli

The capital expenditure for setting up the plant was met through BMGF funding. The cost of setting up the FSTP along co-composting was approximately INR 70 Lakhs for a plant with a capacity of 6000 L of faecal sludge per day on land which was sanctioned by the TMC, Devanahalli. Operational expenditure of running the plant and the co-composting facility includes the salary of the operator, maintenance costs, cost of unforeseen breakdowns, electricity and water costs, cost of protective gear etc. Together this amounts to close to INR 7 Lakh per annum.

Since desludging trucks are an important part of the equation, the cost of these trucks also need to be considered for a complete picture of the cost of this entire treatment system. The capital expenditure needed for a truck on average is INR 1.5 Lakhs. In Devanahalli, the TMC has its own truck, but it would be prudent that the two operations (the plant and the truck) be thought of and costed as one unit, since without regular faecal sludge which is provided by the desludging service provider, the plant would be defunct. If a truck is not owned and operated by the TMC, a tie-up with private players or outsourcing could be a prudent move. Overall the operations of a truck cost INR 10.5 Lakhs per annum.

The sustainability of the plant has always been a point to ponder on, especially when it is common knowledge that small town ULBs do not get funds from the state or the centre as easily. In pursuit of making the FSTP sustainable the TMC, Devanahalli with support from CDD Society passed a series of resolutions which will be applicable with Karnataka state's approval which is awaited :

The operations and maintenance of the plant and trucks would be outsourced. A private party will be roped in for maintaining the truck and plant, through a tendering procedure bound by strict guidelines for selection of vendors. The performance would be hence closely monitored by the TMC based on parameters provided by CDD Society. A fixed fee would be paid to the vendor by the TMC. This improves accountability and quality through customer intensive service, optimal utilization of resources and better book keeping and monitoring standards.

Regulation of faecal sludge disposal - This move was needed to ensure private players are not disposing collected faecal sludge indiscriminately, which would water down the TMC's efforts of FSM essentially. The private players need to register with the TMC and get their license to provide desludging services. Any operator without such a license may not be permitted to operate within town premises, the license will bind these service providers to ensure the faecal sludge is disposed appropriately at designated disposal points (including the FSTP). Apart from ensuring a regular input of faecal sludge in the plant, this move formalises a sector which is loose and informal today, and has a dire need of recognition and regulation.

Monitoring construction of pits and septic tanks
Any new household toilets constructed will need to receive a no objections certificate from the TMC which would be given if the pits and toilets are designed and constructed adhering to appropriate standards. CPHEEO and National Building Code standards would be referred to for the same.
Inclusion of a small charge for maintenance and operation of the plant in the Property Tax.

This move was proposed to get an inflow of a steady fund for the plant's and truck's operation and maintenance. This ensures the sustainability of the FSTP and also eases management of fund. Slab based structure for property tax collection. An addition will be made to the existing property tax slab. The TMC would in return schedule desludging services provided, at a minimal cost to be paid compared to current cost for desludging. Though a bold move, it would by far decrease the uncertainty of funding FSM in the town

Particulars	Cost (INR) per annum
Truck Operations	1,047,830
FSTP-operations	437,667
Co-composting-operations	252,000
Net Total	1,737,497
Service Tax	5,20,625
Plant management-and admin cost	1,100,000
Gross amount total	3,771,470

The dependence of the plant's sustainability on these resolutions becoming a policy is immense. And being a matter of state, it will take time to make these resolutions implementable. Thus, apart from these resolutions, other sources of revenue are also being explored. The end-product sale, that is, composted faecal sludge sale may serve as a surplus source of revenue. The costing of this product is still being worked out, with and without any value addition to the treated sludge which is rich in nutrients and organic in nature. A space in the faecal sludge treatment plant is also being given for bill-boards for advertising local businesses. A tipping fee may be charged to the desludging service providers who dump there faecal sludge in the plant. There are many such alternative sources of revenue which may be explored as options to fortify the revenue that may come from the property tax, or tide by until these changes are made by the state government.

The Impact

Since the plant's operation has been for merely a year, it would be not fair to conduct an impact assessment. But because this is a learning project for us, the research team of CDD Society has been vigilantly looking at the quality of treatment the plant provides and the possible impact it may have on the town in the near future. Apart from the obvious health benefits, FSM enables complete resource recovery from the waste that we generate on a daily basis, which is rich in nutrition. The treated faecal sludge after composting could be a boon to practitioners of agriculture around towns, which it is in Devanahalli. Despite not pricing the treated sludge, there is a high demand for the composted sludge we observe at the plant.

Faecal sludge has relatively high Nitrogen content while municipal solid waste is high in organic carbon and has good bulking properties – although the resource potential of municipal solid waste is much more variable than human excreta and it depends on waste composition, which varies considerably from city to city.

The FSTP has several advantages over the previous system of faecal sludge treatment:

- It eliminates direct human contact with faecal sludge, mitigating health hazards
- It eliminates foul smell and nuisance from pests/ flies
- It will be able to handle larger quantities of faecal sludge
- It will be immune to weather conditions in its effectiveness

The output of such a co-composting system would be a soil-conditioner / bio-solid which will add more value to soil health as compared to direct application of dried faecal sludge.

Empirical research indicates that co-composting improves the nutrient characteristics of faecal sludge – thus making the mixture more suitable for use in agriculture. Co-composting causes the temperature of the mixture to increase above 65°Celsius which causes up to 99% destruction of helminth eggs (HE).

The effect on the crop yield of application of composted faecal sludge varies by crop and quantity of sludge applied in combination with fertilizers. Trials conducted at the University of Agricultural Sciences in Bangalore on soya bean, finger millet and tomato have demonstrated an improvement in yields for certain combinations. The impact of application of co-compost of faecal sludge and solid waste on agricultural yields has not been quantified yet; however pilot research indicates that the use of co-compost yielded significantly higher crop yield as compared to no application of compostand as compared to the use of refuse compost. This could potentially be a significant advantage for end users of the output of the FSM plant.

Parameter	Untreated Faecal Sludge	Faecal Sludge from DE-WATS	Co-compost with solid waste
Nitrogen (% by weight)	0.45	1.60	0.4 – 3.5
Phosphorus (% by weight)	0.77	1.20	0.3 – 3.5
Potassium (% by weight)	0.13	0.19	0.5 – 1.8
Carbon (% by weight)	14 – 15	0.11	0.5 – 1.8
HE (no. / g TS)	150 - 200	> 1,500	< 5

Conclusion

The faecal sludge treatment plant in Devanahalli is the first of its kind, and hopefully a first of many. This initiative was in the beginning considered a stop-gap for small towns and cities which may get a underground drainage system in the future, but, is now being seen as a solution in itself ever since the realisation that there isn't enough water available to operate a centralised sewer network and treatment will be nearly impossible. The glaring inefficiency of centralised sewage treatment plants pushed us even harder to come up with a decentralised solution which was simple to understand, operate and maintain. To come up with a decentralised solution meant the cost has to be controlled so that it is affordable for a ULB to build and maintain it.

The faecal sludge management system thus setup in Devanahalli was the result of many trials and errors, and is still a learning project for CDD Society. Many challenges are faced on a daily basis in operating the plant such as operational issues with modules, backing up of sludge into the planted gravel filter, thus rendering it dysfunctional, blockage of valves and pipes, delays in drying of faecal sludge during rainy weather, inconsistent load leading to disproportionate volume of water and sludge which impacts the treatment efficiency, manual removal of solid waste that comes with the sludge etc. These challenges are guiding our engineers to design better plants which are robust, require minimal human contact and can sustain deviations from time to time. Another challenge we accepted from the beginning was to make this treatment plant a part of the community, by ensuring a completely sanitised surrounding which is aesthetically pleasing and devoid of any foul smell or vermin.

With this pilot we attempt to catapult FSM in semi-rural and peri-urban areas to the mainstream, with the steering wheel in the hands of the local governing bodies to ensure sustainable treatment of faecal sludge while maintaining standards of treatment and dignity to all personnel involved in the process which is more or less lacking today. We also aim to influence the central government with our efforts, to implement faecal sludge management at the national level as a faecal sludge management policy which mandates it for all states in towns and cities dependent on on-site sanitation systems. This is only a small step towards conquering the big issue of indiscriminate disposal of faecal matter that is plaguing us at a national level and has the potential to be a real hazard in the near future.

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Day 1 - Session 4

Collection and Conveyance of Faecal Sludge

Collection mechanisms if not estimated properly for its demand and technical viability, could lead to resorting to manual scavenging at a few instances. One technology for collection and conveyance cannot satisfy the diverse needs of the city. It is hence required that various options be considered and implemented as per the efficacy of the ULB or private party.

This session provides few guidelines for the collection mechanism and conveyance mechanism for a safe and effective operation.

Day 1

Session 4

Outcomes

- Participants are aware of various options for collection and conveyance of faecal sludge
- Participants are able to estimate the number of trucks for their town/city.

Objectives of the session

Familiarize the technology options and equipments used in desludging
Planning for collection and transportation options

Operations guidelines – Collection

The following steps are recommended for the operation of vacuum trucks:

1. Park the truck as close to the system as possible. The maximum distance is determined by the length of hose and elevation rise from the bottom of the pit or septic tank to the vacuum truck tank inlet. This should typically be no more than 25 meters in linear distance and 4 meters in elevation gain. Further distances or elevation differences may require intermediate pumps.

2. Inform the occupant of the pending service and note any concerns or issues.

3. Inspect the site for possible hazards, such as clearing the area of people, or identifying highgroundwater that could cause a tank to 'float' if emptied.

4. Secure the truck using wheel chocks.

5. Lay out and connect the hoses from the truck to the tank or pit to be emptied.

6. Open the tank or pit by removing the access ports or covers over the storage system.

7. Engage the vacuum equipment by using a power take-off from the truck's transmission.

8. Increase the vacuum to the proper level with the valve closed by watching the vacuum gauge, then lowering the end of the hose into the storage system, and open the valve sufficiently such that the FS is drawn out of the tank or pit. Closing the valve periodically re-builds the vacuum to enable theremoval of further FS.

9. Continue this process until the job is complete.

10. Break up FS that has agglomerated into a solid mass, either by making use of a long handle shoveland adding water when necessary to reduce the viscosity of the F8; or by reversing the directionof the flow and forcing the contents of the vacuum truck tank back through the hose and into thesanitation system in order to use the high pressure stream to break up the sludge. The direction of the flow is then returned to normal and the contents removed. It is essential to ensure that the hose is in sound condition, and that the hose connections are locked into place prior to using this method;

11. Operators should remove between 90% and 95% of the contents. It is recommended that this isverified by management through periodic spot checks.

12. Identify any abnormal conditions, such as high concentration of non-biodegradable materials, oils and grease. The colour and odour of the FS can provide clues as to how the occupants are using thesystem, and if excessive chemicals are being discharged down the drain.

13. Inspect the system once empty. In the case of a septic tank, the following checks should be carried out by the operator:
a. Listen for water running back from the discharge pipe, which could indicate plugged leach lines(if present);
b. Check to make sure that inlet and outlet tees are properly in place. Frequently, these structures break off and can sometimes be found at the bottom of the tank;
c. Inspect the tank for cracks or damage;
d. Verify that the tank is properly vented;
e. Ensure that the tank lids are properly attached when the pumping is complete and that they are properly secured;
f. Prepare a written report indicating:
how much waste was removed;
the condition of the tank or pit;
any recommendations for repairs or maintenance;
any recommendations for proper use of the system.

14. Secure the tank lid and pack away the hoses;

15. Clean up any spillage using proper sorbent materials;

16. Inform the client that the work is complete, and give them the final report. In some instances, payment is received immediately for the service however, payment is often made directly to the service provider through some type of billing system. During this final interview, the operator informs the client of the findings and any recommendations;

17. Remove the wheel chocks and drive the truck to the next site or to the nearest approved disposal Site.

Operations guidelines – Disposal at treatment plant

Independent of the delivery method of Faecal Sludge to the treatment plant or transfer station, operators should adhere to the following safety guidelines:

1. Check in with facility guard or operator.

2. Carefully following instructions regarding the sampling of FS. Some FSTPs have designated sites for residential septage, and others for commercial sludges. Plant operators may request samples of the FS prior to allowing discharge if it is suspected that the FS may contain materials hazardous to the plant.

3. Position the truck in the designated location for sludge removal, park and take the truck out of gear, apply the parking brake, and chock the wheels.

4. Remove the hose and make the connections.

5. Engage the power take-off or other mechanism for unloading the tank and complete the offloading process.

6. Obtain the necessary authorisation and access to the transfer station prior to transporting FS, as some transfer stations have locked inlets.
7. Ensure sufficient water is available for washing the solids as some transfer stations have screens to remove non-biodegradable solids.
8. Store any screened non-biodegradable solids in a safe location to drain and dry prior to containment and/ or proper disposal either through incineration land filling.9. Use proper lifting techniques when discharging drums into a transfer station such as standing on astable surface, and ensur all protective equipment is worn.

10. Clean up any spillage in the area around the inlet after completing the discharge of FS into the transfer station and re-seal the inlet.

11. Use personal protective equipment such as gloves and hard hats, and do not smoke during the entire collection and discharge operation.

12. Replace hoses and equipment, following adequate hygiene practices (e.g. hand washing), and completing the required paperwork.

References

Technical Brief: Sanitation System: Faecal Sludge Treatment. (n.d.). Centre for Affordable Water adn Sanitation Technology.


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Day 1 - Session 5

Approach to Faecal Sludge Treatment

It is necessary to understand the characteristics and quantities of faecal sludge from on-site sanitation technologies, like a pit latrine or septic tank. This information is essential to plan and design appropriate faecal sludge management options.

The first step is to know what faecal sludge is.
Where does it come from? What is it made of?
How much is there? Faecal sludge from one onsite sanitation technology can be very different than sludge from another technology. It is highly variable in consistency, concentration, and quantity. The characteristics and quantities of faecal sludge depend on various technical, operational, and environmental factors. Characterizing and quantifying faecal sludge is often overlooked because implementers are not aware of its importance. As well, faecal sludge is often still treated like wastewater despite differences in their characteristics. With more research and pilot projects, the sanitation sector will grow its capacities and knowledge on this topic. Guidelines or standards for characterizing and quantifying faecal sludge will also be developed.

Day 1

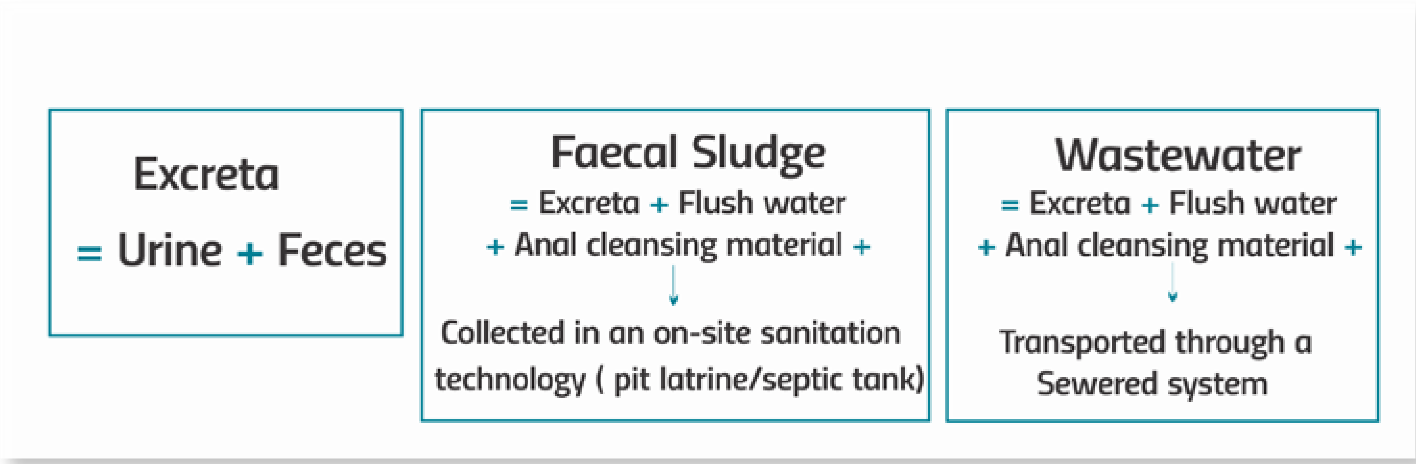
Session 5

Outcomes

- Participants understand the difference between sewage and faecal sludge.
- Particpants are familiar with treatment principles objectives and outcomes.

Objectives of the session

Characterístics of faecal sludge
Objectives of treatment
Stages of treatment
Treatment mechanisms



What is Faecal Sludge?

Faecal sludge is excreta from an on-site sanitation technology (like a pit latrine or septic tank) that may also contain used water (for example, flush water, greywater, anal cleansing water) and other anal cleansing materials (for example, paper). In a composting latrine, it will also include cover material (like ash or sawdust). As well, faecal sludge may have solid waste that is often disposed in a latrine.

Characterizing and Quantifying Faecal Sludge

It is important to know the characteristics and quantities of faecal sludge to plan and design appropriate management options. The key faecal sludge characteristics include the following:

Water content: The more water there is in faecal sludge, the more volume it takes up andthe heavier it is. It is easier to empty watery sludge, but it is more expensive to transport.

Solid waste content: Users often add garbage to their latrine. Various waste products commonly found in latrines include menstrual hygiene products, baby diapers, plastics, textiles, glass, metals, household contaminants, stones, sand and food waste. It should be assumed that faecal sludge will contain at least a small portion of solid waste.

Stability of organic material: Faecal sludge varies from fresh to stabilized (or stable). Freshsludge has not had time to degrade. Organic material is not broken down. Older sludge has undergone degradation (for example, anaerobic or aerobic digestion) and the organic material is broken down. This process is known as stabilization.

Faecal sludge from one latrine can be very different than sludge from another latrine. The composition of faecal sludge (what's in it) as well as its consistency (how liquid or solid it is) will depend on various factors:

Variety of on-site sanitation technologies: Septic tank, pit latrine, dry latrine

Storage duration: Faecal sludge will be more or less stabilized depending on how long it is stored.

Infiltration: ZFaecal sludge will be more or less viscous (thick) if there is a high infiltration rateinto or out of the containment.

Amount of greywater: Faecal sludge will be more or less dilute depending on the differenttypes of used water going into the on-site sanitation technology (for example, water from bathing, dishwashing, laundry, and cleaning).

Emptying method: Water could be added to help liquefy faecal sludge for pumping. Someemptying methods can only remove part of the contents, for example, faecal sludge at the bottom of a containment technology that is very thick. Other methods can remove the entire contents, for example manual emptying. Sometimes the household can only afford to get part of the contents removed.

Climate: During rainy seasons, on-site sanitation technologies can fill up with runoff andoverflow. Warmer temperatures increase degradation rates.

Solid waste: Quantities of solid waste (garbage) disposed in the on-site sanitationtechnology, depending on access to solid waste management and awareness.

Even though it is difficult to characterize and quantify faecal sludge, it shouldn't prevent us from doing the best that we can with the information that we have available. Information on the on-site sanitation technology and how it is operated can indicate some of the sludge characteristics, such as water content.

Characterization

The actual latrine itself can provide a lot of information about the faecal sludge characteristics. Key information includes the excreta containment technology, type of user interface, and how long the sludge has been stored. You can better understand the following sludge characteristics by observing the on-site technology and having discussions with the users, emptiers and maintenance staff:

Water content: You can describe how watery the sludge is by understanding the following:type of latrine (for example, wet or dry toilet), excreta storage technology (for example, pit with infiltration to the soil), number of latrine users, amount of water going into system, type of soil, groundwater level, how the sludge is emptied (for example, with or without adding water), and how frequently it is emptied. For example, septic tanks are commonly operated with a greater amount of water and therefore tend to have a greater water content then pit latrines.

Solid waste content: Ask the household if they use the latrine for waste disposal. People may be reluctant to admit what they put in their latrine. A pronged fork can be inserted inside the pit. The volume of solid waste retrieved can give you a better understanding of the quantity and types of solid waste in the faecal sludge.

Stability of organic material: Ask the owner how frequently the latrine is emptied. The storage time will give you a better understanding of the stability of the sludge. For example, the sludge from a public toilet, will tend to be relatively fresh because it requires frequent emptying and was stored for a short period of time.

Quantification

Quantifying faecal sludge is an approximate science. The following information is needed to estimate the quantity of faecal sludge produced in a community:

Number of users

Location

Types of on-site sanitation technologies

Number of on-site sanitation technologies

Faecal sludge accumulation rates

This information is rarely available and time-consuming to collect. There is currently no proven method to quantify faecal sludge. There are different methods that exist to quantify faecal sludge, but their assessments are based on different factors, resulting in widely variable values.

Faecal Sludge Characteristics	Sanitation System Component	Common Challenges	Examples
Water content	Emptying	Thick sludge is difficult to empty.	A pump cannot be used to empty a dry latrine pit. Water will need to be added.
	Transport	Transport watery sludge is heavy and takes up a lot of space.	Wet sludge from a septic tank is easierto pump out with a vacuum truck.
	Treatment	Watery sludge will usually need to be dewatered before focusing on pathogen inactivation.	Sludge from septic tanks will need to be dewatered before composting.
	Use and disposal	Watery sludge has a higher risk of contaminating groundwater if it is to be buried.	Sludge from septic tanks will need to be dewatered before safely burying.
Solid waste content	Emptying	Increases the quantity of sludge.	Owners need to pay higher costs toempty and transport the extra solidwaste that is disposed in a pit latrine.
	Transport	Solid waste can break emptying technologies and clog pipes and pumps.	Solid waste disposed in a pit latrine will break a motorized pump used to empty the pit contents.
	Treatment	Solid waste can break treatment technologies or stop them from working properly.	Sludge with solid waste should be removed before it is discharged into an anaerobic reactor. The solid waste could damage the reactor and disrupt anaerobic digestion.
	Use and disposal	Solid waste affects the quality of the treated product.	No one will want to use compost that has pieces of garbage in it.
Stability of organic material	Treatment	Fresh sludge contains unstabilized organic material and is difficult to dewater.	Sludge from public toilets will be difficult to dewater as it has not had time to degrade.

What Are the Objectives of Treatment?

The type and level of treatment will depend on the final goal for the faecal sludge. There are four main treatment objectives: (1) pathogen inactivation, (2) dewatering, (3) stabilization, and (4) nutrient management.

Pathogen inactivation: A key objective of faecal sludge treatment is oftenpathogen reduction to protect public health. Pathogens are bacteria, viruses, protozoa and helminths that cause disease. The level of pathogen reduction required depends on the final use or disposal of the faecal sludge. For example, sludge applied to crops needs more treatment to reduce pathogens than if it is buried. Faecal sludge treatment inactivates pathogens in various ways.

Dewatering: Faecal sludge naturally has a high water content. Dewateringremoves water from the faecal sludge. The term drying is also sometimes used, and suggests an increased level of dryness. To understand the difference between dewatering and drying, think of a wet towel. You first have to wring the towel (dewatering), then you have to hang your towel to dry (drying).

Water is heavy. Dewatering reduces the weight and volume of sludge making it easier, cheaper, and safer to manage. Dewatered sludge also attracts fewer vectors (like flies and rats) and can reduce smells. As well, the more water in faecal sludge, the higher the risk of surface and groundwater contamination. Pathogens in wet faecal sludge will infiltrate into the ground faster and travel farther than pathogens in dry faecal sludge.

Dewatering is sometimes needed before using other treatment technologies. For example, if you wanted to compost sludge from a septic tank, you would have to dewater it first. This is because the sludge from a septic tank is very wet, and composting is more efficient with drier sludge. However, not all sludge is easy to dewater. In general, sludge that has not been stabilized is more difficult to dewater.

Stabilization: Stabilized faecal sludge means that easily degradableorganic material is degraded by microorganisms. Faecal sludge contains a lot of organic material, which can be beneficial for plants, or can be a contaminant in surface water. Stabilized sludge is more predictable, smells less, and contains nutrients that are in a form plants and microorganisms in the soil can more readily use. If your goal is to produce energy, you will want less stabilized faecal sludge to start with. The breakdown of organic material during stabilization produces energy. In an anaerobic setting, it will produce biogas. In an aerobic setting, it will generate heat. Less stabilized sludge has the potential to produce greater amounts of energy.

Nutrient management: Faecal sludge contains nutrients, like nitrogen,potassium, and phosphorous. These nutrients are needed for plant growth. Farmers apply them to increase crop yield. However, these nutrients can also infiltrate through soil into groundwater, or be transported by rainwater runoff to surface water bodies. They can contaminate both drinking water and the environment.

Nutrient management: Faecal sludge contains nutrients, like nitrogen,potassium, and phosphorous. These nutrients are needed for plant growth. Farmers apply them to increase crop yield. However, these nutrients can also infiltrate through soil into groundwater, or be transported by rainwater runoff to surface water bodies. They can contaminate both drinking water and the environment.

The form of the nutrient is important for managing the faecal sludge and protecting the environment. For example, nitrogen in an organic form (for example, compost) is stable and slowly released. It can be directly applied to crops and beneficially used. Whereas nitrogen in an inorganic or ionic form (for example, nitrogen found in leachate) can have negative impacts. For example, it could harm plants when applied directly, move down through the soil to groundwater, or volatilize into the environment and cause harm.

References

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Strande, L., Ronteltap, M., & Brdjanovic, D. (2014). Faecal Sludge Management: Systems Approach for Implementation and Operation. London: IWA Publishing.

Day 1 - Session 6

Faecal Sludge Treatment Technologies

There are many technologies available to treat faecal sludge, each with different treatment objectives, treatment products, and level of development. Faecal sludge treatment is a process. To effectively treat faecal sludge, several treatment technologies may be needed in a particular order. For instance, sludge may have a lot of water, which often needs to be removed before other technologies can be used, like composting or incineration.

The choice of technologies will largely depend on the following factors:
Final goal: It is important to keep the final goal in mind when selecting appropriate treatment technologies. You first need to know how the sludge will be used or disposed of so you know what treatment is required. For example, you need to focus on dewatering, stabilization and inactivating pathogens to a safe level if you are using faecal sludge for agriculture. However, if the goal is to produce energy, then dryness is important while pathogen inactivation may be a lower priority.

Sludge characteristics and quantity: Sludge from one on-site sanitation technology can be very different than sludge from a different technology. The composition of sludge (what's in it), as well as its consistency (how liquid or solid it is) and quantity will depend on various factors. These include the type and number of on-site sanitation technologies, amount of greywater added, emptying method, and climate. It is important to know the characteristics of the sludge to choose the appropriate treatment technologies. Some treatment technologies, for example, work better with dry sludge (like composting) while others treat wet sludge (like a settlingthickening ponds).

Day 1

Session 6

Outcomes

- Participants are aware and remember at least five treatment technologies
- Participants understand the need for combination of treatment technologies

Objectives of the session

Treatment technologies

1. Mechanical Dewatering

Design: Mechanical dewatering technologies include belt filter press, frame filter press,screw press, and centrifuge. Mechanical forces dewater faecal sludge (for example, centrifugal force).

Operation: Conditioners often need to be added to the faecal sludge before mechanical dewatering. Conditioners are products that help to de-water the sludge more efficiently.

Time and energy required: Mechanical dewatering is fast (takes minutes to hours) and it needs less space, but it uses large amounts of energy.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization/ Nutrient Management
High	Low	No
Pathogen Inactivation	No information is available about pathogen inactivation for mechanical dewatering.	
Level of Development	Mechanical dewatering technologies are being transferred from wastewater treatment. There is limited experience in design, operation, and maintenance specifically for faecal sludge treatment.	

References

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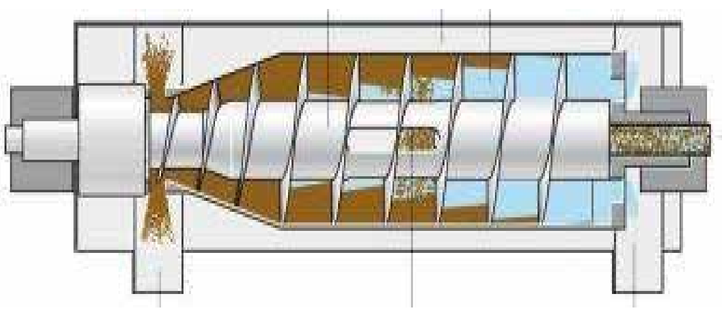

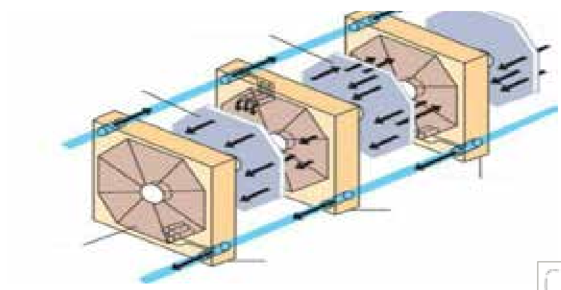

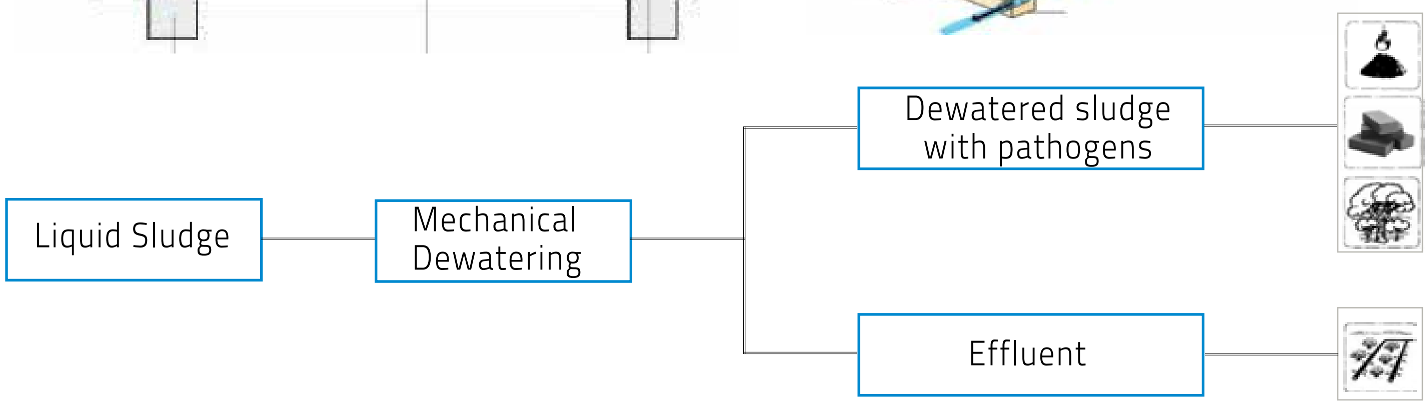

2. Planted Drying Bed

Also called planted dewatering beds, vertical flow constructed wetlands, and sludge drying reed beds.
Design: A planted drying bed is filled with filter material, usually gravel at the bottom andsand on top. Plants selected for a specific climate grow in the filter media. The bottom of the bed is sloped and lined with perforated pipes to drain away the liquid (called effluent).

Operation: Planted drying beds operate (semi-)continuously. Faecal sludge is placed onthe surface of the bed and the liquid flows through the sand and gravel. The majority of the solid portion of the sludge stays on the surface. Some of the remaining water in the sludge is removed by evapotranspiration. Sludge can be loaded on the beds without removal for a period of years. Depending on the retention time, the dewatered sludge is stabilized.

Time and energy required: The plants are harvested depending on their growth cycle. Dewatered sludge is removed every few months to years. Planted drying beds require low amounts of energy.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
Medium	Medium	Yes
Pathogen Inactivation	Some pathogens are inactivated through drying and storage depending on the retention time. At the surface of the sludge, some pathogens are inactivated by sunlight. The majority of helminth eggs are retained on the surface of the drying bed. More bacteria, viruses, and protozoa leave the bed with the effluent.	
Level of Development	Has been implemented in multiple countries for faecal sludge treatment. There is experience in design, operation, and maintenance.	

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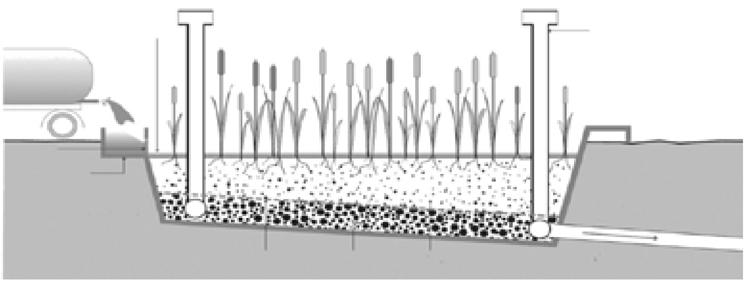

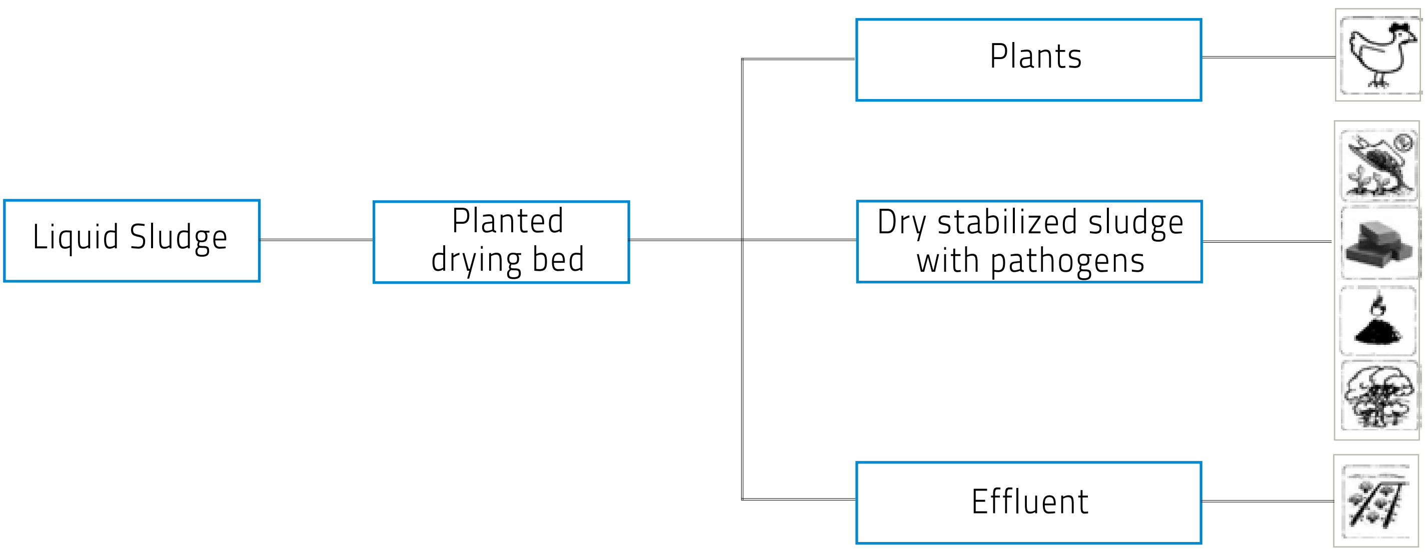

3. UnplantedDrying Bed

Also called sand drying bed.

Design: Unplanted drying beds dewater faecal sludge. An unplanted drying bed is filledwith filter material, usually gravel at the bottom and sand on top. The bottom of the bed is sloped and lined with perforated pipes to drain away the liquid (called effluent or leachate).

Operation: Unplanted drying beds are operated in batches. Sludge is placed on thesurface of the bed and the liquid flows through the sand and gravel for a period of days. The majority of the solid portion of the sludge stays on the surface. Some of the remaining water in the sludge is removed by evaporation. The dewatered sludge is then removed from the surface manually or mechanically.

Time and energy required: Dewatered or dried sludge is removed every few weeks to months. Unplanted drying beds require low amounts of energy.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
High	Medium	No
Pathogen Inactivation	Some pathogens are inactivated through drying and storage depending on the retention time. At the surface, some pathogens are inactivated by sunlight. More helminth eggs are retained on the surface of the drying bed than in the effluent. Some of the bacteria, viruses, and protozoa leave with the effluent.	
Level of Development	Many countries have implemented drying beds for faecal sludge treatment. There is some experience in design, operation, and maintenance.	

References

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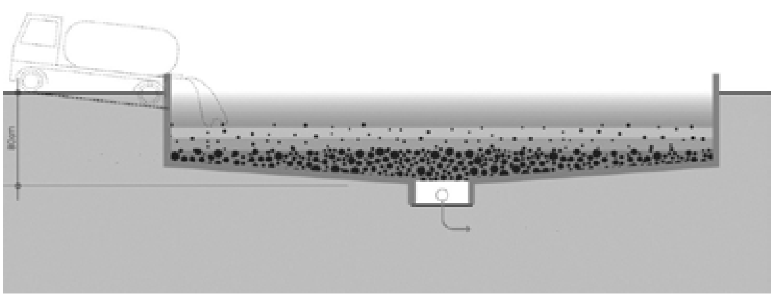

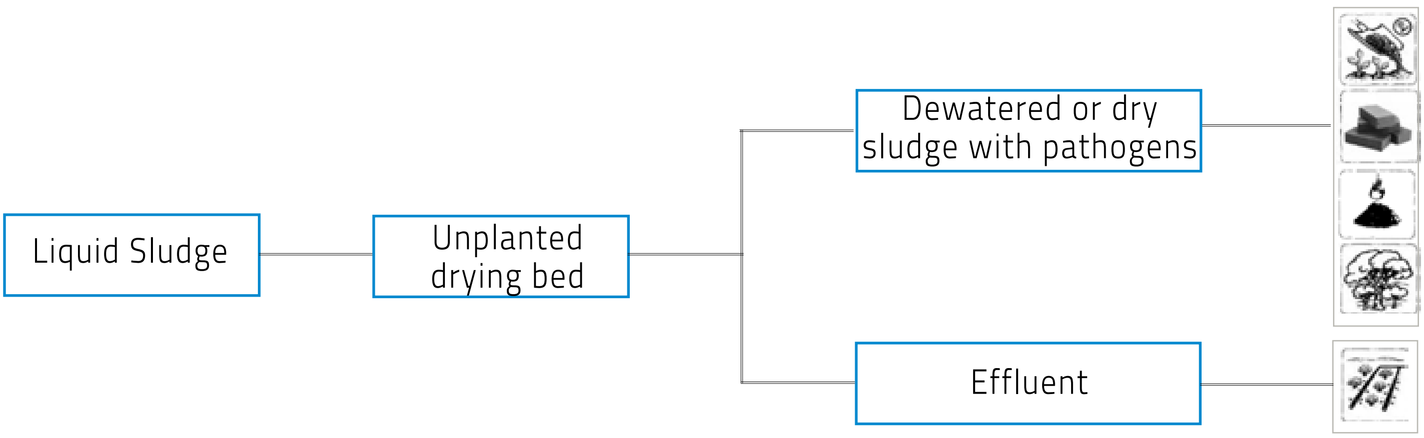

4. Settling-Thickening

Design: Settling-thickening technologies thicken and dewater faecal sludge. Solids settleto the bottom as the faecal sludge flows from one end of the pond or tank to the other. The liquid (effluent) flows through the outlet and requires further treatment. Some solids (for example, fats, oils, and grease) float to the top and form a scum layer. Example technologies include settling-thickening tanks, settlers, Imhoff tanks, and septic tanks.

Operation: Settling-thickening technologies operate (semi-)continuously. Settling-thickening technologies often include two lined ponds or tanks. While one is being operated, sludge thickens in the second. The sludge is then pumped out for further treatment.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
High	Low	No
Pathogen Inactivation	The objective is to dewater and increase the concentration of solids in faecal sludge, not to reduce pathogens. Some pathogens may be killed through storage, depending on the retention time. The effluent requires further treatment before use for irrigation in agriculture.	
Level of Development	Has been implemented in many countries for faecal sludge treatment. There is experience in design, operation, and maintenance.	

References

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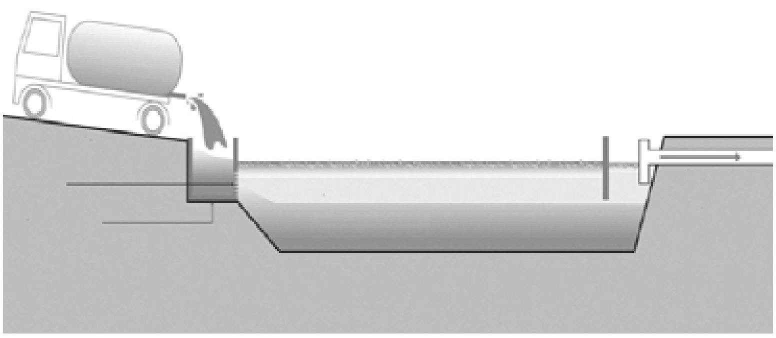

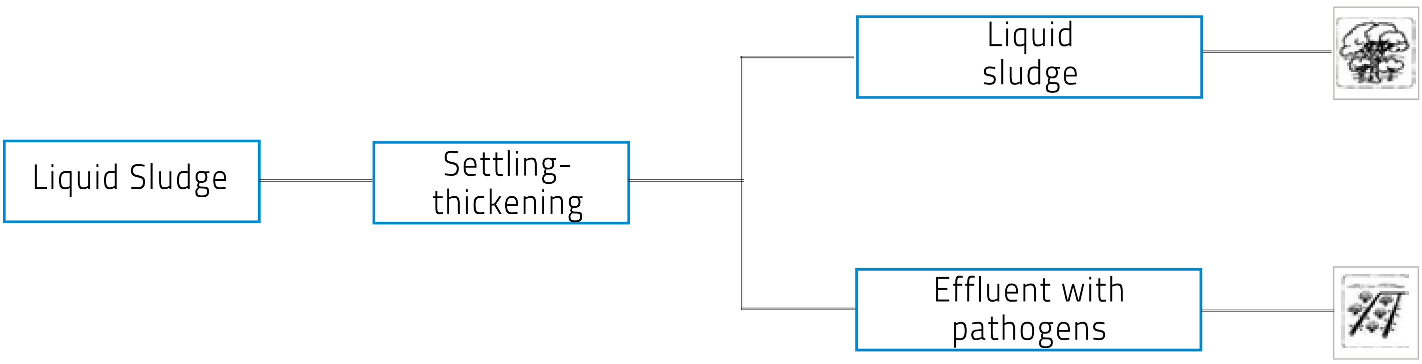

5. Thermal Drying

Design: Thermal drying technologies remove more moisture from dewatered faecalsludge.

Operation: Thermal drying technologies operate in batches, continuously or (semi-)continuously. Energy for drying can be solar or through other forms of energy, for example waste heat from industries. Solar drying usually takes place in a greenhouse with transparent covers. Sludge is spread on the floor in shallow basins. The temperature in the greenhouse increases with sunlight and the water in the sludge evaporates. The greenhouse needs to have good ventilation to remove the moist air.

Time and energy required: Thermal drying takes hours to weeks. They require a lot of energy, which can be provided through solar and waste heat.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
Medium	Medium	No
High	Medium	No
Pathogen Inactivation	Some pathogens are inactivated through drying and storage, depending on the retention time. Some pathogens at the surface of the sludge layer are inactivated by sunlight.	
Level of Development	Thermal drying technologies are being transferred from wastewater treatment. There is limited experience in design, operation, and maintenance specifically for faecal sludge treatment.	

References

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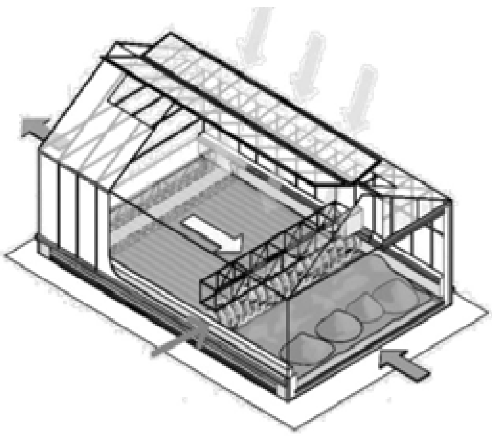
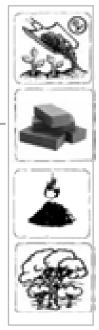


Liquid Sludge → Thermal Drying → dry sludge with pathogens



6. Anaerobic Digestion

Also called a biogas reactor.

Design: Anaerobic digestion stabilizes faecal sludge. It converts faecal sludge into (1)biogas that can be used for energy, and (2) a slurry that can be used as fertilizer.

Operation: Anaerobic digestion is operated (semi-) continuously. Faecal sludge goes in an airtight reactor. Microorganisms break down the organic material in faecal sludge in the absence of oxygen (anaerobic conditions). This process produces methane, also called biogas. Some part of the faecal sludge remains in the reactor following breakdown. This is called digestate and needs to be removed for continuous operation. Faecal sludge can be co-digested with organic material (like food waste and animal excreta) to increase the volume of biogas. Anaerobic digestion is a delicate process to operate, and can be easily upset.

Time and energy required: Time and energy required is different depending on the reactor design.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
Now	Low	Yes
High	Low	No
Pathogen Inactivation	Pathogen inactivation depends on the operation of the anaerobic digester. Under thermophilic conditions, pathogens are inactivated by high temperatures. Under mesophilic conditions, the effluent and digestate requires further pathogen inactivation.	
Level of Development	Anaerobic digestion technologies are being transferred from wastewater treatment. There is very limited experience in the design, operation, and maintenance for faecal sludge treatment.	

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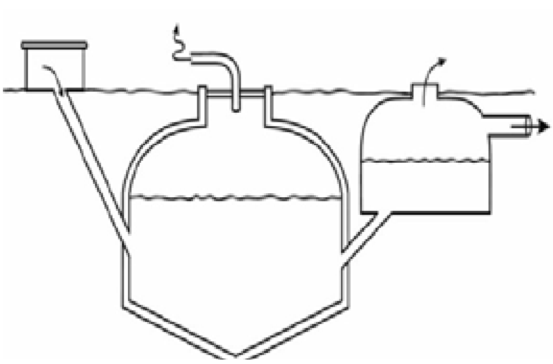

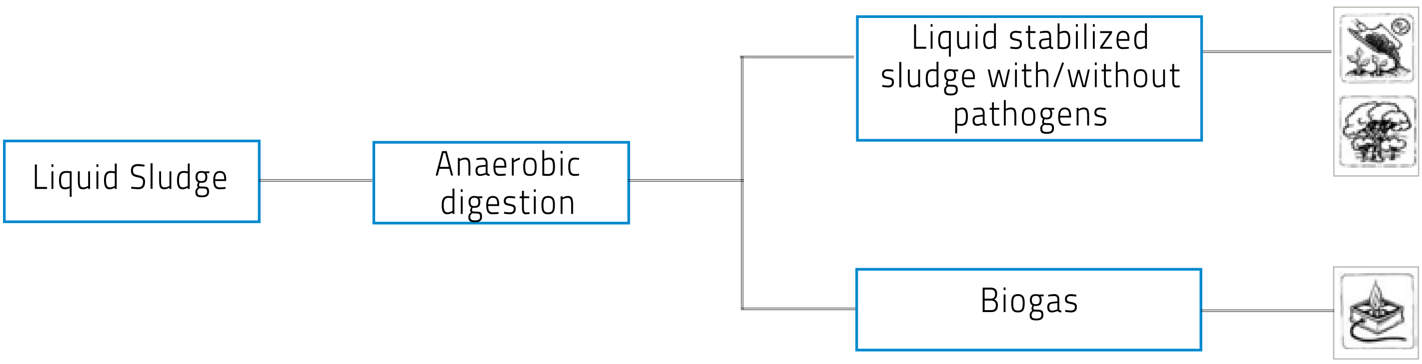

7. Incineration

Design: Incineration means that dry faecal sludge is converted into ash at hightemperatures (between 850-900oC). Incineration reduces the sludge volume and kills all pathogens. The ash can be buried, or used for construction material or as a cover material. Dried faecal sludge can fuel industrial processes, such as cement kilns. Incineration produces air emissions, which needs to be controlled to avoid negative environmental impacts.

Operation: Sludge needs to be dewatered before it is incinerated.

Time and energy required: Incinerating dry faecal sludge takes seconds to minutes. It takes some energy to ignite the sludge, but then it should burn on its own and the net energy is positive.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
High	High	Yes
Pathogen Inactivation	Pathogens are exposed to very high temperatures, which kills everything.	
Level of Development	Sludge incineration is being transferred from wastewater treatment. There is very limited experience in design, operation, and maintenance for faecal sludge treatment.	

References

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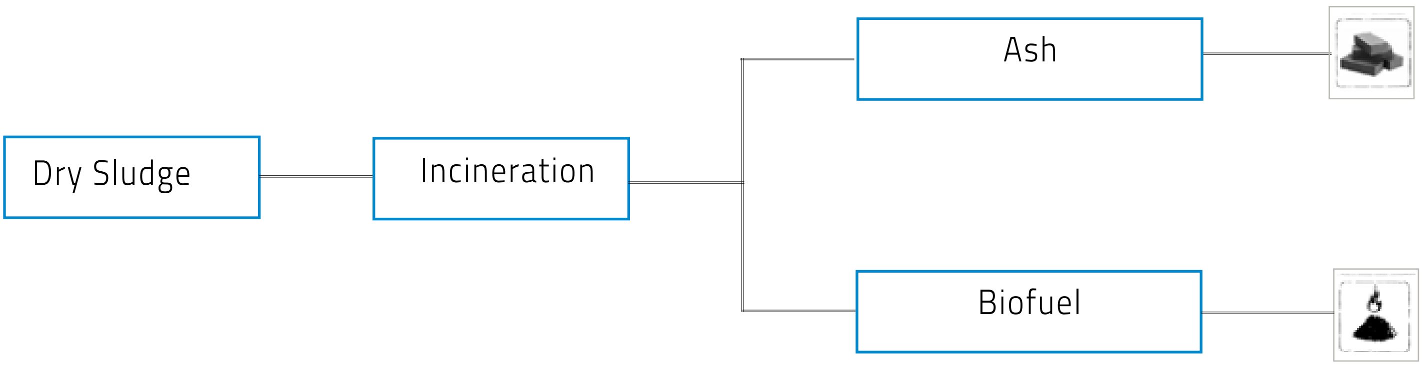

8. Co-composting

Design: Co-composting stabilizes faecal sludge and inactivates pathogens.Microorganisms break down the organic material in the presence of oxygen. If the process is properly controlled, the temperature of the pile increases resulting in pathogen inactivation, otherwise additional storage or curing is needed to reduce pathogens. The process produces compost, a dark, rich soil-like material, which can be used as a soil conditioner.

Operation: Co-composing is done in batches. Faecal sludge and other organic material(for example, food waste, wood chips) are placed in piles or rows. Various parameters need to be controlled to ensure an optimal composting process, including temperature, moisture, carbon to nitrogen ratio, and oxygen concentration.

Time and energy required: Co-composting takes several months and needs low amounts of energy.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
Low	High	Yes
Pathogen Inactivation	Pathogens can be inactivated through storage, depending on the retention time. Pathogens are killed by high temperatures in the compost pile. This heat is produced through the aerobic digestion of organic material. Temperatures should be kept at temperatures above 50°C for at least one week to ensure that pathogens are killed to a safe level (WHO, 2006).	
Level of Development	Co-composting faecal sludge has been widely implemented. There is experience in design, operation, and maintenance.	

References

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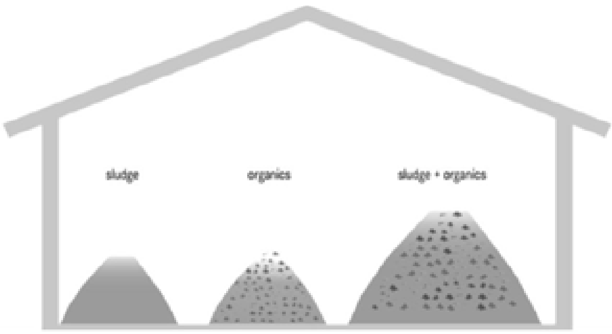

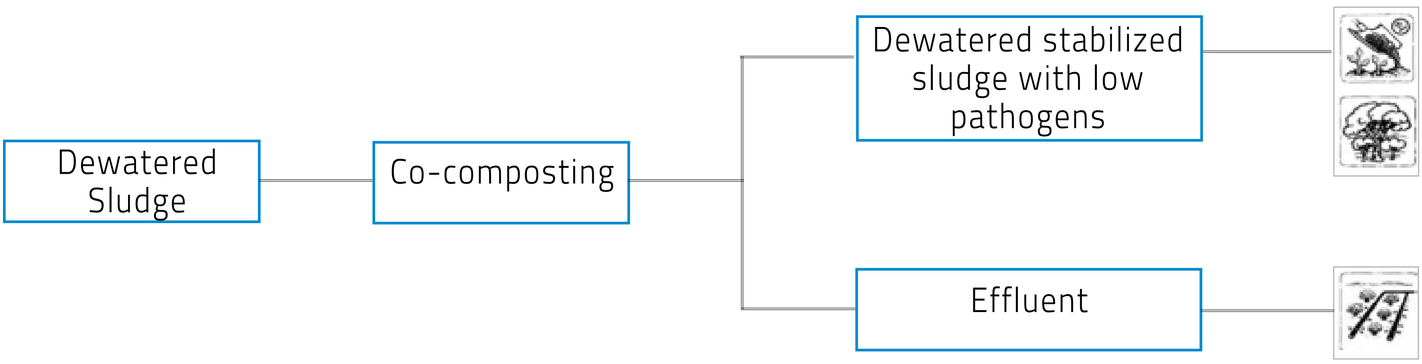

9. Storage

Design: Faecal sludge is safely stored to inactivate pathogens. Storage must be plannedand monitored, and it is not recommended over other faecal sludge treatment options.

Operation: Storage is done in batches or (semi-)continuously. Dried faecal sludge isstored in a designated dry area. The conditions must be conducive for pathogen reduction.

Time and energy required: Faecal sludge storage for pathogen reduction needs a long periods of time (up to years) and a large amount of land, but it has low energy requirements.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
Low	High	No
Pathogen Inactivation	Pathogens can be inactivated through storage (for example, time, predation, lack of food), depending on the retention time.	
Level of Development	Has been implemented for pathogen inactivation, although precise operating conditions cannot be recommended.	

References

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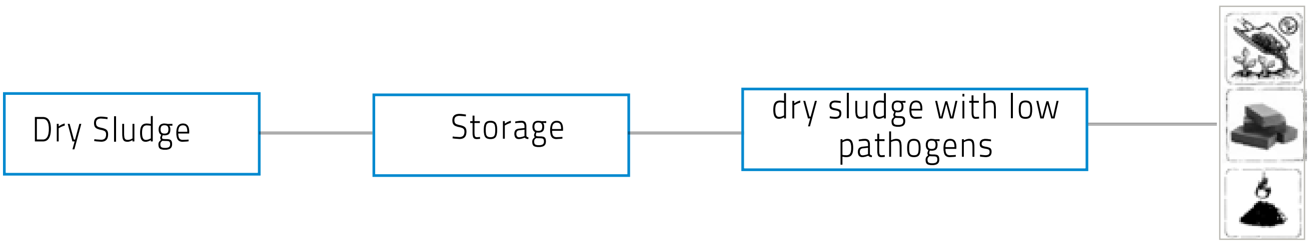

10. Pelletizing

Design: Dewatered sludge is processed into pellets by pressing it through a nozzle orplate. Pellets are dense, consistent in composition, and relatively easy to store, transport, and market.

Operation: Pelletizing can be used to enhance drying, for example with the Bioburnprocess that can process pellets at 50% moisture, that can then dry to 90% without additional thermal energy. Other pelletizers dewater or dry sludge when they are combined with other technologies, such as a thermal dryer in the LaDePa technology. Other pelletizing technologies require that the sludge is first dried, and then compressed into pellets with a binder.

Time and energy required: Pelletizing takes seconds and requires a low amount of energy, which varies among technologies.

Level of Dewatering	Level of Pathogen Inactivation	Stabilization
Depends on technology	Depends on technology	Depends on technology
Pathogen Inactivation	Pelletizing technologies alone do not inactivate pathogens, unless they are combined with another technology (for example, LaDePa).	
Level of Development	Pelletizing technologies are transferred from animal feed or biomass fuel production. However, some pelletizers have innovative features (for example, they can pelletize wet faecal sludge). Proven experience in design, operation, and maintenance for faecal sludge treatment; however, there is not wide spread or full-scale implementation.	

References

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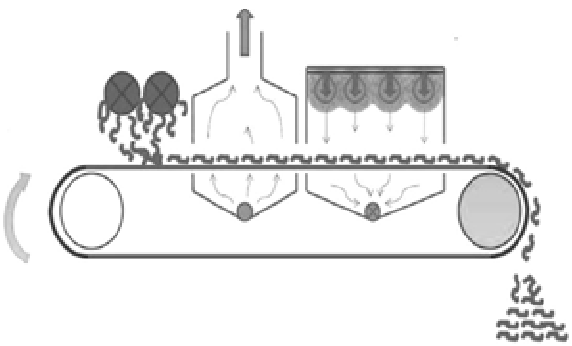
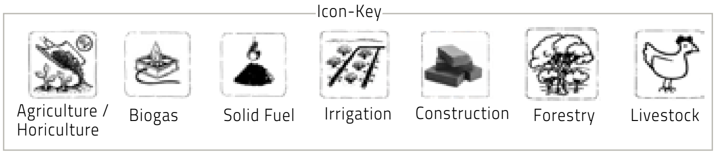
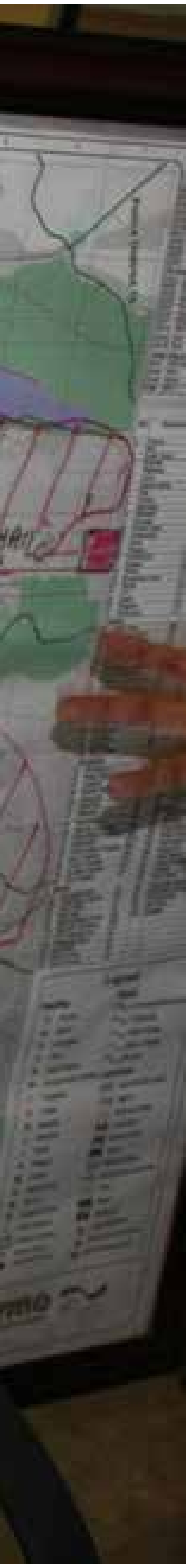


Dry Sludge → Pelletizing → Dried sludge pellets




Kabul Map
Police District 11



Day 1 - Session 7

Planning for FSTP Implementation

The most important part of the planning is the estimating the quantity of faecal Sludge that needs to be treated. In this session, various methodologies for estimating the same is discussed.

Day 1

Session 7

Outcomes

- Participants are aware of the process involved in implementing an FSTP for their cities
- Participants are aware of various contract methods for implementing FSTP

Objectives of the session

Systems approach in FSTP implementation
Contract models in FSTP

Household surveys – Estimating the sample size

$$n = \frac{t_p^2 * P * (1-p) * N}{t_p^2 * P * (1-p) + (N-1) * y^2}$$

Where,
n is the sample size,
N is the population size,
y is the margin of sampling error,
p is an estimate of the target population as part of the total population. In this case, the value of p is taken as 0.5, assuming that about 50% of the population would have some sanitation characteristics that need to be studied.
tp is equal to 1.96 for 95% confidence level

Case Study

Town Profile:
Town Name: Lucknow
Population: 10,00,000
Total Number of Households: 2,00,000 (Population / Average Household Size (5))
Total Households Surveyed: 100
Estimating Faecal Sludge – Household survey
Data Collected from survey:
Number of HHs having septic tanks: 30
Number of HHs having single pits: 40
Number of HHs having twin pits: 25
(In principle, twin pits do not require desludging. However, if they are not operated properly, desludging is required)

Quantification of Containment Units:

Total Number of Septic Tanks in Coimbatore: (30/100) x 2,00,000 = 60,000

Total Number of Single Pits in Coimbatore: (40/100) x 2,00,000 = 80,000

Total Number of Twin Pits in Coimbatore: (25/100) x 2,00,000 = 50,000

Faecal Sludge Generation:

Volume of containment units:
In this method, the volume of septic tanks (Length, Breadth and Depth), twin pits (Number of Rings, Diameter of each ring, Height of each ring) and single pits (Number of Rings, Diameter of each ring, Height of each ring) are used to determine the amount of faecal sludge generated in the town

Population based:
In this method, the faecal sludge generation is based on the population of the town and is determined by the sludge accumulation rate in septic tanks and pits.

Faecal Sludge Generation – Volume of containment units (from survey data):
Mode volume of
septic tanks= 6 m3 (Mode length x Mode breadth x Mode depth)
twin pits = 3 m3 (3.14 x (mode radius of ring) 2 x (mode number of rings x mode height of each ring))
single pits =1.5 m3 (3.14 x (mode radius of ring)2 x (mode number of rings x mode height of each ring))

We consider mode values, as this gives the volume of containment units which is most prevalent
Desludging Interval (Assumption) :

Desludging interval of septic tanks	= Once in 3 years
Desludging interval of twin pits	= Once in 2 years
Desludging interval of single pits	= Once in 1.5 years

Total Volume of Faecal Sludge generated:

Septic tanks	= 3,60,000 m3 = 6 x 60,000 (Volume of septic tank x Number of septic tanks)
Twin pits	= 1,50,000 m3 = 3 x 50,000 (Volume of twin pit x Number of twin pits)
Single pits	= 1,20,000 m3 = 1.5 x 80,000 (Volume of single pit x Number of single pits)

Total Volume of Faecal Sludge generated (per year):

Septic tanks	= 1,20,000 m3 = 3,60,000 m3/3
Twin pits	= 75,000 m3 = 1,50,000 m3/2
Single pits	= 80,000 m3 = 1,20,000 m3/1.5

Total volume of Faecal Sludge generated per year	= 2,75,000 m3
Daily generation of Faecal Sludge	= 13,75,000 m3/365 = 754 m3 per day

Esitmating Faecal Sludge – Population method
Faecal Sludge generation – Population Based (Realistic Approach):

Total Population	= 10,00,000
Population using septic tank	= 5 x 60,000 = 3,00,000 (Average HH size x Total number of septic tanks)
Population using pits	= 5 x 1,30,000 = 6,50,000 (Average HH size x Total number of pits)

Sludge Accumulation (gradually gathering) Rate:
The sludge accumulation rate is a function of a wide range of variables including water table level, containment unit age, water and excreta loading rates, microbial conditions in the unit, temperature and local soil conditions and the type of material used for anal cleansing.

Septic tanks: Sludge Accumulation Rate	= 30 liters per capita per year = 0.03 m3 per capita per year
Pits: Sludge Accumulation Rate	= 70 liters per capita per year = 0.07 m3 per capita per year

Total Faecal Sludge Generated:
Sludge generated from septic tanks = 3,00,000 x 0.03 = 9,000 m3 per year (Population using septic tanks x sludge accumulation rate)
Sludge generated from pits = 6,50,000 x 0.07 = 45,500 m3 per year (Population using pits x sludge accumulation rate)
Total Faecal Sludge generated per year = 54,500 m3
Faecal Sludge generated per day = 54,500/365 = 150 m3

Estimating desludging vehicles

From previous calculations:
Total volume of faecal sludge generated = 54,500 m3 per year
Number of days the desludging vehicles can operate = 250 days (excluding all holidays)
Volume of sludge collected per day = 54,500 m3/250 = 218 m3

General Information:
Capacities of desludging vehicle available = 1 m3, 2m3, 4m3 and 8m3
A desludging vehicle can carry out 3-4 services per day
Therefore the desludging capacities for each vehicle is (Assuming that each vehicle makes 4 trips per day):
1m3 Vehicle = 4m3 Capacity
2m3 Vehicle = 8m3 Capacity
4m3 Vehicle = 16m3 Capacity
8m3 Vehicle = 32m3 Capacity

It is always preferred to have a combination of all volumes of desludging vehicles

Width of lanes:
Easily accessible – Roads with width more than 3 meters
Accessible – Road width between 2 meters to 3 meters
Low Accessibility – Roads with width less than 2 meters
Volumes of containment units – Economic Viability
(Volume of vehicle x Number of trips made by vehicle x Number of vehicles) + ……. = Volume of faecal sludge to be collected per day

In case of Lucknow, if we consider that there are three
1m3 vehicles,
four 2 m3 vehicles,
three 4m3 vehicles and
four 8m3 vehicles,
then the total volume of faecal sludge that can be desludged per day:
1m3 vehicle = 1 x 4 x 3 = 12 m3 per day
2m3 vehicle = 2 x 4 x 4 = 32 m3 per day
4m3 vehicle = 4 x 4 x 3 = 48 m3 per day
8m3 vehicle = 8 x 4 x 4 = 128 m3 per day
Total volume of faecal sludge that can be desludged per day = 220 m3 per day

Sewage Treatment Plant siting criteria - Guidelines

1. The STP site should be at least 250 metres away from any lake or pond preferably in the down stream side of lake or pond so that the sewage shall not reach the water bodies.
2. The STP site should be located more than at least 250 metres away from river or stream and shall ensure that the treated / untreated sewage should not reach the above water sources.
3. The STP site should be located at least 500 metres away from a notified habitated area and zone of 100 metres around STP site boundary should be declared as no-development zone so that green belt can be developed in that area.
4. The STP site should be at least 500 metres away from public utility areas such as parks, temples, educational institutions etc.,
5. The site of STP should be selected on dry lands and the treated sewage shall be utilized on land for irrigation.
6. The local body shall also ensure that the land availability and consent from the land owners for the disposal of treated sewage, which should be mentioned at the time of application for NOC itself.
7. In case of disposal of treated sewage into marine water bodies, the local body shall obtain CRZ clearance and this should be submitted along with NOC application.
8. The local body shall obtain appropriate land use certificate from DTCP for STP site.
9. The local body shall consider the most suitable treatment technology while selecting the site in respect of extent of land. Advanced treatment technology will require less footprint area in order to meet the inland surface water standards prescribed by the TNPCB. This should be supported by data in the DPR prepared by the local body.
10. A preliminary assessment of public / nearby residents' opinion neighboring the location of STP site is essential.

sd/-...
R.Balakrishnan, I.A.S.,
Chairman.

References

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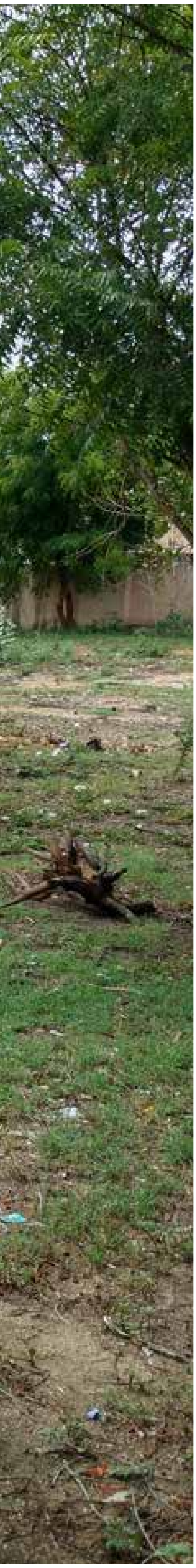


Day 2 - Session 1

Feasibility study

The thorough understanding of the existing situation is essential to tackle the right problems and to consider the right constraints while developing solutions. The first approach should be to gather a broad understanding of the situation and to know about all relevant issues and the relations between them.

Day 1

Session 7

Outcomes

- Participants have experience in conducting feasibility studies
- Participants are aware of data collection methods for a feasibility study

Objectives of the session

- Stakeholders in FSM
- Type of information to be collected from each stakeholder group

Introduction

The thorough understanding of the existing situation is essential to tackle the right problems and to consider the right constraints while developing solutions. The first approach should be to gather a broad understanding of the situation and to know about all relevant issues and the relations between them.Do not spend too much effort gathering technical data that may be of no practical use. Always ask yourself what you will do with the information you collect. The requirements for technical data will become apparent later, when specific solutions are envisaged.

Beside the basic goal of understanding the situation, you should always seek to identify the main problems with FS management and their causes.

Explore the local context (geography, society, infrastructure)

A good knowledge of the general context around the specific problem is very important. This is especially valid if you are a representative of an external agency and not yet familiar with the local context.The general conditions of the local situation set the frame within which potential solutions are possible. Basically, the planner should achieve enough knowledge of the situation to develop a good feeling for what is possible in the local context and what might be problematic.

Useful and easily available sources for information might be reports of projects located in the studied area and country reports issued by governmental or external agencies. Political, legal and institutional issues are best explored through various interviews with representatives of the different political levels and of discussions with persons outside these institutions. It is often necessary to be careful with official descriptions of these issues, as reality may look different. Environmental regulations for instance often have little effects on practice due to lacking awareness and enforcement.

Geography

Geographical factors such as topographical situation, geology or climatic conditions may have considerable influence on sanitation problems. They are major constraints influencing the feasibility of technological and organizational solutions.

Socio-economic situation, health and cultural aspects

Socio-economic and cultural aspects tell about the populations' ability and willingness to contribute or to accept proposed measures. It is very useful to assess the situation and potentials of private entrepreneurship in provision of public services. Health data may indicate problems related to sanitation and how urgent it is to solve them.

Political and legal framework

Good knowledge of the political system, the administration system, planning procedures etc. is essential for a planner. Legislation concerning environmental and construction issues, including discharge standards and construction policies need to be taken into account when planning treatment and disposal facilities.

Existing plans

The different municipal or state departments and the public utilities may already have their own plans dealing with sanitation and faecal sludge management. These plans should be taken into account when preparing a new plan. Try to find out about the strengths and the weaknesses of existing plans. Pay particular attention to the way in which these plans deal with operation and maintenance and their financing. It is very useful to explore how earlier plans have been implemented or why they have not been implemented.

Sanitation infrastructure and services

Wastewater management, solid waste management, urban drainage and other environmental and sanitary services are closely related to FS management, or they could be so in future. Public utilities or private enterprises are responsible for the provision of those services. It is important to know what are the different enterprises' activities, how the enterprises are organized, what are the available human and financial resources, and how are they equipped.

Cost-recovery of services or the percentage of subsidizing are other important issues to explore. It is essential to know how responsibilities for the different services are shared among the different enterprises, which enterprises are involved in FS management, and which are their weak points in management. A good overview about the existing infrastructure like toilet facilities, sewers and drains, treatment facilities, disposal or dumping sites, should be achieved. Find out what are currently the sanitation problems of highest priority, and how are they connected to problems related to FS management.

Land availability

The construction of facilities for FS management, e.g. for sludge treatment or storage will require land. It would be useful to have at early planning stages an overview on the general availability of land for this purpose, and on the cost or constraints of the land acquiring processes. Try to find out if the municipality already possesses land potentially suitable for sludge treatment, and what are the local constraints on these sites regarding accessibility, possible odour emissions or wastewater discharge.

Explore the situation of faecal sludge management

The next step must be to find out more in detail about the current and the expected future situation of FS management and all aspects that are related to it or may influence it.

Toilet facilities

Knowing the distribution of the various types of toilet facilities helps estimating what kind of faecalsludge you have to deal with. Don't assume that the distribution of different sanitation systems is stable, the situation may be quite dynamic, with some systems replacing others.

Following the National Institute for Agronomic Science in Hanoi, the lack of organic fertilizer in rice cultivation is a limiting factor for rice production in the Red River Delta. Compost from solid waste or treated faecal sludge is currently not traded, but all farmers state that such a product would be very welcome if price and effectiveness were satisfying.

It might be rather difficult to obtain exact figures about the distribution of different toilet facilities and the on-going developments. The best sources of information are usually household surveys where a statistically representative number of households are questioned about their situation regarding sanitation infrastructure, habits and awareness. Conducting such a survey is, however, a major exercise, which can rarely be justified for the purpose of FS management only. If no data from earlier surveys is available, you will need to conduct a smaller, "qualitative" survey by the mean of key interviews. It is not of primary importance to have at hand statistically significant data. Rather you should try to obtain, with a reasonable input of time and resources, a realistic picture of the current situation and the main tendencies.

A large household survey is usually conducted when a city wide sanitation plan, comprising overall sanitation, not FS management only, is going to be developed. In that case, the large number of information, which can be collected from the household questionings, justifies usually the high expenses for a large survey in the inception phase.

FS collection

The removal of sludge from toilet facilities, and the transport to the site of treatment or disposal, is the first important component of FS management. You need to understand well the current practice and what are the problems with it.

Who is collecting the FS - a municipal agency, private companies, individual entrepreneurs, farmers, or others? Why the facilities are emptied - on demand of the owners, on initiative of the authorities? How they are emptied - manually, or by vacuum tanker? How frequently they are emptied? How is the collection financed - by fees for the households, or by municipal subsidizes? How much is the fee? How much is the actual cost for the collection? What are the problems with FS collection - are facilities difficult to access, are the fees too high? Are transport distances a problem? These and more questions need to be answered to get a good picture of the situation.

The best way to get a complete impression on how is working the FS collection is to talk to the implicated persons. Don't limit the interviews to municipal officials. Ask as well the workers of municipal agencies, householders, private FS collectors and so on. Very useful is to visit several households and to accompany the workers on a few collection tours.

FS treatment, disposal or reuse

The second main component of the FS management is what is being done with the sludge after collection from the facilities. The sludge may be disposed off, or used in agriculture, untreated or after having received a treatment.

How the sludge is treated, disposed off or used is best found through interviews with the agencies or individuals that are carrying out the collection. Observation of the disposal, treatment or reuse and visiting corresponding sites is essential. Be aware that the sludge may be treated, disposed or used in different ways, depending on the sludge type and who collects it. For example, if there is a municipal agency and individual entrepreneurs active in emptying toilets, the former may use a specific dumping site, whereas the latter may dump sludge into the drainage channels, or sell it to farmers. It is important to analyse the existing treatment, disposal or reuse system on its strengths and weaknesses. Where are the main problems? Which components work well and should be preserved? Try to understand the money flow: How is treatment or landfilling is financed? Are farmers paying for faecal sludge?
Finding out what actually happens with the sludge is a crucial point, because it's there where most of the environmental pollution and health risks are generated.

Lessons from neighbouring cities

It may be very helpful to visit a few neighbouring cities to get informed about the situation of faecal sludge management in similar places. You may find situations where faecal sludge is managed in a much more satisfactory way, and get precious indications how you can solve the problems on your location. You may also find similar problems in similar contexts and though get confirmed the results of your only analysis.

Explore stakeholders' needs and perceptions

Any solution works best if it satisfies as far as possible the interests of all involved stakeholders, if everybody has a benefit through improvement of his individual situation or through incentives provided for motivation purpose. Proposed measures are most successful if they are able to solve the actual problems of all involved. The above makes clear that it is indispensable to consider the perceptions, the needs, the interests and the personal situation of all involved stakeholders. Therefore you have to identify the stakeholders, all persons, groups or institutions who are directly or indirectly involved in FS management, and you have to talk to them.

Exploring the stakeholders' perceptions should not stand alone, but go along with exploring the general situation and the practices of FS management. The most valuable sources of information about the FS management situation are the involved stakeholders. You will have to talk to them to learn about the facts, but in the same time you should ask them about their personal point of view, situation and interests. The most effective way to get representative information is to choose a number of persons who all belong to the same group of stakeholders but have different positions within this group. For example if you want to know about the situation of a municipal service agency, talk to the director, to administrators, and to several workers. If you want to know the problems of toilets users, ask people from different city neighbourhoods and people using different toilet types. Try to find those who know most and who are most likely to tell what they know. Be always aware that the statements are very subjective and may be incomplete for one or the other reason.

Stakeholders

The following list gives possible stakeholders and their role in FS management. The list may be not complete; you will find different stakeholders depending on every different situation.

Householders

The householders are the ones using the toilet facilities in which sludge accumulates. Usually it's them who decide about the type of toilet facility they build, about the time when they empty the toilet, and it's them who have to pay for the emptying. They know best who actually empties their toilet, what is the real price for it, and what are the technical problems with the emptying. Also if shared or public toilets are used, the householders, as their users, are able to provide corresponding information.

You should interview a number of people from different social classes, in different neighbourhoods, and with different sanitation facilities. Best is to visit them at home, see their facilities and talk about their experience and problems with the emptying. Try to find out about their awareness for environmental and health issues, and about their attitude towards possible changes with the emptying regime.

Always keep in mind that the possible improvement measures need to be supported or at least tolerated by the individual citizens. You should find out what are important aspects for them, and where they might be lacking of knowledge to understand the necessity of improvements. This may provide hints as to future needs for public awareness and promotion activities. A further important issue, which can be clarified through talks to individual citizens, is the cultural attitude towards the handling of human waste and the acceptance of use of human waste for fertilizing of food crops.

Community based organizations and non-governmental organizations

There might by various groups being active in the sanitation and health sector of the project area. These groups can be a valuable source of information representing the community in which they are active, as they are well informed about the needs and concerns of the community. On the other hand, these groups may facilitate the access to the community, for example if you plan awareness raising campaigns or household surveys.

Authorities

It is important to first identify all agencies potentially involved in the planning of FS management. These might be the local government or specialist governmental agencies on municipal, provincial or state level, responsible for planning, public services, construction, health, environment, etc. Understand which agency is responsible for which issue, and how responsibilities may interfere or where they are not clearly defined. Get informed about the habitual procedures for decision making.

In the particular case of faecal sludge management, the initiative for citywide planning has to come from the authorities. Therefore you have to explore how much the authorities are aware of the existing problems, and if necessary, you have to make them understand the need for actions. Try to make sure to have their continuous support for the planning, and keep them informed about your work.

Public utilities

The opinion of the people doing the daily business of FS management is very valuable and cannot be neglected while searching for improvements. Talk to representatives from all utility enterprises which are currently active in FS management, or which could be involved in future. Important is, again, to talk to persons from different hierarchic levels, from the director to the workers.

Does the director think his enterprise has sufficiently support by the municipal government? What do the employees of the utility enterprises think are the main problems for their enterprise and for the provision of an adequate service? Try to get a feeling for the real interests of the people.

For example: how do the workers earn their main income – through the salary paid by the enterprise, or do they earn money by emptying toilets on their own account, or by selling the sludge?

Always try to find out by what mean the workers could be motivated to act in the desired way. For example: is it necessary to provide incentives to make sure that the driver of a vacuum tanker will take his load to the treatment plant rather to sell it to a farmer or to dump it on the next possible spot?

Private sector
The private sector active in FS management can be represented by companies operating vacuum trucks or similar equipment, or by individual workers who usually empty the toilets with shovels.

You should ask them similar questions as to the public utility enterprises. Learn how they earn money - by payment for the emptying, or by selling the sludge. Try to find out, what kind of motivation or incentives it would need to make them act in the desired way.

Whereas it should be no problem to contact companies, it may be difficult to actually find the individual entrepreneurs. You could find some of them through the householders by asking who has emptied their toilet.

Be aware that private entrepreneurs might be at the same time employees of the public enterprises and do empty toilets on their own account as a secondary job.

Data collection

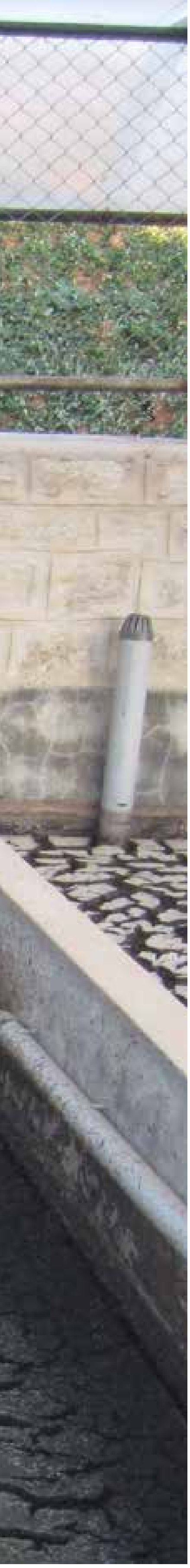
It will be necessary to collect more detailed data for the (pre-) design of components of the future management concept. This requires that you already are familiar with the situation, know about the problems, have defined the main objectives, and that you have already pre-selected several potential solutions. Therefore, the data collection does not follow directly the logical sequence of the other described points of the situation analysis. Planning process cannot be treated as a one-way process, that you should use the information collected in the initial stages to identify further needs for more detailed information.

The data you need can be of very different nature: a more detailed survey to know about the distribution of different toilet types; a thorough market analysis for a fertilizer from treated FS; a detailed analysis of a specific sanitation service; a meaningful sludge analysing for the design of treatment facilities; etc.

Always try to maintain a reasonable balance between the expenses for the data collection and the benefit from it. Detailed data is not always much more useful than already available data from similar locations or even data from standard literature.

References

Strande, L., Ronteltap, M., & Brdjanovic, D. (2014). Faecal Sludge Management: Systems Approach for Implementation and Operation. London: IWA Publishing.



Day 3 - Session 3

Design of Drying beds

The thorough understanding of the existing situation is essential to tackle the right problems and to consider the right constraints while developing solutions. The first approach should be to gather a broad understanding of the situation and to know about all relevant issues and the relations between them.

Day 3

Session 3

Outcomes

- Participants carry out preliminary design of the treatment module Sludge drying and planted sludge drying bed

Objectives of the session

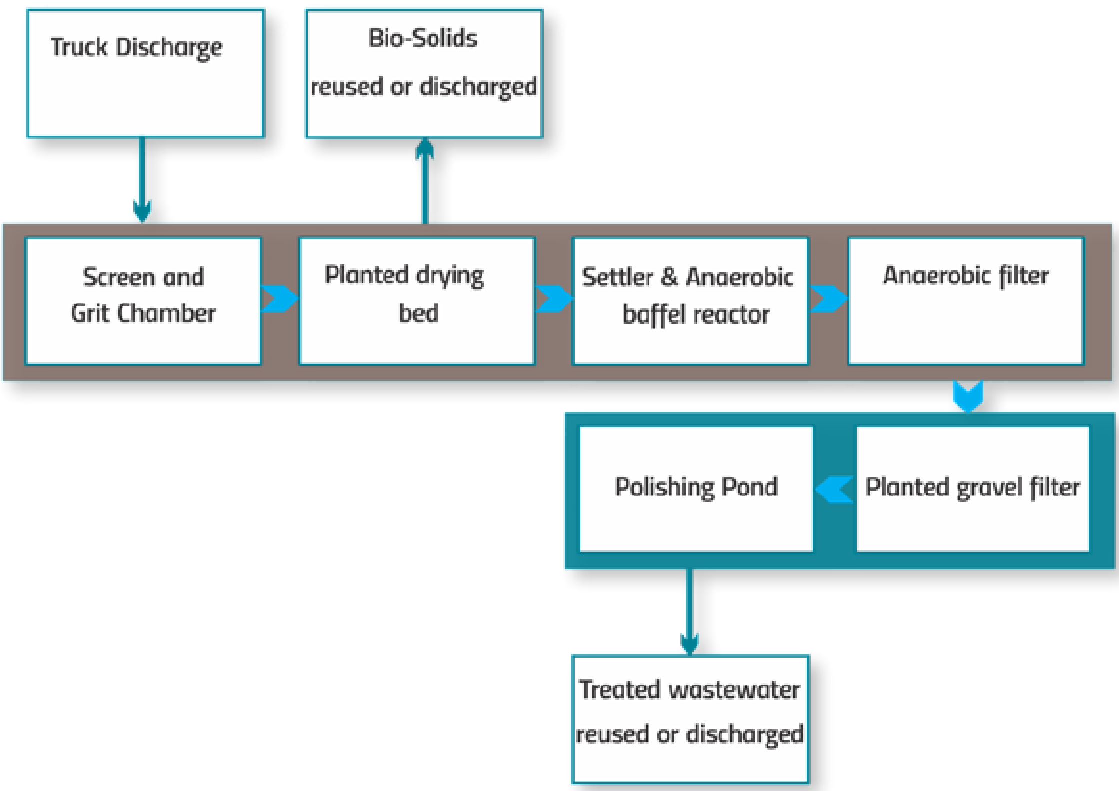
Method of making calculations to arrive at the design estimates

The treatment goals:

Stabilized bio solids
Treated water as per CPCB standards
Minimal operational requirement
Robust performance

Methodology

Trash and grit removal
Sludge dewatering
Percolate treatment
Sludge stabilization



Faecal sludge and Septage emptied from pits and septic tanks is discharged into screen and grit chamber, where inert materials such as plastics, paper, fabric, soil and silt are removed using bar screen and gravity settling. The screened sludge is disposed into planted drying bed, which is filled with sand andgravel to support vegetation and to act as a filter media. The filtrate flows down through the media and is collected in drains, while the solidsremains on the filter surface and is dewatered through gravity and evapotranspiration.The main advantage of the planted bed is that the filters do not need to be de-sludged after each drying cycle. Therefore fresh sludge can be directly applied over the previous layer with interval between subsequent applications.

The plants and their root systems maintain the porosity of the filter and hence the beds require de-sludging only once every 2-3 years. The end product from drying bed is the bio-solids, which is stabilized and rich in nutrients, which can be used directly as a soil conditioner or co-composted with municipal organic waste to produce compost. The percolate collected from the bottom of the drying bed is treated through a series of treatment modules such as settling tank, anaerobic baffle reactor, anaerobic filter, constructed wetland and polishing pond to achieve the desired effluent standard.

Suitability

Planted drying bed as a treatment option for faecal sludge is suitable (and not restricted to) for following conditions:

High variation in quantity of faecal sludge to be treated at the facility
Moderate variation in the characterestics of faecal sludge
Limited or no reuse option
Ambient temperatures of less than 20 degree Celsius
Wide fluctuation in temperatures across seasons
Minimal operational requirement

Parameters	Input faecal sludge	Final treated effluent	CPCB standards for discharge of treated water
COD	20 – 50 g/litre	100-150 mg/litre	< 100 mg/litre
Total solids	20 – 50 g/litre	300 – 500 mg/litre	< 300 mg/litre
TKN	3000 mg/litre	50 mg/litre	< 50 mg/litre

Treatment modules		
Pre-treatment	Screen and Grit chamber	Faecal sludge contains trash and grit such as plastics, soil, paper and fibre which reduce the treatment efficacy and value of end products, hence these need to be removed before sludge undergoes any further treatment. Bar screens with vertical mesh is preffered for trash seperation. Removal of grit usually happens through gravity settling. Appropriate arrangement for their collection and removal need to be designed in the pretreatment process The seperated trash and grit can be disposed along with municipal solid waste arrangement
Sludge stabilisation and dewatering	Planted drying beds	Planted drying beds consists of graded filter media such as gravel and sand. Pre-treated sludge is applied over these filter materials having macrophyte plantation. The percolate from the sludge flows through these filter materials, undergoing treatment by filtration and bilogical digestion. The solids get retained in the top layers of the drying bed, which over a period of 2-3 years undergo digestion and stabilisation. Planted drying beds are designed to treat a solid loading rate of 150-250 kg total solids/m2 per annum. The macrophytes help in stabilisation and dewatering, the roots of these plants enable growth of certain type of bacteria which also aid in nutrient removal. After 2-3 years of loading, the beds are left unused for 6 months where further dehydration and stabilisation of the solids occur. The end product from the drying bed is stabilised bio-solids which can be further processed for value addition or used for land applications. A drainage mechanism is provided at the bottom of the drying bed to collect percolate, which still contains organic load and hence needs to be further treated.
Percolate treatment	Settler	Percolate from drying beds is retained in a settler, typical with 3-4 hour retention time, this provides for settling of the settleable solids.
	Anaerobic baffle reactor (ABR)	Percolate from settler is further treated in anaerobic baffle reactor providing for an upflow movement of sludge through a sludge blanket. The retention time provided in the ABR is about 24-26 hours, with an upflow velocity of 0.9-1.2 m/hr
	Anaerobic filter	Further treatment occurs at the anaerobic filter provided with a retention time of 12-24 hours. The filter material provide surface for the growth of microorganism which aid in digestion and absorbsion of organic matter present in percolate.
	Planted drying bed	Post anaerobic treatment modules, the partially treated wastewater is introduced into aerobic modules, such as horizontal subsurface flow constructed wetlands. Flowing through this, the percolate comes in contact with natural air, which aid in nutrient and organic removal. In addition the plantation in these modules also absorb essential nutrients from the percolate.
	Polishing pond	The final treated wastewater is stored in an open tank where, surface aeration and UV radation together reduce the organic and microbial load of the treated wastewater.

Reuse

Biosolids: Stabilised biosolids can be used as a soil conditioner enhancing the physical and nutrient properties of soil. Alternatively these can also be further processed along with municipal organic waste to yeild compost. At places of no reuse application, biosolids can be dried to act as a source of fuel or can be filled in land fill sites.

Treated wastewater: Treated percolate can be used for irrigating farmlands, green belt within the treatment facility or can also be discharged into percolation pits to recharge ground water (when favaourable conditions exist).

Consideration while choosing the treatment technology

- Planted drying beds receive partially stabilised sludge, and hence might pose a threat of odour and nuisance due to insects.
- They consume extensive area for treatment, a limited resource in Indian cities and towns.
- Due to its low operational requirement, the treatment unit is often neglected which can lead to its failure.
- Macrophytes in the drying bed need to be acclimatized to faecal sludge by application of low strength faecal sludge or wastewater for a period of 3-4 months prior to commissioning of the system.

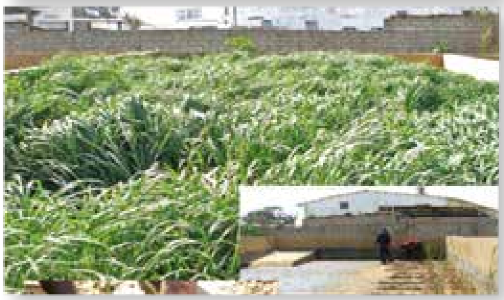
Characteristics

Characteristics	10 KLD	Per KLD	20 KLD	Per KLD
Area requirement – treatment module	1250 m^2	125 m2	2400 m2	120 m2
Area for non treatment facilities (road, greenbelt, etc)	2500 m2	125 m2	2000 m2	105 m2
Total Area	2500 m2	250 m2	4500 m2	225 m2
CAPEX	Rs.1,35,75,000	Rs. 13,57,500	Rs. 2,60,00,000	Rs. 13,00,000
OPEX	Rs. 2,50,000	Rs. 25000	Rs. 3,50,000	Rs. 17,500

Case Studies

Thailand
Constructed in 1996, the pilot treatment facility was built in AIT campus in Thailand for conducting research on planted drying beds. The treatment consists of three stages: a. Pre-treatment – retention of coarse materials, b. balancing and mixing tank – to achieve certain homogenisation, c. planted drying beds along with waste stabilisation pond and vertical flow constructed wetland for percolate treatment. Three planted drying beds are designed with a sludge loading rate of 250 kg TS/m2 annum.

Senegal
Implemented in 2008 under the guidance of EAWAG, planted drying beds were used as a treatment option for a full scale faecal sludge treatment plant in Dakar, Senegal.



Sludge Drying Beds

Unplanted sludge drying beds are shallow filters filled with sand and gravel with an under-drain at the bottom to collect leachate. Sludge is discharged onto the surface for dewatering. The drying process in a drying bed is based on drainage of liquid through the sand and gravel to the bottom of the bed, and evaporation of water from the surface of the sludge to the air. The design as well as the operation of the drying bed is fairly straightforward, provided the sludge loading rate is well selected and the inlet points for depositing the sludge onto the bed are properly designed.

Depending on the faecal sludge (FS) characteristics, a variable fraction of approximately 50-80% of the sludge volume drains off as a liquid (or leachate), which needs to be collected and treated prior to discharge (Tilley et al., 2014). After reaching the desired dryness, the sludge is removed from the bed manually or mechanically.

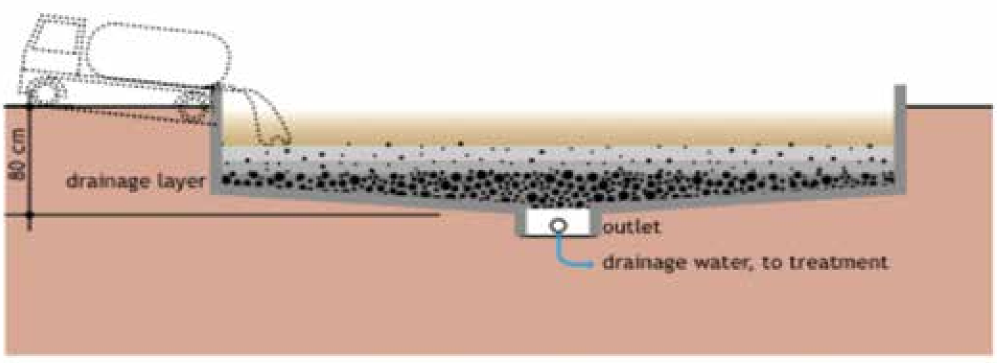
Further processing for stabilisation and pathogen reduction may be required depending on the intended end use option. When considering the installation of a drying bed, the ease of operation and low cost needs to be considered against the relatively large footprint and odour potential.

Treatment principle

A FS treatment plant (FSTP) consists of several drying beds in one location. Sludge is deposited on each of these drying beds where it remains until the desired moisture content is achieved. It is subsequently mechanically or manually removed for disposal or further treatment and reuse.

The drying process is based on two principles. The first principle is percolation of the leachate through sand and gravel. This process is significant with sludge that contains large volumes of free water and is relatively fast, ranging from hours to days (Heinss et al., 1998).

The second process, evaporation, removes the bound water fraction and this process typically takes place over a period of days to weeks. Heinss et al. (1998) reported removal of 50 to 80% by volume due to drainage, and 20 to 50% due to evaporation in drying beds with FS. This range is typical for sludge with a significant amount of free water, but there is more evaporation and less percolation with sludge that has more bound water. For example, no leachate was observed in a study with preliminary thickened sludge (Badji, 2011). In planted sludge drying beds evapotranspiration also contributes to water loss.



References

Technical Note for faecal sludge treatment using planted drying beds

Day 3 - Session 4

Treatment concept - DEWATS

Feacal sludge treatment doesn't stop with just stabilizing the solids. The effluent/ percolate has to be managed. For this purpose, natural treatment processes such as DEWATS which primarily employs anaerobic treatment are preferred.

This section provides information on suggestive treatment options for effluent/percolate and also provides the design specifications.

Day 3

Session 4

Outcomes

- Participants can list and understand the components of effluent treatment and design it

Objectives of the session

Characteristics of effluent
Treatment mechanisms for of effluent treatment

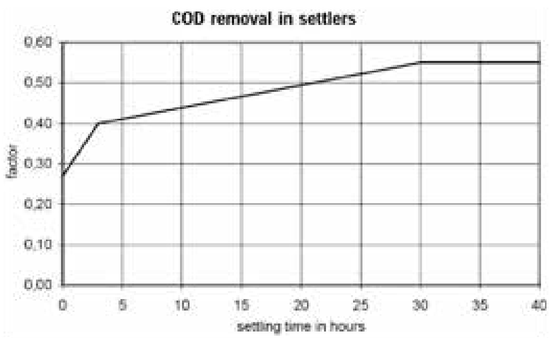
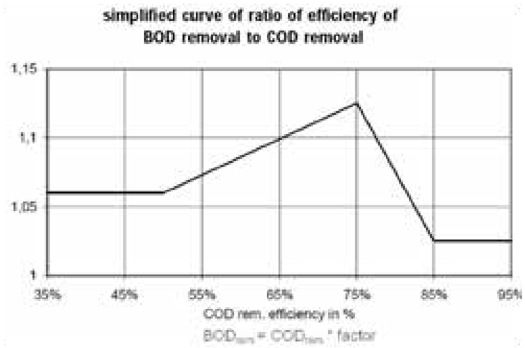
Design of Settler

Design calculations of 2 chambers Settler:

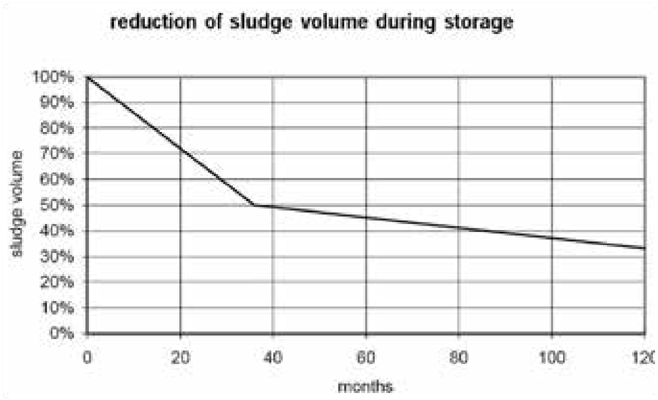
Given Parameter	Daily wastewater flow (based on actual calculation of water consumption) Time of most wastewater flow (peak hours based on activities generating wastewater) BODin and CODin(based on lab test result or per capita calculation) SS/COD ratio(based on lab test result or thumb rule)
Chosen Parameter	PlanHydraulic Retention Time (see D.Thumb Rules) Desludging interval (see D.Thumb Rules) Surface load (see D.Thumb Rules) Water depth at outlet point Inner width of settlerted drying beds
Calculation Factors	Factor HRT to COD removal Factor efficiency ratio of BODremoval to COD removal Factor reduction of sludge volume during storage

Thumb Rules

1	Sludge volume L /g BOD removal	0.005 L /g BODrem
2	SS/COD ratio	Domestic: 0.35 – 0.55 ~ 0.42
3	Surface load factor	0.6
4	Height of scum layer	0.2 – 0.3 m
5	Hydraulic Retention Time	1.5 - 2.0 hrs
6	Length to width ratio	3:1 - 2:1
7	Outlet water depth	1.8 m – 2.2 m
8	1st chamber/2nd chamber ratio	1st chamber 50% of total volume (2 chambers; first chamber is 2/3 of total length, 3 chambers; first chamber is ½ of total length)
9	Desludging interval	18 – 24 months. Bottom should have a gentle slope toward sludge hopper
10	Gas ventilation	Extend above roof

<table>
<tr><th colspan="3">Calculations</th></tr>
<tr><td>Determine max flow at peak hours (m3/h)</td><td>=</td><td>$\frac{\text{volume of wastewater (m3)}}{\text{time of most wastewater flows (h)}}$</td></tr>
<tr><td>Determine COD/BOD ratio</td><td>=</td><td>CODin(mg/L) / BODin(mg/L)</td></tr>
<tr><td colspan="3">Determine factor COD removalto HRT(refer graph below)</td></tr>
<tr><td colspan="2">
</td><td>HRT < 1:
Factor = HRT*0.3
HRT < 3:
Factor = $\frac{(HRT-1)*0.1+0.3}{2}$
HRT < 30:
Factor = $\frac{(HRT-1)*0.15+0.4}{27}$
HRT ≥ 30:
Factor = 0.58</td></tr>
<tr><td>Determine COD removal rate</td><td>=</td><td>$\frac{\text{(SS/COD ratio) * factor HRT}}{\text{Surface loadTR}}$</td></tr>
<tr><td>Determine CODout(mg/L)</td><td>=</td><td>(1 – COD removal rate) * CODin(mg/L)</td></tr>
<tr><td colspan="3">Determine factor efficiency ratio of BOD removal to COD removal</td></tr>
<tr><td colspan="2">
</td><td>CODrem< 0.5:
factor = 1.06
CODrem< 0.75:
factor = $\frac{(CODrem-0.5)*0.065+1.06}{0.25}$
CODrem< 0.85:
factor = 1.125 - $\frac{(CODrem-0.75)*0.1}{0.1}$
CODrem ≥ 0.85:
factor = 1.025</td></tr>
<tr><td>Determine BOD removal rate</td><td>=</td><td>factor efficiency of BOD removal to COD removal* COD removal rate</td></tr>
<tr><td>Determine BODout(mg/L)</td><td>=</td><td>(1 – BOD removal rate) * BODin(mg/L)</td></tr>
</table>

Determination of Sludge and Storage volume



SRT<36
Factor =1-(SRT*0.014)
SRT<120
Factor =0.5-(SRT-36)*0.002
SRT≥ 120
Factor =1/3

Determine sludge volume per BOD removal(L /g BOD)al rate	=	factor sludge reduction(from graph)* sludge volume (L /g BODrem (TR))
Determine BOD reduction (g/m3) or (mg/L)	=	BODin(mg/L) – BODout (mg/L)
Determine sludge volume from BOD reduction (m3/m3)	=	Sludge volume per BOD removal (L /g BODrem) * BOD reduction (g/m3) / 1000 L
Determinesludge volume (m3)	=	sludge volume BOD reduction (m3/m3) * daily wastewater volume (m3/day)* Desludging Intervals (Months)* 30 days
Determination Total Settler Volume		
Determine water volume (m3)	=	HRT (h)* max flow at peak hours (m3/h)
Determine water volume + sludge volume (m3) in Settler	=	sludge volume (m3) + water volume (m3)
Determine Setter surface area (m2)		Sludge Volume (m3) + Water Volume (m3) / Chosen water depth at outlet (m)
Determine scum volume (m3)	=	Surface area (m2) * Height of scum layer (m) (TR)
Determine Total Settler Volume (m3)	=	Sludge Volume (m3) + Water Volume (m3) + Scum Volume (m3)

Determination of Chamber Sizes		
Determine required 1st chamber inner length(m)	=	(2/3) * Volume of settler (m3) / Chosen inner width (m) * chosen water depth (m)
Determine 1st chamber inner length(m) ≥ required length (m) Note: Round off the required 1st chamber inner length to higher side. For e.g. if required inner length is 2.8m, then choose 3.0m as 1st chamber inner length. This for the convenience during construction		
Determine required 2nd chamber inner length (m) = required 1st chamber inner length (m) / 2		
Determine 2nd chamber inner length (m) ≥ required length (m) Note: Round off the required 2ndchamber inner length to higher side. For e.g. if required inner length is 1.3m, then choose 1.5m as 2ndchamber inner length. This for the convenience during construction		
Determine inner surface area (m2)	=	chosen inner width (m) * (rounded off1st chamber inner length(m) + rounded off2nd chamber inner length(m))
Determine Actual volume of settler(m3)	=	(area (m2) * water depth (m)

Design of AF

Design calculations of Anaerobic Filter (AF)

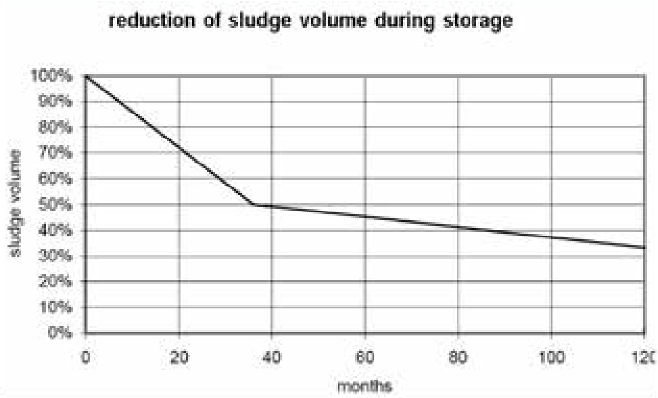
Given Parameter	Daily wastewater flow Time of most wastewater flow(Peak hours based on activities) BODin and COD in (based on outlet of ABR) SS/COD ratio (based on thumb rule) Average temperature Specific surface of filter medium (based on thumb rule) Voids in filter mass (based on thumb rule)
Chosen Parameter	Depth of filter chamber Length of filter chamber Width of filter chamber Number of filter chambers
Calculation Factors	Factor temperature Factor strength Factor surface Factor HRT Factor organic load Factor chamber Factor efficiency ratio of BOD removal to COD removal

Thumb Rules

1	SS/COD ratio	Domestic: 0.35 – 0.45 ~ 0.42
2	Hydraulic Retention Time	In the range of 24 – 48 hrs for standalone systems
3	Filter height	0.75 - 1 m
4	Specific surface of filter medium	80 – 120 m2/m3
5	Voids in filter mass	30 – 45%
6	Filter materials	Cinder, Gravel, cut pieces of corrugated pipes, other specially designed materials
7	Up-flow velocity	Max 2 m/h
8	Organic load	< 4kg/m3 * day COD
9	Outlet water depth	1.8 m – 2.2 m

Calculations - Determination of Chamber sizes and numbers		
Determine BODinand CODin(outlet from ABR)		
Determine max flow at peak hours (m3/h)	=	volume of wastewater (m3) / time of most wastewater flows (h)
Determine filter height (m)		
Determine no. of chambers Note: Minimum number of 1 to 2 chambers. Additional chambers can be added according to requirement of the outlet wastewater quality		
Determine net volume of AF reactor(m3)	=	Effective filter chamber height (m)= depth of filter chamber (m) – [filter height (m) * (1 - voids in filter mass from thumb rule)] Net volume of AF reactor (m3) = Length of each chamber (m) * width of filter chamber (m)* effective filter chamber height (m) * number of filter chambers
Determine HRT inside AF reactor(h)	=	net volume of AF reactor (m3) / [Daily wastewater flow (m3) / 24(h)]
Note: If standalone Anaerobic Filter module, recommended HRT need to be in the range of 24 – 48 hrs		
Determine max upflow velocity in filter voids (m/h)	=	max peak flow per hour (m3/h) / Width of filter chamber (m) * length of each chamber (m) * voids in filter mass (TR)
Note : Max upflow velocity in AF is recommended upto 2 m/h		
Removal of Organic pollutants (BOD and COD removal)		
Determine organic load on AF (kg/m3*day)	=	{Volume of wastewater (m3) * BODin(g/m3)} / Net volume of filter chamber / 1000 (g/kg))

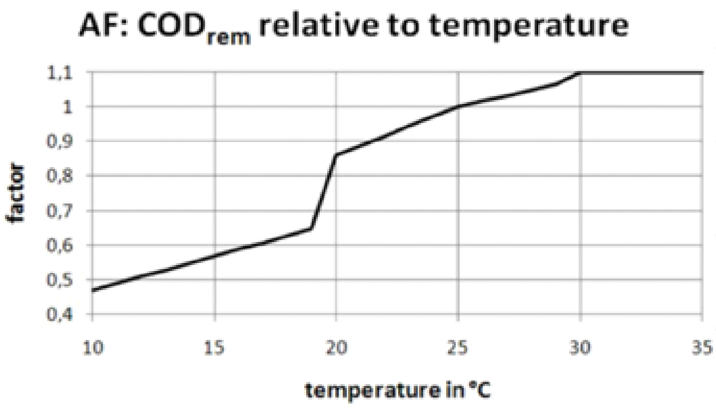
Determination of Sludge and Storage volume



SRT<36
Factor =1-(SRT*0.014)
SRT<120
Factor =0.5-(SRT-36)*0.002
SRT≥ 120
Factor =1/3

Determine sludge volume per BOD removal(L /g BOD)al rate	=	factor sludge reduction(from graph)* sludge volume (L /g BODrem (TR))
Determine BOD reduction (g/m3) or (mg/L)	=	BODin(mg/L) – BODout (mg/L)
Determine sludge volume from BOD reduction (m3/m3)	=	Sludge volume per BOD removal (L /g BODrem) * BOD reduction (g/m3) / 1000 L
Determinesludge volume (m3)	=	sludge volume BOD reduction (m3/m3) * daily wastewater volume (m3/day)* Desludging Intervals (Months)* 30 days
Determination Total Settler Volume		
Determine water volume (m3)	=	HRT (h)* max flow at peak hours (m3/h)
Determine water volume + sludge volume (m3) in Settler	=	sludge volume (m3) + water volume (m3)
Determine Setter surface area (m2)		Sludge Volume (m3) + Water Volume (m3) / Chosen water depth at outlet (m)
Determine scum volume (m3)	=	Surface area (m2) * Height of scum layer (m) (TR)
Determine Total Settler Volume (m3)	=	Sludge Volume (m3) + Water Volume (m3) + Scum Volume (m3)

Determine factor temperature



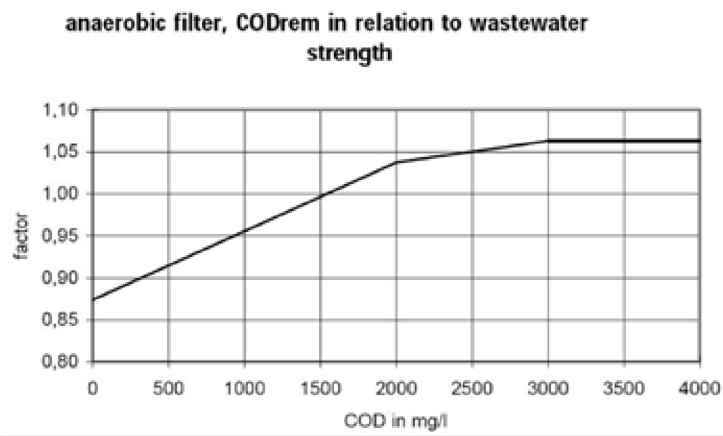
temp < 20 °C:
factor = (temp-10)*0.39/20+0.47

temp < 25 °C:
factor = (temp-20)*0.14/5+0.86

temp < 30 °C:
factor = (temp-25)*0.08/5+1

temp ≥ 30 °C:
factor = *1.10*

Determine factor strength

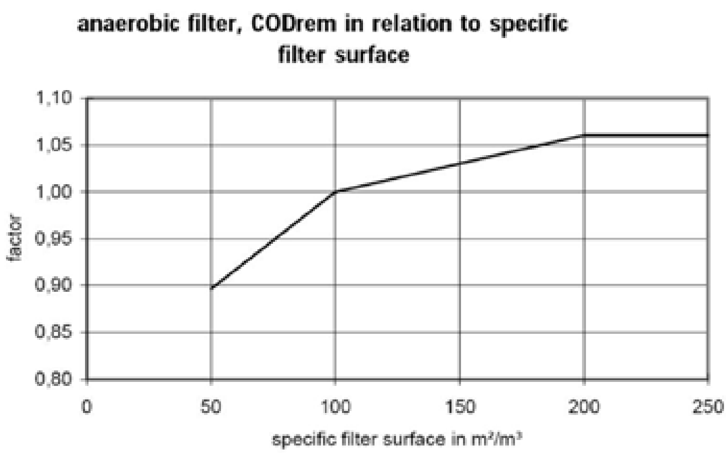


COD_{in} < 2000 mg/L:
factor = COD_{in}*0.17/2000+0.87

COD_{in} < 3000 mg/L:
factor = (COD_{in} -2000)*0.02/1000+1.04

COD_{in} ≥ 3000 mg/L:
factor = *1.06*

Determine factor surface.

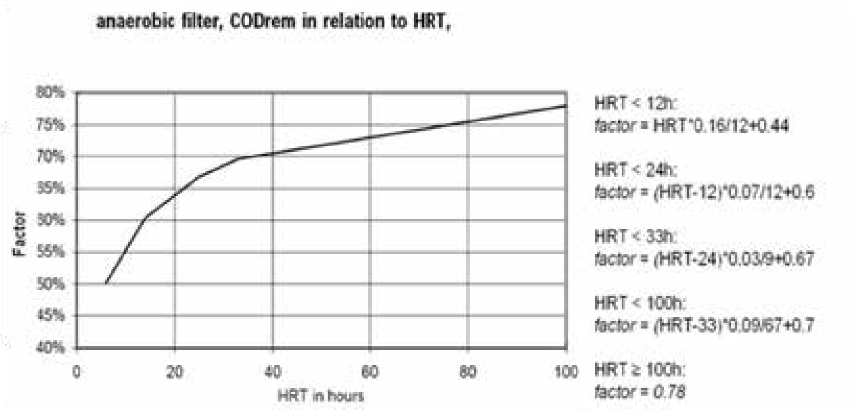


surface < 100 m^2/m^3:
factor = (surface-50)*0.1/50+0.9

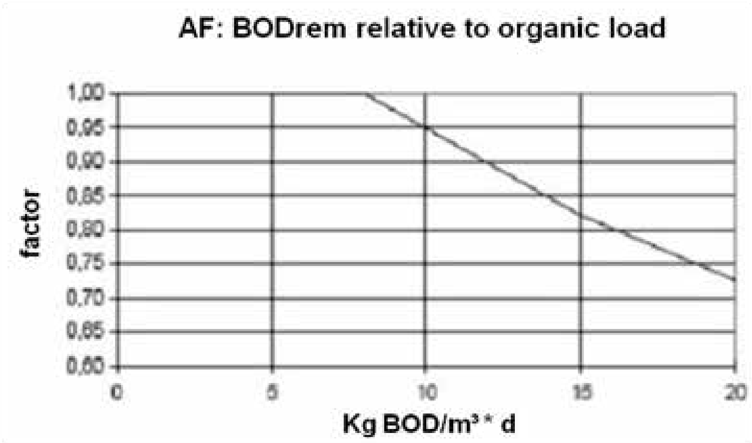
surface < 200 m^2/m^3:
factor = (surface-100)*0.06/100+1

surface ≥ 200 m^2/m^3:
factor = 1.06

Determine factor HRT



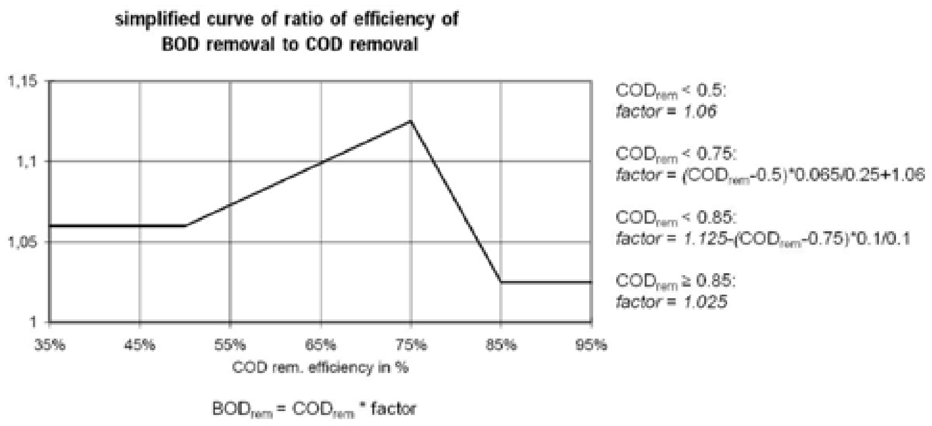
Determine factor organic load



Determine factor chamber

Factor CODrem related to number of up-flow chambers (f-chamber) factor	=	1 + (no of chambers * 0.04)
Determine COD removal rate	=	(factor temperature* factor strength * factor surface * factor HRT * factor organic load * factor chamber)
Determine CODout(mg/L)	=	((1 - COD removal rate) * CODin(mg/L))

Determine factor efficiency BOD removal to COD removal



Determine factor strength		
Determine BOD removal rate=	=	(COD removal rate* factor efficiency BOD removal to COD removal)
Determine COD removal rate	=	(factor temperature* factor strength * factor surface * factor HRT * factor organic load * factor chamber)
Determine BODout(mg/L)	=	((1 – BOD removal rate) * BODin(mg/L))

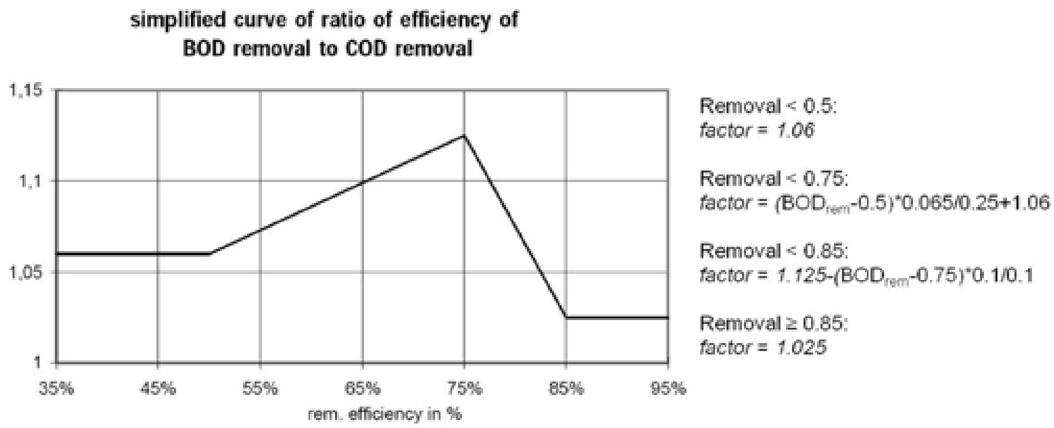
Design of Planted gravel filter

Design calculations for Horizontal Planted Gravel Filter (HPGF)

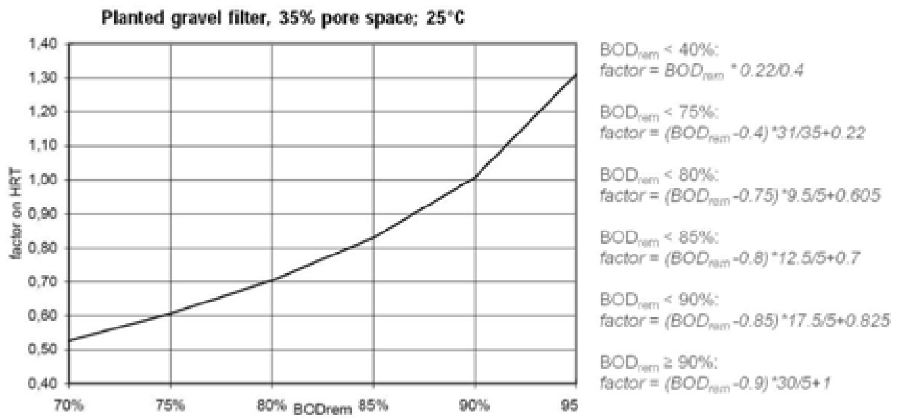
Given Parameter	Daily wastewater flow BODin and CODin (based on outlet of ABR or AF). Average temperature
Chosen Parameter	Expected BODout Bottom slope = 1% Depth of filter at inlet = 0.6 m
Calculation Factors	Factor efficiency ratio of BOD removal to COD removal Factor HRT – BOD removal Factor HRT – temperature

Thumb Rules

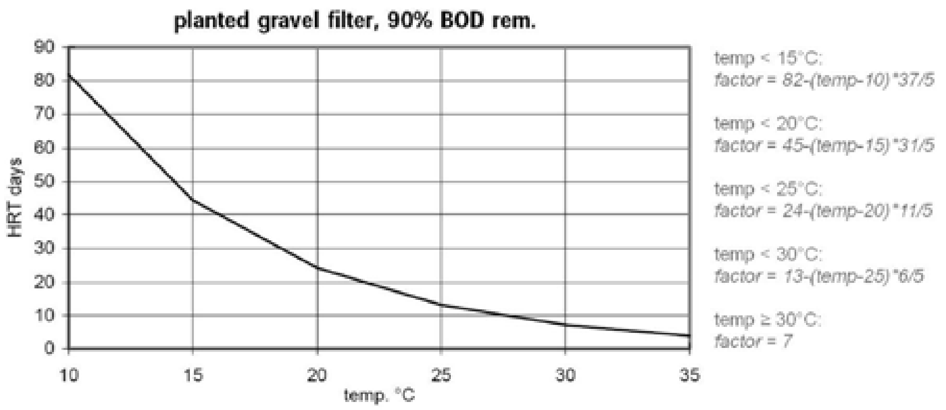
1	Void of gravel	Domestic: 0.35 – 0.45 ~ 0.42
2	Max organic load on cross sectional area	150 g/m2of BODin
3	Max organic load on chosen surface(Organic load limit)	10 g/m2 of BODin
4	Size of gravel	10 – 12 mm, 16 – 20 mm, 70 – 90 mm diameter of gravel Bigger filter size must be located at inlet and outlet cross section to evenly distribute water.
5	Slope	1% of total length
6	Height of filter	0.5–0.6 m
7	Hydraulic Conductivity	372 m/ day

Calculations - Removal of Organic pollutants (BOD and COD removal)		
Determine BODinand CODin(outlet from ABR)		
Determine COD/BOD ratio	=	(CODin(mg/L) / BODin(mg/L))
Determine BOD removal rate	=	$\frac{\text{BODin(mg/L)} - \text{expected BODout(mg/L)}}{\text{BODin(mg/L))}}$
Determine factor efficiency ratio of BOD removal to COD removal		
		
Determine COD removal rate	=	$\frac{\text{BOD removal rate}}{\text{Factor efficiency ratio of BOD removal to COD removal}}$
Hydraulic design requirements		
Determine Hydraulic Conductivity (m/d) (Thumb rule)		

Determine factor HRT to BOD removal



Determine factor HRT to temperature



Determine HRT (d)	=	((factor HRT to BOD removal) * (factor HRT to temperature))
Determine HRT in 35% pore space (d)	=	(35% * HRT)
Determine CODout(mg/L)	=	((1 - COD removal rate) * CODin(mg/L))
Determination of Chamber sizes		
Determine cross section area (option 1) (m2), considering hydraulic load	=	daily wastewater flow (m3) / Conductivity (m/d) (TR) *elevation (%) (TR)

Determine chosen cross section area		
If cross section area 1 > cross section area 2, then 1. If cross section area 1 < cross section area 2, then 2!!!		
Determine required width of filter basin (m)	=	$\frac{\text{cross section area (m2)}}{\text{Depth (m)}}$
Determine chosen width of filter basin(m) Note: Round off the required width of filter basin to higher side. For e.g. if required width is 2.8m, then choose 3.0m as width of filter basin. This for the convenience during construction		
Determine required surface area option 1 (m2), considering organic load	=	$\frac{\text{Daily flow (m3) * [BODin(g/m3) – expected BODout(g/m3)]}}{\text{Max organic load (g/m2)}}$
Determine required surface area option 2 (m2), considering hydraulic load	=	$\frac{\text{Daily flow (m3) * HRT (d)}}{\text{Depth of filter (m)}}$
Determine chosen required surface area(m2) If required surface area 1 > required surface area 2, then 1. If required surface area 1 < required surface area 2, then 2!!!		
Determine required length of filter basin (m)	=	$\frac{\text{chosen surface area (m2)}}{\text{width of filter basin(m)}}$
Determine chosen length of filter basin (m) Note: Round off the required length of filter basin to higher side. For e.g. if required length is 4.8m, then choose 5.0m as length of filter basin. This for the convenience during construction		
Determine actual surface area (m2)	=	(chosen length (m) * chosen width(m))
Note: Actual surface area > chosen required surface area.		
Determine hydraulic load on chosen surface (m/d	=	$\frac{\text{daily flow (m3/d)}}{\text{Actual surface area (m2)}}$
Note: Hydraulic load should be less than 0.3 m/d depending on the type of filter material chosen		
Determine organic load on chosen surface (g/m2 BOD)	=	(hydraulic load (m/d) * BODin(g/m3))
Note: Organic load should < 10 g/m2per day		

References

Participants Kit. (n.d.). CDD Society .

Strande, L., Ronteltap, M., & Brdjanovic, D. (2014). Faecal Sludge Management: Systems Approach for Implementation and Operation. London: IWA Publishing.


2500
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Day 3 - Session 5

Operation and Maintenance of Treatment plants

In most of the Faecal Sludge Treatment Plants (FSTP), ease of construction, capital cost and reuse infrastructure is taken in consideration in great significant in order to ensure a holistic approach to environmental sanitation. However, one should remember that a faecal sludge treatment plant that is operated and maintained efficiently has the potential to be productive and long lasting. Even well designed treatment technologies often fail because of poor operation and maintenance (O&M). Operation and Maintenance tasks becomes crucial once the plant gets commissioned, it is observed from past experiences that the performance of treatment plant directly depends upon how well it is maintained and operated regularly. The day-to-day operational tasks are adopted for smooth functioning and upkeep of treatment plant. The tasks are simple and requires basic training.

This session provides information to participants in order for them to carry out the routine specific and critical tasks. It has been prepared focusing on the detailed operation and maintenance related activities which need to be carried out to ensure effective and efficient performance of all of different infrastructure related to faecal sludge treatment infrastructure

Day 3

Session 5

Outcomes

- Participants are aware of the various O&M requirements of the technology options discussed during the training.

Objectives of the session

- To familiarise with the operation and maintenance procedures of the FSTP

Operation

All the activities that are required to ensure that a faecal sludge treatment technology delivers treatment services as designed. Examples of common operations activities are:

Adding sludge on to drying beds
Removing sludge from settling tanks
Removing sludge from drying beds
Controlling and emptying screening process
Processing (like mixing during composting or adding lime)
Collecting and further treating or disposing effluent
Storing and selling the treatment products

Maintenance

All the activities that ensure long-term operation of equipment and infrastructure. Examples of common maintenance activities are:

Cleaning
Controlling corrosion
Repacking and exercising valves
Oiling and greasing mechanical equipment (for example, pumps)
Servicing mechanical equipment (for example, clearing pump screen)
Controlling vegetation and pest

Common operation and maintenance challenges observed globally include:

Lack of financial viability
Failure of equipment (for example, pumps)
Weak material supply chains
Poor operation and maintenance by service contractors (for example, removing sludge from ponds or tanks)
Contamination from industrial sludge
Electricity shortages
Low capacity of staff
Climate (for example, rainfall)
Smell

The following table identifies possible solutions to overcome the most common operation and maintenance challenges. A key solution is to develop and implement a detailed operation and maintenance plan, and then have a monitoring program to ensure it is successfully implemented.

Risk Management

Treatment is a barrier that can reduce the risk of pathogen transmission. However, it is difficult to monitor treated faecal sludge and know when it is pathogen-free. There is always a risk. It is therefore important that other protective measures be put in place.

There are many protective measures (also called barriers) that should be put in place when treating faecal sludge. This is often known as a multi-barrier approach. The following table shows barriers that can be used to avoid the spread of pathogens and protect public health.

Solutions to Overcome Common Operation & Maintenance Challenges			
Improve financial viability	Prevent equipment failure	Improve material supply chains	Prevent contaminationfrom industrial sludge
Identify financial flows within the entire treatment process Set appropriate sanitation taxes or discharge fees Investigate or change market for treatment product Investigate role of public-private partnerships	Introduce Standard Operating Procedures (SOPs) for all equipment and treatment processes Introduce a monitoring plan for treatment facilities Set servicing intervals Introduce servicing contracts Increase servicing intervals	Use materials which can be produced or obtained locally Use equipment with locally available spare parts Use equipment which can be repaired locally Establish supply chains	Planted Monitor the influent to the treatment facility Identify "upstream" sources of industrial sludge Record the origin, volume and special characteristics of faecal sludge in a manifest system Randomly measure the pH of faecal sludge during discharge Train faecal sludge treatment operators on the physical inspection of sludge samples drying beds

Barriers to Protect Health	Action
Improve financial viability	Wear protective equipment, such as clothing, gloves, shoes, and mask.Clean and disinfect the equipment used.
Wash hands	Wash hands with soap after handling faecal sludge, tools, and equipment.
Restrict access	Construct a fence to keep children and animals away from the treatment technology. Display warning messages.
Clean tools	Disinfect the tools used. Safely store the tools so people do not touch them or use them for another purpose.
Manage effluent	Treat and safely use or dispose effluent. Effluent contains pathogens and can contaminate the environment.
Train	Train workers on safety precautions and hygiene practices. Train thelocal community on the purpose and potential hazards of the treatment technology.

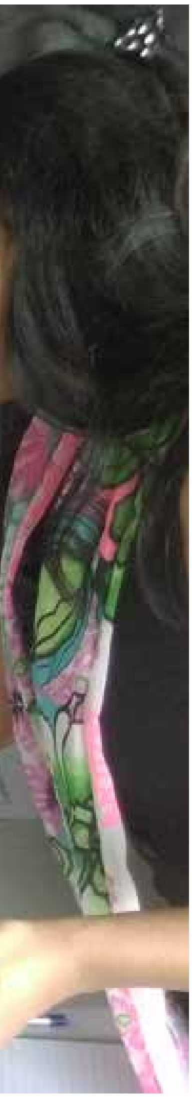
References

Participants Kit. (n.d.). CDD Society .


Maternal under-nutrition
Use of food
Stability
Chronic malnutrition ='Stunting'
Undernourishment
Malnutrition
Under-nutrition
Hunger
Lucas

Day 3 - Session 6

Components and Review of DPR



Detailed Project Report is base-document for planning and implementing the Feacal Sludge Treatment Plant. It provides details for investment decision-making and helps the reader understand the technical, economic and social details for the proposed faecal sludge management plan. It is a detailed document that guides an implementation process, it also expresses the rationale behind various assumptions and explains the method adopted to validate various parameters considered in decision making.

This session elaborates the components of a DPR document, the details that are encapsulated in each of the section. Also this session helps the participants to learn and understand how to review a DPR that is submitted to the local decision making authorities for sewerage and feacal sludge management projects.

Day 3

Session 6

Outcomes

- Participants are aware of the components of DPR review

Objectives of the session

Components of Detailed Project Report
Activity based session to enable reviews DPR

Checklist for Assessment of Septage /Sewerage and Wastewater management DPRs

Design Considerations	Detailed design parameters	Checklist
Institutional	Capacity	Is there a plan proposed for capacity building of the caretakers and other stakeholders involved with regular O&M of the proposed infrastructure?
		Is there a plan for O&M cost recovery of the infrastructure?
		Is there a plan for building capacities in the ULB or caretakers of the infrastructure on revenue collection and accounting?
		Has a PPP model been explored?
Environment	Standards	Is the STP/FSTP designed to treat wastewater to standards specified by CPCB/State Pollution control boards?
		Are water sources in the vicinity such as ground water and nearby water bodies protected for contamination from sewer networks, sewer components , STP/FSTP etc. ?
		Are the locations of pump wells, STP/FSTP, etc. away from human habitation? Is there a provision for buffer zone or management of odour and vectors such as mosquitos and other inspects?
		Are the STP/FSTPs designed aesthetically with landscaping elements?
Treatment	Wastewater characteristics	Is the characteristic of wastewater assessed appropriately using relevant assumptions and analysis? Is there literature recommendation for the proposed characteristics? Does it match or compare with the standards provided in the CPHEEO manual for sewerage and treatment?
	Treatment plant design	Are various treatment options considered for the treatment? Is there a rationale for choosing a particular options? Does it satisfy the boundary conditions imposed for treatment?
		Is the proposed treatment option mentioned in the CPHEEO manual? Are the design principles for the STP/FSTP, sewer lines, manhole, pump wells, wet wells, lift stations etc, similar to those specified in CPHEEO?
		Is there information on the land availability for various sewer network systems such as pump wells, lift stations, STP/FSTPs etc? Are the characteristics of land incorporated while planning for the infrastructure? Does the land have access to electricity?
		Is there an option for increasing the capacity of the treatment plant for catering to future needs? is the treatment plant modular and does the site have excess land for future needs and (or) septage management

Checklist for Assessment of Septage /Sewerage and Wastewater management DPRs		
Design Considerations	Detailed design parameters	Checklist
Financial	CAPEX	Is there an option for increasing the capacity of the treatment plant for catering to future needs? is the treatment plant modular and does the site have excess land for future needs and (or) septage management
		Are all capital expenditures related to the sewer network and treatment detailed and listed? Are the assumptions made reasonable? Is there a BOQ for the cost calculation? Does the BOQ use recent and updated rates applicable for the region?
		Is the cost of construction supervision and project management consultancies covered under the CAPEX estimation?
		If land needs to be purchased, does the capex include cost of land and its transfer
		Is the STP/FSTP designed to treat wastewater to standards specified by CPCB/State Pollution control boards?
		Is there a plan for funding the investment (CAPEX)? Is the interest payable included in O&M cost?
		Is there a OPEX plan? Does it detail out the operation and maintenance requirement of the conveyance and treatment? Are the assumptions reasonable?
		Is there a plan for cost recovery of the OPEX? in case of taxes or payment by beneficiaries is there an assessment carried out to determine the willingness to pay?
Legal	Statutory requirements	Does the DPR have an environment impact assessment due to the project?
		Does the DPR make a mention of the various legalities to be full fulfilled for the implementation and commissioning of the project?
Community Awareness	Stakeholder sensitisation	Is there a plan and approach strategy for sensitising the beneficiary and the user on the benefits and operations of the system? Are risks clearly explained to the user? Are the stakeholders made aware of the discomforts they have to undergo during implementation?
Coordination	Departmental coordination	Does the DPR enlist the various departments and agencies involved in the process of setting up the infrastructure and operating it? Is there a mention of various roles of these agencies?
City master plan and City sanitation plan	Integration	Is the proposed plan in alignment with the city master plan or city sanitation plan?

References

DPR for implementation of faecal sludge treatment plant at Phulera

Goal

To build the capacity of cities and other stakeholders working in urban sanitation to ensure improved delivery of sanitation services through decentralized approaches

Thematic Areas

- Awareness and Advocacy
- Policy Advise
- Technical Support
- Developing Training Content and Modules
- Delivering Trainings
- Knowledge Building through Research and Learning events

What is SCBP

Sanitation Capacity Building Platform (SCBP) is an initiative of the National Institute of Urban Affairs(NIUA) for addressing urban sanitation challenges in India. The 3 year programme(starting 2016) is supported by a Gates Foundation grant. It is aimed at promoting decentralised urban sanitation solutions for septage and waste water management.

The Platform is an organic and growing collaboration of universities, training centres, resource centres, non-governmental organizations, consultants and experts. The Platform currently has on board CEPT University, CDD Society and BORDA, ASCI, AIILSG, UMC, ESF, CSE, WaterAid, CPR, iDECK, CSTEP and WASHi. The Platform works in close collaboration with the National Faecal Sludge and Septage Management Alliance(NFSSMA).

What we do

The Platform lends support to the Ministry of Housing and Urban Affairs (MoHUA), Government of India, by focussing on urban sanitation and supporting states and cities to move beyond the open defecation free (ODF) status by addressing safe disposal and treatment of faecal sludge and septage.

The Platform supports National Urban Sanitation Missions, States and Towns, by developing and sourcing the best Capacity Building, Policy Guidance, Technological, Institutional, Financial and Behaviour Change advise in favour of decentralised sanitation solutions.

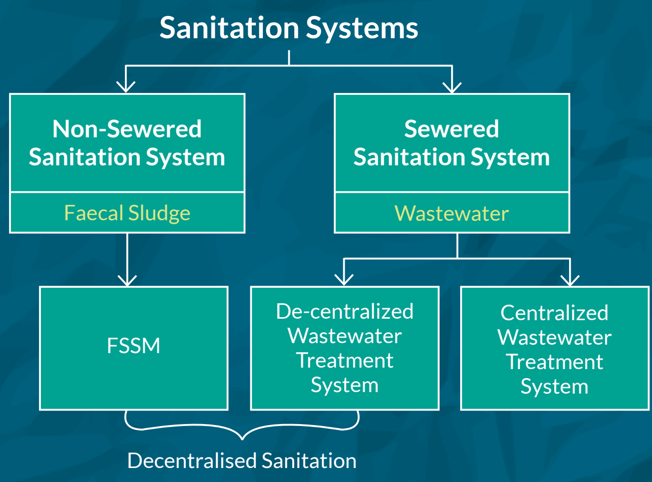
How does the Platform work

NIUA initiates and facilitates engagement of the SCBP Platform Partners at the State government level, for advocating and awareness generation for Faecal Sludge and Septage Management(FSSM). Followed by on demand support for capacity building and implementation of decentralised sanitation solutions at state and city level. SCBP promotes a four-module based Capacity Building support.

Why Decentralised Sanitation Solutions

Given that 49% of the urban population in India relies on on-site sanitation, such as septic tanks and pits, decentralized sanitation options, such as Faecal Sludge and Septage Management (FSSM) and Decentralized Wastewater Treatment Systems (DEWATS) are critical for achieving the goals for urban sanitation under various national missions. Decentralized sanitation options are scientifically proven solutions to complement centralized systems, serving the underserved, particularly in peri-urban areas and informal settlements.

FSSM is the collection and transportation of faecal sludge from the containment system, treatment of the sludge at a designated site, followed by safe disposal or reuse of the treated sludge. DEWATS uses sewers to convey domestic wastewater from a neighbourhood or local catchment to a small, local treatment plant where it is treated through natural processes without any requirement for external energy to operate the system.



Target Audience

All stakeholders ranging from National Missions, State and Town Officials(Public Health, Engineering and Administration), Elected Representatives, Private Sector Consultants and Vendors, NGOs, Academia, Masons and the Citizens at large.

The Platform provides a sharing and cross learning opportunity for SCBP Partners. To pool in their knowledge resources on all aspects of urban sanitation capacity building. Facilitates joint development of training modules, learning and advocacy material including developing Key Messages and Content. And a platform for sharing and dissemination of FSSM Research, Advocacy and outreach to State governments and Urban Local Bodies.

FSSM Capacity Building Focus

1. **State Level Capacity Building for FSSM**
2. **Institutional Capacity Building for FSSM at National Level**
3. **Evidence Based Advocacy for FSSM**

Training Modules Development under SCBP

- FSSM Training of Trainer Module
- Integrated waste Water and Septage Management Module
- FSSM Orientation Module and Handbook
- Orientation Module for ULB Elected Representatives
- Specialized Module(3 day Advanced Technical Training Module for FSSM)
- Specialized Module(3 day Advanced Technical Training Module on Integrated Waste Water and Septage Management)
- ODF and FSSM Training Module
- Consultants Training Module on FSSM DPR preparation
- FSSM Training Module for Masons
- Learning Material on International FSSM experience

All Modules and learning materials translated in Hindi

Technical Support

Assessments
- Capacity need assessments
- Sanitation situation assessment – IWWSMP, CSP, Rapid assessment of FSSM situation

DPR for FSSM
- DPR for FSSM
- Transation advisory support
- Support for incremental changes

Policy Framework
- Review of legal and institutional framework
- Formulation of Policy / operational guideline / regulations for FSSM

1. State Level Capacity Building for FSSM

Supporting select State governments, their Para state Agencies, Towns and Urban Local Bodies

- Orientation and exposure visits for understanding septage and faecal sludge risks and challenges
- Institutional capacity strengthening through Training of Trainers programmes
- Four Modules Based FSSM Capacity Building Strategy

Capacity building activities are planned to cover all stakeholders involved in the FSSM value chain – government officials, elected representatives, masons, private sector and community

State and ULB officials

Training module and learning material – Orientation, specialized training on FSSM and IWWSM, Trainig of Trainers

Exposure visit – ODF sustainability, technology for FSSM, IWWSM, International visit to Malaysia

Institutional capacity building
Regional / state level training institutes, support for training programme under various national missions

Other stake holders
Academic Institute, Regional / state level training institutes, Consultants

Sensitization / orientation training → **First Specialized Training & National Exposure visit** → **Second Specialized Training on planning for FSSM** → **International Exposure visit**

Capacity Building for FSSM : Uttar Pradesh (UP)

- **Developing the State FSSM Operations Policy Guideline (Draft)**
- **Exposure visits and Orientation on FSSM for SBM Director and ULBs**
- **Planning support.** Submission of Faecal Sludge Treatment Budget for 61 AMRUT towns for the State Annual Action Plan(SAAP)
- **Technical Support.** Development of the first DPR for an FSTP in the state(Unnao town), and adopted for other towns
- **State Nodal Agency Capacity Building.** Supporting RCUES Lucknow in conducting FSSM Training for ULBs and conducting independent research in new towns

Capacity Building for ODF and FSSM : Rajasthan

- **Division level ODF and ODF++ City Trainings.** Followed by Exposure visits to Maharashtra and Madhya Pradesh(conducted for 90 officials)
- **Four Module based FSSM capacity building strategy**
  - Sensitization/ orientation training for 191 ULBs (till date 250 officials trained)
  - First Specialized Training
    - *Integrated waste water management and exposure visit to Pune (conducted for 30 officials)*
    - *Technology option for FSM and exposure visit to Devanhalli (cities where DPR is planned)*
  - Second Specialized Training
    - *Planning and Financing of FSSM projects (planned for officials from 10-15 towns – for incremental improvements in managing septage and sludge, Assessments)*
  - International Exposure visit for State officials and ULB officials (planned)

2. Institutional Capacity Building for FSSM at National Level

Nodal AMRUT Agencies Capacity Building Support for FSSM Trainings

- Training of Trainers on FSSM Planning : Eight AMRUT Institutes faculty
- Training of Trainers on Integrated Waste Water & Septage Management : Ten AMRUT Institutes
- Four AMRUT training agencies supported for integrating Training on FSSM into AMRUT training frame work – covering 200 officials from 12 states
- Exposure visits on Feacal Sludge Treatment Plant(FSTP) visit : 80 officials from 7 states to Devanahalli
- Exposure visit and integrated Waste Water and Septage Management (IWWSM) Training in Pune
- Advanced FSSM Technology Training

Private Sector Capacity Building

- National Consultation on private sector engagement in FSSM held in 2017
- Study initiated for developing a strategy for supporting manufacturers, vendors and project management consulting companies capacity building strategy
- Training Module developed for Consultants capacity building

Supporting Academia

- National consultation held in 2017 for 20 Faculty members from 15 academic institutes, to orient them on FSSM and explore demand for support by the academia
- Specific University level support plans being developed
- Workshops for Training of Trainers (ToT) support for universities and institutes. For integrating FSSM content in existing course work
- Developing dedicated Modules and related support for research and internships for students
- Promoting a platform for learning and exchange, research and advocacy

3. Evidence Based Advocacy for FSSM

Collation of existing knowledge, promoting new research, documentation and dissemination and learning

- Developing Training Modules, appropriate for different contexts (States, FSSM Thematic priorities and Stakeholders)
- Collating and creating Advocacy and Knowledge resources for all stakeholders on different aspects of FSSM service chain
- Urban Sanitation Research on urban sanitation status, pro poor implications of existing and proposed plans : for the states of Madhya Pradesh, Odisha, Karnataka, Telangana, Jharkhand, UP, Rajasthan and Uttarakhand
- FSSM Workshops, Advocacy and Learning events : Financing, Technology and Life Cycle costs of FSSM projects, Monitoring, Behaviour Change, etc
- Landscaping Study of Septage Treatment initiatives. Documentation and dissemination experiences and lessons of setting up and operations of Faecal Sludge Treatment Plants
- Research and advocacy on thematic FSSM challenges : Legal and Institutional, Operations, Financing, etc

SCBP Publications and Reports

- Capacity Need Assessment for FSSM Report
- Assessment of FSSM for 100 small towns of Rajasthan
- City sanitation Plans for four AMRUT cities in Odisha
- Detailed Project Reports(DPRs) for FSSM for UP, Rajasthan and Bihar
- Draft FSSM Operations Policy for UP and Rajasthan
- Assessment of legal and Institutional Frame work for FSSM in Uttar Pradesh
- FSSM Training Modules(7)
- Workshop Reports :
    - Practitioners Meet on Capacity Building for FSSM
    - Private Sector in FSSM
    - Academia engagement for FSSM
    - ToT Workshops for Institutes
    - Exposure Visits to Maharashtra
    - Rajasthan State Workshop
    - Achieving ODF : Recommendations for Rajasthan

Key Results SCBP FSSM Capacity Building

State Level Capacity Building	• State FSSM Perspective (Rajasthan) • City Sanitation Plans(4 towns of Odisha) with FSSM perspective • 191 ULBs of Rajasthan supported for ODF and FSSM • 61 AMRUT towns of Uttar Pradesh supported for FSSM • First Detailed Project Reports (DPRs) for setting up Faecal Sludge Treatment Plants in 3 towns (Uttar Pradesh, Bihar & Rajasthan)
Institutional Capacity Building at National Level	• Capacity Building of Nodal AMRUT Institutes(5) • State para state agencies supported for Planning and Technology • Private sector engagement in FSSM • Academia engagement and curriculum advise • 200 officials from 12 states provided with FSSM trainings • 80 ULB officials from 7 states taken for exposure visits to the Devanhalli FSTP plant.
Evidence Based Advocacy	• Capacity Needs Assessment for FSSM undertaken for 3 states (Uttar Pradesh, Bihar and Andhra Pradesh) • Thematic and Spatial Research on Urban Sanitation • State FSSM Policy Drafts (Uttar Pradesh and Rajasthan) • Training Modules Developed (8) • National and State level Advocacy with NFSSM Alliance • Advocacy Factsheets • Workshops & Learning Events

About NIUA

NIUA is a premier national institute for research, capacity building and dissemination of knowledge in the urban sector, including sanitation. Established in 1976, it is the apex research body for the Ministry of Housing and Urban Affairs (MoHUA), Government of India.

NIUA is also the strategic partner of the MoHUA in capacity building for providing single window services to the MoHUA/states/ULBs.

The Institute includes amongst its present and former clients Housing and Urban Development Corporation, Niti Ayog, City and Industrial Development Corporation of Maharashtra, USAID, World Bank, Asian Development Bank, GIZ, UNICEF, UNEP, UNOPS, Cities Alliance, Bill & Melinda Gates Foundation, Rockefeller Foundation, Global Green Growth Institute, and Bernard van Leer Foundation.

Some of the major areas of work include:

- Provide research support to MoHUA
- Conduct research studies on contemporary urban issues
- Coordinate capacity building and training activities
- Disseminate information through networks and knowledge hubs
- Analyze and promote policy change agenda
- Monitor and evaluate Government of India's urban programmes/schemes

Partners of the Platform

National Institute of Urban Affairs

National Institute of Urban Affairs

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ADVANCED TRAINING ON FAECAL SLUDGE AND SEPTAGE MANAGEMENT PART A - PARTICIPANT KIT