DESIGN MODULE

FOR

CO-TREATMENT OF FAECAL SLUDGE AND SEPTAGE WITH SEWAGE IN SEWAGE TREATMENT PLANT

PART A: PRESENTATION SLIDES

National Institute of Urban Affairs

NFSSM Alliance

ECOSAN SERVICES FOUNDATION

TITLE
Co-Treatment of Faecal Sludge and Septage with Sewage in Sewage Treatment Plant – (Part A: Presentation Slides)

PUBLISHER
National Institute of Urban Affairs, Delhi

RESEARCH PROJECT
SANITATION CAPACITY BUILDING PLATFORM

GRAPHIC DESIGN
Deep Pahwa, Devender Singh Rawat, Bhavnesh Bhanot, Preeti Shukla

Year of Publishing 2021

CONTENT
The module has been developed with the collaborative effort of NFSSMA partner organisations under Training Module Review Committee (TMRC) anchored by NIUA.

Editor	Authors	Contributor and reviewer
National Institute of Urban Affairs (NIUA)	National Institute of Urban Affairs Ecosan Services Foundation	National Faecal Sludge and Septage Management Alliance (NFSSMA)

CONTACT
National Institute of Urban Affairs
1st and 2nd floor Core 4B,
India Habitat Centre,
Lodhi Road, New Delhi 110003, India
Website: www.niua.org, scbp.niua.org
E-Mail: scbp@niua.org

DESIGN MODULE

FOR

CO-TREATMENT OF FAECAL SLUDGE AND SEPTAGE WITH SEWAGE IN SEWAGE TREATMENT PLANT

PART A: PRESENTATION SLIDES

Collaborative Effort Under Training Module Review Committee (TMRC)

About National Faecal sludge and Septage Management Alliance (NFSSMA)

The 'NFSSM Alliance' was formed with a vision to "Create an enabling environment which amplifies scaling of safe, sustainable and inclusive FSSM through knowledge, partnerships and innovative solutions by 2024".

Convened by Bill and Melinda Gates Foundation in 2016, the Alliance is a voluntary body that aims to:

- Build consensus and drive the discourse on FSSM at a policy level, and
- Promote peer learning among members to achieve synergies for scaled implementation and reduce duplication of efforts.

The Alliance currently comprises 32 organizations across the country working towards solutions for Indian states and cities. The Alliance works in close collaboration with the Ministry of Housing and Urban Affairs (MoHUA) and several state and city governments through its members to support the progress and derive actions towards mainstreaming of FSSM at state and national level. The NFSSM Alliance works on all aspects of city sanitation plans to regulatory and institutional frameworks across the sanitation value chain. The NFSSM Alliance working in collaboration with the Ministry of Housing and Urban Affairs has been instrumental in the 'drafting of India's Policy on FSSM launched in 2017. This resulted in 19 out of 36 states and UTs adopting guidelines and policies for FSSM in India.

The strength of the Alliance lies in its diverse membership, which includes research institutes, academic institutions, think-tanks, quasi-government bodies, implementing organizations, data experts, consultants, and intermediaries. This enables a multi-disciplinary view of urban sanitation, with members building on each other's expertise. The Alliance has had enormous success in championing FSSM as a viable solution to the Government of India by broadly focussing on:

1. Influencing and informing policy.
2. Demonstrating success through innovation and pilots.
3. Building capacities of key stakeholders across the value chain.

The collaborative continues to work towards promoting the FSSM agenda through policy recommendations and sharing best practices which are inclusive, comprehensive, and have buy-in from several stakeholders in the sector.

NFSSM Alliance

ASCI	CSTEP	EY	NIUA	USAID
Athena Infonomics	CDD	GIZ	PSI	WASHi
BBC Media Action	CPR	IIHS	RTI International	Water Aid
BMGF	CFAR	ISC	Tide Technocrafts	World Bank Group
Borda	CSE	IWMI	UMC	
CEPT University	Dasra	KPMG	UNICEF	

About Training Module Review Committee (TMRC)

To ensure quality control in content and delivery of trainings and capacity building efforts, a **Training Module Review Committee (TMRC)** was formed with the collaborative effort of all Alliance partners. TMRC which is **anchored by National Institute of Urban Affairs (NIUA)**, has the following broad objectives:

- Identification of priority stakeholders and accordingly training modules for Capacity Building.
- Development of a Normative Framework – For Capacity Building at State Level.
- Standardization of priority training modules – appropriate standardization of content with flexibility for customization based on State context.
- Quality Control of Trainings – criteria for ensuring minimum quality of training content and delivery.
- Strategy for measuring impact of trainings and capacity building efforts.

About the Module

Title	Co-Treatment of Faecal Sludge and Septage with Sewage in Sewage Treatment Plant (Part A: Presentation Slides)
Purpose	This module gives the participants hands-on knowledge about designing a co-treatment system including assessment of existing STP capacities and available treatment technology options. With the announcement of SBM-U 2.0 and AMRUT 2.0, continuation of NMCG and the recommendations of the 15th Finance Commission, this module provides participants a detailed understanding for adopting co-treatment, which is a key component under septage management in these national missions..
Target Audience	Officials with engineering background and professional experience in wastewater and septage management such as technical faculties from nodal training institutes, technical officials/ engineers from state govt, parastatal bodies and ULBs; consultants from TSU/PMUs and sector partners.
Learning Objectives	The module aims to convey the following learnings: • Understand the working principles of Sewage Treatment Plant • Understand how to conduct feasibility assessment of existing sewage treatment plants (STPs) to evaluate co-treatment potential and quantify the amount of FSS that can be co-treated • Know the approaches for adding faecal sludge in a STP for co-treatment along with the design of additional components such as septage receiving station • Gain insight into the operation and maintenance as well as mitigation measures for different treatment units in a STP
Structure of the Module	The training module is based on case methodology where in the sessions will be combined with exercises based on real-life cases. This helps to trainees to apply the knowledge grasped during the session and reinforce it further. The module is divided into three parts: **Part A: This contains the slides used during the session in the presentation format.** Part B: This is a comprehensive compilation of the all the session briefs and further reading material which helps to strengthen the learning. Part C: This contains the exercise developed for training based on the real-life cases.
Duration	In this face-to-face training format, this training is conceptualized for two days without site visits and can be adopted for including the site visits depending upon the city where it is being conducted.

AGENDA

Time Duration	Session Title
Day 1	
09:30 – 09:45	Registration
09:45 – 10:00	Introduction - Round of Introduction; Setting ground rules; Understanding expectations, aims & objectives
10:00 – 10:45	Context for co-treatment in India and relevant policies and programmes
10:45 – 11:20	Approaches for Faecal Sludge and Septage Treatment
11:20 – 11:30	**Tea and Coffee Break**
11:30 – 12:30	Characterization of Liquid Waste: Faecal Sludge, Septage and Sewage
12:30 – 13:30	Sewage Treatment Plant and Co-treatment
13:30 – 14:30	**Lunch Break**
14:30 – 14:45	Exercise: Forming Treatment Chain at the Sewage Treatment Plant
14:45 – 15:30	Planning of Co-treatment of Sludge and Sewage
15:30 – 15:45	**Tea and Coffee Break**
15:45 – 16:15	Exercise: Pre-feasibility check for co-treatment of septage with sewage
16:15 – 17:00	Septage Receiving Station

Time Duration	Session Title
Day 2	
09:30 – 10:15	Recap, Feedback & Quiz
10:15 – 11:15	Co-treatment in Liquid Stream at STP
11:15 – 11:30	**Tea and Coffee Break**
11:30 – 12:15	Exercise: Check for Primary and Secondary Units of Activated Sludge Process for co-treatment
12:15 – 13:15	Co-treatment in Solid Stream at STP
13:15 – 14:15	**Lunch Break**
14:15 – 15:00	Exercise: Check for thickening, digestion treatment units of Activated Sludge Process for co-treatment
15:00 - 16:00	Disinfection of Sludge
15:00 – 16:15	**Tea and Coffee Break**
16:15 – 16:45	Videos and Exercise: Disinfection of Sludge
16:45 – 17:30	Feedback and Wrap-up Session

Contents

Session

01

Setting the context for co-treatment in India

1. Setting the context for co-treatment in India

Learning objectives

- To understand urbanisation and the sanitation challenges associated with it in Indian cities
- To understand the need for co-treatment and its relevance in India
- To learn how the adoption of co-treatment helps in achieving Citywide Inclusive Sanitation (CWIS)

Contents

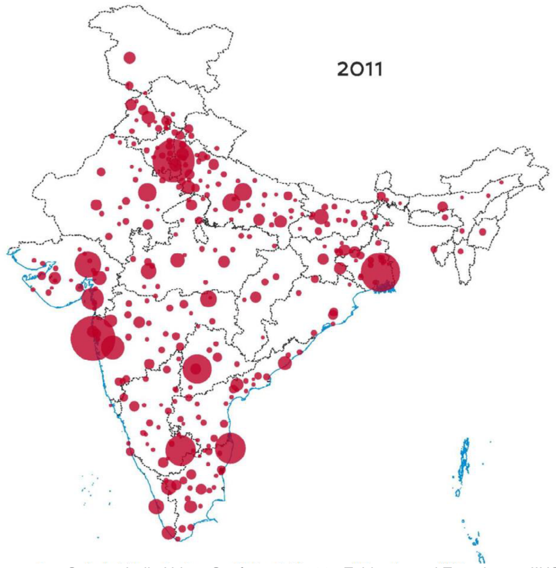
- Urbanization and sanitation situation in India
- Relevance of co-treatment in India
- Relation between co-treatment and CWIS approach
- Achieving SDGs goals through co-treatment

1.1 Urbanization and sanitation situation in India

Urbanisation in India

- About 377 million i.e. 1/3rd of the country lives in urban settlements.
- Share of India's urban population
  - ❖ 28% (2001)
  - ❖ 31% (2011)
- India is set to become half urban by 2041

Source: Census 2001 and 2011



Source: India Urban Conference 2011 : Evidence and Experience -IIHS

This slide shows the pace at which India has undergone urbanization as compared to other countries in the world. Although, India will have less percentage of population living in the urban centers, it will be host to many cities having population more than 10 million. The pace at which the urban centers are experiencing population explosion, it is very difficult to provide adequate municipal services such as drinking water, access to toilet and safe management of solid and liquid water. Add to this the population migrating from the rural to urban centers in search of better employment opportunities puts more stress in the infrastructure.

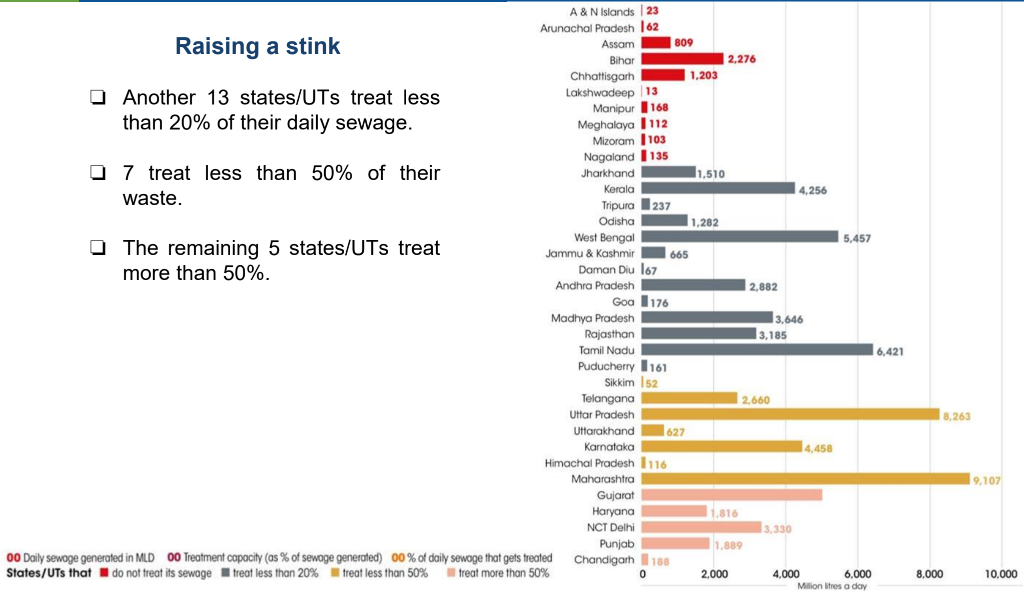
Definition of Urban:

- All places with a Municipality, Corporation, Cantonment Board or notified town area committee etc
- All other places which satisfies the following criteria:
  - A minimum population of 5,000
  - At least 75% of the male main working population engaged in non agricultural pursuits
  - A density of population of at least 400 persons per sq.

Sanitation challenges in urban India

Raising a stink

- ❑ Another 13 states/UTs treat less than 20% of their daily sewage.
- ❑ 7 treat less than 50% of their waste.
- ❑ The remaining 5 states/UTs treat more than 50%.



Source: State of India's Environment 2021 by CSE

Lack of limited as well as proper O&M of sanitation infrastructure has resulted in many challenges for our urban cities. One of them is the treatment of liquid waste or domestic wastewater generated from the toilets.

The graph here clearly indicates that only 5 states/UTs namely, Gujarat, Haryana, NCT Delhi, Punjab and Chandigarh treat more than 50% of their sewage. Whereas, 10 states do not treat their sewage at all.

Status of sanitation in urban India

Sewage overload

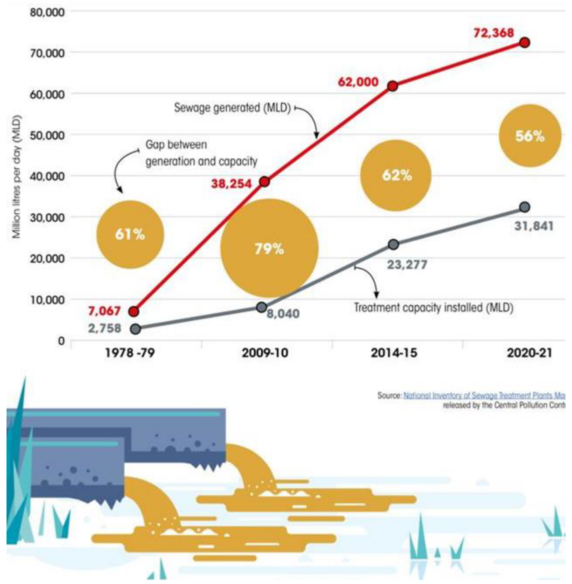
Only 28% of India's sewage gets treated. This is because the current installed capacity is only 44% of what the cities generate and even these plants remain underutilized.

Between 2014-15 and 2020-21

17% increase in India's sewage generation

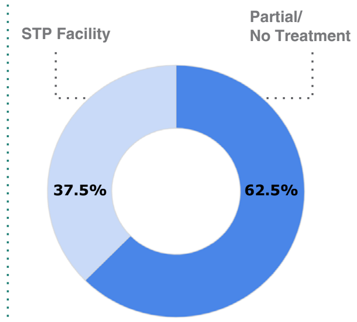
37% increase in the installed treatment capacity

72% of sewage generated in 2020-21 was dumped untreated



Source: State of India's Environment 2021 by CSE

Status Of Wastewater Treatment in Urban India (MLD)



Source: CPCB- National Inventory of STPs (2021)

The sewage generation is estimated to be 72,368 MLD out of which only 20,235 MLD is being treated. In other words, 28% of the sewage generated in India is being treated. In addition to this, the treatment capacity installed is only 44% (31,841 MLD) of the total wastewater generated in cities. (Source: State of India's Environment 2021 by CSE)

Looking at the CPCB's national inventory of STPs from 2021, the treatment plants cater to only 37.5% of wastewater generated in urban cities. The remaining 62.5% either receive partial or no form of treatment at all.

Can you think of the main reason behind this gap of actual treatment capacity and utilised capacity? Yes, most of the participants have guessed it correctly. It is the lack of conveyance and treatment system for handling domestic wastewater like sewage from sewered systems and faecal sludge and septage from non-sewered systems.

1.2 Relevance of co-treatment in India

Relevance of co-treatment in India

- Co-treatment may refer to treating different wastes together, for example liquid septage with municipal solid wastes, liquid septage or FS with sewage, or partially solid FS with sewage sludge (IWA 2020).
- Co-treatment is defined as a process where Sewage Treatment Plant (STP), in addition to treating the sewage, also treats Faecal Sludge and Septage (FSS) emptied from various Onsite Sanitation Systems (OSS).
- Main benefits of adopting co-treatment in India:
  a) Increasing wastewater treatment through treating faecal sludge and septage in the underutilised sewage treatment plants
  b) Prevent environment pollution caused due to direct discharge of untreated faecal sludge and septage

In this module, we will be looking specifically at an approach that is relevant and has potential for increasing the treatment of domestic wastewater in India.

One such approach is co-treatment. Co-treatment can be simply defined as treatment of different waste products together using existing infrastructure for waste management, for example liquid septage with municipal solid waste, liquid septage and faecal sludge with sewage, or partially stabilised faecal matter with sewage sludge. (Refer to Co-treatment of septage and faecal sludge at sewage treatment facilities by Dorai Narayana)

Our focus here would be co-treating faecal sludge and septage with sewage in a sewage treatment plant (STP).

But, why is co-treatment relevant in India? As seen in our earlier slides, there is an underutilised capacities of sewage treatment plants in our country. Co-treatment will enable the use of these existing treatment plants for treating the faecal sludge and septage. As a result, the need for separate infrastructure and investments for dealing with faecal sludge and septage can be reduced considerably.Another benefit is that today we can observe direct discharge of untreated faecal sludge and septage into open environments like rivers, lakes, etc. This has resulted in severe pollution of our water bodies and related ecosystem that can be easily prevented through interventions such as co-treatment.

1.3 Relation between co-treatment and CWIS approach

Relation between co-treatment and CWIS approach

Adopting the co-treatment approach can help in achieving citywide inclusive sanitation as seen in the CWIS principles

Source: https://adb.eventsair.com/online-adb-sanitation-dialogue-2021/resources

The Citywide Inclusive Sanitation (CWIS) approach is an innovative way of sanitation management that focuses on service provision and creating an enabling environment, rather than building sewer networks and wastewater treatment plants.

The CWIS approach has seven principles that focuses on different aspects of sanitation management. With regards to co-treatment, there are four principles namely: a) everyone benefits from safe services and public investment equitably b) Human waste is safely managed along the sanitation chain c)Authorities operate with a clear, inclusive mandate and d) authorities deploy range of hardware, funding and business model which enables adopting simple, local, and financially sustainable technologies that increase the scope of faecal sludge and septage treatment while benefiting all the stakeholders, especially the citizens relying on on-site sanitation systems.

1.4 Achieving SDGs goals through co-treatment

Achieving SDG goals through co-treatment

Thinking "beyond toilets" to achieve Sustainable Development Goal (SDG)

India is also signatory to the '2030 Agenda for Sustainable Development', adopted at the Sustainable Development Summit of the United Nations in September 2015. Out of the seventeen Sustainable Development Goals (SDGs), SDG 6 is directly related to sanitation. The SDG 6 aims to achieve the goal 'Ensure availability and sustainable management of water and sanitation for all'. Especially SDG 6.2 and 6.3 are related to this module on co-treatment of FSSM. In addition to this, there are other SDGs like 11 and 12 are related to SDG 6 and target sustainable development of human life through safe, resilient and inclusive development of cities and human settlements.

Summary

- Rapid pace of urbanisation in India has indicated a growing need for reimagining the approach to sanitation systems.
- Discharge of untreated faecal sludge and septage into the environment including water bodies causes environmental pollution and degradation of water quality and ultimately, affects human health.
- Adopting co-treatment is a highly attractive solution to treat faecal sludge and septage by making use of available treatment capacities in STPs.
- CWIS approach to sanitation provides guidance to overcoming sanitation challenges and also enables adopting the co-treatment approach.

Session

02

National missions and programs

2. National missions and programs

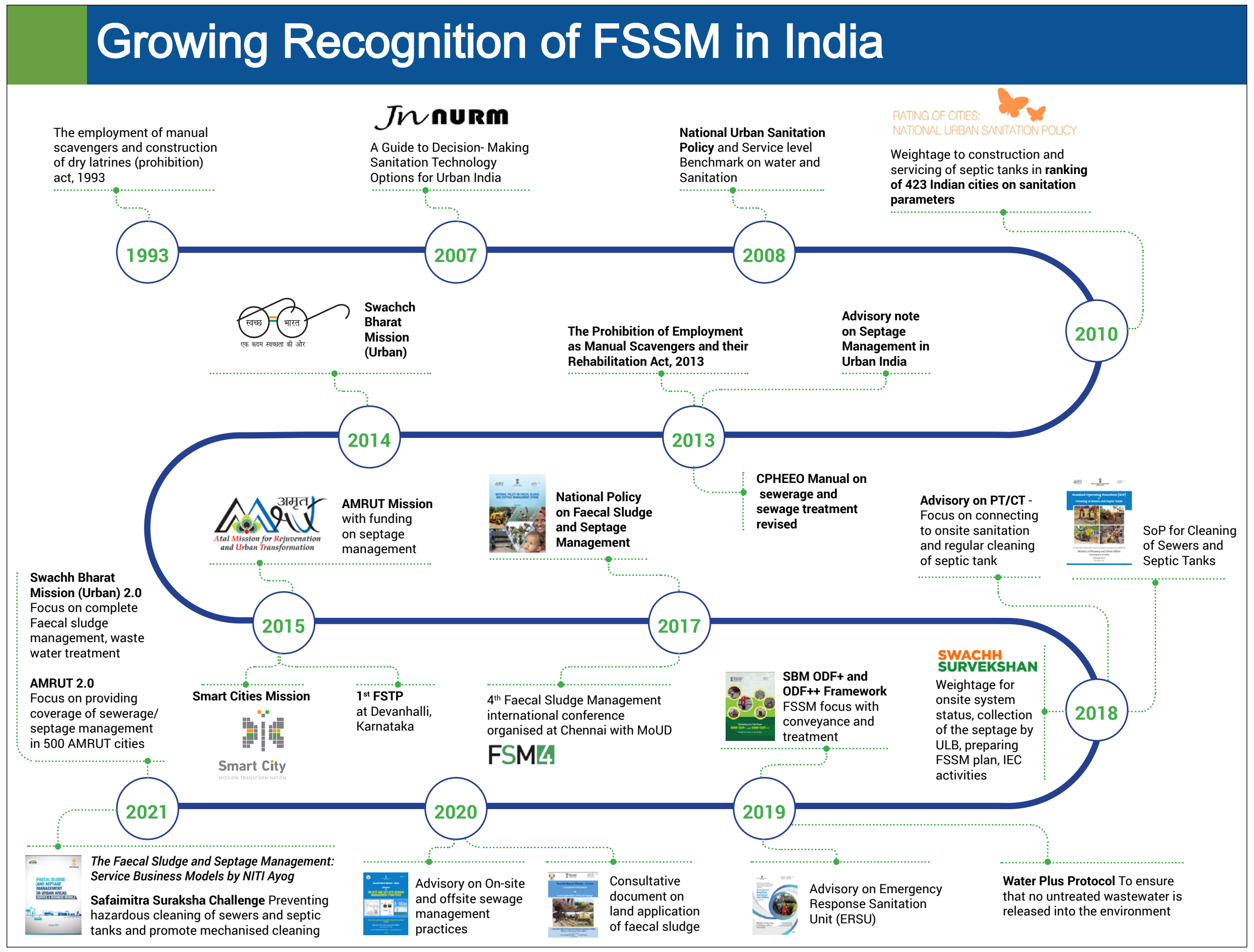
Learning objectives

- To inform genesis of sanitation policies and programs at national level with focus on non-sewered sanitation
- To understand priorities under various national missions for urban sanitation with focus on co-treatment of faecal sludge and septage with sewage
- To gain knowledge of different policies and guidelines for enabling co-treatment approach in FSSM
- To analyse avenue for funding various aspects of co-treatment under national missions

Contents

- Growing recognition of Faecal Sludge and Septage Management (FSSM) in India
- National missions and programs
- Advisories and guidelines related to sanitation in India

2.1 Growing recognition of Faecal Sludge and Septage Management (FSSM) in India



FSSM is fast gaining traction in India. In 2007, under JNNURM, a guide to decision making sanitation technology options for urban India was launched under which onsite sanitation systems were recognised. In 2010, under the National Urban Policy, rating of 423 Indian cities was done on various sanitation parameters. In 2013, 'The Prohibition of Employment as Manual Scavengers and their Rehabilitation Act' came which focussed on safety protocols of sanitation workers. Also, the CPHEEO guidelines were revised from sewerage and sewerage treatment to sludge treatment and septage management and an advisory note on septage management was launched. In 2014, sanitation gained momentum with the launch of Swachh Bharat Mission and AMRUT Mission with funding on septage management by the government. In 2015, the first FSTP was set up in Devanhalli, Karnataka. In 2017, National Policy of Faecal Sludge and Septage Management was launched. In 2018, under the Swachh Sarvekshan, weightage for onsite system status, collection of septage by ULBs, preparation of FSSM plans and IEC activities were considered. In 2019, MoHUA launched the SBM ODF+ and ODF++ framework with a focus on conveyance and treatment. An advisory on on-site and off-site sewage management was launched in 2020 thriving the FSSM momentum continuously. In 2021, MoHUA launched the Swachh Bharat Mission (Urban) 2.0 and AMRUT 2.0.

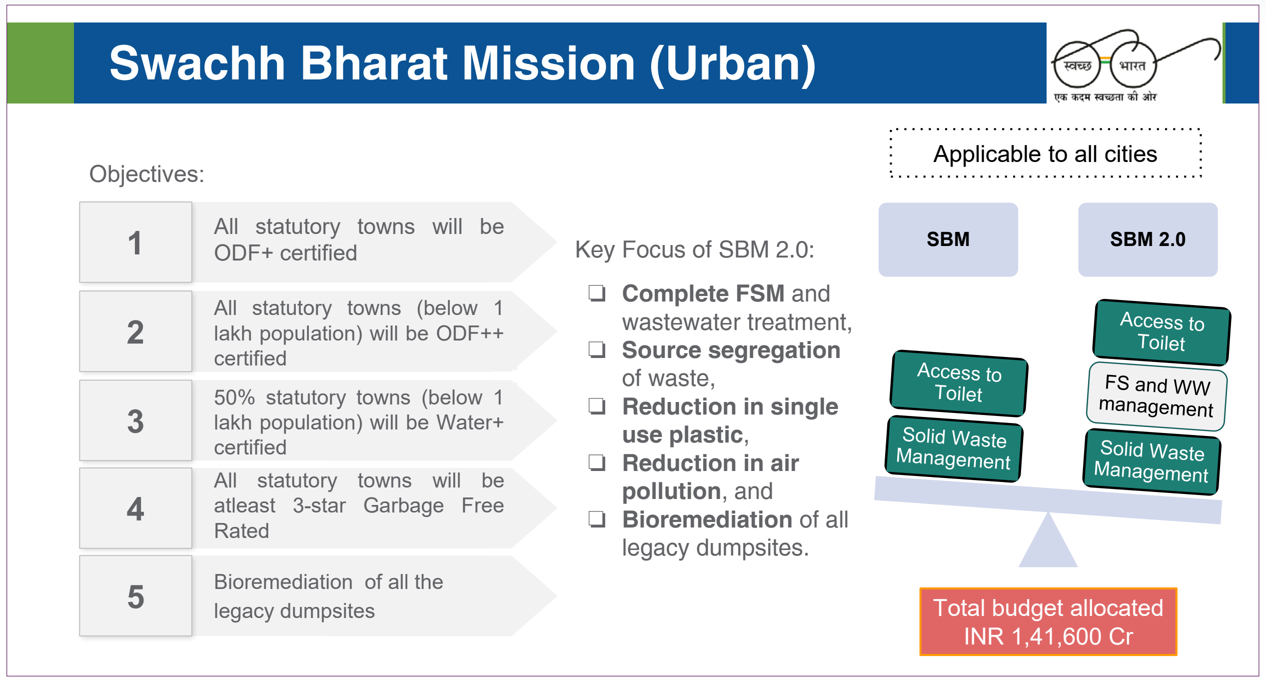
2.2 National missions and programs

Smart Cities Mission was initiated in June 2015 and aimed to promote cities that provide the basic infrastructure with a view to give a decent quality of life to its citizens, a clean and sustainable environment and application of 'smart solutions'. The focus is on sustainable and inclusive development. The underlying idea is to look at compact areas, create a replicable model which will act like a light-house to other aspiring cities.

The core infrastructure elements in a 'Smart City' would include:

- Water management
- Waste management
- Energy management
- Urban mobility
- E-governance and Citizen services
- Other services

Under this mission, emphasis has been laid under the waste management element to implement with innovative solutions that consider faecal sludge and septage as a resource in energy generation, as fuel, and as compost in agriculture after treatment. And, the co-treatment of faecal sludge and septage with sewage has proven to be very useful in Indian context that provides treated biosolids to be reused as a resource.

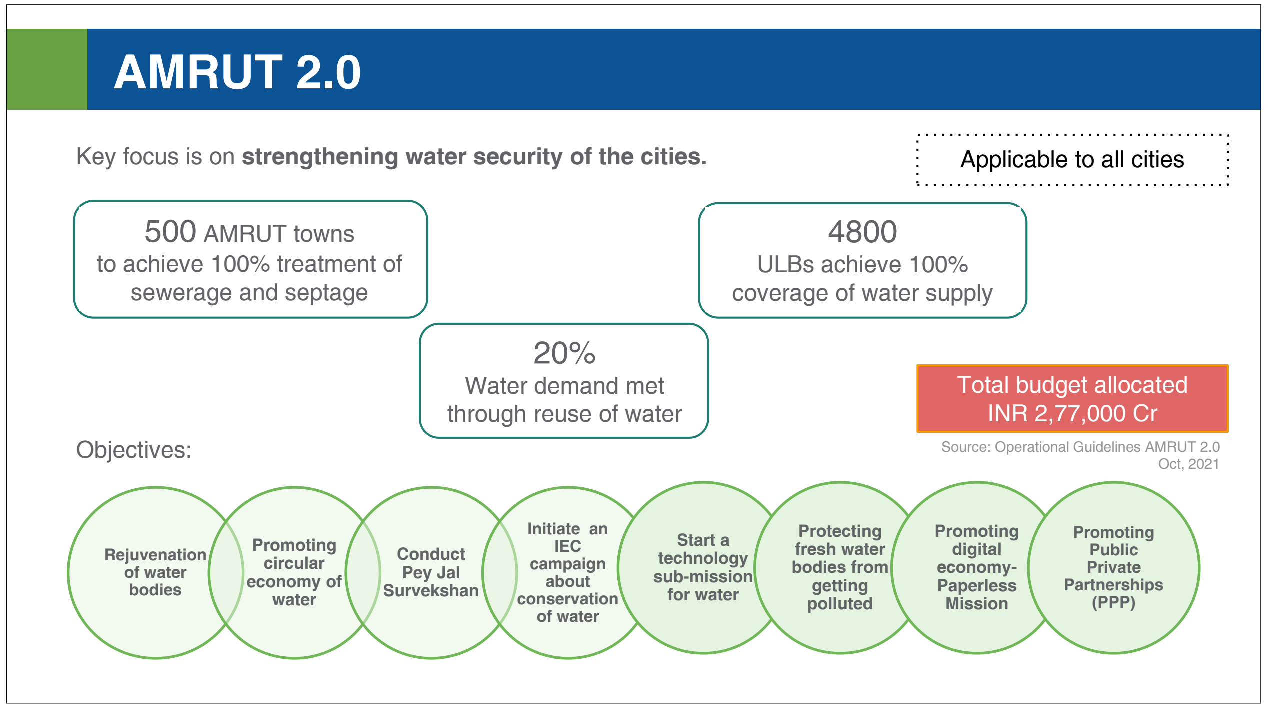


Swachh Bharat Mission (SBM) was launched in the year 2014 to eliminate open defecation and improve solid waste management. In first phase, it had aimed to achieve 100% ODF status for Urban and Rural areas by 2nd Oct 2019. The objectives of the first phase of the mission also included eradication of manual scavenging, generating awareness and bringing about a behaviour change regarding sanitation practices, and augmentation of capacity at the local level. The second phase of the mission (SBM 2.0) aims to sustain the open defecation free status and improve the management of solid and liquid waste. The mission is aimed at progressing towards target 6.2 of the Sustainable Development Goals (SDGs) established by the United Nations in 2015.

In continuation to SBM(U), the Ministry of Housing and urban Affairs launched SBM(U) 2.0 in 2021 with a focus on complete faecal sludge management, wastewater treatment, and other key areas related to sanitation. The participants should note here that this mission has clearly identified the co-treatment approach as one of the interventions under wastewater management.

The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) mission was initiated in June 2015 which aimed to provide the basic utility services (e.g. water supply, sewerage, septage management, urban transport) to households and build amenities in cities which will improve the quality of life for all. The purpose of Atal Mission for Rejuvenation and Urban Transformation (AMRUT) is to ensure that every household has access to a tap with the assured supply of water and a sewerage connection, to increase the amenity value of cities by developing greenery and well-maintained open spaces (e.g. parks) and to reduce pollution by switching to public transport or constructing facilities for non-motorized transport (e.g. walking and cycling).

With respect to faecal sludge and septage management (FSSM), the guidelines prescribe adopting cost-effective technologies to deal with faecal sludge and septage collection, transportation, and its treatment before disposal or reuse.



AMRUT 2.0 is a new initiative of Ministry of Housing and Urban Affairs launched in 2021 which focuses primarily on providing universal coverage of water supply to all urban households. Under AMRUT 2.0, the estimated gap of 2.68cr household taps and 2.64cr sewer connections/septage in 500 AMRUT cities is proposed to be covered.

Its key objectives are:

- To ensure the rejuvenation of water bodies and urban aquifer management will be undertaken to augment sustainable fresh water supply.
- To promote circular economy of water through development of city water balance plan, focusing on recycle/reuse of treated sewage, rejuvenation of water bodies and water conservation. 20% of water demand to be met with reused water by development of institutional mechanism.
- To start a technology sub-mission for water that will leverage latest global technologies in the field of water.
- To initiate an IEC campaign to spread awareness among masses about conservation of water.
- To conduct Pey Jal Surveksham to ascertain equitable distribution of water, reuse of wastewater and mapping of water bodies with respect to quantity and quality of water through a challenge process.

- To protect fresh water bodies from getting polluted to make natural resources sustainable.
- Cities having million plus population to take up PPP projects worth minimum of 10% of their total project fund allocation which could be on Annuity/ Hybrid Annuity / BOT Model.

In addition to the key objectives, the mission has a reform agenda having focus on strengthening of urban local bodies and water security of the cities. Major reforms are reducing non-revenue water to below 20%; recycle of treated used water to meet at least 20% of total city water demand and 40% for industrial water demand at State level; dual piping system; unlocking value and improving land use efficiency through proper master planning; improving credit rating & accessing market finance including issuance of municipal bonds and implementation Online Building Permission System under EoDB.
The Mission also seeks to promote AatmaNirbhar Bharat through encouraging Start-ups and Entrepreneurs with an aim to promote GIG economy and on-boarding of youth & women.

15th Finance Commission

Funding for Million Plus Cities

- MoHUA as Nodal Ministry
- INR 38,196 Cr funds as Million Plus City Challenge Fund
- 33.33% Grant for improving air quality
- 66.66% Grant for improving water and sanitation services (drinking water, RWH, recycling, sanitation and solid waste management)

Funding for ULBs (< 1 Million Population)

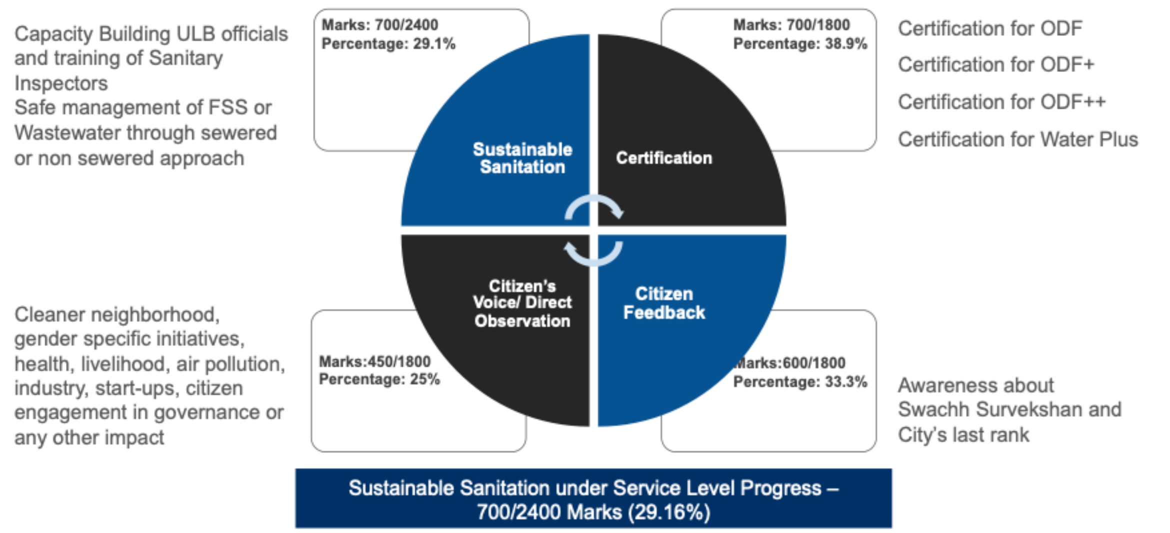
- INR 82,859 Cr for ULBs (< 1 Million)
- 30% Grant for sanitation and solid waste management and attainment of star ratings (as developed by the MoHUA)
- 30% Grant for drinking water, rainwater harvesting and water recycling

Fund allocation under 15th Finance Commission To cater to the needs of the growing urbanisation needs of the country, the 15th Finance Commission has recommended a total of Rs.1,21,055 crore for the urban local bodies for the period of 2021-26. Among the states and among the ULBs the fund will be primarily be distributed with a weightage of 90% on population and 10% on area.

Funds for Million Plus Cities UAs Fifty urban centres with million plus population have been identified. They consist of forty-four urban agglomerations (excluding Delhi, Chandigarh and Srinagar) and six cities Jaipur, Visakhapatnam, Ludhiana, Faridabad, Vasai- Virar City and Kota. For these cities, during its five-year award period, grants have been recommended to the tune of INR. 38,196 crore in the form of a Million-Plus cities Challenge Fund (MCF). Each urban centre shall have one ULB as a nodal entity which will be made responsible for achieving the performance indicator for the whole UA. One third of the total MCF of each city is earmarked for achieving ambient air quality. The balance two thirds of the city-wise MCF is earmarked for achieving service level benchmarks for drinking water (including rainwater harvesting and recycling) and solid waste management. The MoHUA shall act as a nodal ministry for determining the urban agglomeration eligible to get MCF funds for drinking water (including rainwater harvesting and recycling), sanitation and solid waste management criteria under service level benchmarks.

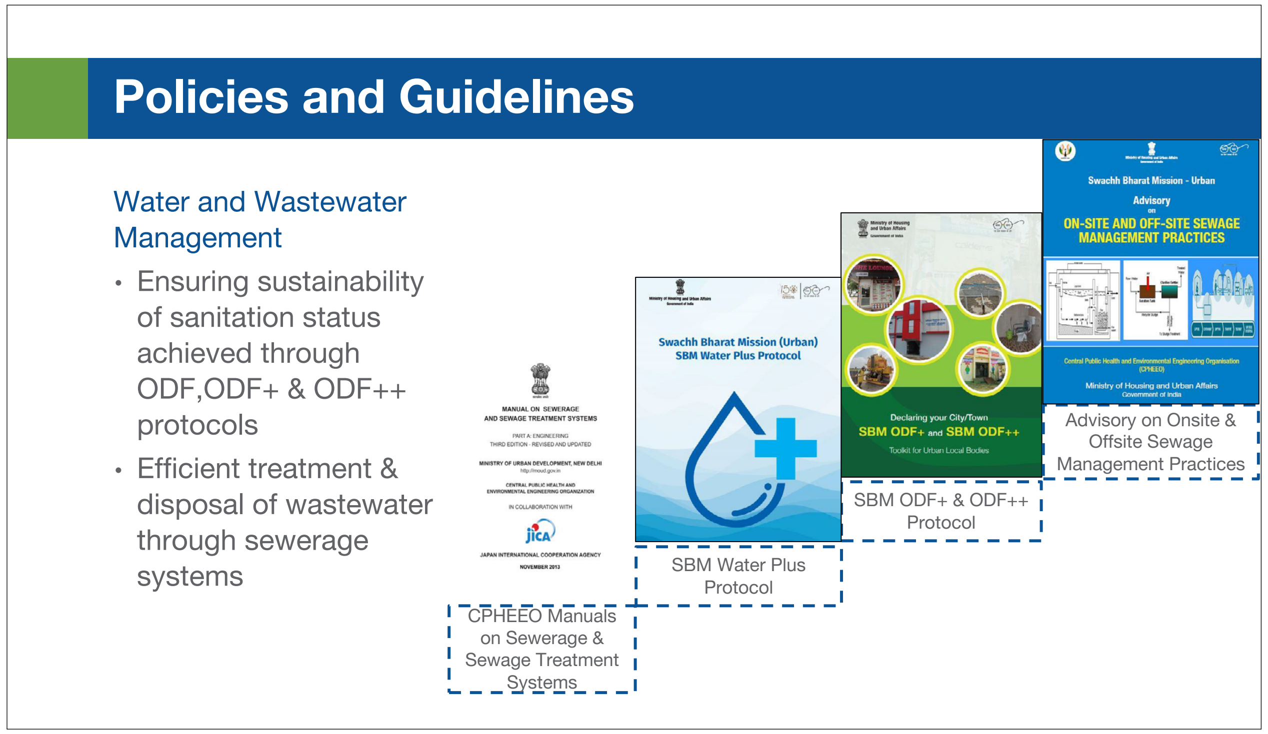
Grants for ULBs (less than Million Plus) The other than Million-Plus cities/towns shall get the grants as per population. Thirty per cent of the total grants to be disbursed to urban local bodies shall be earmarked for sanitation and solid waste management and attainment of star ratings as developed by the MoHUA. In addition, 30 percent of the total grants to be disbursed to urban local bodies shall be earmarked for drinking water, rainwater harvesting and water recycling. However, if any urban local body has fully saturated the needs of one category and there is no requirement of funds for that purpose, it can utilise the funds for the other category.

Swachh Survekshan 2021



The Government of India also validated that work done under the flagship program of Swachh Bharat Mission and AMRUT through Swachh Survekshan. Swachh Survekshan also included parameters pertaining to FSSM that helps in monitoring progress made by cities in attaining as well as sustaining ODF and Water Plus status. It also takes into consideration the non-sewered sanitation approach for FSSM as a key parameter to ensure delivery of sanitation services.

2.3 Advisories and guidelines related to sanitation in India



SBM Water Plus Protocols: The purpose of this toolkit is to provide a readiness check and guideline for cities and towns that have already achieved Open Defecation Free (ODF)/ODF+ /ODF++ status as per the existing protocols prescribed by the Ministry of Housing and Urban Affairs (MoHUA) and to work towards ensuring sustainability of sanitation status. This toolkit provides the detailed SBM Water Plus protocol laid down by MoHUA, along with declaration formats to be obtained from various stakeholders, that wards / work circles (in case under jurisdiction of development authority) and cities are required to submit, as part of the SBM Water Plus declaration and certification process

CPHEEO Manuals: The manuals on sewerage & sewage treatment systems provide a detailed process of the wastewater management, sewerage systems usage and everything related to sewage management spanning over 3 parts of engineering, operation & maintenance and management.

SBM ODF+ & ODF++ Protocol: This toolkit can serve as a readiness checklist for all ULBs/ Development Authorities/ Cantonment Boards to prepare themselves and their concerned stakeholders in achieving either SBM ODF+ and/or SBM ODF++status and officially declare the same, followed by certification, as per the protocol outlined.

Advisory on onsite & offsite sewage management practices: This advisory describes the way of integrated planning of sanitation in a city comprising of onsite and off-site sewage management systems. It has identified interventions, as above, for optimal performance of on-site systems and subsequent progressive coverage of on-site systems with off-site systems as and when necessity arises.

National Faecal Sludge and Septage Management (FSSM) Policy was released in 2017 to set the context, priorities, and direction for and to facilitate, nationwide implementation of FSSM services in all ULBs such that there will be safe and sustainable sanitation approach at city level. The key objective of the policy is to mainstream the FSSM in urban India by 2019 and ensure that the all benefits of wide access to safe sanitation accrue to all citizens across the sanitation value chain with containment, extraction, transportation, treatment, and disposal / re-use of all faecal sludge, septage and other liquid waste and their by-products and end-products. Another objective of the policy is to enable and support synergies among relevant central government programs such as SBM, AMRUT and the Smart Cities Mission to realise safe and sustainable sanitation for all. The FSSM policy expects to mitigate gender-based sanitation insecurity directly related to FSSM, reducing the experience of health burdens, structural violence, and promote involvement of both genders in the planning for and design of sanitation infrastructure.

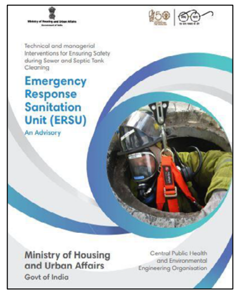
Consultative Document on Land Application of Faecal Septage: This Advisory covers all the key aspects of land application of faecal sludge and septage. It further discusses about the pre-treatment to be given to the faecal septage, precautionary measures to be taken, site selection criteria, dosage and various methods of land application. The monitoring mechanism and record keeping procedures for the land application process are also adequately addressed in the Advisory.

FSSM in Urban Areas- Service & Business Models: The Faecal Sludge and Septage Management: Service Business Models describes leading practices and innovations to improve how faecal sludge is managed, and how to expand services to the millions of people living in thousands of cities in urban India, lacking access to safely managed sanitation.

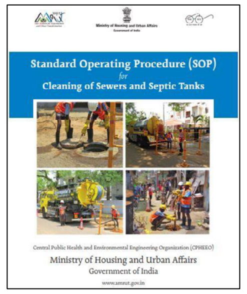
Policies and Guidelines

Occupational Health & Safety

- Occupational health deals with all aspects of health and safety at the workplace with special emphasis on primary prevention of hazards
- Safety and health of workers has a positive impact on productivity and economic and social development



Advisory on Emergency Response Sanitation Unit



SOP for Cleaning of Sewers & Septic tanks

Advisory on Emergency Response Sanitation Unit: This advisory describes the technical & managerial interventions for ensuring safety during sewer & septic tank cleaning. It represents an innovative approach to institutionalizing safety practices & putting in place frameworks to mitigate the dangers of this practice.

SOP for Cleaning of Sewers & Septic tanks: The scope of the SOP is to impart the knowledge into the stakeholders about the cleaning of sewers and emptying of septic tanks before and after the assignment. This document would be found useful by all Urban Local Bodies (ULBs), Public Health Engineering Departments and other agencies engaged in the process of cleaning of sewers / emptying of septic tanks across the country.

Convergence and financing for co-treatment

User interface	Containment unit	Conveyance unit	Treatment unit	Disposal or reuse
Dry toilets (Ecosan Toilets) Wet toilets (flush toilets, vacuum toilets)	Soak Pits Septic tanks Anaerobic treatment units (ABR, AF)	Gravity sewers Small bore sewers Vacuum trucks	Mechanised / Non mechanised Centralised / Decentralised	Surface water bodies Agriculture Industry
SBM Phase 1 and 2	State level funding (Community OSS)	• SCM • SBM 2.0 • AMRUT • 15th FC • NMCG	• SCM • SBM 2.0 • AMRUT • 15th FC • NMCG	• AMRUT 2.0 • NMCG

This slide provides the participants with an overview of different components in both, sewered and non-sewered sanitation systems. In addition to this, it lists down different technologies commonly selected in our cities. More importantly, it outlines the different national missions and programs that have laid down guidelines and provisions for providing safe, effective and efficient sanitation services in Indian cities.

Looking at the co-treatment approach, the main focus areas for any city would be ensuring proper conveyance, treatment, and disposal or reuse of treated wastewater and biosolids. As discussed earlier, this approach makes use of existing sewerage infrastructure like a sewage treatment plant for treating faecal sludge and septage with sewage. Therefore, national missions and programs such as the Swachh Bharat Mission Urban 2.0 clearly outline co-treatment of faecal sludge and septage with sewage as one of the components considered for funding. Other missions and programs like the Smart Cities Mission, Atal Mission for Rejuvenation and Urban Transformation, 15th Finance Commission, and the National Mission for Clean Ganga have made provisions towards faecal sludge and septage management in their guidelines.

Summary

- Non-sewered sanitation (FSSM) has been gaining traction in the Indian sanitation sector as reflected in various national missions and programs
- National missions like SBM-U 2.0 has considered co-treatment as an approach to faecal sludge and septage treatment for providing funds
- Policies and guidelines have been issued for cities in dealing with challenges related to sanitation
- Various aspects of co-treatment has funding mechanism available under various national missions and programs

Session

03

Approaches for Faecal Sludge and Septage Treatment

3. Approaches for Faecal Sludge and Septage Treatment

Learning objectives

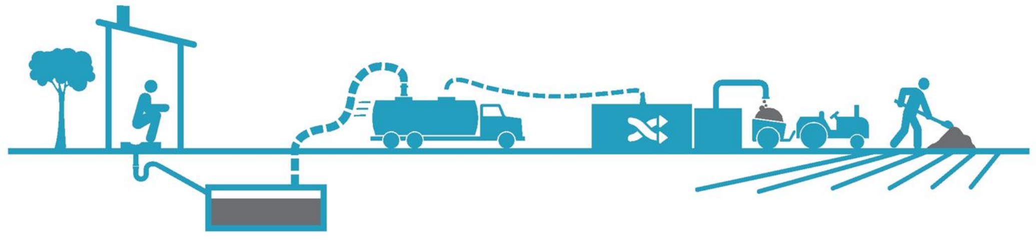
- Revisit the learnings from planning and technology module on faecal sludge and septage management (FSSM)
- Build a foundation for an in-depth understanding of co-treatment of faecal sludge and septage with sewage in sewage treatment plant

Contents

- FSSM planning
  - Stages of planning for FSSM
  - Approaches for FSSM
- FSS treatment
  - Objectives of treatment
  - Standards for treatment
  - Treatment mechanisms and stages
  - Treatment chain
- Rationale for co-treatment at STP
  - Hydraulic loading
  - Organic loading
  - Holistic treatment

3.1 Planning of FSSM

Planning for FSSM



Quantification and characterisation of sludge ...... Select an approach for treatment ...... Create an enabling environment

Planning of FSSM happens across the sanitation service chain. The sanitation service chain of non sewered / hybrid sanitation system consist of containment, emptying, transport, treatment and reuse or disposal of the treated end products. There are three main stages while planning FSSM at a city scale: (1) quantification and characterization of sludge, (2) selecting appropriate approach for treatment and (3) creating enabling environment. In the first stage, data collection is done mainly across the four steps of service chain- containment, emptying, transport, reuse/disposal. Along with this, characterization of sludge is done from various sources such as households, public toilets, community toilets, decentralized wastewater treatment plants etc. Depending on the quantity, characteristic of the sludge and the existing infrastructure with the ULB, approach for treatment is defined. Viability checks are performed for the while defining and selecting the treatment approach. Creating enabling environment for ensuring sustainability of FSSM it very important. It needs to be noted that success of FSSM does not only depend on the technological intervention but also on the non technical aspects such as stakeholder engagement etc.

Quantification and characterisation

- Amendment in ODF++ protocol
  - Septic tanks to be as per IS 2470 Part-I (1985)
  - Soak pits and dispersion trench to follow septic tanks as per IS 2470 Part-II (1985)

Desludging at least once in three years

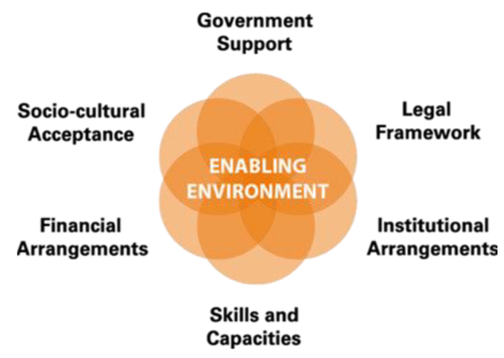
- Quantification methodology
  - Sludge generation method
  - Sludge collection method
- Mode of desludging
  - Demand desludging
  - Scheduled desludging
- Type of sludge
  - Faecal sludge
  - Septage
  - Sewage sludge

Quantification and characterization of the sludge is a very critical step in the selecting the approach for treatment. As per the amendments in the ODF++ protocol, the new septic tank constructed after May 2020 are supposed to conform to the Bureau of Indian Standards (BIS), IS 2470, 1985. These standards provide design criteria for septic tanks as well as ready design and drawing for septic tanks for population equivalent of 5 to 300 users. The old and new septic tank should be followed by soak pits or dispersion trench. The soak pits and dispersion trench should conform to BIS, IS 2470 Part II, 1985. These standards provide design criteria for secondary treatment using anaerobic filters and disposal using soak pits and dispersion trench. It also provides a design and drawing for these units with the dimensions.

The choice of quantification methodology depends on the byelaws and their enforcement and mode of desludging to be implemented. For understanding the characteristics of the sludge and to categorize the type, sampling and analysis of multiple trips is recommended.

Enabling environment

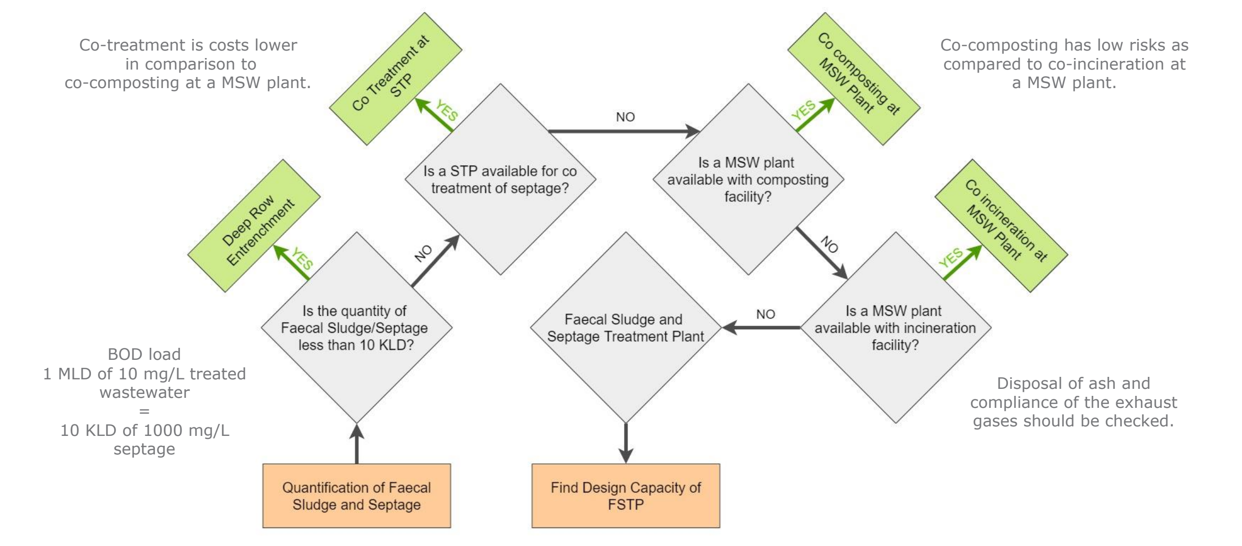
- Enabling environment provides mutual agreement among stakeholders
- Some key components for enabling environment are:
  - Byelaws
  - Skilling and training the workforce
  - Clarity in contracts and agreements
  - Licensing



Source: Luthi et al., 2011

Enabling environment plays a crucial role in the success of the FSSM projects. Multiple stakeholders are involved in the FSSM, some might have influential position in the project where as other might have interest in a part of the complete project. Enabling environment creates and harmony between the stakeholders and helps to distinguish between the roles and responsibilities. The key components for creating an enabling environment is – byelaws, skilling and training the work force, contracts, agreements and licensing between different parties for smoother financial transactions. This ensures that no disputes happen in the future which might hamper the FSSM service chain.

Approaches for FSSM



The approach for FSSM depends on the quantity and quality of the sludge to be handled. The diagram above provides a decision making algorithm for choice of the approach. It is always recommended to check the infrastructure already present with the ULB. This will ensure a high benefit to cost ratio in achieving the aim of FSSM. For ULBs with municipal finances up to the mark and generating smaller quantity of sludge to be handled, scientific land application such as Deep Row Entrenchment (DRE) is recommended. As capital expenditure, DRE only requires an appropriate plot of land with a fence to restrict entry of unauthorized persons and animals. Co-treatment of sludge can be achieved either at Sewage Treatment Plant (STP) or Municipal Solid Waste (MSW) Management Plant. Co-treatment of the faecal sludge and septage with sewage is recommended as expense involved is minimal. Co-treatment at MSW plant can be done either at the composting stage or incineration stage. Composting is beneficial as the sludge contains nutrients which are necessary for composting. Incineration is only recommended when the energy required for drying of sludge is less than to energy produced by incineration.

3.2 Treatment of Faecal Sludge and Septage

Treatment standards

- Treated wastewater discharge standards by CPCB
- No standards for treated solids by CPCB
  - Fertilizer Control Order (2013), India
  - Standards by the United States Environmental Protection Agency (US EPA)

Fertilizer Control Order (2013), India

- City compost
  - Total organic carbon - 12% by weight
  - Total nitrogen - 8% by weight
  - Total phosphates - 0.4% by weight
  - Total potash - 0.4% by weight
  - Carbon to nitrogen (C:N) ratio - <20
  - Pathogens - NIL

Standards for Class A Bio-solids by US EPA

- Faecal coliform density < 1000 MPN/g of total dry solids
- Salmonella sp. Density < 3 MPN/4 g of total dry solids
- Helminth egg concentration < 1 per g of total dry solids (WHO, 2006)
- *E. coli* 1000 per g of total solids (WHO, 2006)

The primary criteria is that the treatment facility should be able to produce end products meeting the standards of discharge/ enduse. Currently there are standards for the wastewater which have been adopted for the treated liquid fraction for FSTPs. However, there are not standards laid down for bio solids in STPs and FSTPs. Hence, the primer and the National FSSM policy recommend to follow US EPA standard or WHO standards.

Treatment objectives

Dewatering

- Reduction of design capacities
- Simplifies treatment scheme
- Gravity settling or filter drying beds
- Dewaterability of faecal sludge and septage
- Adding dry materials (wood chips, saw dust, organic solid waste, etc.) to increase solid content
- Liquid fraction - high in ammonia, salts and pathogens

One of the very important treatment objective of the faecal sludge and septage is dewatering. Dewatering helps to reduce the volume of sludge to be handled and treated using other treatment mechanisms, hence it reduces the CapEx significantly. Separating the solids and liquid stream simplifies the treatment of the faecal sludge and septage and helps to optimise the process. Ex. In case of heat drying, dewatering will save significant amount of energy.

Dewatering can be achieves by gravity settling or filtration. However, it needs to be noticed that dewaterability of faecal sludge is less as compared to septage. Hence, in such cases, stabilisation is recommended before dewatering.

Dewatering can also be achieved by increasing the solid content in the faecal sludge or septage. In case of pyrolysis or incineration, addition of dehydrating agent such saw dust or wood chips is done to increase the solid content as well as the calorific value of the solids.

It needs to be kept in mind that after dewatering, the liquid fraction might contain high amount of ammonia, salts or pathogens.

Treatment objectives

Pathogen removal

- FSS contains large amount of pathogenic microorganisms
- Significant health risk due to direct or indirect exposure
- Treatment should meet an adequate hygienic level
- Reduction or inactivation can be achieved through:
  - Starvation
  - Predation
  - Exclusion
  - Desiccation
  - Temperature

The second most important objective is pathogen removal. Pathogen removal is important from the discharge and reuse point of view of the end products. Faecal sludge and septage is known to contain high amount of pathogens and hence indiscriminate disposal of it may result into cross contamination of the water resources. Reduction of pathogen is achieved by various ways as listed in the slide.

Starvation refers to starving the pathogen to death. Predation refers to introducing or allowing specific types of bacteria to eat (predate) the pathogens. Exclusion refers to physical exclusion of pathogens depending on their size using filters. Desiccation refers to reducing the moisture content to the level where the cell wall ruptures due to dryness. Pathogens are believed to reduced significantly at temperature above it is 60^{o}C.

Treatment objectives

Nutrient recovery

- FSS contains significant concentration of nutrients like nitrogen (N) and phosphorus (P)
- Good substitute for synthetic fertiliser as:
  - nitrogen-based fertiliser is dependent on fossil fuels
  - phosphorus-based fertiliser that require phosphorus to be mined from ores
- If FSS is not managed properly, it can lead to negative impacts such as:
  - eutrophication of water bodies and algal blooms
  - contamination of drinking water sources

Nutrient recovery is a specific treatment objective which is very important when we are intending to use the end products as soil supplements for improving its characteristic. Faecal sludge and septage contain good amount of nutrients. If managed properly these nutrient can be used as supplement to synthetic fertilisers in agriculture. However, if not managed properly, it leads to eutrophication of water bodies and further it may lead to contamination of drinking water resources.

Treatment objectives

Stabilisation

- Faecal sludge has high oxygen demand as compared to septage
- Direct discharge would deplete the oxygen levels of surface water bodies
- Stabilisation is basically digestion of organic matter present in FSS
- Stabilisation increases the dewaterability of sludge

Degradable organic matter → Biodegradation → Carbon based molecules that are not readily degradable, stable complex molecules (cellulose and lignin)

Stabilisation of faecal sludge is also one treatment objective. Faecal sludge contains more organic solids which needs stabilisation before it can be discharged into the environment. Stabilisation reduced the oxygen demand of the liquid fraction of the faecal sludge. Hence, disposal of faecal sludge and septage into water bodies needs to be avoided.

However, in case of treatment processes, stabilization of faecal sludge produces stable solids. This increases the dewaterability of the sludge, improving the efficiency of dewatering process.

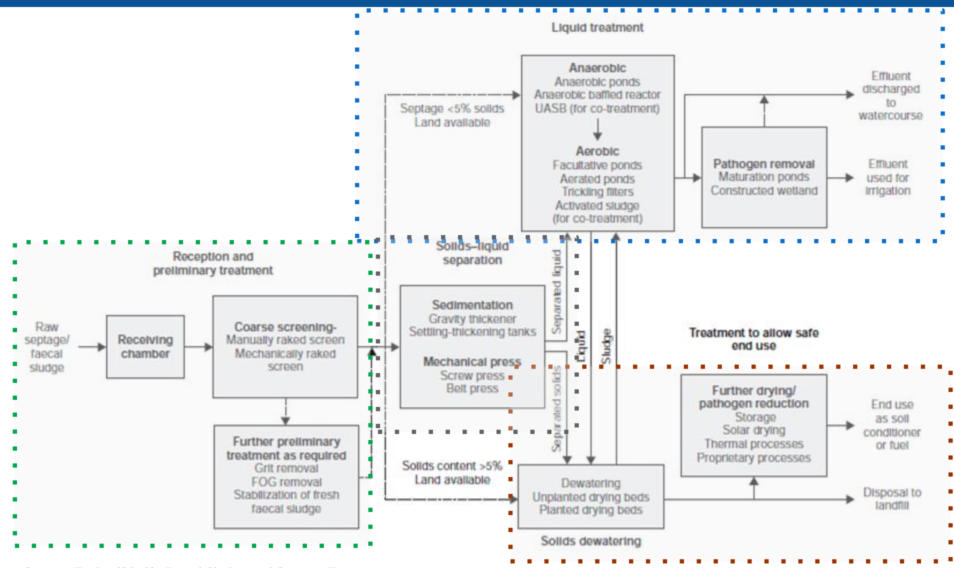
Treatment mechanism and stages

Solid-liquid separation	Stabilisation	Dewatering /Drying	Pathogen reduction	Potential end products
Physical mechanism Easily settleable solids are separated • Settling tanks • Thickening ponds • Imhoff tanks	**Biological mechanism** Organic solids are digested and sludge is stabilized • Digester • Anaerobic baffled reactor	**Physical mechanism** Reduction in moisture content of sludge • (Un) Planted drying beds • Mechanical drying	**Physical mechanism** Disinfecting sludge for its safe reuse or disposal • Storage and further drying • Co-combustion	• Dry sludge • Humified sludge • Biomass • Biogas • Compost • Energy • Building material

There are mainly two treatment mechanisms which are used for treatment of faecal sludge and septage: (1) physical mechanism and (2) biological mechanism. The physical mechanisms takes advantage of physical properties of the contents of the sludge such as size, specific gravity etc. The biological mechanisms depend on the bacteria which undertake digestion of organic contents of the sludge with or without the presence of oxygen. Anaerobic digestion i.e. in digestion in absence of oxygen by anaerobic bacteria is recommended for faecal sludge for two reasons: (1) it has very high COD and (2) dissolvability of oxygen in faecal sludge is less.

There are mainly four treatment stages: (1) solid liquid separation, (2) stabilization, (3) dewatering and drying, (4) pathogen reduction.

Treatment chain



Source: Tayler (2018), Faecal Sludge and Septage Treatment

The treatment chain employed in a Faecal sludge and Septage Treatment Plant is different from Sewage Treatment Plant. The first step is preliminary treatment where in, removal of solid waste (rags, sanitary pads, plastic bags etc.) is done. Depending on the subsequent treatment, removal of grit, fat-oil-grease (FOG) or even stabilization of sludge is included here. The primary treatment of sludge consists of solid liquid separation. After this treatment, two streams – one that of solids (thickened sludge) and other that of liquid (water part of the sludge) are produced. From this stage, two separate treatment chains are employed for treating the solids and the liquid separately. Any sludge generated during the liquid treatment is sent to the solids stream and the any liquid generated from solids treatment is sent to the liquid treatment.

3.3 Rationale for co-treatment at STP

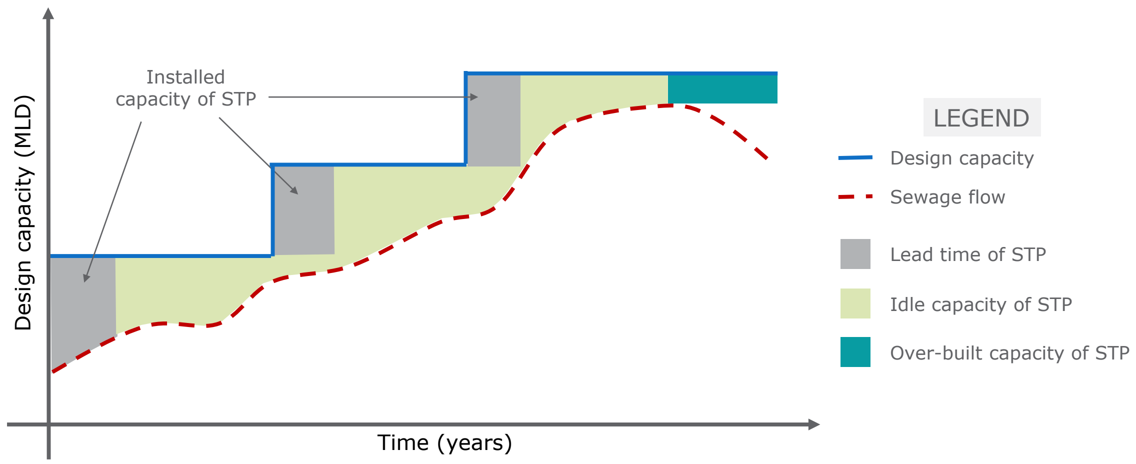
Achieving co-treatment objectives through CWIS

- Citywide Inclusive Sanitation (CWIS) is an approach that aims to shift the urban sanitation paradigm. One of its principles highlights:

  "Ensuring everyone has access to safely managed sanitation via both on-site and sewered solutions, in either centralized or decentralized systems"

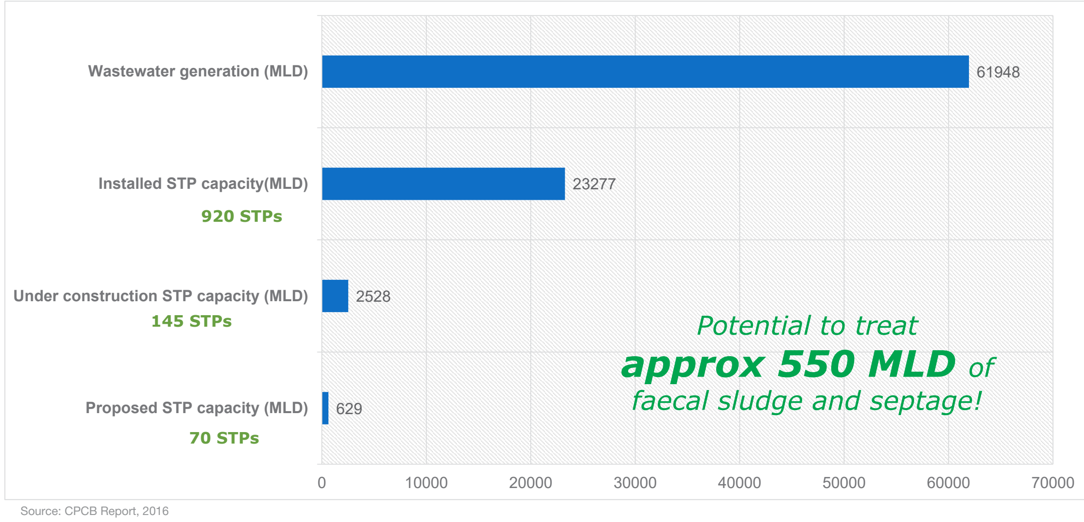
- Since the treatment objectives for safe management of sewage are similar to those for handling faecal sludge and septage, adopting co-treatment in existing sewage treatment plants with idle capacity is a very crucial solution in our cities with non-sewered sanitation system.
- CWIS being a public service approach builds upon conventional knowledge of urban sanitation and promotes inclusive and sustainable sanitation services by prioritising the sanitation requirements of a city.

Hydraulic loading



The graph shows design capacity verses the time. The red dotted line represents the sewage flow through the sewerage network. Since, the STPs are designed for a period of 15 years, in the initial 5-10 years, the STPs are heavily underutilized. This is represented in the graph by light green color. The augmentation of the design capacity or setting of another STP happens after 12-15 years and again there is significant capacity which remain unutilized. Thus, unutilized capacity of the designed SPT can be utilized for accommodating the faecal sludge and septage.

Wastewater in urban India



Source: CPCB Report, 2016

As per the CPCB Report published in year 2016, there were 920 STPs in the cities in India with a total capacity of treatment equal to 23,277 MLD. At the time, 145 STPs were under construction with the capacity of 2,528 MLD and another 70 STPs were proposed with treatment capacity of 629 MLD. Thus, after commissioning of all the STPs 1135 STPs in India, the total capacity of treatment would have been 26,434 MLD which is approximately 43% of the wastewater generated in India. This provides a potential to treat 550 MLD of septage in India.

STPs in Class-I cities

City category & population	Number of cities	Sewage generation, MLD	Installed sewage treatment capacity, MLD	Capacity gap in cities having STPs, MLD (A)	Sewage generation in cities having no STPs, MLD (B)	Total capacity gap, MLD�(A+B)	Planned treatment capacity, MLD
Class I cities having more than 10 lac population	39	13503	4472 (In 29 cities)	6135	2896	9031	1549
Class I cities having 5 to 10 lac population	32	3836	485 (In 13 cities)	1293	2058	3351	123
Class I cities having 2 to 5 lac population	119	4807	768 (In 34 cities)	804	3235	4039	4
Class I cities having 1 to 2 lac population	224	4018	322 (In 36 cities)	373	3323	3696	32.5
All the above Class I cities together	414**	26164 (100%)	6047(23.1%) (In 112 cities)	8605 (32.9%)	11512 (44%)	20117 (76.9%)	1708.5 (6.5%)

Source: http://cpcb.nic.in/status-of-stps/

STPs in Class-II cities

City category & population	Number of cities	Sewage generation, MLD	Installed sewage treatment capacity, MLD	Capacity gap in cities having STPs, MLD (A)	Sewage generation in cities having no STPs, MLD (B)	Total capacity gap, MLD (A+B)	Planned treatment capacity, MLD
Class II towns having 0.5 to 1 lac population	489**	2965 (100%)	200 (>143*) (4.8%) (In 22 towns)	Nil	2822 (95.2%)	2822 (95.2%)	34.1 (1.15%)
All Class I cities and Class II towns	893**	29129 (100%)	6190 (21.3%)	8605 (29.5%)	14334 (49.2%)	22939 (78.7%)	1742.6 (6.0%)

Assuming that, 1/4th of the existing capacity is unutilized, the scope of co-treatment in Class-I & II cities and towns is **65 MLD** of faecal sludge and septage!

Typically Class I and Class II cities face problems with management of wastewater. Cities which have STPs are unable to expand the sewerage network because if inadequate financial and managerial capacities. These are the cities where FSSM needs to started to reduce the impact of pollution on water bodies. With a total treatment capacity of 7932 MLD, there is potential of treating 65 MLD of septage.

Organic loading

Parameter (sewage)	Design concentration (mg/L)	Average concentration (mg/L)
BOD	250	<180
COD	425	<350
TSS	375	<250

- Values for design concentration are taken from the CPHEEO Manual on Sewerage and Sewage Treatment, 2013
- Actual concentration depends on:
  - Water usage
  - Design of sewerage network
  - Type of waste
  - O&M of sewerage network

The STPs are designed based on certain assumptions. As per the CPHEEO Manual on Sewerage and Sewage Treatment (2013), the average concentration of design parameter such as BOD, COD and TSS is taken as 250 mg/L, 425 mg/L and 375 mg/L. The actual concentration of these parameters depend on the water usage, type of waste carried by the sewerage network, design of the sewerage network and its appurtenances and the periodic operation and maintenance of the sewerage network. The average concentration of sewage reaching at the STP is observed to be around 60-70% of the designed concentration. Thus, it is observed that the STPs during its lifetime might function at reduced organic loading. Thus, there is a possibility that even when 80-90% hydraulic loading of design capacity, the STP can still be able to take larger organic load.

Part B: These design concentration are based on the assumption that the average water consumption at consumer end is 135 LPCD and 80% of the water consumed will be transformed into sewage. Thus, with change in the water consumption and water usage patterns, the concentration of the parameters change. The concentration will also change depending on the type of waste. If indiscriminate or illegal discharge of industry effluent is done in the sewerage system, then the concentration will get affected. Design of the sewerage network can also affect the concentrations. If the design/implementation of certain appurtenances of the sewerage network lead to deposition of solids in the network, then this will result in decrease in concentration of the parameters. O&M of the sewerage network helps to maintain the structural integrity and life of the network. If the appurtenances are broken, then infiltration or exfiltration of water can also lead to decrease of increase in the concentration. Such variation are observed during the dry and wet weather flow.

Holistic treatment

- Faecal sludge and septage has very high solid content
- Faecal sludge and septage treatment
  - Solids treatment chain
  - Liquid treatment chain
- With appropriate preliminary treatment
  - Solids can be treated with sewage sludge
  - Liquid can be treated with sewage
- Minimal investment for setting up a receiving station with preliminary treatment

Benefit-to-cost ratio is high!

Faecal Sludge and septage has a very high solids content. Subsequently , the BOD and COD is also high. Reducing the solids content in the faecal sludge and septage also leads to reduction is BOD and COD. Thus, after solid liquid separation, the thickened sludge can be treated with sewage sludge and the liquid can be treated with sewage at STP. Thus, complete treatment of faecal sludge and septage is possible with minimum addition of treatment units at the STP. Thus the benefit to cost ratio is high as compared to other treatment approaches for FSSM.

Co-treatment at MSW plant

Co-composting	Co-incineration
• Input waste product should have: ○ High nutrient content ○ Optimum moisture content	• Input waste product should have: ○ High calorific content ○ Minimum moisture content
• Required treatment of input waste product: ○ Preliminary treatment – screening, FOG removal, grit removal ○ Primary treatment – solid-liquid separation ○ Secondary treatment – dewatering (solid content: 30 - 40%)	• Required treatment of input waste product: ○ Preliminary treatment – screening, FOG removal, grit removal ○ Primary treatment – solid-liquid separation ○ Secondary treatment – dewatering, drying (solid content: at least 80%)

Liquid treatment plant will be needed in both cases!

The other avenues for co treatment is at Municipal Solid Waste management plant. Usually, the municipal solid waste management plants has either composting or incineration or both as part of the treatment process. Similar to STPs, the MSW management plants are also designed for the period of 15 years. Thus, in this case too, there is a certain unutilized capacity of the treatment units which can be put to use for co treating faecal sludge and septage at the MSW plant.

Co-composting- for co composting the sludge need to have high nitrogen content and the optimum moisture content for composting. Thus, the sludge needs to be screened, along with removal of grit and FOG. After solid liquid separation, thickened sludge needs to be dewatered to produce bio solids with solid content between 30-40% needs to be used for co composting.

Co-incineration- for this, the sludge needs to undergo preliminary and primary treatment as suggested for co composting. For secondary treatment along with dewatering, drying needs to be performed to increase the solid content to at least 80%. This is the basic requirement for incineration.

For liquid treatment, a treatment plant needs to set up. Only then complete treatment of solids and liquid streams will be achieved.

Summary

- Quantification and characterisation of faecal sludge and septage plays a critical role in planning and selection of approach of FSSM
- Objective of faecal sludge and septage treatment depends on the treatment standards and end use of treated end products
- Faecal sludge and septage treatment plant consists of separate treatment chains for solids and liquid treatment
- Co-treatment of faecal sludge and septage at STP provides a holistic solution to managing sludge
- Co-treatment at STP has a very high benefit-to-cost ratio

Session

04

Characterisation of Liquid Waste: Faecal Sludge, Septage and Sewage

Learning objectives

- Understand the difference between faecal sludge, septage, sewage and sewage sludge
- Learn about characterisation ratios required to select appropriate treatment processes
- Know the operational factors that affect the characteristics of faecal sludge and septage

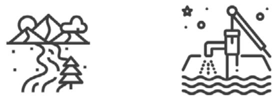
Contents

- Parameters for characterisation
  - What determines the characteristics?
  - Parameters
- Characteristics of sewage
  - Physical parameters
  - Chemical parameters
  - Biological parameters
  - Comparison of septage and sewage
- Types of sludge and its characteristics
  - Type of sludge
  - Characterisation of sludge
  - Characterisation ratios
  - Operational factors

4.1 Parameters for characterization

What determines the characteristics?

- Source of generation
  - Residential/commercial/industrial
  - Toilet/bath/kitchen/public toilet /community toilet
- Quality of water used
- Culture/habits of users
- Water conserving plumbing fixtures
- Type and treatment provided to industrial effluent



Parameters

- Solid Concentration (TSS, TDS, TFS, TVS)
- Chemical oxygen demand (COD)
- Biochemical oxygen demand (BOD)
- Nutrients (TKN, NH_3-N, Total P)
- Pathogens
- Metals

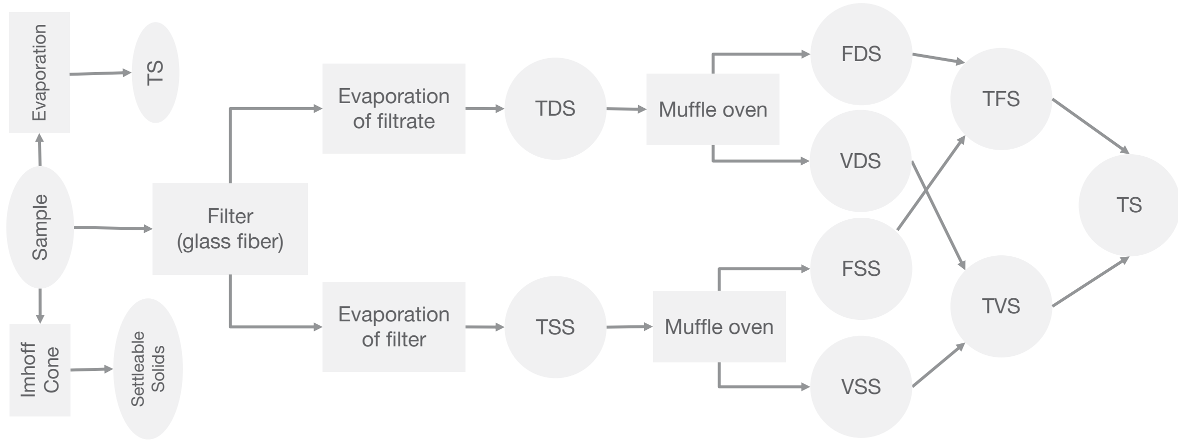
The parameters which are used to characterise septage are similar to the one used in case of wastewater. The parameters are listed above in the slide. It is very important that all the parameters and their interdependence is understood well. In case od the septage coming from the septic tank installed at the household, one need not worry about metals. However, in case where small medium scale industries are run at the household level, the septage might also contain heavy metals.

Ex. In unorganized housing units, usually small scale industries such as dying of textile or metal fabrication units are run. In this case, if the process water is disposed off into the septic tank then the septage will contain the heavy metals from the dyes and fabrication processes.

4.2 Characteristics of sewage

Physical characteristics

Leads to deposition of solid sludge and anaerobic conditions when untreated wastewater is discharged in the aquatic environment



Source: Metcalf & Eddy, Inc. Wastewater Engineering : Treatment, Disposal, and Reuse.

The most important physical characteristics of wastewater is its total solid content, which is composed of floating matter, settleable matter, colloidal matter and matter in solution. Other important physical characteristics of wastewater includes the particle size distribution, turbidity, colour, transmittance, temperature, conductivity, density and specific gravity etc.

The solids in the wastewater, faecal sludge and septage can be classified as shown in the slide above. The solids are either dissolved or suspended. The suspended solids are further classified in easily settleable solids. The suspended and dissolved can be further classified into volatile and fixed solids. Fixed solids are those which are retained in the sample after exposing it to higher temperatures. The content of volatile solids determine the degree of stabilisation of the solids. However, the literature says that the TSS in septage is quite high and most of which are easily settleable. Hence a simple solid liquid separation helps to reduce the VSS and COD of the liquid portion of the septage.

Chemical characteristics

Organic chemical characteristics

Biodegradable organics

If discharged untreated into the aquatic environment, it can cause biological stabilization -> depletion of oxygen resources -> septic conditions

BOD & COD

Inorganic chemical characteristics

- Nutrients
- Priority pollutants (carcinogenic, mutagenic, etc.)
- Refractory organics (pesticides, phenols)
- Heavy metals (As, Cd, Cr, Cu, Pb, Hg, etc.)
- Dissolved inorganics (calcium, sodium sulphates)

The chemical characteristics of the wastewater are classified as inorganic and organic constituents. Inorganic chemical constituents of concern include, nutrients, nonmetallic constituents i.e. refractory organics or dissolved organics etc., heavy metals and gases etc. Organic constituents are classified as aggregate or individual. Aggregate organic constituents are comprised of a number of individual compound that can't be distinguished separately. Both aggregate and individual organic constituents are of a great significance in the treatment, disposal and reuse of wastewater.

Aggregate organic constituents are normally composed of combination of carbon, hydrogen and oxygen, together with nitrogen in some cases. The organic matter in wastewater typically consists of proteins (40 -60%), carbohydrates (25-30%) and oils & fats (8-12%). Urea, the measure constituent of urine, is another important organic compound contributing to fresh wastewater.

Classification of COD

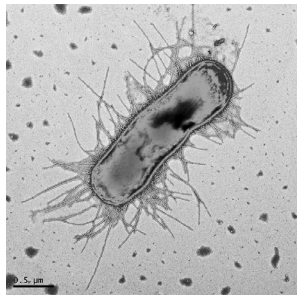
- Total COD
  - Biodegradable COD
    - Readily biodegradable: low molecular weight, (sugars, alcohols and fatty acids), in few minutes
    - Slowly biodegradable: high molecular weight, needs anaerobic digestion for removal
  - Non-biodegradable COD
    - Soluble non-biodegradable: does not undergo any changes during biological treatment
    - Particulate non-biodegradable: not consumed by biomass, settles out with the sludge

Source: Tayler, K (2018) Faecal Sludge and Septage Management : A guide for low middle income countries

The slide shows classification of COD in liquid waste such as faecal sludge or septage. The total COD can be classified into biodegradable and non-biodegradable COD. The Biodegradable COD can be further classified into readily biodegradable and slowly biodegradable. The slowly biodegradable COD content of faecal sludge is much higher than septage. Hence in order to stabilise the faecal sludge, anaerobic digestion with more retention time is required. The non-biodegradable COD can be further classified into soluble and particulate non-biodegradable COD. It is important to note that septage has significantly higher amount of particulate non-biodegradable COD. This means septage does not need much stabilisation and COD reduction in septage can be achieved by simply removing the suspended solids from the liquid fraction.

Biological characteristics

Communicable diseases can be transmitted by pathogenic organisms that may be present in wastewater



Source: www.eurekalert.org

Coliform organisms

E. coli, Faecal coliform, Total coliform

MPN (Most Probable Number)

The biological characteristics of wastewater are of fundamental importance in the control of diseases caused by pathogenic organisms of human origin and because of the extensive and fundamental role played by bacteria and other microorganisms in the decomposition and stabilization of organic matter, both in nature and in wastewater treatment plants. The purpose of the biological characteristics in wastewater treatment are to identify: i) the microorganisms found in surface waters and wastewater, ii) the pathogenic microorganisms associated with human diseases, iii) the use of indicator organisms, iv) the methods and techniques used for enumeration of bacteria, v) the method of enumerating viruses.

Biological characteristics

- Bacteria - convert complex organic matter into a simpler form
- Algae - utilize the radiant energy, absorb CO_2 and release oxygen by photosynthesis
- Fungi - fully depended on organic matter for obtaining their energy
- Protozoa - feeds on bacteria and destroy pathogens

Organisms found in surface water and wastewater include bacteria, fungi, algae, protozoan and viruses etc.

Comparison of septage and sewage

Parameter	Septage	Sewage	Ratio of parameter septage to sewage
TS	40,000	720	55:1
TVS	25,000	365	68:1
TSS	15,000	220	68:1
VSS	10,000	165	61:1
BOD_5	7,000	220	32:1
COD	15,000	500	30:1
TKN	700	40	17:1
NH_3-N	150	25	6:1
Total P	250	8	31:1
Grease	8,000	100	80:1

Source: USEPA Handbook on Septage Treatment and Disposal

This slides shows the strength of septage and sewage and provides us with an ratio to understand how concentrated septage can be when compared to sewage. The total solid content is significantly high when compared to sewage. This is the result o digestion of the accumulated sludge over a period of time. It can be seen that volatile solids and suspended solids both are significantly high as compared to sewage. This results in high COD too. Since the accumulated faecal sludge is digested over a period of time, the result of the digestion is inorganic particles. Nutrient content is also high in septage and so it's the grease. The grease content is high because fats, oil and grease has been accumulating over a period of time in the septic tank and now has been mixed and emptied with limited quantity of the water (equivalent to volume of septic tank).

4.3 Types of sludge and it's characteristics

Types of sludge

Faecal sludge

Collected from on-site sanitation system such as pit latrines

Has undergone partial digestion

Septage

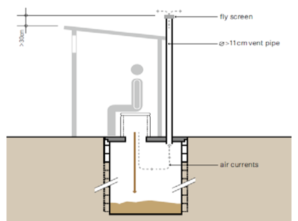
Collected from on-site sanitation system such as septic tanks, ABR, etc.

Has undergone complete digestion

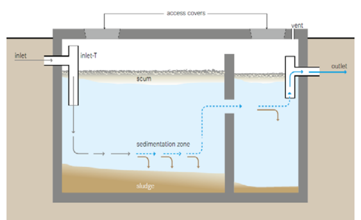
Sewage sludge

Generated during aerobic treatment of domestic wastewater at a sewage treatment plant

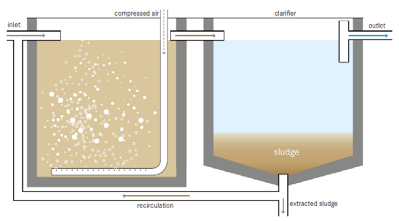
Requires further digestion for improving dewaterability of sludge



Dry toilet



Septic tank

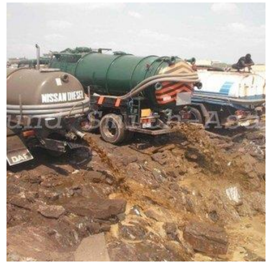


Sewage treatment plant

There are three different types of sludge considering its source and digestion rate i.e. a) faecal sludge which is collected from on-site sanitation system such as pit latrines which has undergone partial digestion, b) septage which is collected from on-site sanitation systems such as septic tanks, ABR etc. and has undergone complete digestion and c) sewage sludge which is generated during aerobic treatment of domestic wastewater at the sewage treatment plant and requires further digestion for improving dewaterability of the sludge.

What is faecal sludge?

- Contents of pits and vaults accumulating excreta and anal cleaning water
- Very high solid content as compared to wastewater
- Characterised by:
  - Fresh and yellowish
  - Low dewaterability
  - Higher BOD
  - Needs higher degree of treatment



Source: Modjinou et. al. (2015)

Source: Eawag/Sandec 2008

Depending on the type of the containment system and its design and holding period, the content of the pits (human excreta) undergoes digestion. The containment unit such as pits or under designed septic tank results into faecal sludge, whereas the units such as septic tanks is sludge holding capacity of 2-3 years or anaerobic treatment system such as digester produce septage. The content of septic tank has high TSS and TDS than wastewater. Faecal Sludge as mentioned earlier is fresh yellowish, higher BOD, non settleable solids. Hence, it needs higher degree of treatment. Septage on the other hand, is well digested black in color, higher content of settleable solids and requires lesser degree of treatment.

What is septage?

- Contents of septic tanks and vaults accumulating black water
- Very high solid content as compared to wastewater
- Characterised by:
  - Well digested and black
  - High dewaterability
  - Lower BOD
  - Needs lower degree of treatment

Source: Modjinou et. al. (2015)

Source: Eawag/Sandec 2008

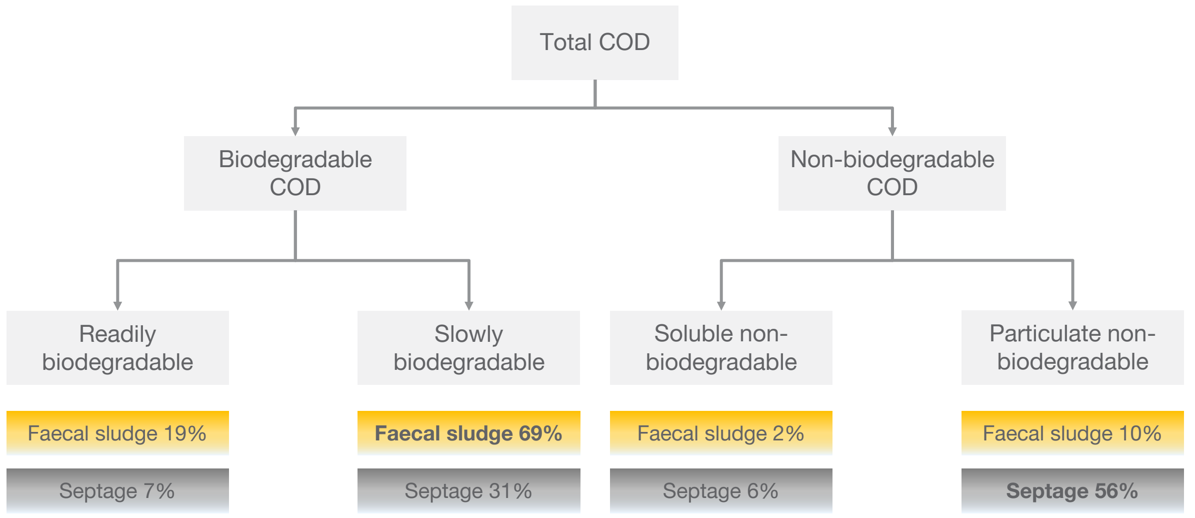
Characterisation of sludge

	Public toilet sludge	Septage	Sewage
Characteristics	Highly concentrated, fresh excreta, stored for weeks or months	Low concentration, more stabilized than public toilet sludge, stored for several years	Tropical sewage
COD [mg/L]	20 - 50,000	< 10,000	500 - 2,500
NH_4 – N [mg/L]	2 - 5,000	< 1,000	30 – 70
Total solids [%]	≥ 3.5%	< 3.0%	< 1.0%
Suspended solids [mg/L]	≥ 30,000	≈ 7,000	200 – 700
Helminth eggs (no./L)	20 – 60,000	≈ 4,000	300 – 2,000

Source: Heinss et al. 1998

This slide shows the characteristic of three different types of sludge depending upon its source- public toilet, septic tank (household) and STP. Thus in case of Indian cities, it needs to be understood that different types of sludge might arrive at the treatment facility. In India, due to increasing number of decentralised wastewater treatment plants (aerobic as well as anaerobic) sewage sludge might also be received at the treatment facility. Ex. In case of Port Blair, every resort having more than 20 rooms are mandated to have a STP. Most of the resorts, in order to avoid the odour nuisance, store the sewage sludge in the storage tanks and call for the vacuum trucks to empty them frequently. Thus, in case of Port Blair, all the three types of sludges are bound to come for treatment at the treatment facility. The degree of treatment required to treat these sludges is different.

Characterisation based on COD



Source: Tayler, K (2018) Faecal Sludge and Septage Management : A guide for low middle income countries

19

Characterisation ratios

Ratio (gm/gm)	Public toilets	Septic tanks	Medium strength wastewater
VSS:TSS	0.65-0.68	0.50-0.73	0.60-0.80
COD:BOD_5	2 - 5	5 - 10	2
COD:TKN	0.10	1.2-7.8	8-12
BOD_5:TKN	2.2	0.84-2.6	4-6
COD:TP	109	8.0-52	35-45
BOD_5:TP	17	5.6-17.3	15-20

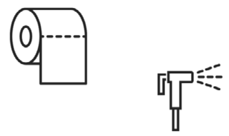
Source: Linda et. Al; Faecal Sludge Management- System Approach and Implementation

Characterisation ratios help us to understand the degree of treatment required for the waste. These ratios help us to identify appropriate treatment processes. The percent of volatile solids to suspended solids tell us about stabilisation of the sludge. Higher the quantity of the VSS means the sludge needs stabilisation. If stabilisation is done using anaerobic digestion, then there is production of biogas which can be used for energy production. The COD:BOD ratios tells us, how much fraction of the organic solids are easily degradable. The higher ratio indicates higher presence of difficult to digest solids. Hence, such kind of sludge can be sent for anaerobic digestion to obtain biogas. The organic content to nitrogen ratios also indicate that the organic concentrations are not sufficient for nitrogen removal by denitrification.

Operational factors

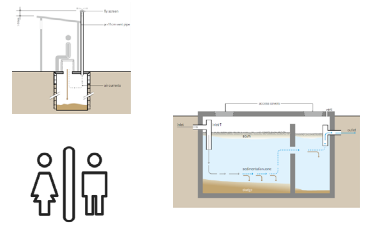
Toilet usage

- Washers & wipers
- Inclusion – exclusion of grey water
- Use of additives for reducing filling rates of onsite sanitation system



Storage duration

- Type of technology
- Toilet usage



Operational factors such as toilet usage and cleansing material also affects the sludge production rate. Grey water inclusion may increase or decrease the sludge production. The grey water might include more chemical which change the pH of the water, this affects the digestion rate. The storage duration also determines the volume of sludge in the septic tank. Higher the storage duration, the volume decreases.

Some households also use additives such as microbial cultures which accelerates the digestion rate. Thus, it extends the septic tank emptying frequency.

Operational factors

Climate

- Temperature and moisture dependent
- High temperature – high biological degradation rate

Infiltration and Exfiltration

- Quality of construction
- Exfiltration – thicker sludge and infiltration – diluted sludge

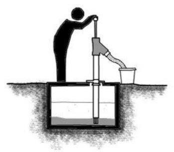
Infiltration and exfiltration of water from the containment system also affects the quality of the sludge. In monsoon season, during high rainfall the infiltration of the water into the septic tank dilute sludge. The SS content will be less and so will be the BOD and COD of the water.

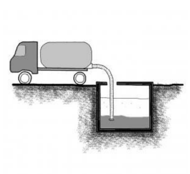
The cities having low average annual temperature will experience high sludge production rate. The rate of digestion of the sludge reduces at lower temperature and hence septic tank fills up at a faster rate.

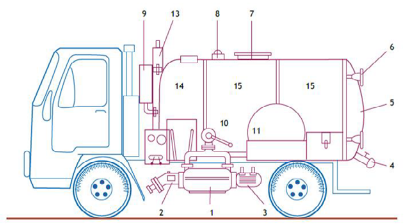
Operational factors

Equipment used

- Human powered emptying – thicker sludge
- Motorised emptying – diluted sludge







Vacuum pump

- High power – does not need water for dilution
- Low power – needs water for reducing viscosity

The collection method also determines the consistency of the septage from the septic tank. In cases, where the septic tank is not desludged for prolonged time, water is used to break the sludge and help the vacuum to work efficiently. In that case the water content in the septage will be higher.

Summary

- Parameters considered for characterisation of FSS is same as those considered for wastewater
- FSS although similar in characteristics, is stronger than sewage (organic and solid concentration)
- Characteristics of FSS change depending upon the source of waste
- Characterisation ratio is considered while choosing the right treatment processes
- Operational factors affect the characteristics of FSS

Session

05

Sewage Treatment Plant and Co-treatment

5. Sewage Treatment Plant and Co-treatment

Learning objectives

- Understand the objectives, processes and different stages of sewage treatment
- Learn the approach for co-treatment of faecal sludge and septage (FSS) with sewage in sewage treatment plant and know about the impacts of unscientific addition of FSS on sewage treatment processes

Contents

- Objectives of sewage treatment
- Treatment mechanisms - stages
    - Primary treatment
    - Secondary treatment
    - Tertiary treatment
- Treatment chain – multi-barrier approach
- Co-treatment of faecal sludge and septage (FSS)
    - Points of FSS addition for co-treatment
    - Impact of unscientific addition of FSS for co-treatment on treatment process
    - Best practices of FSS co-treatment

5.1 Sewage treatment plant

Objectives of treatment

To preserve the environmental health by limiting the entry of pollutant load directly into our natural environment

Although the ultimate aim of wastewater treatment is to reduce the quantity of pollutants entering the natural environment, in some cases the specific goals can change from case to case. Specific goals of wastewater treatment can be as follows:

- To supply water to the industry such as cement, pipe manufacturing, stone cutting or thermal power plant as process water,
- To reduce the eutrophication of the surface water bodies such as lakes,
- To reduce the dependency on the rain and irrigation canal water by reuse in agriculture in drought prone areas,
- To improve the ground water table through indirect aquifer recharge techniques.

Treatment processes

Physical	• Sedimentation • Floatation
Biological	• Anaerobic • Aerobic
Chemical	• Chlorination/Ozonation • Flocculation
Photolytic	• Ultra-violet disinfection • Photosynthesis

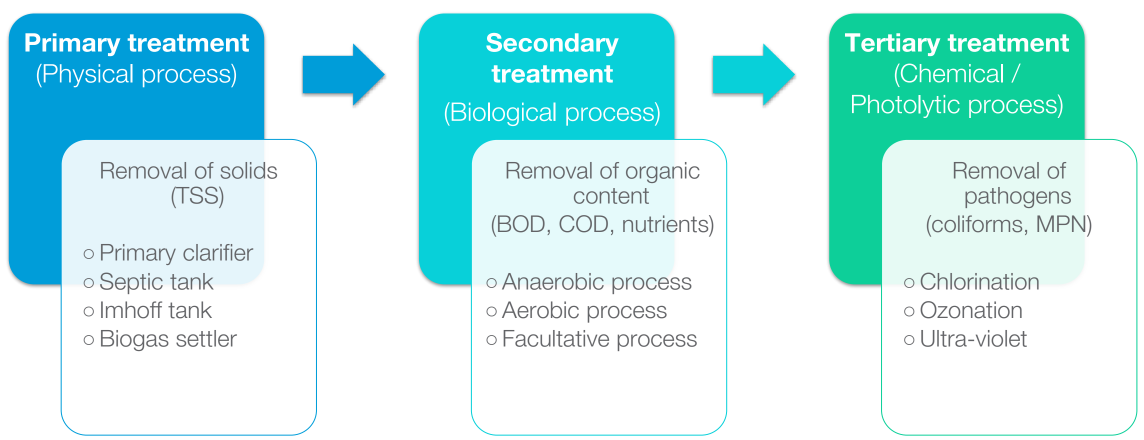
Wastewater treatment processes are of different types- Physical, Biological, Chemical and Photolytic. Physical processes are based on the physical characteristic of the wastewater constituents. Mainly it's the specific gravity of the constituent which assists the separation from the water. Biological processes relies on the micro organisms to carry out digestion of the organic matter in anaerobic or aerobic conditions. Biological processes are the main heart and soul of any wastewater treatment plant. Chemical processes relies on the use of chemicals either to treat the water (eg. Ozonation- to kill pathogens) or to assist the physical or biological processes (eg. Alum or ferric chloride to coagulate the sludge). Photolytic processes replies on the photon in the light to treat the wastewater directly (eg. UV to kill pathogens) or indirectly (eg. Photosynthesis help to uptake the nutrients from the wastewater in case of constructed wetlands).

Design parameters

- Organic loading (kgBOD/d, kgCOD/d)
- Volumetric loading rate (m^3/d)
- Temperature (°C)
- Hydraulic retention time (HRT) (hours or days)
- Sludge age (d)
- Biomass yield (kgVSS/kgCOD)
- Up flow velocity (m/s)
- Specific surface area (m^2/m^3)

The slide shows different type of design parameters used to design wastewater treatment units. The importance of few design parameter may increase or decrease from case to case basis.

Treatment stages

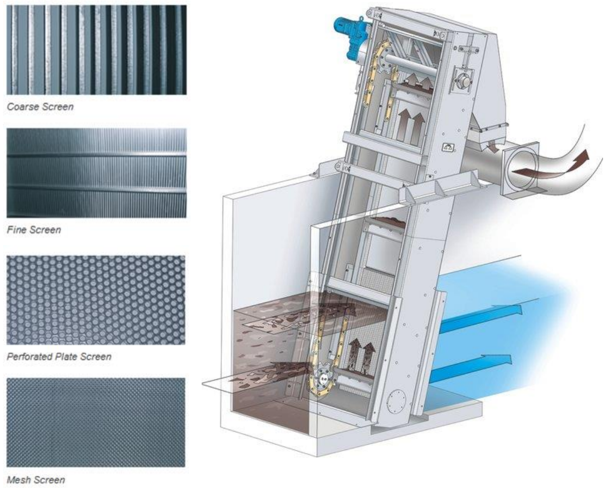


A wastewater treatment facility consist of different treatment stages combining different treatment processes. In case of wastewater treatment plant, after the preliminary treatment i.e. screening; the wastewater undergoes treatment in primary stage. In primary stage, the physical treatment processes are used to remove the easily settleable solids usually known as grit. The units which provide primary treatment are listed in the slide above. In secondary stage, biological treatment processes removes the BOD and COD using the digestion process carried out by anaerobic and aerobic micro organisms. In the tertiary stage, chemical or photolytic treatment process is used to disinfect the wastewater.

5.2 Stages of treatment in an STP

Primary treatment | Screens

- Removal of coarse solids in wastewater
- Can be of different sizes and configurations
- Manually or mechanically cleaned
- Velocity through openings during peak flow: 0.6 – 1.2 m/s



Source: www.huber.de

Screens are used to remove the solid waste from the wastewater. Different sizes and configuration of the screens are available. Screens are either manually cleaned or mechanized to clean using a raking system as shown in the slide.

Primary treatment | Screens

Operation	Size of opening (mm)	Moisture content (%)	Specific weight (kg/m^3)	Volume of screening (L/1000 m^3)	
				Range	Typical
Coarse screen	12.5	60-90	700-1100	37-74	50
	25	50-80	600-1000	15-37	22
	37.5	50-80	600-1000	7-15	11
	50	50-80	600-1000	4-11	6
Fine screen	12.5	80-90	900-1100	44-110	75
Rotary drum screen	6.25	80-90	900-1100	30-60	45

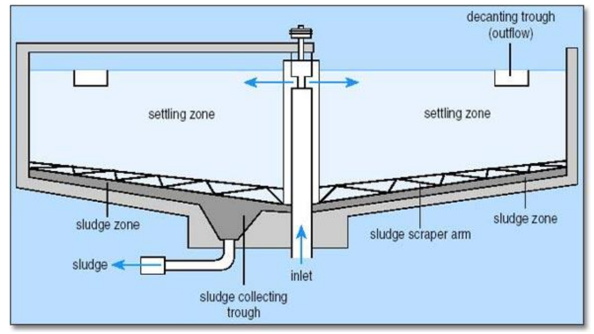
Source: Metcalf and Eddy (2003), Wastewater Engineering

In this slide, the specifications of different types of screens i.e. coarse screen, fine screen and rotary drum screens are shown.

Primary treatment | Grit chamber

Horizontal flow – Circular grit chamber

- Horizontal velocity – 0.25 to 0.4 m/s
- Removal of grit: 95% of 0.15 to 0.21 mm
- Cleaned mechanically



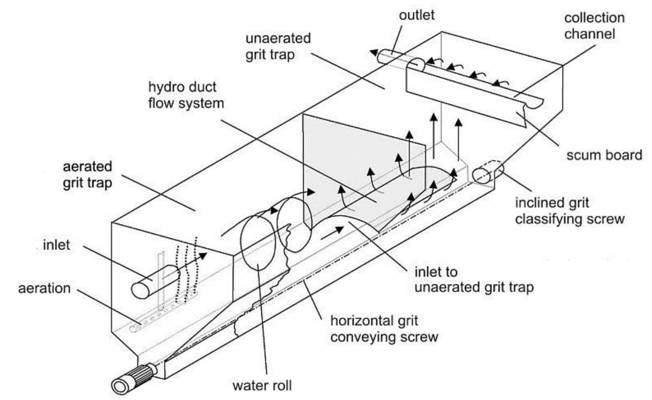
Source: http://sewagetreatment.us

Horizontal Flow – Circular Grit Chamber. In the horizontal flow circular type, the flow passes through the chamber in a horizontal direction and the straight-line velocity of flow is controlled by the dimensions of the unit, an influent distribution gate and a weir at the effluent end. The units are designed to maintain the horizontal velocity in between 0.25 – 0.4 m/s. These are normally designed to remove 95% of the 0.15mm diameter particle at peak flow.

Primary treatment | Grit chamber

Aerated grit chamber

- Spiral flow pattern
- Detention time at peak flow rate – 2 to 5 min
- Grit quantities: 0.004 to 0.20m^3/10^{3}m^3

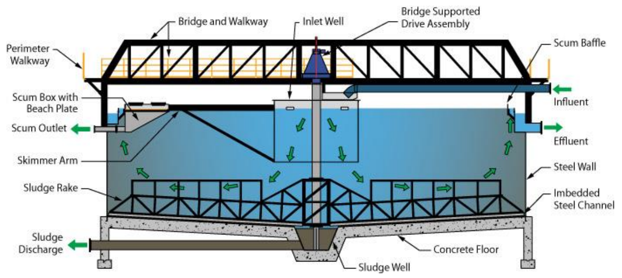


Source: www.huber.de

Aerated grit chamber – In aerated grit chambers, air is introduced along one side of a rectangular tank to create a spiral flow pattern perpendicular to the flow through the tank. The heavier grit particles that have higher settling velocities settle to the bottom of the tank. Lighter, principally organic particles remain in suspension and pass through the tank. These chambers are normally designed to remove 0.21mm diameter or larger with 2 – 5min detention periods at peak hourly rate of flow.

Primary treatment | Clarifier

- Separates suspended solids through gravity settling
- Reduces organic load on secondary stage of treatment
- Mechanically cleaned
- Detention time – up to 4 hrs
- TSS removal: 50-70%
- BOD removal: 25-40%



Source: Wastewater Engineering by Metcalf and Eddy (2003)

Application of Primary Clarifier:

- Inorganic suspended solids or grit if it is not removed in grit chamber described earlier
- Organic and residual inorganic solids, free oil and grease and other floating material
- Chemical flocs produced during chemical coagulation and flocculation
- Mechanically cleaned tanks of standardized circular or rectangular design

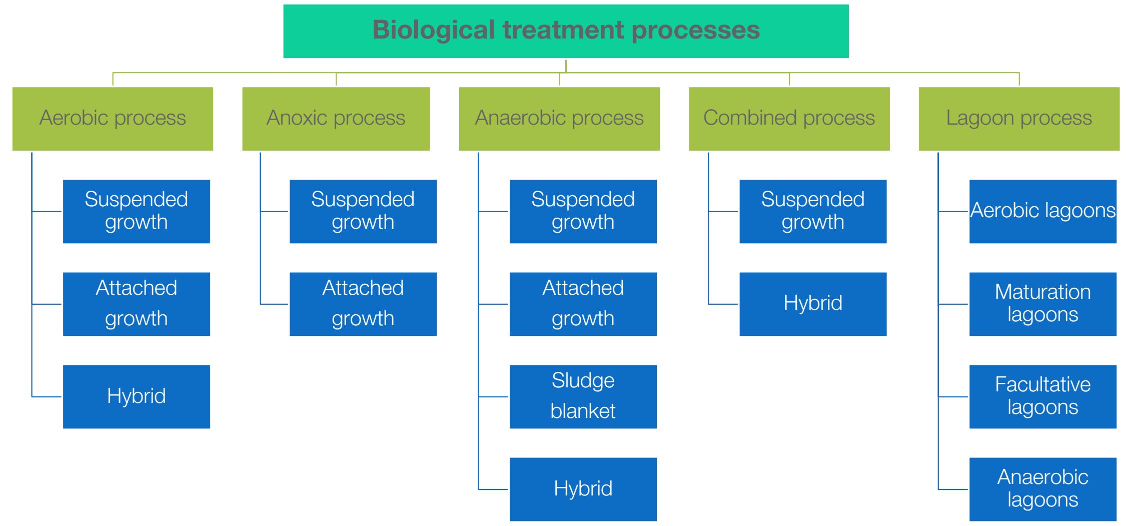
Secondary treatment - Objectives

Objectives

- Transform (oxidize) dissolved and particulate biodegradable constituents into acceptable end products
- Capture and incorporate suspended and non-settleable colloidal solids into biological floc or biofilm
- Transform or remove nutrients such as nitrogen and phosphorus
- Remove specific trace organic constituents and compounds

The key objective of secondary treatment of wastewater is oxidizes the dissolved and particulate biodegradable constitutes into acceptable end products. It also captures and incorporate the suspended and non-settleable colloidal solids into biological floc or biofilm form. In this treatment stage, we can transform or remove nutrients such as nitrogen & phosphorus and specific trace organic constitutes and compounds.

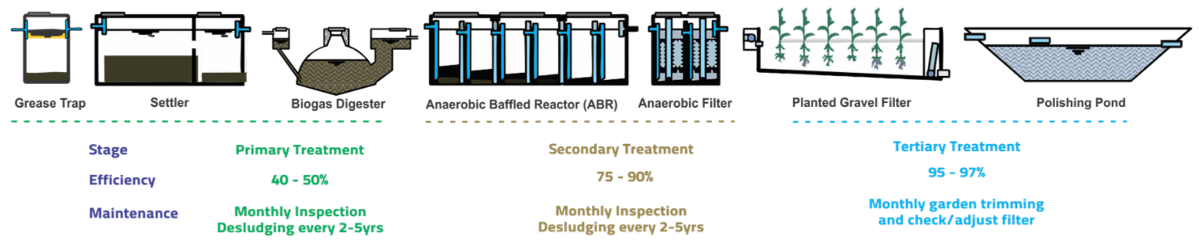
Secondary treatment



Benefits of Biological Treatment Processes:

a. Most of the aerobic processes provide carbonaceous BOD removal and nitrification.
b. All anoxic processes provide denitrification.
c. Most of the anaerobic processes provide carbonaceous BOD removal and stabilisation.
d. Combined processes provide carbonaceous BOD removal, nitrification, denitrification & phosphorus removal.

Non-mechanised treatment system - DEWATS

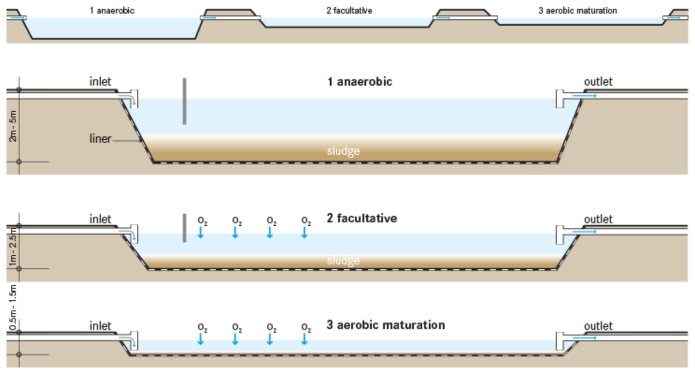


- An approach, rather than just a technical hardware package
- Treatment of wastewater flows 1 – 500 KLD
- Reliability, longevity and tolerance towards inflow fluctuation
- No sophisticated control and maintenance required
- Works without energy- cannot be switched off!
- Guarantees permanent and continuous operation
- Is not the best solution everywhere!
- Suitable where skilled and responsible operation and maintenance cannot be guaranteed

Non-mechanised treatment system - WSP

Lagoon biological process - Waste stabilisation ponds

- Sedimentation and biological processes
- High pathogen reduction and relatively high removal of NH_3 and P
- BOD & TSS removal: 90%
- HRT: 20 to 60 days

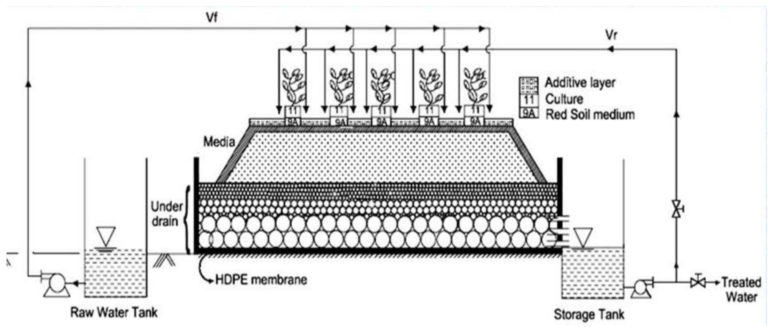


Source: TILLEY et al. (2014)

Non-mechanised treatment system - SBT

Combined hybrid biological process - Soil bio-technology

- Filtration, degradation
- Microbiological attachment, growth and transfer of oxygen
- COD_{eff}: < 50 mg/L
- BOD_{eff}: < 10 mg/L
- TSS_{eff}: < 10 mg/L

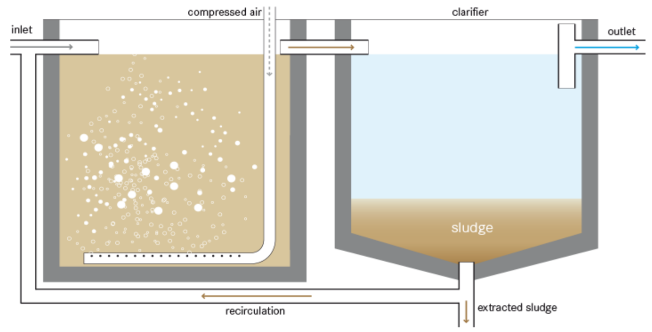


Source: www.sugam.in

Mechanised treatment system - ASP

Aerobic suspended growth biological process - Activated sludge process

- BOD removal: 80 to 90%
- TSS removal
- P accumulated in biomass and removed via sludge
- High N removal (if anoxic reactor is included)
- Low pathogen removal
- HRT of some hours up to several days



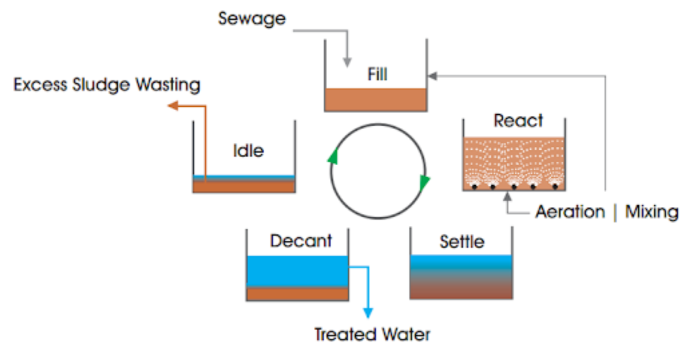
Source: TILLEY et al. (2014)

An activated sludge process wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter. Part of organic matter is synthesized into new cells and part is oxidized to CO2 and water to derive energy. In activated sludge systems the new cells formed in the reaction are removed from the liquid stream in the form of a flocculent sludge in settling tanks. A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge.

Mechanised treatment system - SBR

Aerobic suspended growth biological process - Sequential batch reactor

- Batch process consisting of 4 to 5 steps
- Flexibility of treatment
- BOD, COD and TSS removal: up to 90%
- N removal if anoxic reaction is integrated
- P removal is high



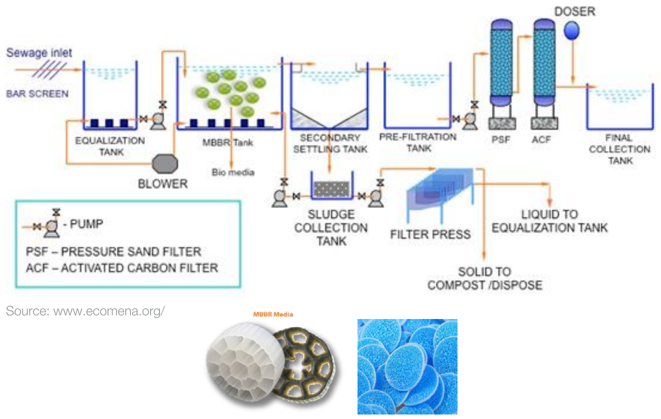
Source: Ethics Infinity Pvt. Ltd.

A sequencing batch reactor is a fill-and-draw activated sludge system for wastewater treatment. Oxygen is bubbled through the wastewater to reduce biochemical oxygen demand (BOD) and chemical oxygen demand (COD), producing a high-quality effluent with a low turbidity and nitrogen levels capable of meeting CPCB effluent quality standards. The SBR accomplishes equalization, aeration, and clarification in a timed sequence in a single reactor basin. By varying the operating strategy; aerobic, anaerobic, or anoxic conditions can be achieved to encourage the growth of desirable micro-organisims.

Mechanised treatment system - MBBR

Aerobic attached growth biological process - Moving bed bio-reactor

- Biological treatment with floating media and aeration
- Specific surface area of media varies from 300 to 4000 m^2/m^3
- Suitable for treatment of weak wastewater
- BOD and P removal: 80 - 90%
- Low pathogen removal

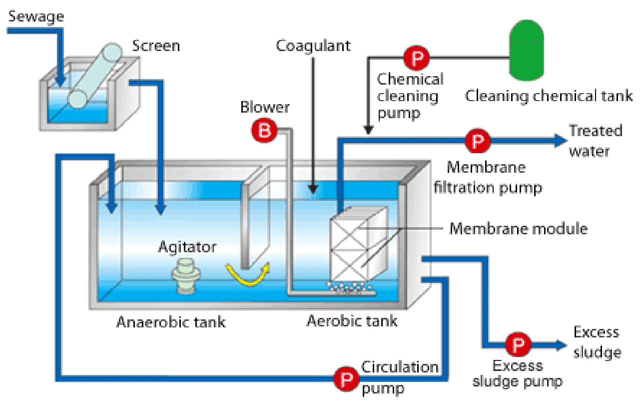


MBBR is a highly effective biological treatment process based on a combination of conventional activated sludge process and biofilm media. The MBBR process utilizes floating media within the aeration and anoxic tanks. The microorganisms consume organic material. The media provides increased surface area for the biological microorganisms to attach and grow. The increased surface area reduces the footprint of the tanks required to treat the wastewater. The treatment process can be aerobic and/or anaerobic and operates at high volume loads.

Mechanised treatment system - MBR

Aerobic attached growth biological process - Membrane bio-reactor

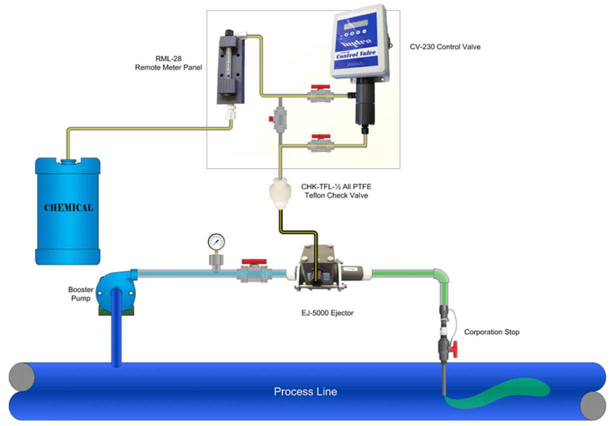
- Biological treatment coupled with membrane filtration
- Minimal area requirement
- High O&M cost
- High performance efficiency and consistency
- BOD, COD, TSS, nutrients removal: > 90%



The Membrane Bioreactor or MBR is based on the conventional wastewater process, but the separation of micro-organisms is performed by filtration with membranes. The MBR has some distinctive advantages compared with the conventional treatment systems: (1) very compact design, (2) high quality effluent and (3) low sludge production.

Tertiary treatment | Chlorination

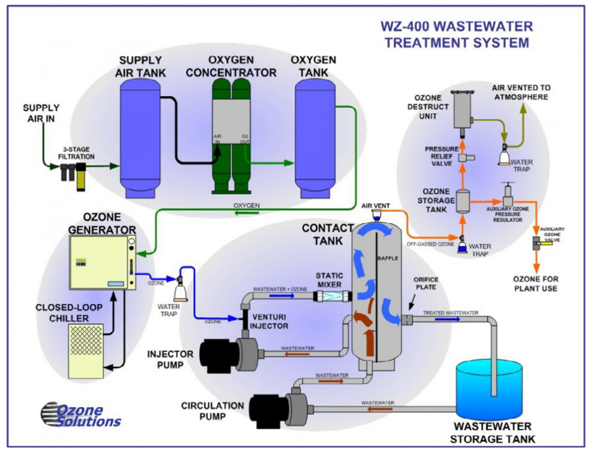
- Provides prolonged effect
- Eliminates obnoxious odour
- Residual chlorine is toxic to aquatic life
- Highly corrosive and hence storage, shipping and handling pose a risk



Chlorination is by far the most common method of wastewater disinfection and is used worldwide for the disinfection of pathogens before discharge into receiving streams, rivers or oceans. Chlorine is known to be effective in destroying a variety of bacteria, viruses and protozoa, including Salmonella, Shigella and Vibrio cholera. Chlorination plays a key role in the wastewater treatment process by removing pathogens and other physical and chemical impurities. Chlorine's important benefits to wastewater treatment are listed as follows: (a) Disinfection, (b) Controlling odor and preventing septicity, (c) Aiding scum and grease removal, (d) Controlling activated sludge bulking, (e) Controlling foaming and filter flies, (f) Stabilizing waste activated sludge prior to disposal, (g) Foul air scrubbing, (h) Ammonia removal.

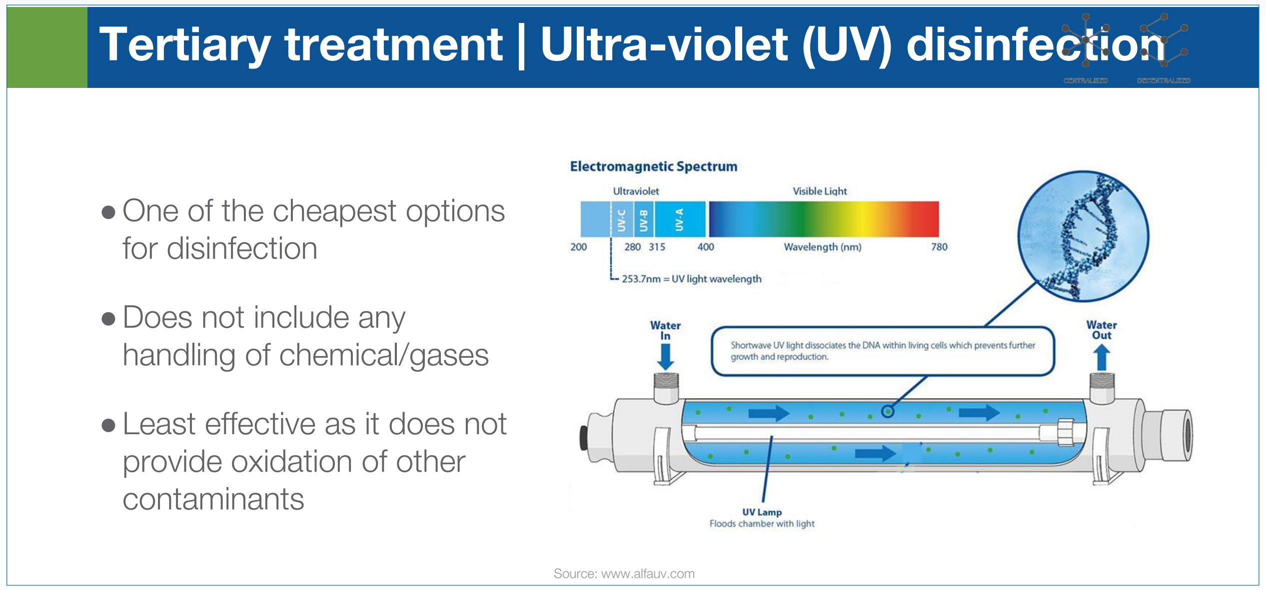
Tertiary treatment | Ozonation

- Infusion of ozone
- Highly technical and complex equipment is required
- High efficiency
- Relatively high O&M cost
- Expensive than chlorination

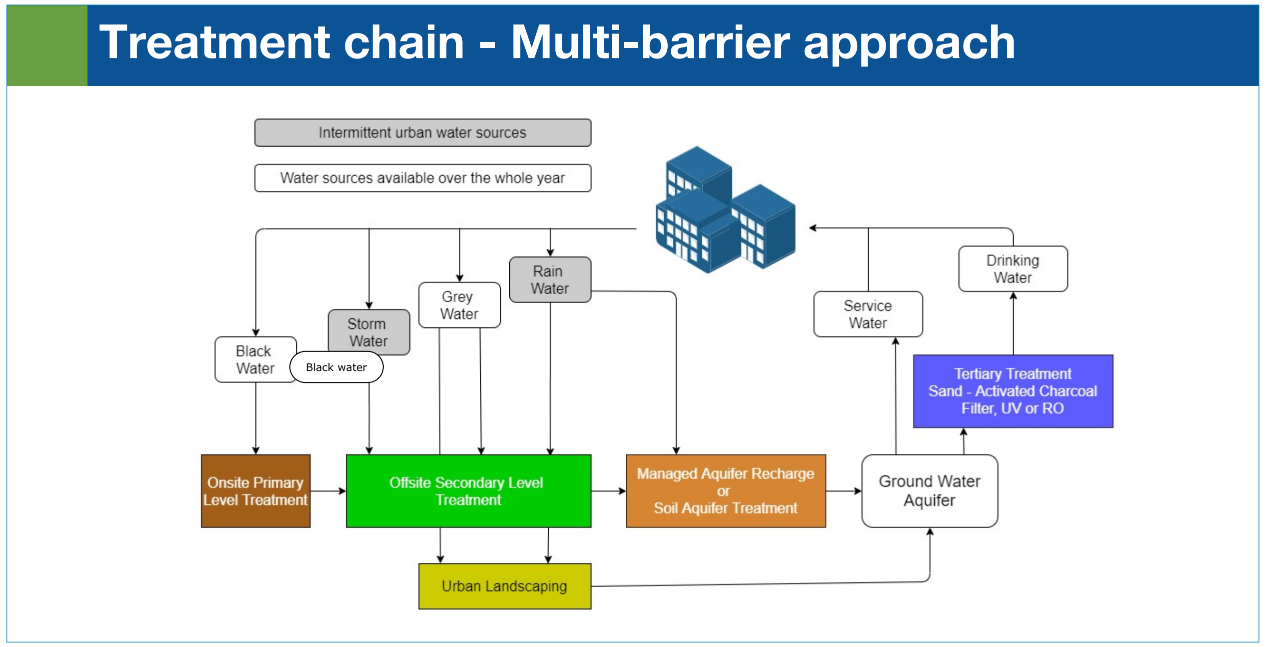


Source: Ozone Solutions

Disinfection of water using ozone is advantageous compared to more traditional methods, such as chlorine or UV disinfection. Ozone effectively breaks down the lipid layers in the cell membrane. Firstly, ozone is more effective at deactivating viruses and bacteria than any other disinfection treatment, while at the same time requiring very little contact time.



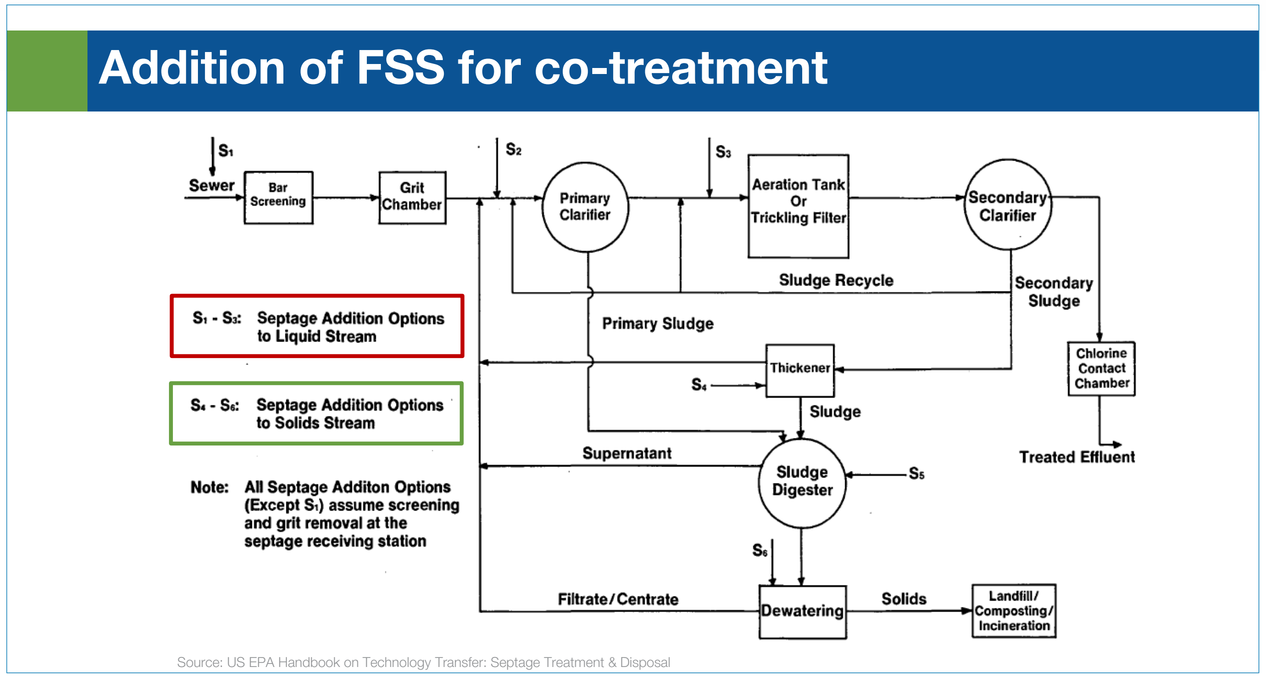
An ultraviolet (UV) disinfection system transfers electromagnetic energy from a mercury arc lamp to pathogenic organism's genetic material (DNA and RNA). When UV radiation penetrates the cell wall of a pathogenic organism, it destroys the cell's ability to reproduce. The effectiveness of the UV disinfection is depending on the characteristics of wastewater, the intensity of UV radiation, the amount of time the microorganisms are exposed to the radiation and the reactor configurations.



The multi barrier approach focusses more on integration of natural water treatment technologies in the urbanscape. These technologies treat perennial and intermittent water sources with special emphasis on resource recovery and reuse.

The approach was successfully demonstrated through Indo-EU project called NaWaTech.

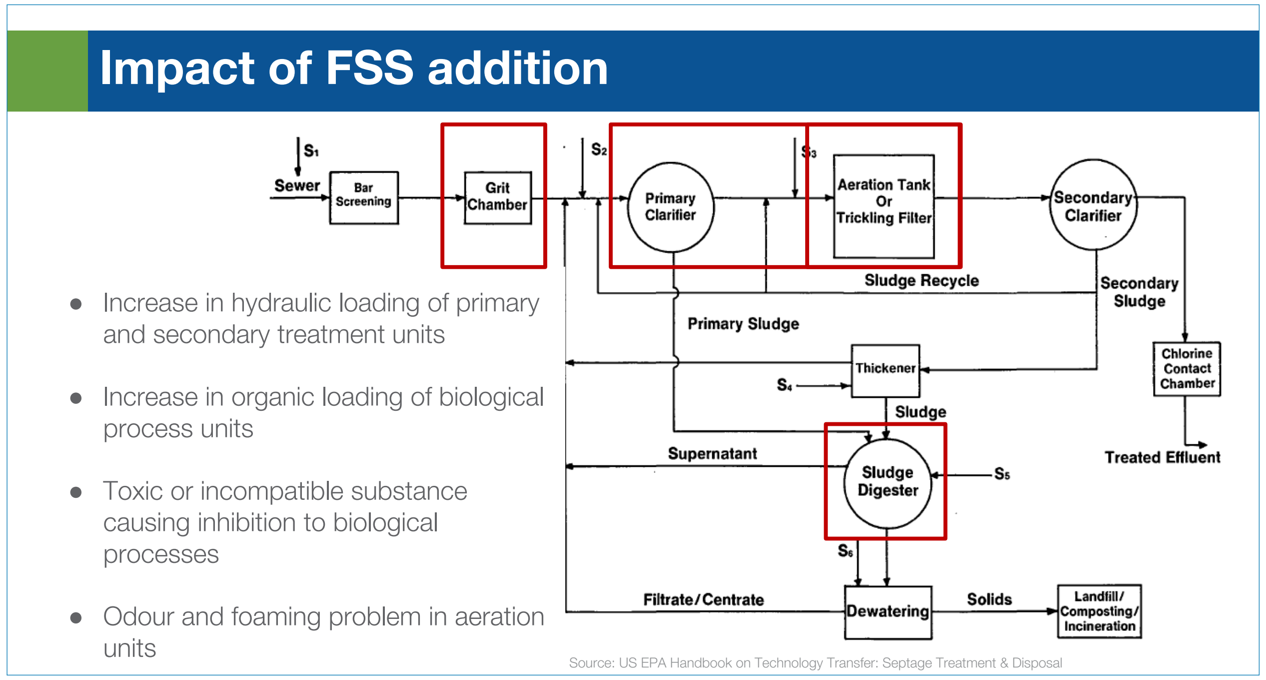
5.3 Co-treatment of faecal sludge and septage



Pretreated septage can be added in liquid stream or sludge stream as shown in the diagram. There are three points in each stream where pre treated septage can be added.

The point of addition is mainly decided by the kind of pre treatment i.e. provided to the raw septage. It also depends on the efficiency of these pre treatment processes and the type of addition i.e. slug loading or controlled loading. A careful analysis designed – utilised hydraulic and organic loading rates is needed to decide the point of addition of pre treated septage to the treatment chain. Only through such analysis one can understand the possible impacts co treatment will have and be able to plan for the mitigation of the problems accordingly.

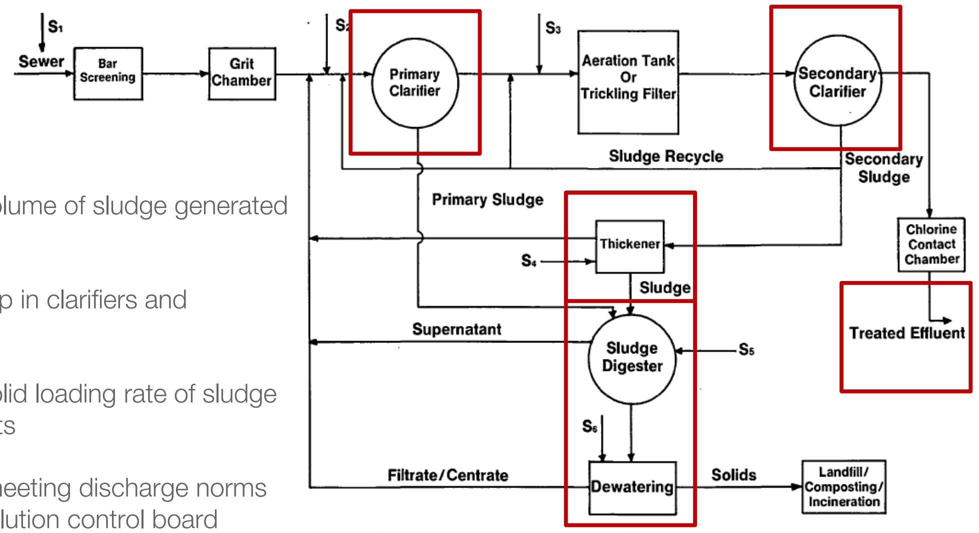
It is to be noted that addition to the liquid stream will have higher risk of affecting the STP performance as it will affect both the treatment chains i.e. liquid and sludge treatment chain.



- Smaller STPs are more prone to this problem. Even a tanker load of septage can increase the hydraulic load to the primary clarifier and aeration tank. Retention time of both the components will get reduced for a specific duration. The primary clarifier will not efficiently remove the solids and transfer them to the secondary stage where higher oxygen transfer will be required to digest the organic constituents. This is only possible if the aeration unit has buffer capacity. Retention time of aeration tank will also be reduced and as a result of this the effluent from the secondary stage will not meet the designed output.
- Increased organic load to the biological treatment units hampers the efficiency of treatment. The effluent from these units do not meet the design assumptions and may also hamper the further treatment chain.
- If the receiving station is not monitored and industrial sludge of septage containing toxic substance is introduced, then the microbial balance in the biological steps gets hampered. Toxic substances change the pH of the reactors and microorganisms are susceptible to the pH. Thus the efficiency of the treatment decreases and revival of it takes a considerable amount of time.
- Odour and foaming problem occurs in case of slug loading. Due to shock load, there are chances that septic conditions are created. This leads to problems related to odour and foaming.

Impact of FSS addition

- Increase in volume of sludge generated in clarifiers
- Scum build-up in clarifiers and thickener
- Increase in solid loading rate of sludge treatment units
- Effluent not meeting discharge norms set by the pollution control board

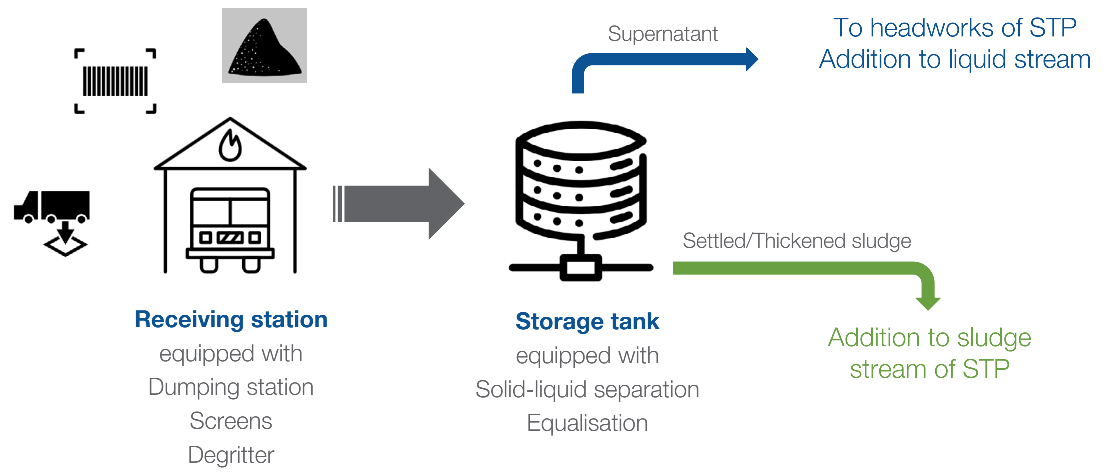


Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

- Co-treatment of septage and sewerage surely impacts generation of sludge in the clarifiers. Primary sludge will now have higher percentage of organic content. The increase in the sludge quantities surely impact the sludge treatment chain. In the cases where the sludge handling facility is does not have a buffer capacity, this will create major challenge. The bio solids now created wont be digested and dewatered as expected. In case of anaerobic digester, there are high chances of the digester becoming sour due to excessive acid formation. However, in case of aerobic digester, it is seen that the BOD removal efficiency increases.
- If oil, grease and fats are not removed during the pre treatment of the raw septage, scum builds up in the clarifiers. Skimming of this excessive scum is the only remedy. This can be achieved by increasing the rpm of the skimmers and extending the length of it.

- Due to increase in the sludge production, the solid loading rate increases in the sludge treatment units. Septage inherently takes time to thicken as compared to sewage sludge. Addition of septage hinders the thickening process. Increase in the solid loading in digester leads to souring if the solids are high on organic content. The dewatering equipment usually have constraints on Kg of solids it can handle. If the solid content increases, then the wear and tear increases. However, the efficiency of dewatering increases.
- Finally if the liquid treatment chain gets affected, there are high chances that the treated effluents do not met the discharge norms set by the pollution control board. This situation needs to be avoided as far as possible, as reviving the performance of the plant to achieve the set standards is difficult and time consuming process. The increase in the pathogen levels can be catered to by increasing the chlorine/ozone dosing or increasing the intensity of the UV.

Addition of FSS to waste streams – best practices



The safest and less risky way to co treat septage and sewage is to separate the solids and liquids and provide a control feed to the STP based on the actual flow rate during the day. In this way, higher quantities of the septage can be handled with creating a large impact on the STP components and its performance. Such receiving stations can also be planned at the sewage pumping station where the supernatant will be discharged into the sewer line and the solids can be hauled at the STP for addition in the sludge treatment stream directly.

Summary

- Purpose and goal of wastewater treatment should be clear before considering different options for treatment
- Wastewater treatment technologies consist of different stages or components and their design needs to be understood while designing the system
- Nitrification, denitrification and aerobic treatment is needed in order to achieve standards of treatment
- Wastewater treatment system design needs to be studied before deciding the points of addition of faecal sludge and septage while adopting co-treatment approach

Session

06

Planning of Co-treatment of Sludge with Sewage

6. Planning of Co-treatment of Sludge with Sewage

Learning objectives

- To familiarize the participants with steps involved in planning and scaling up of co-treatment of faecal sludge and septage with sewage at an STP
- To understand the impact of unscientific addition of faecal sludge and septage in the sewerage network
- To showcase the administrative controls required for a smooth implementation of co-treatment at an STP

Content

- Planning for co-treatment
  - Identifying opportunities
  - Checklist for collection of data
- Adding sludge in sewerage system
  - Working of sewerage system
  - Impact of sludge addition at
    - Manhole chambers
    - Sewage pumping station
- Administrative controls
  - Before commissioning co-treatment
    - Byelaws
    - Licensing of operators
    - Monitoring of sludge characteristics
  - Performing co-treatment
    - Standard operating procedure
    - Monitoring tipping of sludge
    - Monitoring at STP

6.1 Identifying co-treatment opportunities

Identifying opportunities

- Wastewater management infrastructure
- Sewerage network and its appurtenances – manhole chambers, pumping station, lift stations
- Sewage treatment plant - treatment units, design criteria, layout of the plants


Manhole Chamber


Sewage Pumping Station


Sewage Treatment Plant

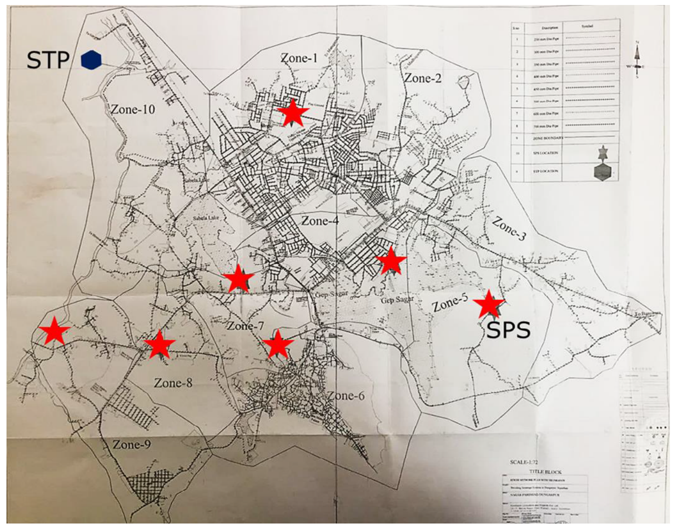
For co-treatment of faecal sludge and septage with sewage, complete overview of wastewater management infrastructure needs to be taken. For this the two key elements is the sewerage network and the Sewage Treatment Plant (STP). The sewerage network comes into picture in the collection and transport stage of a sewered sanitation whereas the STP comes in the treatment stage.

In sewerage network, there are multiple elements such as – sewer pipes, junctions (commonly known as manhole chambers), lift stations and sewage pumping station. For the purpose of co-treatment, sewage pumping stations are of primary importance along with manhole chambers in some cases. Since, the treatment of the faecal sludge and septage will be ultimately happening at the STP, the complete STP with its liquid and solids treatment chain needs to be investigated.

Sewerage network

Sewage pumping stations

- Catchments/zones
- Location
- Layout
- Schematic diagrams
- Capacity
- Installed units



Source: Dungarpur Municipal Corporation

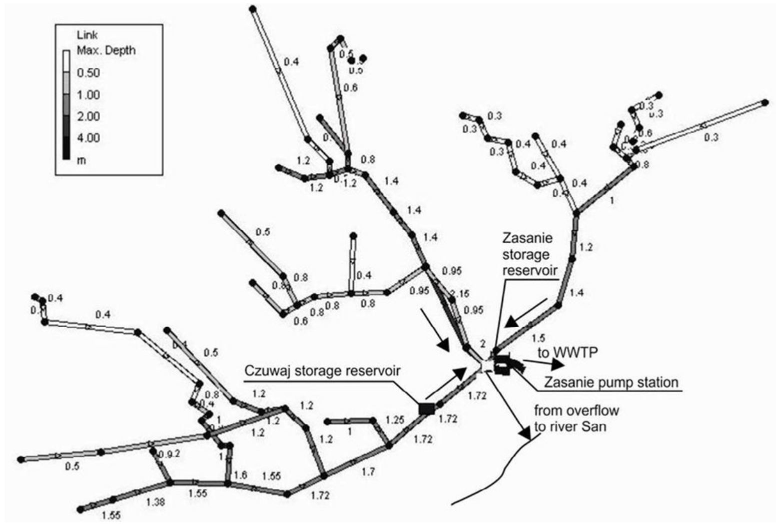
For studying the sewerage network, the sewerage map is the basic requirement. Using the sewerage map one can know the catchments or sewerage zones, the location of the lift stations and sewage pumping stations (SPS). This information plays a critical role during the planning stage of the co treatment project. The specific data pertaining to each sewage pumping station such as its design capacity, the schematic diagram and list of electro mechanical components installed, one needs to details mentioned in tabular format on these drawings or its annexures. Alternatively, such data can also be seen in DPR. Selection of SPS for further investigation can be done based on this information.

The selected SPS should be investigated in detail. First and foremost, layout of the SPS should be checked. The layout should be such that the a receiving station can be constructed for receiving the daily trips of the trucks. If this criteria is satisfied then the things to be checked are the design flow rate, design of grit chamber, mechanism to remove grit and screenings and the (solids handling) capacity of the pumps.

Sewerage network

Manhole chambers

- Locations
- Depth
- Size of the incoming and outgoing sewer
- Gradient of the incoming and outgoing sewer

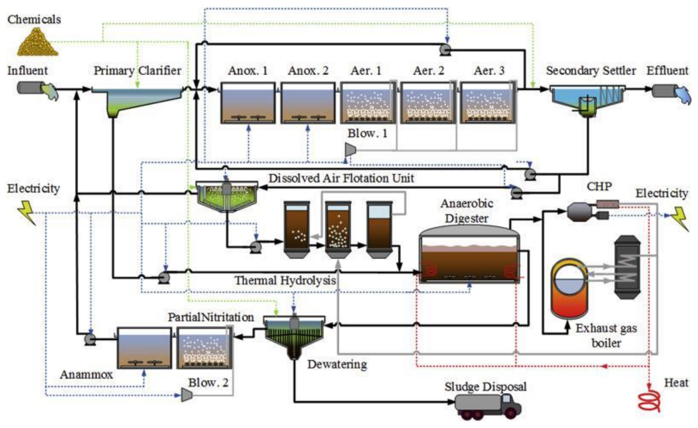


Source: Slys D. and Atec A.; 2012

In certain cases, where in the daily load is minimal as compared to the flow in the sewer, the sludge can be decanted in the manholes. In such cases, identification of manholes can be done using the individual catchment maps. The primary details of the manholes which one needs to know are the invert level of the chamber, incoming and outgoing pipes. With this the gradient for the pipes will also be useful to assess to risk of decanting faecal sludge and septage with high solids content.

Sewage treatment plant

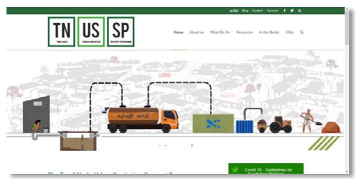
- Layout of treatment plant
- Treatment stages
- Treatment units
- Electro-mechanical components
- Design criteria and values
- Consumables



Source: Fernandez Arevalo T. et al.; 2017

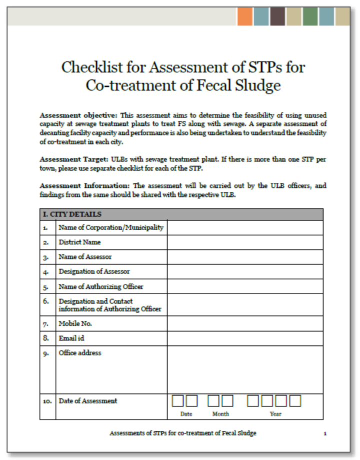
In case of sewage treatment plant (STP), the layout of the plant and adjoining areas or the main pumping station needs to be checked. If there is adequate space to accommodate a receiving station, then further investigation of the STP is recommended. While conducting detailed investigation, the schematic of treatment chain, the design criteria for treatment units, electro mechanical components needs to be analyzed. The current quantity and cost of consumables needs to be recorded. This helps to perform a cost benefit analysis, to ascertain financial viability of the project. This data will be further used to make changes in the working contracts between the local government and the STP operator, so as to mitigate the risk of dispute and legal issues later on in the project..

Checklist for data collection

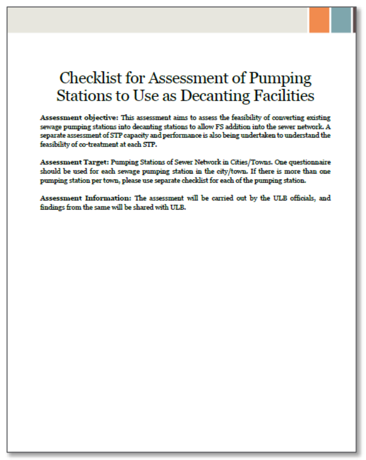


Tamil Nadu Urban Sanitation Support Program (TNUSSP)

Tamil Nadu has commenced state-wide co-treatment


Checklist for Assessment of STPs for Co-treatment of Fecal Sludge

Comprehensive data collection checklist for STP


Checklist for Assessment of Pumping Stations to Use as Decanting Facilities

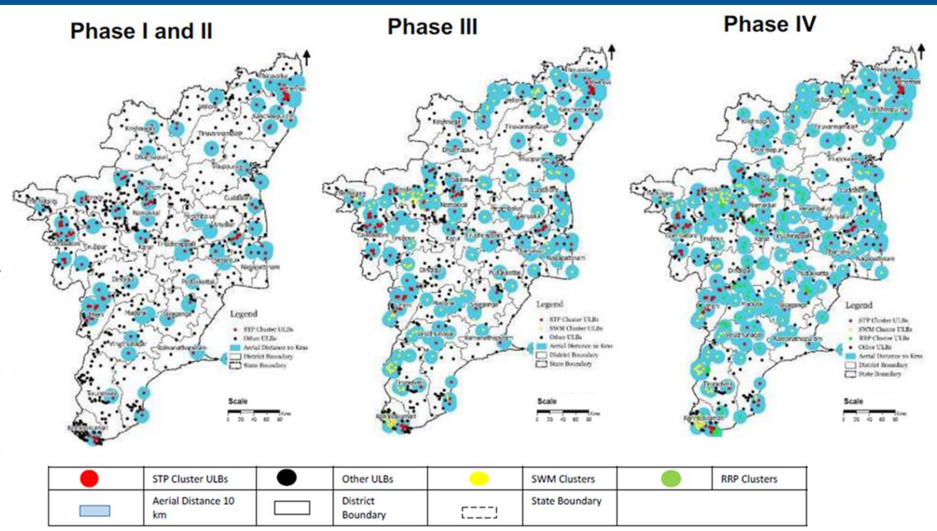
Comprehensive data collection checklist for SPS

A comprehensive checklist for collection of data at STP and SPS has been created by one of the SCBP partners, Indian Institute of Human Settlements (IIHS), Chennai. IIHS is engaged by the state of Tamil Nadu to plan and implement sanitation projects across the state. The Tamil Nadu Urban Sanitation Support Program (TNUSSP) is one such platform created by IIHS to facilitate the exchange of resources. The checklist and other research and projects documents can be accessed through TNUSSP website. The checklist is provided to the participants as a part of this design module.

Scaling up of co-treatment

Suggested phase-wise coverage of ULBs for FSM

1. **Phase I and II** co-treatment at STPs in all ULBs.
2. **Phase III** Municipalities with Solid Waste Management (SWM) sites.
3. **Phase IV** Town Panchayats land secured within Resource Recovery Parks (RRP).
4. **Phase V** ULBs not falling in any of the above clusters.



Planning and scaling of co-treatment should be the first stage in FSSM across the state. In the case of Tamil Nadu, all the STPs were identified and studied. The STPs where co treatment was feasible were plotted on the map (red dots) and the 10 km radius circles (blue circles) were used to define the clusters. On a macro level, it can be seen that geographically lot of area can be covered with this approach. The same approach is taken with MSW plants for using co composting of the faecal sludge and septage.

Although the planning seems to be straight forward and simple, the challenges appear during the execution stage. The main challenge is financial transfers between the two ULBs or the Gram Panchayat and the ULB for accepting and treating the waste. So very strong administrative controls need to set up for scaling up of co treatment across the state.

Planning for co-treatment through CWIS approach

- Apart from the earlier steps for planning of co-treatment, a key step is to assess sanitation requirements of citizens, especially the unserved or underserved population like women and children, marginalized, etc.
- CWIS approach emphasises on service provision and creating an enabling environment, rather than simply focusing on building infrastructure:
  - This approach aims to pool together urban services like water supply, drainage, greywater management, and solid waste management into a comprehensive urban sanitation plan.
  - Such a comprehensive plan will bring together both infrastructure as well as non-infrastructure components including all stakeholders, strong institutional arrangements and service

6.2 Adding FSS in sewerage system.

Working of gravity sewers

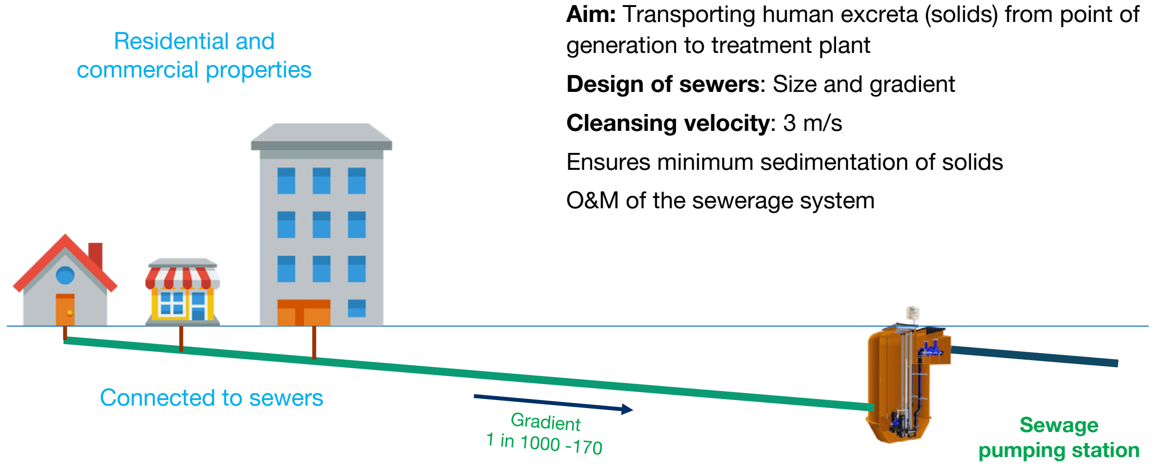
Aim: Transporting human excreta (solids) from point of generation to treatment plant

Design of sewers: Size and gradient

Cleansing velocity: 3 m/s

Ensures minimum sedimentation of solids

O&M of the sewerage system

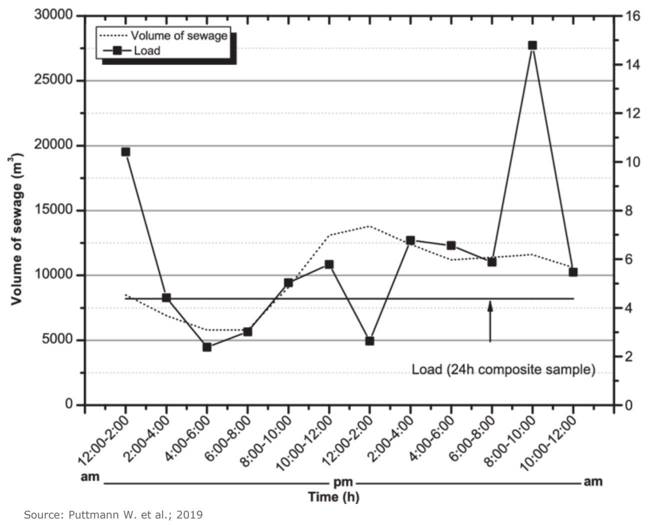


The aim of the gravity sewers is to transport the solids i.e. the human excreta from the points of generation to the treatment plant, where it will be treated and the treated end product will be reused or responsibly disposed off in the environment. The design of the sewer i.e. the diameter of the sewer and the gradient i.e. the slope of each pipe between two nodes is critical. The design criteria here is not the let the solids settle and the system to attain self-cleansing velocity of between 3 – 6 m/h. According to the CPHEEO Manual on Sewerage and Sewage Treatment Systems, it is recommended that after reaching the depth of 6m, a sewage pumping station needs to be set up. However, in practice, the SPS are even implemented at larger depths. To be able to function as designed, the sewerage systems need to be operated and maintained well. The usual operations are to carry out inspections and checks for breakage and intrusion of roots in the pipes. As a part of preventive maintenance to avoid clogging, use of sewer jetting machines to remove the wax and grit and rodding machines to unclog the pipes is recommended. Periodic desludging of manhole chambers is also needed to avoid clogging of the chambers during the peak flow.

Impact of FSS addition

Manhole chamber

- Diurnal variation of flow and load
- Discharge during peak hours: No deposition of solids, however significant increase in load at STP
- Discharge during non-peak hours: deposition of solids, leading to clogging
- Erosion of inner wall pipes, reducing its life significantly



Source: Puttmann W. et al.; 2019

Diurnal curve as shown in the slide represents the hourly variation in the volume as well as organic load in the sewerage system. From the graph it is visible that the peak hours (time when peak flow occurs in the system) is in the morning and later in the evening. It can also be observed the diurnal curve of the organic load does not match with that of hydraulic load and hence, it is very important these variations if addition of sludge needs to be done at manholes. The curves will very for different sewer catchments (sewerage zones) in a city. Hence, for planning co-treatment in a city, the locations of the sewerage systems in the specific sewerage catchment need to be checked.

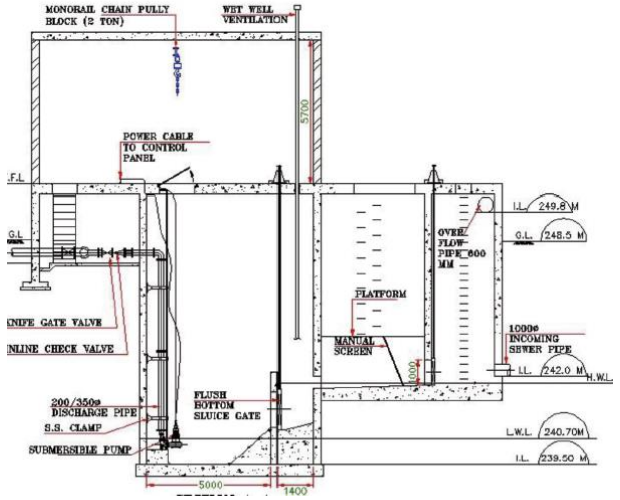
Addition of sludge during peak hours in the manhole chamber might help to avoid deposition of solids into the sewers; however, this might also result in increase in shock loading at the STP if the hydraulic and organic loading diurnal curves match.

Addition of sludge during the non-peak hours, might lead to deposition of solids and clogging of pipes or subsequent chambers. In such cases, during the next peak flow, some of the solids might dislodge and get carried with the water. However, this results in heavy erosion of the inner walls of the pipe leading to breakage and leakage.

Impact of FSS addition

Pumping station

- Ideally consists of:
  - Screens
  - Grit removal
  - Wet well and pump set
- Higher solids content can:
  - Damage the pumps
  - Erode the pipes
- Long term impact:
  - Increase in the maintenance of the pumps and other appurtenances
  - Decrease in the effective volume of wet well



Source: CPHEEO Manual on Sewerage and Sewage Treatment Systems, 2013

According to CPHEEO Manual on Sewerage and Sewage Treatment System, the SPS should ideally consist of screens (preferably mechanized), grit removal chamber and pump sets for dry and wet weather flow. Grit removal is recommended, because higher amount of grit leads to erosion of sewer pipes (especially RCC sewer pipes are highly susceptible to erosion). However, in practice most of the times grit removal is not integrated into the SPS design (as shown in the figure in the slide taken from CPHEEO Manual). The addition of the sludge at the SPS should be done upstream, that is in the inlet side of the station. This ensures that the incoming sludge is screened, de gritted and them pumped along with the sewage. In the cases where the sludge is added to the wet well directly, the screens and the grit chamber is bypassed and there is serious chances of increase in wear and tear of the pumps. Although there might not be immediate consequences which are observed, but the long-term impact on the operation and maintenance of the such a sewerage system will be significant.

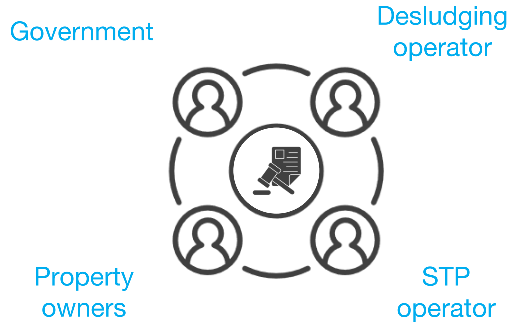
6.3 Administrative controls

Administrative controls

Before commissioning co-treatment – byelaws, paperwork, FSS characteristics
Performing co-treatment - standard operating procedure, monitoring desludging and tipping of FSS, monitoring at STP

Before commissioning - byelaws

- Byelaws to compliment policy/ strategy put forward by the state or ULB
- Contents of byelaws:
  - Roles and responsibilities of each party
  - SOPs for practicing co-treatment
  - Service indicators and benchmarks to be achieved
  - Contractual and legal implications

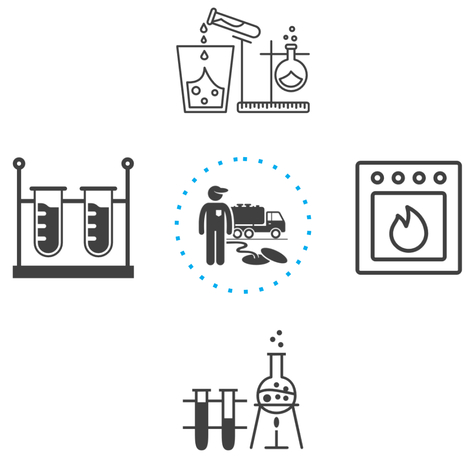


As discussed earlier in the section of planning of co treatment, the requirement of administrative controls in indispensable. The state/local government should have its own FSSM policy or strategy developed which considered co treatment as one of the approaches for FSSM. Subsequently, during the planning of co treatment, appropriate byelaws should be drafted which will be binding the key stakeholders in co treatment – local government, desludging operators, STP operators and property owners. The byelaws should definitely contain the following (but not be limited to):

(1) clarity on roles and responsibilities of each stakeholder, (2) standard operating procedure, (3) service indicators and benchmarks and (4) contractual/legal implications. Currently, in many states, the desludging service are provided by the private operators who are not bound in any way to the local government. In few cases, they do not even have a registered business and hence it is difficult to monitor them. For such irregular and informal services, the SOP and the service indicators and benchmarks bring a certain level of integrity to the business. Thus, this key information should be made available to the operators and if required an IEC campaign should be developed around it.

Before commissioning – sludge characteristics

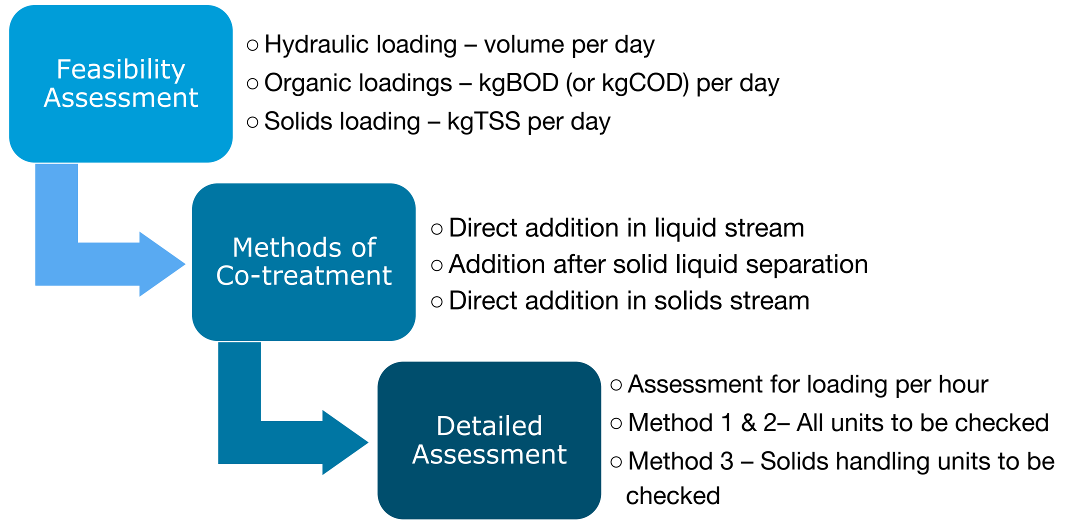
- Sludge characteristics:
  - Type of containment
  - Desludging interval
  - Dietary habits
  - Climatic conditions
  - Emptying method
- Monitoring of following parameters:
  - Total suspended solids (TSS)
  - Chemical oxygen demand (BOD)
  - Biological oxygen demand (COD)
  - Nitrogen (N)
  - Phosphorus (P)



Sludge characterization is highly recommended. Sludge characteristics can vary depending on various ground conditions such as type of containment, desludging interval, climatic conditions, emptying method and dietary habits as well.

During sludge characterization process, the following parameters need to be checked – TSS (for designing the solid liquid separation), COD and BOD (for designing biological treatment) and Nitrogen for (denitrification and nitrification treatment unit) and Phosphorus.

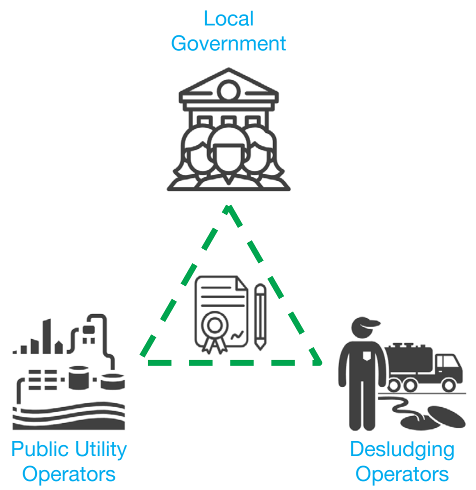
STP assessment



After characterization of faecal sludge and septage and monitoring of influent and effluent of the STP, assessment of STP can begin. First step is to perform feasibility assessment on the STP. In this stage, hydraulic loading, organic loading and solids loading is checked on the STP as a while. Unutilized loading per day is checked in order to understand the constraint parameter and the volume of faecal sludge and septage that can be co-treated. Second step is to understand different methods of co-treatment. Co-treatment can be performed in three ways as discussed in the previous session. Third step is to perform detailed assessment. In this step, relevant treatment units are checked based on the method of co-treatment.

Before commissioning - paperwork

- Certification of STP
  - Plant details and working for accommodating extra load
  - STP operator to get consent to establish and operate co-treatment
- Licensing operators
  - Truck details and RTO registration
  - License to provide service to properties
  - Need to abide to byelaws



Paper work pertaining to formal engagement with the stakeholders. Paperwork, might seem small step in the whole process, but it makes a difference when it comes to mapping out the service extent and benchmarks achieved. The STP operator should opt for certification from the local government for practicing co treatment. Co-treatment can lead to increase in secondary revenue for the operators and hence, they might be interested to opt for co-treatment at their plant. For getting the certification, the operator needs to submit details of the STP along with a strategy to manage the load coming from co-treatment. If significant changes are planned to accommodate the extra load, then the STP operator might have also to get consent from establish (receiving station and treatment units) and operate before commencing co-treatment.

Licensing the desludging operator is another way to formalize the desludging services. For this, the primary documents which can be asked for are truck details, RTO registrations etc. After assessment, the license should be provided to the operators. The operators should abide by the byelaws.

After commissioning - SOP

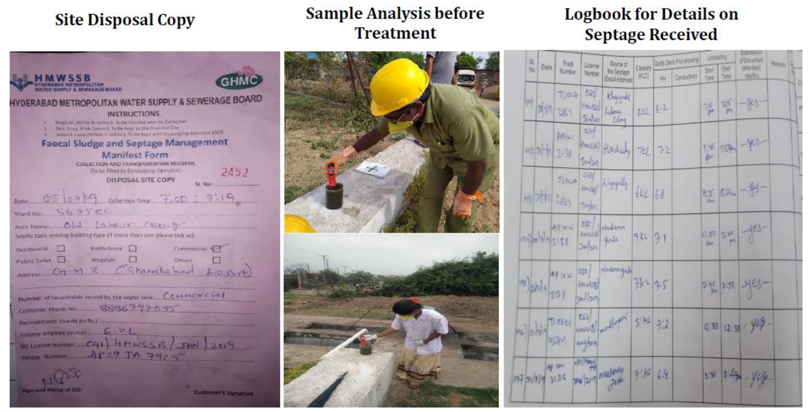
- Enforcing SOP as mentioned in the byelaws
- Standard operating procedures:
  - For employment of workforce [IS Code 11972, 1987]
  - For safe desludging of septic tanks [SOP by CPHEEO & MoHUA, 2018]
  - For vacuum trucks [IS Code 13496, 1992]
- Robust monitoring mechanisms
  - Engaging citizens for monitoring OHS in FSSM
  - Sanitary inspector to perform random surprise checks!
- SOPs to be revised based on feedback and observation

After commissioning of co-treatment, enforcement of the byelaws is important. The SOPs should be as far as possible based on the BIS Code or the guidelines and advisories put forward by the national government. The monitoring mechanisms for keeping check on the desludging and STP operators should be robust. For monitoring desludging operators citizen engagement is possible. For this IEC campaign around standards of operation needs to be done. Surprise checks can be carried out to see the adequacy of the safety and personal protective equipment and their status.

It is really important that SOP and the relevant documents are revised periodically based on the feedback taken from the operators and observations made by the sanitary inspectors. This ensures that policy makers and decision makers understand that is actually needed by the work force on the ground to improve their productivity and quality of work.

After commissioning - monitoring

- 3 copy receipt system
- Operator to produce Decanting copy before tipping.



Source: Co-treatment of Septage at STP, HMWSSB (2020)

- Logbook to maintain the record of day, time, truck, volume etc.

Incoming sludge to be checked for pH, color, EC, smell, etc.
Sampling and detailed analysis in case of any doubt

Monitoring at the receiving station before decanting the sludge into the premise is critical. A multi step approach can be used here. As shown in the slide, a 3 copy receipt system ensures that a paper trail is left with property owner, desludging operator and the STP operator. This paper trail can be used to asses the indicators for service level benchmarking. The desludging operator should handover the copy of the service slip to the STP operator upon reaching the receiving station. It should be ensured that the copy is signed by the property owner, so as to ensure that the sludge is brought from a domestic, public or commercial property and not from any industry.

Preliminary checks such as pH, color, smell, electrical conductivity can help to distinguish between industrial sludge from domestic sludge. In case of doubt, the sample should be taken and sent for detailed analysis to laboratory. In the samples fails to pass the test, the particular desludging operator should be fined and for repeated offence, the license can be revoked.

A log book should be maintained to keep a track of date, time, trip and details of the truck. This should help to trace back the cause of any issue/challenge faced at the STP during treatment.

All of the above can also be digitized, which enables the local government to collect substantial data. This data can be further used for analysis and optimizing the services. Optimizing the services can lead to lowering of the desludging fee and increasing the quality of the service. There by making the service more affordable to the households.

After commissioning – impact monitoring

Wastewater	Sludge
• Influent quality	• Primary sludge production
• Effluent quality	• Secondary sludge production
• Grit production	• Dewatering efficiency
• MLSS in secondary stage	• Energy balance


Source: Annabel, 2011


Source: NIT, Trichy


Source: NIT, Trichy

Impact monitoring at the STP is another key step once co treatment has commissioned. Usually only the effluent quality is checked at the STP, however, it will not provide enough information about the performance of the treatment units. In case, when the effluent quality is not up to the mark, then is difficult to ascertain whether the something was wrong with influent or there was some issue with one the several treatment units in the STP. The sludge treatment chain is not monitored in most of the cases, as there are not standards of discharge for biosolids from the STP. However, the biggest impact on the STP can be in sludge stream while co treating the faecal sludge and septage. The higher organic loading usually results into higher amount of sludge formation. Since primary and secondary sludge is mixed in the sludge treatment chain, issues can arise where in the digestion of the sludge is inadequate and therefore dewatering efficiency reduces.

Summary

- Planning for co-treatment needs mapping of sewerage appurtenances, detailed data collection and analysis
- Unscientific addition of faecal sludge and septage can affect the functioning of sewerage system and its appurtenances such as pumping stations
- Administrative controls are as important as the engineering controls in case of co-treatment is to be implemented
- While performing co-treatment, monitoring and checks need to be performed at various stages of the treatment process

Session

07

Septage Receiving Station

7. Septage Receiving Station

Learning objectives

- Understand about septage receiving station - a necessary unit for safe transfer of faecal sludge septage from a desludging equipment (such as vacuum truck) at a treatment facility
- Know about mechanised septage receiving stations which are necessary at STPs for co-treatment of faecal sludge and septage and sewage

Contents

- Septage receiving station
  - Objectives
  - Design
  - Components
- Components of a septage receiving station
  - Dumping stations
  - Screening
  - Grit removal
  - Odour control unit
- Types of receiving station
  - Pre-treatment at the headworks of an STP
  - Pre-treatment before equalisation
  - Pre-treatment after equalisation
- Solid-liquid separation
- Standard operating procedure at a septage receiving station

7.1 Importance of septage receiving station

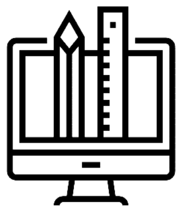
Septage receiving station

Objectives

- Safe and easy transfer of faecal sludge and septage
- Prevent clogging/fouling and excessive wear and tear of plant equipment
- Storage and equalisation of septage flows
- Prevent fouling of biological treatment process due to inert material

Septage receiving station

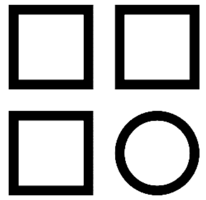
Design



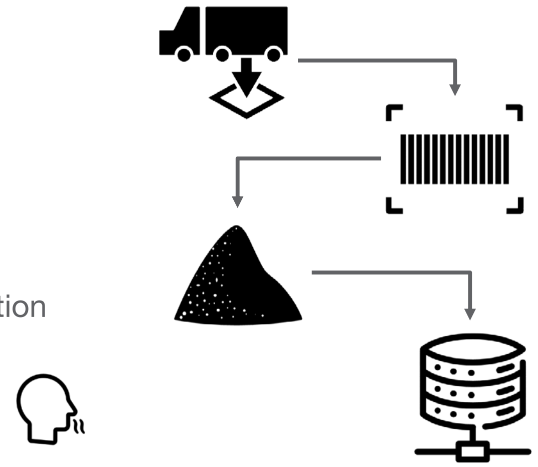
- Amount of faecal sludge and septage to be received
- Design of the desludging truck
- Type of pre-treatment required
- Disposal of solid waste and grit
- Odour considerations

Septage receiving station

Components



- Dumping station
- Screening
- Grit removal
- Storage/equalisation
- Odour control



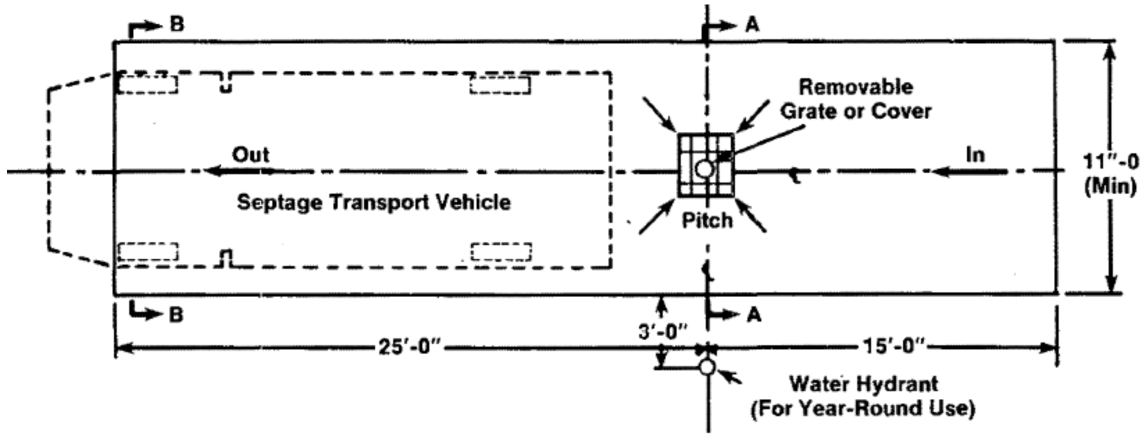
Faecal sludge and septage receiving facilities provide the interface between FSS delivery vehicles and the treatment plant. The aim of the facility is to allow for FSS transport vehicle access, providing adequate space for vehicles to discharge their contents and exit the treatment facility. Even it contain septage/faecal sludge during discharge so that it does not splash and overflow; and this facility direct it to the next treatment unit in FSTP. In other way, the aim of the septage receiving station is to reduce the impact and risk on STP due to co treatment of septage and sewage.

The key objectives of the receiving station are: (1) it should enable safe and hygienic transfer of septage from desludging truck to the next unit of FSTP or STP (2) It will be like the preventive measure to keep a check on O&M cost of the STP, (3) storage and controlled discharge (addition) of septage into the sewage and (4) reduce impact on the secondary stage of the liquid and solid treatment chain at the STP.

7.2 Dumping station

We will first discuss the component DUMPING STATION. The dumping station is the initial point of reception of septage at a receiving facility. It has different parts in it which we will see in next few slides.

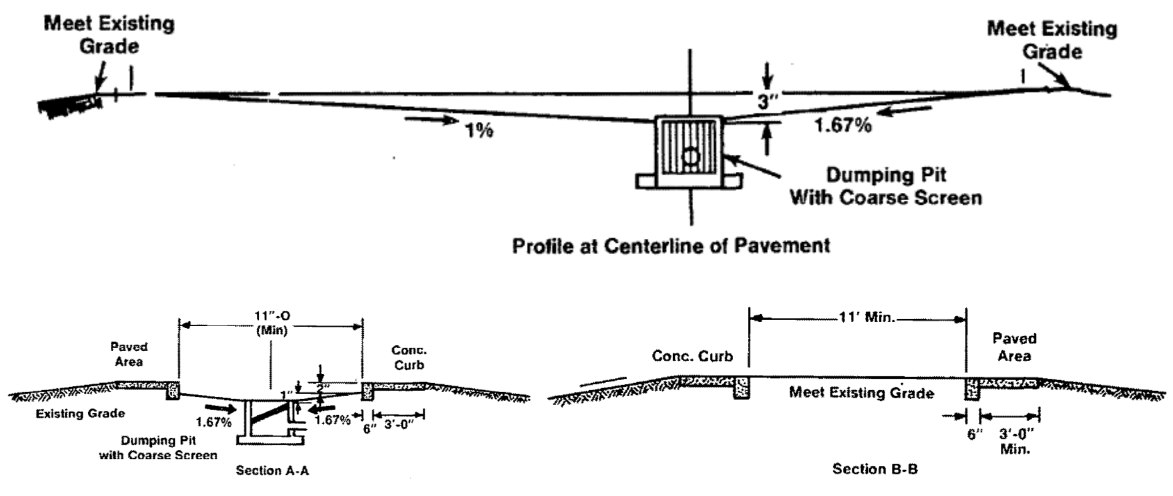
Layout of dumping station



Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

This is a layout of **Dumping station**. It has the components such as: (1) **Ramp** for the vacuum truck to enter and exit. The ramp should be sloping towards the dumping inlet so that any spillage or wash water will drain into the dumping hole (2) **Dumping inlet** arrangements with a removable lid, (3) **Water hydrants** with pressurised water hose to wash down any spillage or the truck components after dumping.

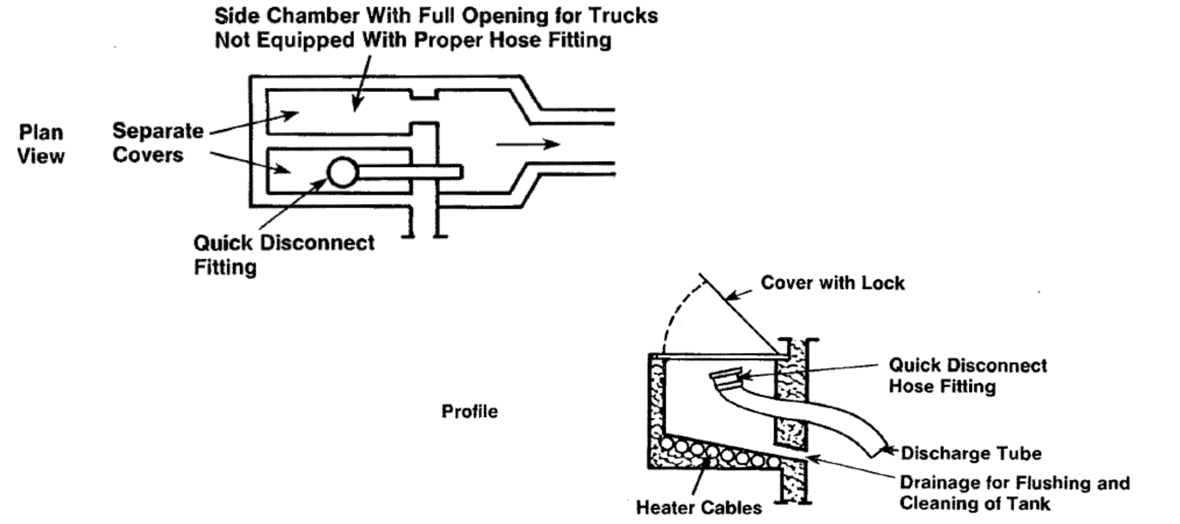
Layout of dumping station



Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

In this, the sections of the dumping station are described. It should be always noted and recommended that high grade concrete (M-30 and above) should be used with adequate reinforcement in the civil construction as heavy desludging vehicles would be plying on the ramp from time to time. Even, you can see here how the slope is considered on the ramp towards the dumping inlet which directs spillage or wash water in the humping hole.

Dumping station inlet



Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

In this, the most important component of the dumping station dumping inlet is described. The dumping inlet usually has two parts, the first as Pipe with a quick disconnect fitting and second as chamber for trucks which are not equipped with proper hose fitting. You can observe two sections in first image and quick disconnect hose fitting in second image.

7.3 Screening

Prefabricated manual bar screen

Features

- 4" – 6" quick disconnect fitting
- Flow diverter
- V-shaped screen
- Manual raking
- Solid waste to be pushed in a discharge channel for further disposal
- Collection in a bin or wheel barrow

Source: Screencosystems

Manual screens are used for smaller receiving station. Usually these screens are developed for emptying on single truck at a time. It has a 4-6 inch quick disconnect fitting which eliminates chances of spillage. The flow diverter is provided which eliminates any splashing of septage while emptying. Also it even distributes the septage over the screen which eliminates the chances of choking of screen. The V shaped screen can accommodate higher flow and is easier to rake. The solid waste which is caught in the screen is raked manually into the channel which has holes in the bottom. Thus the waste which is leaching septage will also get captured and is drained in the pan below. The solid waste then has to be pushed into a bin or wheel barrow.

Prefabricated mechanical screen

Features

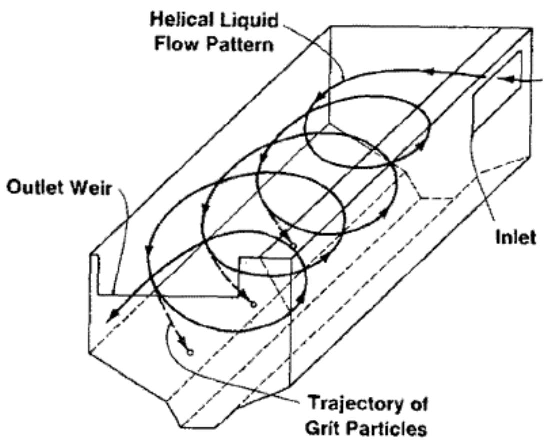
- 4" – 6" quick disconnect fitting
- Removal of stones and heavy object
- Shredding of solid waste
- Mechanical drum fine screen
- Screw conveyor for solid waste
- Automatic washing system
- Compacting of solid waste
- Washed solid waste is collected in a bin

Source: WAM Group

The mechanical screens are used where human intervention needs to be completely eliminated and higher flows need to be accommodated. A 4-6 inch quick disconnect fitting is provided which is ensures there is no spillage. Stone and heavy object removal can be done however it is optional. This is followed by shredder which shreds the solid waste such as rags, plastics etc. to appropriate size. The mechanical drum ensures that the all the solid waste is arrested and disposed into the screw conveyor which washes, compacts and transfers the waste to the bin or bag.

7.4 Grit removal

Parabolic grit trap

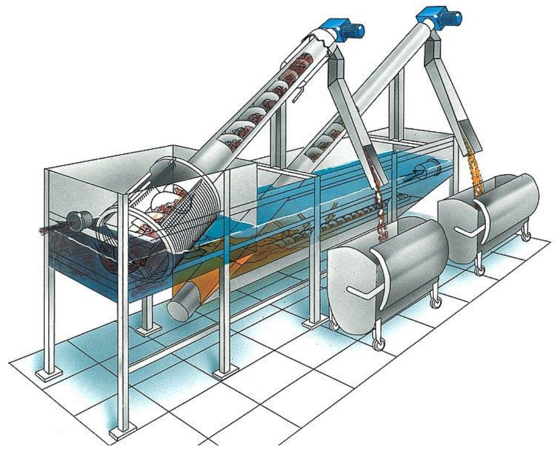


Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

Source: HUBER Longitudinal Grit Trap ROTOMAT Ro6

Parabolic grit chambers or aerated grit chamber are used where high flows are expected. In the aerated grit chambers, diffused air is pumped into the chamber to cause a spiral flow motion r helical liquid flow pattern that enhances the breakup and ultimate settling of grit. So, the septage after screening moves in the helical shape as shown in the figure on the left. During this movement, the grit settle down in the channel provided below. There is screw conveyor at the bottom which collects all the grit to one end of the grit chamber from where is removed, washed and dried before collecting in a bin.

Integrated pre-treatment module



Source: HUBER Complete Plant ROTAMAT Ro5

Features

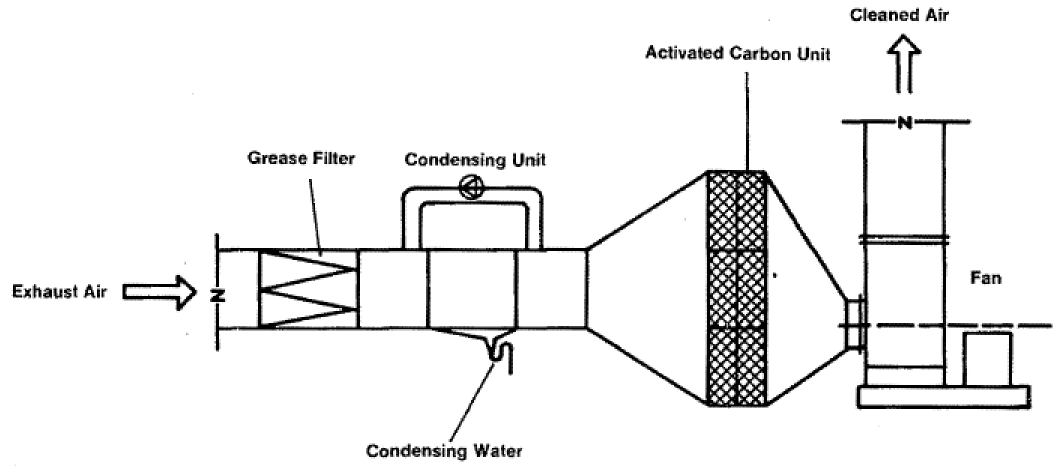
- Fine screening with washing and dewatering
- Grit aeration, separation, dewatering and washing
- Removal efficiency with Q_{max}: 90% (particle diameter 0.2 – 0.25 mm)
- Capacity up to 300 L/s
- No odour nuisance
- Completely made of stainless steel

Integrated pre-treatment module combines the mechanical screen and longitudinal grit trap. This is a single equipment which can be placed after the dumping station. Washing, and dewatering is optional and is recommended so that the solid waste and grit can be safely handled and disposed appropriately.

7.5 Odour control unit

The odour control unit is recommended if the FSTP is in close proximity to residential premise or in case of sewage pumping station (SPS) as they are located in close proximity of the residential and commercial areas. Odour control- In cases where multiple dumping stations are provided and storage unit does not have aeration unit, odour might be generated. Therefore an odour control unit needs to be placed. Odour control can be done using chemical scrubbers or activated charcoal filters.

Activated charcoal filter



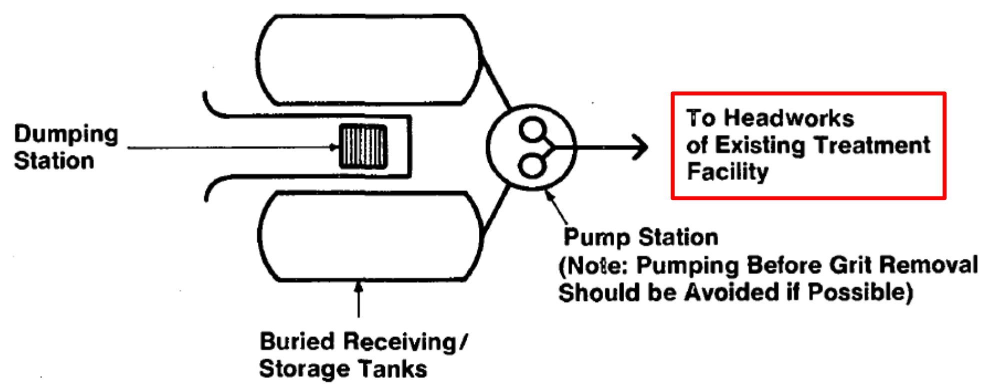
Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

Activated charcoal filters are easy to operate and maintain. They are passive filters where the exhaust air passes through grease filter followed by condensation unit and then through activated charcoal filter. The grease filter and condensation unit are essential for proper functioning and long life of the Activated Charcoal filter. The filters needs to be replaced completely at the end of its life. Since no hazardous chemicals are involved, these filters are easy to operate and maintain.

7.6 Receiving station

Receiving station - option 1

Pre-treatment at headworks of STP



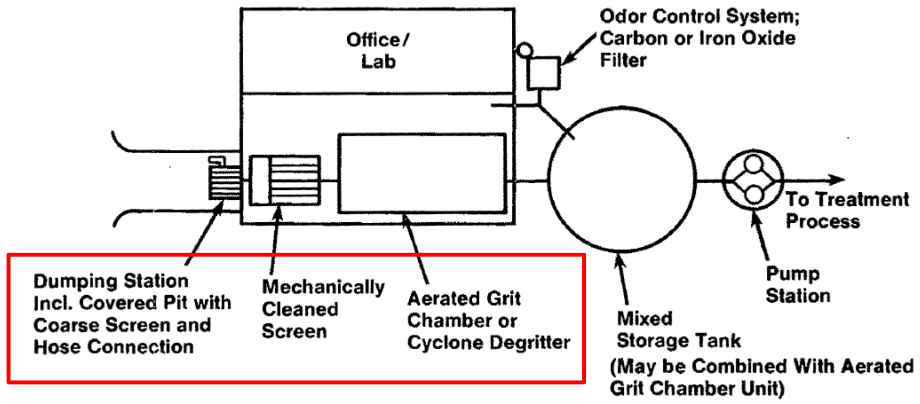
Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

This is recommended for co-treatment at STP. So such station should be installed at STP just before the headworks i.e. preliminary treatment (screens and grit removal).

In such cases the main objective of the receiving station is to only safely transfer the raw septage from the hauler trucks to the headworks in a controlled manner. Post which the raw septage will pass through screening, grit removal at the head works of the STP.

Receiving station - option 2

Pre-treatment before equalisation



Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

This type station is recommended for FSTP (grit removal is optional). 2-4 dumping stations can be combined and connected to screens and grit chamber if required.

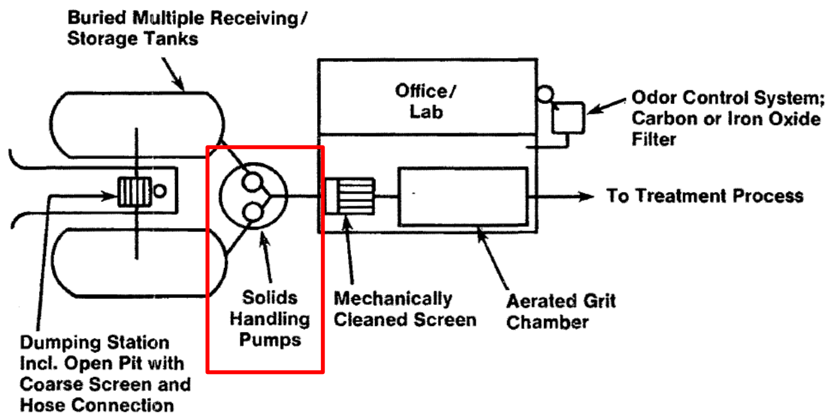
During the design of screens and grit chamber, one needs to understand how many trucks will be dumping the raw septage simultaneously and appropriately estimate the hydraulic peak flow. To avoid over deign of the screening and grit chamber, such receiving stations are recommended for handling small loads.

An odour control system is optional however, it is recommended to allot a space in the design so that in future it can be added.

This configuration is implemented in most of the FSTPs on India.

Receiving station - option 3

Pre-treatment after equalisation

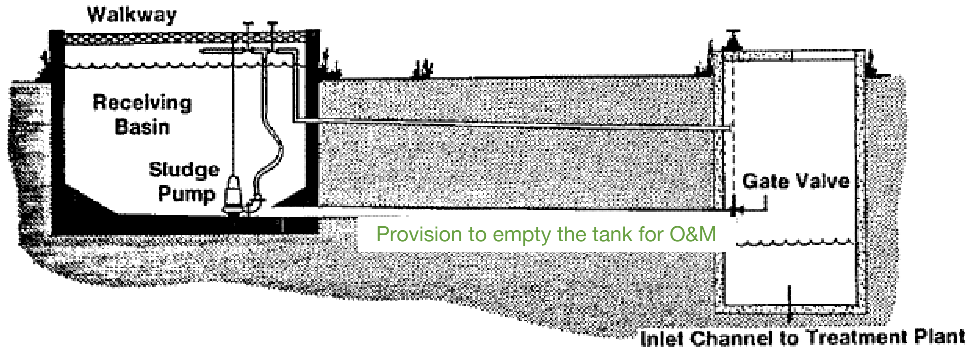


Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

This type of station is recommended in cases of FSTP, STP or Sewage Pumping Stations (SPS) where higher number of trips are expected and large number quantities of septage needs to be handled. Cases where large quantities of the hauler trucks are going to empty the raw septage, it is logical to store the raw septage and then feed to the screen in controlled manner. In this case, in order to lower the cost of preliminary treatment and ease of operation, the equalization tank should be placed which helps to reduce the peak flow to constant. So the pumping rate of the pump decides the flow rate for screens and grit chamber. It also has to be noted that the pump used here needs to be able to handle high amounts of grit (alternatively sludge pumps can also be used).

Receiving station - examples

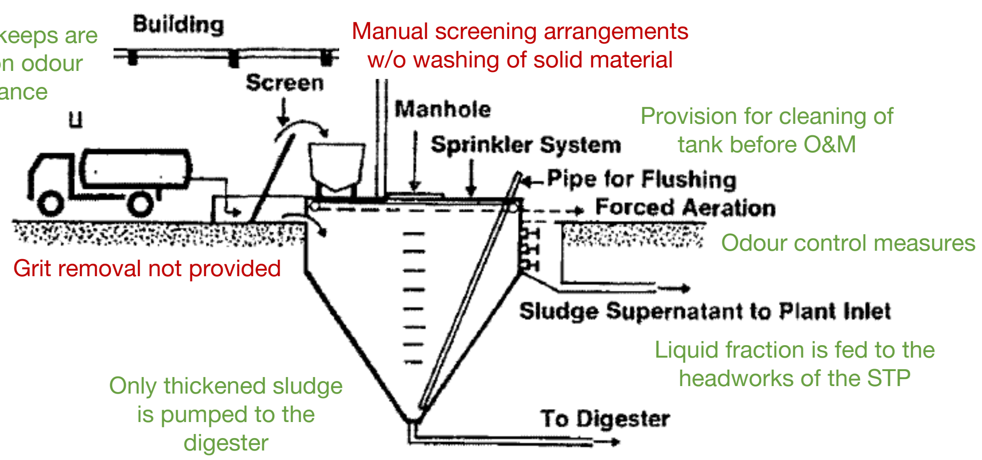
Decanting station for septage at Ekebyhov Treatment Plant, Sweden



Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

Receiving station - examples

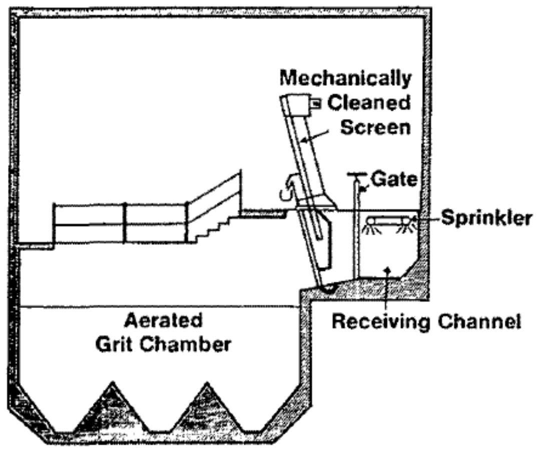
Decanting station for septage to be fed to anaerobic digester, West Germany



Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

Receiving station - examples

Decanting station for septage at Lillhammer Treatment Plant, Norway



Pros

- Provision for cleaning of receiving channel
- Screening provided
- Grit removal provided
- Enclosed structure for odour control

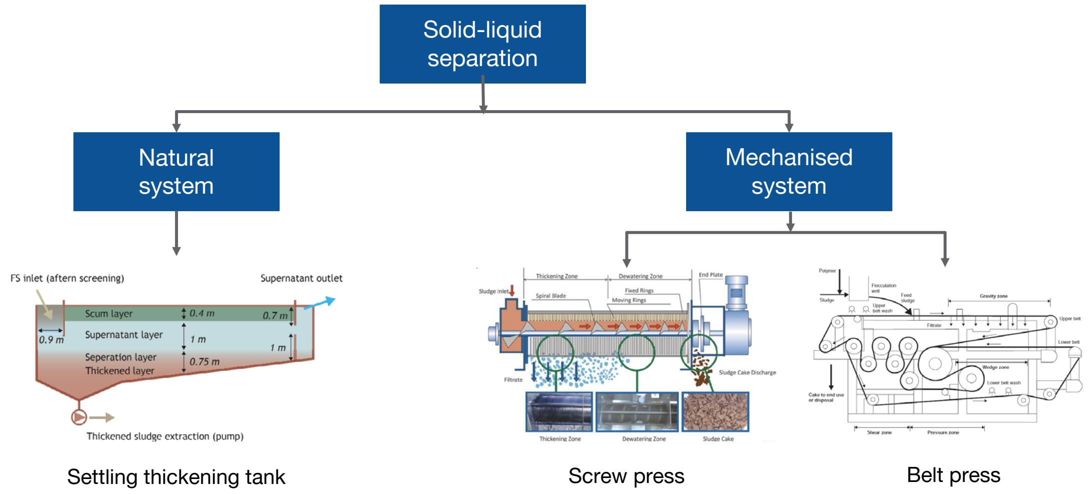
Cons

- Direct feed to headworks of the STP without equalisation

Source: US EPA Handbook on Technology Transfer: Septage Treatment & Disposal

7.7 Solid-liquid separation

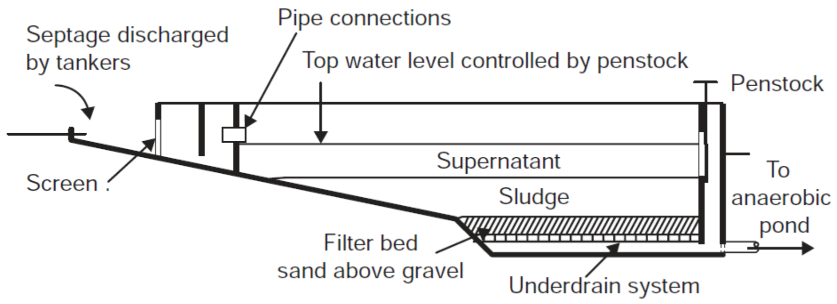
Solid-liquid separation



Solid-liquid separation is an important step in sludge handling at faecal sludge treatment facility or at co-treatment facility. After solid-liquid separation, the semi thickened sludge is transferred to further sludge handling facility and liquid has be transferred to liquid treatment system. It has two different approaches natural system (i.e. settling thickening tank etc.) or mechanized system (i.e. by mechanical presses like screw press or belt press etc.).

Natural system – Settling thickening tank

- Most commonly employed method
- Based on specific gravity of the particles, suspended solids concentration and flocculation
- Settling mechanisms are:
  - Discrete particle
  - Flocculent
  - Hindered
  - Compression

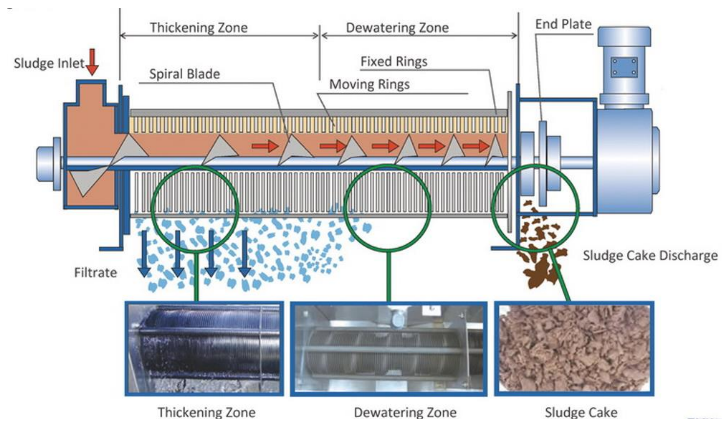


Source: Tayler (2018): Faecal Sludge and Septage Treatment

Settling thickening tanks are the simplest kind of treatment unit. It is the most commonly used treatment unit for solid liquid separation in case of faecal sludge and septage treatment. The separation takes place due to difference in the specific gravity of the solids and their masses. The fat – oil – grease which has lower specific gravity tends to float upon the surface of the water. Hence, in the settling thickening tank, the incoming sludge is given appropriate hydraulic retention time, where in the solids and the FOG separate and the liquid effluent comes out from the outlet. The settled sludge then undergoes compaction due to hydraulic pressure from the top, resulting into thick dense layer suitable for pumping. When designed and operated well, the settling thickening tanks can result solids concentration up to 12% in the thickened sludge.

Mechanised system – Screw press

- Simpler operation
- Can receive sludge with low solid content (<1%)
- 15-25% final dry solids
- Enclosure keeps surrounding environment clean and safe
- Low energy consumption
- Less inventory to maintain

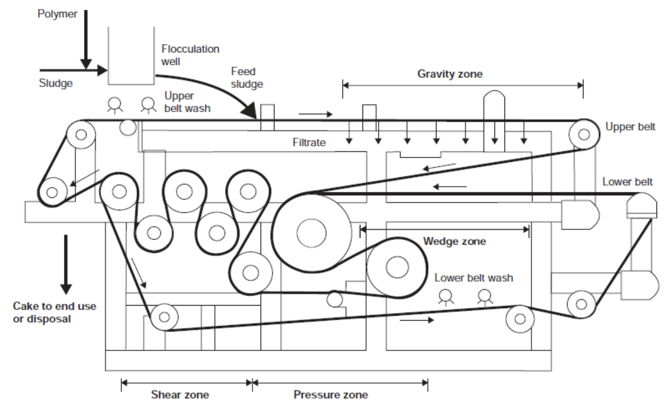


Source: www.ecologixsystems.com

Screw presses separate liquid from solids by forcing sludge through a screw or auger contained within a perforated screen basket. The screw diameter increases with distance along the shaft while the gap between its blades decreases so that the gap between basket, shaft, and flights continuously decreases and sludge is squeezed into a progressively smaller pace. This results in an increase in pressure along the press. Pressure probes are used to control and monitor the pressure to ensure treatment performance. The inclined press includes a pneumatic or manually adjusted counter-pressure cone that maintains a constant sludge pressure at the discharge end of the press. The water squeezed from the sludge drops into a collector channel at the bottom of the press, which conveys it to the next stage of treatment. The dewatered cake drops out of the end of the press for storage, disposal, or further drying on a drying bed or in a thermal dryer. High-pressure water is used periodically inside the press for cleaning.

Mechanised system – Belt press

- Can receive sludge with solid content < 0.5%
- 15-25% final dry solids
- Unenclosed units are messy to operate and present health hazard; however, allow visibility of process performance
- Simple equipment to maintain (rollers, bearing, belt)
- More parts to monitor- inspect and maintain

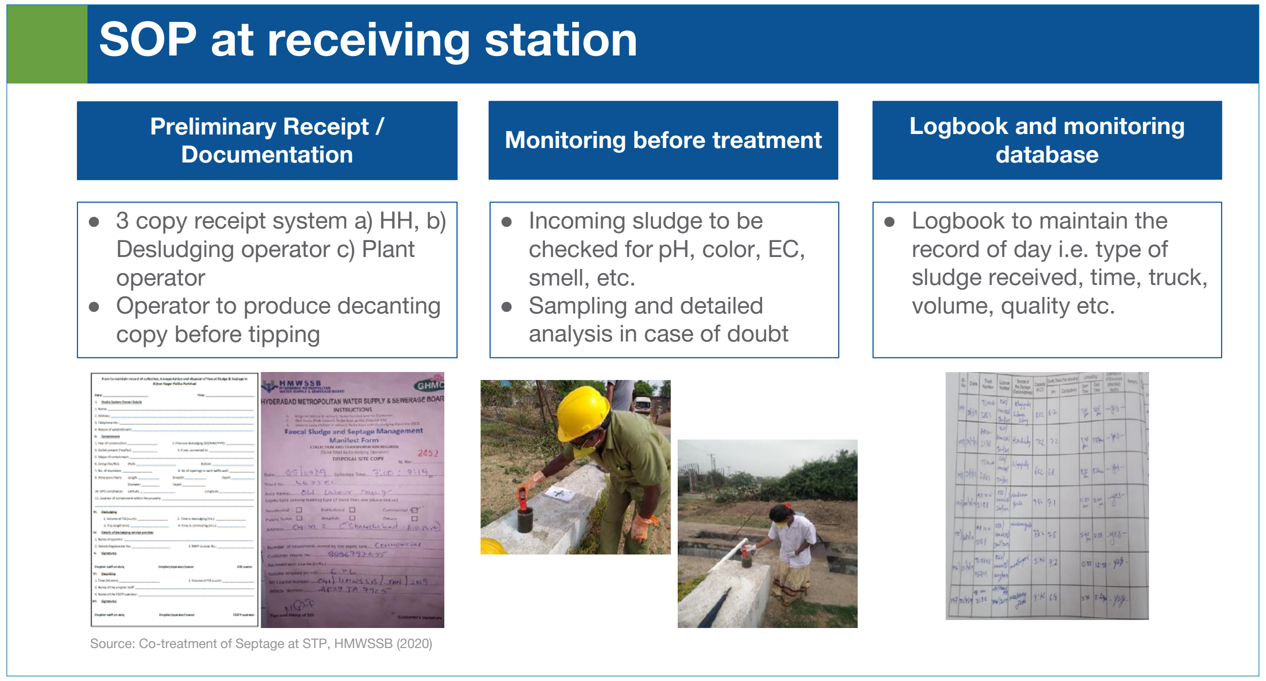


Source: WEF (2010)

Belt filter presses separate liquid from solids, using gravity and applied pressure between fabric belts. The process typically involves four steps: preconditioning, gravity drainage, low-pressure linear compression, and high-pressure roller compression (and shear). After preconditioning, sludge passes through a gravity drainage zone where liquid drains by gravity from the sludge. It is then moved on to a low-pressure zone where two belts come together to squeeze out liquid from the solids, forcing liquid through the fabric belts. In most cases, the sludge is then subjected to higher pressure as it is forced between a series of rollers, which create shearing forces and compression to further dewater the sludge.

The dewatered sludge cake is then scraped off the belts for conveyance to the next stage of treatment or disposal. The belts are cleaned with high-pressure wash water after each pass.

7.8 Standard operating procedure at receiving station

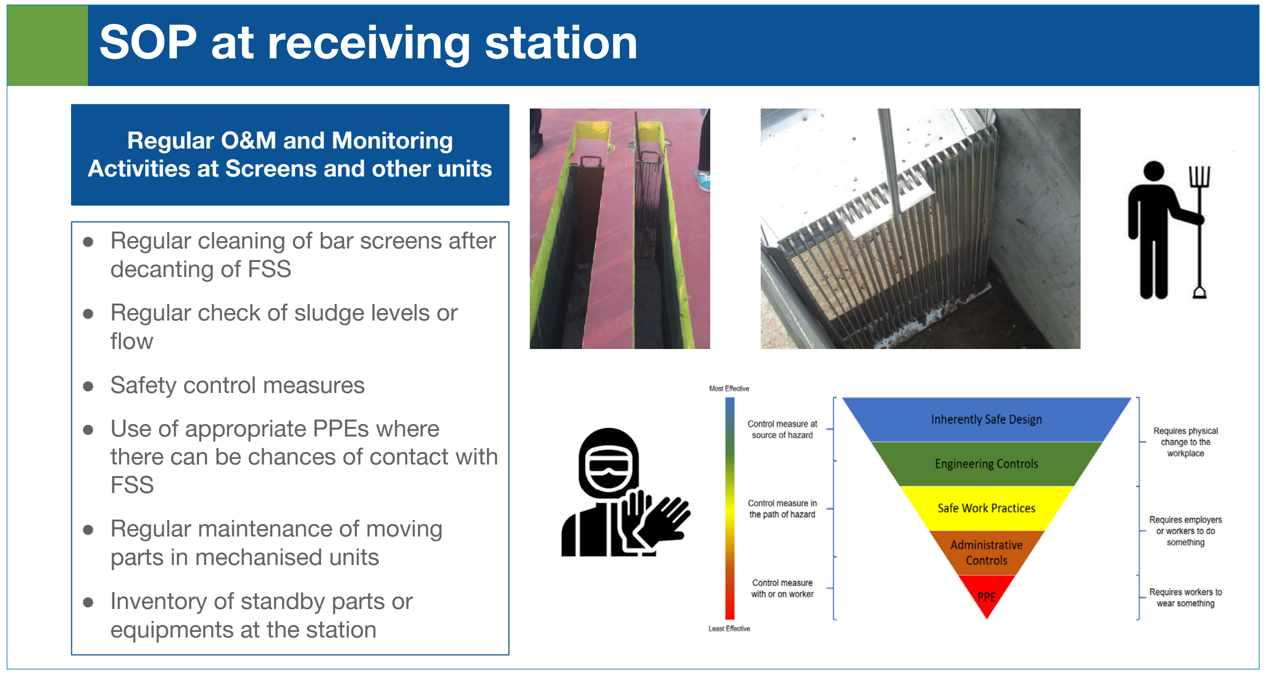


Monitoring at the receiving station before decanting the sludge into the premise is critical. A multi-step approach can be used here. As shown in the slide, a 3 copy receipt system ensures that a paper trail is left with property owner, desludging operator and the STP operator. This paper trail can be used to assess the indicators for service level benchmarking. The desludging operator should handover the copy of the service slip to the STP operator upon reaching the receiving station. It should be ensured that the copy is signed by the property owner, so as to ensure that the sludge is brought from a domestic, public or commercial property and not from any industry.

Preliminary checks such as pH, color, smell, electrical conductivity can help to distinguish between industrial sludge from domestic sludge. In case of doubt, the sample should be taken and sent for detailed analysis to laboratory. In the samples fails to pass the test, the particular desludging operator should be fined and for repeated offence, the license can be revoked.

A log book should be maintained to keep a track of date, time, trip and details of the truck. This should help to trace back the cause of any issue/challenge faced at the STP during treatment.

All of the above can also be digitized, which enables the local government to collect substantial data. This data can be further used for analysis and optimizing the services. Optimizing the services can lead to lowering of the desludging fee and increasing the quality of the service. There by making the service more affordable to the households.



In the next step, the units in receiving station have to maintained and monitoring properly (i.e. regular cleaning of screen, regular maintenance of moving parts in the mechanized systems etc.). The supervisor has to monitor the regular use of appropriate PPEs by ground staff while working on the system and where there are chances of contact with FSS. Log of inventory of standby parts or equipment is also important which can help in troubleshooting of the systems.

Summary

- Aim of having a receiving station is to safely transfer faecal sludge and septage to a treatment facility
- Each component in a receiving station has a specific function of pre-treating the faecal sludge and septage
- Pre-treatment before equalisation is highly recommended
- Solid-liquid separation is an important objective and helps to optimise the treatment system
- Standard operating procedure at receiving station can assure a proper operation by the ground/operating staff of a treatment plant

Case study - videos

- Septage Receiving Station
- WAM Group- The BEAST
- Case Study: EUCA Septage Receiving Station
- Mini Screen Receiving Station
- Honey Monster Septage Receiving Station
- Parkson Combi Treatment & Septage Receiving Station
- Huber Complete Plant ROTAMAT Ro5

Please find the video links below:

- Septage Receiving Station
- WAM Group- The BEAST
- Case Study: EUCA Septage Receiving Station
- Mini Screen Receiving Station
- Honey Monster Septage Receiving Station
- Parkson Combi Treatment & Septage Receiving Station
- Huber Complete Plant ROTAMAT Ro5

Session

08

Co-treatment in Liquid Stream at Sewage Treatment Plant

8. Co-treatment in Liquid Stream at Sewage Treatment Plant

Learning objectives

- Understand in detail about the treatment units involved in a liquid treatment stream of an STP
- Learn about the impact of co-treatment and measures to mitigate the impact of co-treatment in the liquid stream of an STP

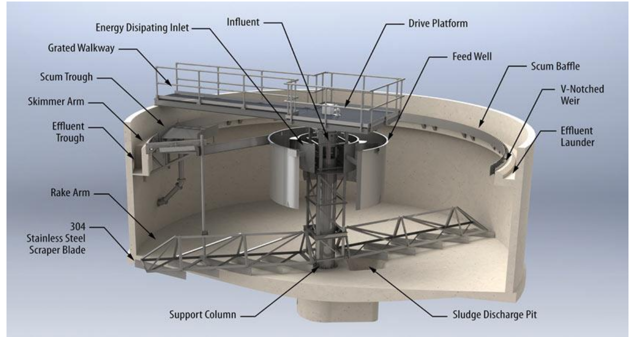
Contents

- Treatment units and design criteria
  - Primary treatment stage
  - Secondary treatment stage
  - Tertiary treatment stage
- Feasibility check
  - Primary clarifier
  - ASP reactor + Secondary clarifier
  - Chlorination
- Mitigating impact
  - Primary clarifier
  - ASP reactor + Secondary clarifier
  - Chlorination

8.1 Treatment units- Design Criteria

Primary treatment - Sedimentation

- Aim: To remove settleable solids with specific gravity between 1.01 and 1.02
- Design criteria
  - Surface loading rate ($m^3/d/m^2$)
  - Solids loading rate ($kgSS/d/m^2$)
  - Weir loading ($m^3/d/m$)
  - Depth (m) & Detention time (h)



Source: Monroe Environmental

The aim of primary treatment is to remove settleable solids with specific gravity higher than that of water. The design criteria for such sedimentation tanks or clarifiers are surface loading area, solids loading rate, weir loading, depth and detention time. The surface loading rate refers to the plan surface area available for the sedimentation process and is measured in flow rate per unit area. The solids loading rate (SLR) is the mass of the suspended solids per unit time and area. Weir loading refers to the flow rate per unit length of the weir. It does not play an important role in the case of primary clarifiers, however, it is expected that the weir is balances so that even withdrawal of settled water takes place. Detention time refers to time for which the wastewater is retained (or detained) in the tank. In case of primary clarifier this is approximately between 2 – 3 hours. The depth (also known as side water depth) refers to the depth of the tank. The water depth has an impact on the hydrostatic pressure on the settled sludge. Thus, deeper tanks produce compact and thick sludge (higher solids content). This reduces the design capacity of the sludge handling units at the STP.

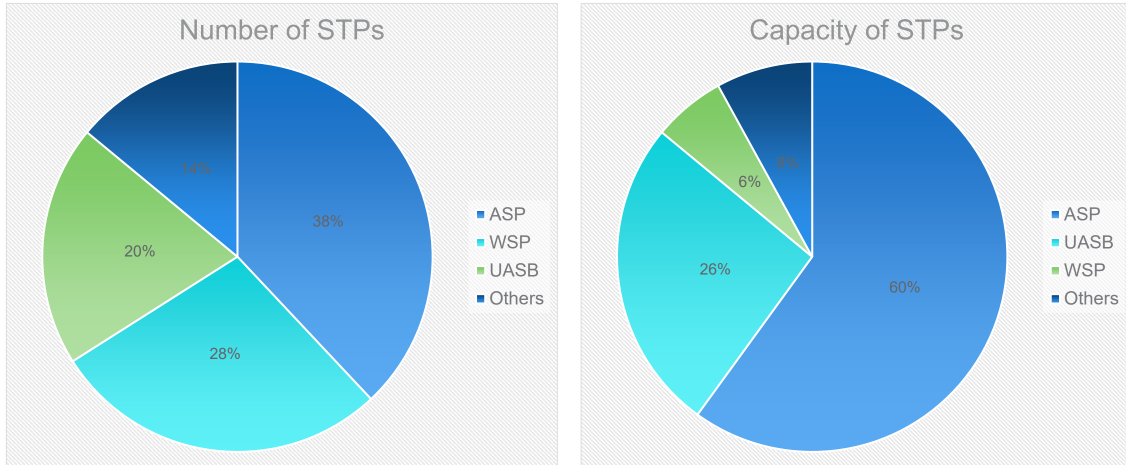
Design values

Type of settling	Surface loading rate ($m^3/d/m^2$)		Solids loading rate ($kgTSS/d/m^2$)		Weir loading ($m^3/d/m$)	Side water depth (m)
	Average	Peak	Average	Peak	Average	Average
Primary settling only	25 – 30	50 – 60	Not Applicable (Primary sedimentation is designed for flocculent settling for TTS < 1000 mg/L)		125	> 2.5 – 3.5
Followed by secondary treatment	35 – 50	80- 120			125	> 2.5 – 3.5
With excess sludge return	25 - 35	50 - 60			125	> 3.5 – 4.5

Source: CPHEEO, 1993

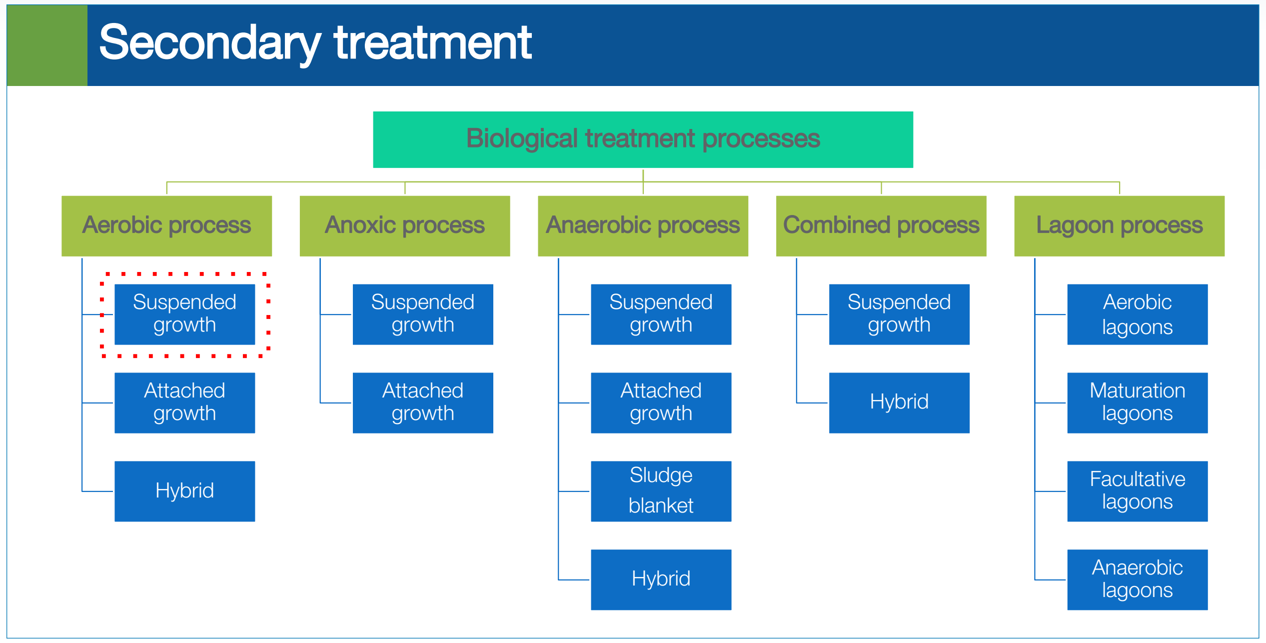
The slide provides the design values of various parameters for primary clarifier. It can be observed that the values change significantly for surface loading rate for average and peak flow. During the peak flow, the up flow velocity of the water increases which inhibits the sedimentation of the particles. Hence larger surface area is recommended. The values also vary for different configuration. In the case where only primary settling is done and the primary treated water is disposed the requirements are the least. However, in the cases where secondary treatment is provided, it is intended that higher percentage of removal is achieved. If the excess sludge return is added before the primary clarifier then the requirement changes. The side water depth is chosen in such a way that the average detention time is between 2 – 3 hours. The Solids Loading Rate (SLR) is not a critical design criteria in case of primary clarifier because the concentration of TSS is less in case of domestic sewage because of which flocculent settling happens.

STPs in India



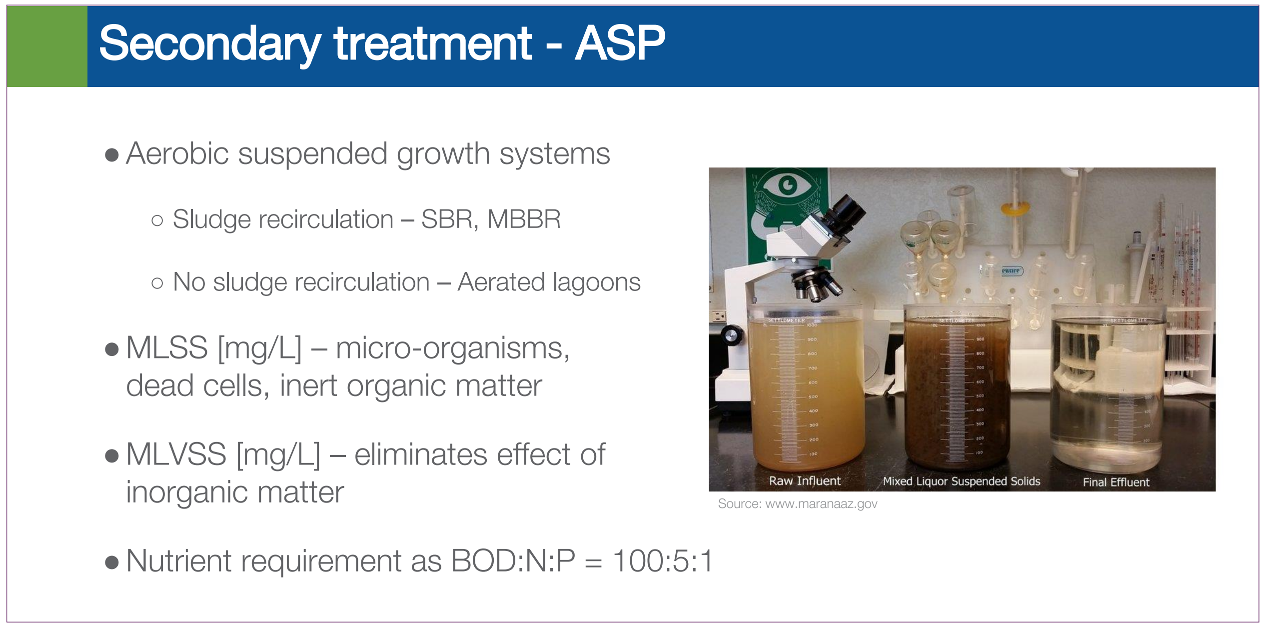
Source: CPCB Report, 2016

The pie charts are based on the data collected by Central Pollution Control Board in 2016. The first chart shows the percent of number of STPs pertaining to specific technology. It can be observed that the number of STPs based on the Activated Sludge Process (ASP) and its other forms (such as SBR, MBBR) are 38% followed by Waste Stabilization Pond (WSP) which is 28% and Up flow Anaerobic Sludge Blanket (UASB) which is 20%. The other treatment systems includes tricking filter, rotating biological reactor etc. The chart on the right represents the cumulative capacities of the STPs based on technologies. It can be observed that 60% of the design capacity is catered by ASP, followed by UASB which is 26% then WSP which is 6% and other which is 8%. The choice of technology at a centralized STP is logical because of the space constraints. Since ASP and UASB required minimum space per unit design capacity, these technologies were popular. The area requirement of WSP is highest among the wastewater treatment technologies and hence have not been adopted for larger design capacities. ASP and its variants are still by far the most adopted technologies when it comes to centralized STPs. Hence, in this session we will be mostly focusing on ASP and the impact of co-treatment on ASP.



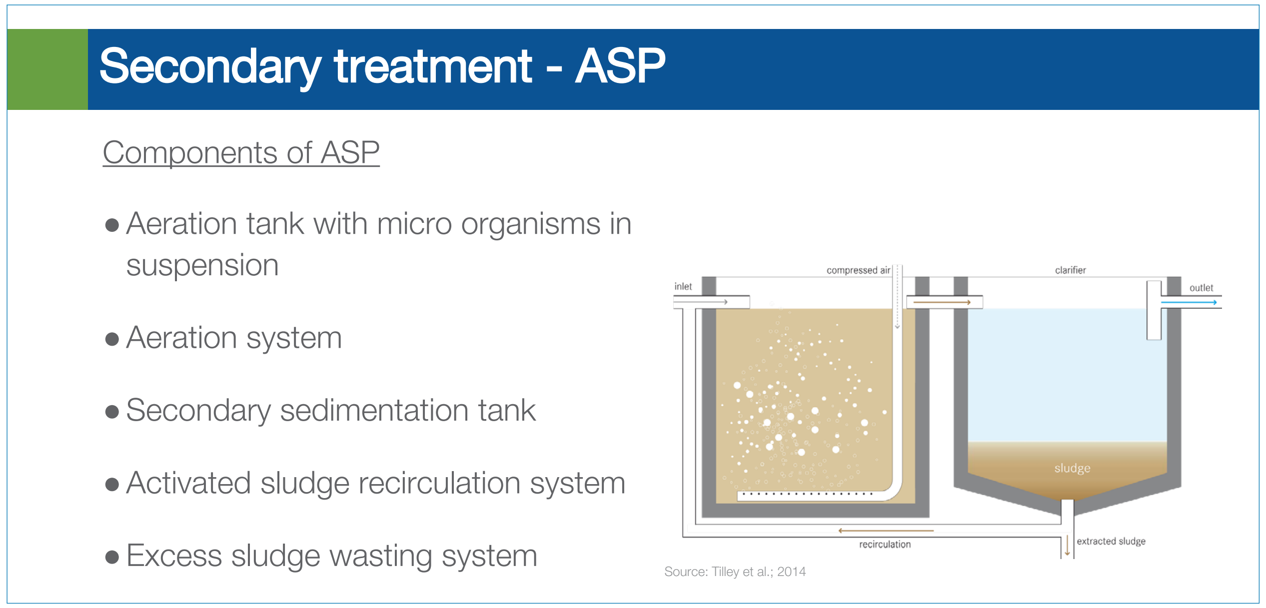
There are different types of biological treatment processes. ASP belongs to the aerobic suspended growth process. This essentially means that the microorganisms contributing to the treatment of wastewater are suspended in water. These microorganisms need oxygen to metabolize the organic content (pollutants) in the wastewater which is provided by external means using aerator. The microorganisms are measured using indicator commonly known as MLSS (Mixed Liquor Suspended Solids).

SBR and MBBR are other variants of ASP which are popular and mostly adopted as compared to conventional ASP. SBR is again aerobic process based on suspended growth mechanism and gives flexibility in operation and is known to most economical treatment. MBBR on the other hand is an aerobic process based on attached growth process. The biggest advantage of this is that requires smaller area as compared to conventional ASP and provides a robust treatment performance.



In ASP, there are two types of processes based on recirculation of sludge. In the case of sludge recirculation type (also known as conventional ASP), the activated sludge from the secondary clarifier is recirculated in to primary treated wastewater to maintain the concentration of microorganisms in the ASP reactor. There are technologies such as aerated lagoons, which do not require sludge recirculation. In this case, the concentration of microorganisms is maintained by providing more conducive environment to them to grow at a faster rate.

The concentration of microorganisms is measured in MLSS. However, MLSS is not the most accurate indicator since it also represents dead cells, inert organic matter along with the active microorganisms. A much accurate indicator is MLVSS which eliminates the effect of inorganic matter. However, measuring MLVSS is a tedious process and hence, treatment plant operators use MLSS for day to day operations. For healthy growth of microorganisms, nutrients are also required. Nutrients in the form of Nitrogen and Phosphorus are necessary. In the case of domestic sewage, the concentration of N and P are adequate enough to sustain the growth of microorganisms, however, in cases where it is insufficient nutrients are externally added either in form of urea or other patented products.



In conventional ASP, there are different components involved: (1) Aeration tank which holds the mixed liquor in suspension, (2) Aeration system which provides the necessary oxygen for microorganisms for metabolizing the organic pollutants, (3) Sedimentation tank (secondary clarifier) which separates the sludge from the treated water, (4) Activated sludge recirculation system which transfers part of the sludge from secondary clarifier to the aeration tank, (5) Excess sludge wasting system which removes the excess sludge from the system and sends it to sludge management units.

Aeration system

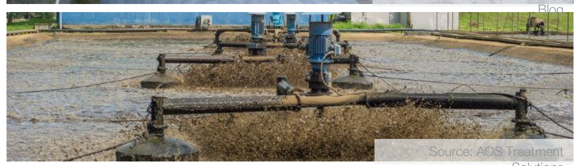
Functions of aeration:

- To fulfill calculated oxygen demand against the specific level of dissolved oxygen
    - Conventional ASP: 0.5 – 1.0 mg/L
    - Extended aeration: 1.0 – 2.0 mg/L
    - Nitrification: > 2.0 mg/L
- To provide adequate mixing for entire MLSS to be available for biological activity
- Oxygen transfer is dependent on temperature

There are mainly two functions of aeration in the ASP: (1) to provide oxygen to the microorganisms for metabolizing the organic pollutants and (2) adequately mix the MLSS in the influent of the tank. Hence, it is important of understand the requirement of air/oxygen for these two criteria while designing the elector mechanical components of the ASP. There are different types of aerators which are commonly used: surface aerators and diffused aerators. Diffused aerators are further classified in to coarse and fine diffuser depending on the size of the bubbles produced by the aerators. Oxygen transfer is dependent on the temperature and hence, the aeration requirements are usually calculated for winter seasons and appropriate design provisions are made during the design.

Aeration system

- Oxygen transfer capacities:
    - Surface aerators: 1.2 – 2.4 kgO_2/kWh
    - Fine diffusers: 1.2 – 2.0 kgO_2/kWh
    - Coarse diffusers: 0.6 – 1.2 kgO_2/kWh
- Power requirement: Mixing > Oxygen transfer
- Power requirement: 15 – 26 W/m^3 of tank volume
- Air volume for mixing in diffused aeration: 1.8 – 2.7 $m^3/h/m^2$



The oxygen transfer capacities of different types of aerators varies. Surface aerators are known to be quite efficient as compared to diffuser type. In diffuser type, the fine diffusers are more efficient as compared to the coarse diffusers. The smaller bubbles provides larger contact surface area for the oxygen transfer. In the case of domestic wastewater, the power requirement for mixing are higher than the power requirement for oxygen transfer. In case of surface aerators the power is consumed by the motor rotating the shaft of the aerator and in case of diffuser type the power is consumed by the blowers. It is estimated that the power requirement for mixing is between 15 – 26 W/m^3 of the reactor volume. The air volume required for mixing using diffused aeration is 1.8 – 2.7 $m^3/h/m^2$.

Design criteria

Hydraulic retention time

$$\theta\,[h] = \frac{V\,[m^3]}{Q\,[m^3/d]}$$

Sludge retention time

$$\theta_c\,[d] = \frac{V\,[m^3] \times X\,[mg/L]}{Q_w\,[m^3/d] \times X_s\,[mg/L]}$$

Affects oxygen requirement and generation of wasted activated sludge

Specific substrate utilization rate

$$F/_M = \frac{Q\,[m^3/d] \times S_0\,[g\,BOD/L]}{V\,[m^3] \times X\,[mg/L]}$$

Where;

V: Volume of reactor

Q: Sewage inflow

S_0: Influent BOD_5 concentration

X: MLSS concentration in reactor

X_s: MLSS concentration in secondary settling tank

There are three main design criteria for ASP. First is the hydraulic retention time which is principally same as detention time. Next is the specific substrate utilization rate which denotes the utilization of the organic pollutants by the microorganisms in the reactor. Last is the sludge retention time (SRT). It denotes the time for which the active sludge is retained in the system.

Design values – ASP

Design parameter	Unit	Flow regime		
		Plug flow	Complete mix	Extended aeration
MLSS	mg/L	1500 - 3000	3000 - 4000	3000 – 5000
MLSS/MLVSS	-	0.8	0.8	0.6
F/M	day^{-1}	0.3 – 0.4	0.3 – 0.6	0.1 – 0.18
HRT	h	4 – 6	4 – 6	12 – 24
SRT	d	5 – 8	5 – 8	10 – 26
Q_R/Q	-	0.25 – 0.50	0.25 – 0.80	0.25 – 1.0
BOD removal	%	85 – 92	85 – 92	95 – 98
$kgO_2/kgBOD$ removal	-	0.8 – 1.0	0.8 – 1.0	1.0 – 1.2
$kgO_2/kgNH_3$-N	-	4.56		
Sludge wastage	kg/kg BOD removed	0.35 – 0.50		0.25 - 0.35

Source: CPHEEO, 1993

The design values for various design criteria and parameters is given in the table above. It is observed that for various configurations, the design parameter changes. The plug flow and complete mix reactor are type of ASP requiring sludge recirculation. Between the conventional and extended aeration, it can be observed that the MLSS requirement is higher which needs higher input of oxygen and greater HRT and SRT. However, the advantage of extended aeration is that the sludge wastage is less. Thus, the design capacity of the sludge handling units reduces.

Complete mix reactors are preferred in India since its area requirement is less as compared to plug flow reactor.

Traditionally, ASP is designed for removal of carbonaceous BOD only. This is so because, the concentration of nutrients (especially Nitrogen) is very less in domestic sewage. Thus, removal of nitrogen is not a design constraint. However, in cases there the treated wastewater is disposed in to non-flowing surface water body such as lakes or ponds, removal of nutrients is highly recommended to avoid eutrophication of the water body. In order to do this, denitrification reactor followed by nitrification is required. Nitrification is achieved by supplying excess oxygen at the rate of 4.56 kg O_2/ kg NH_3-N.

Design values – Secondary clarifier

Type of settling	Surface loading rate [m³/d/m²]		Solids loading rate [kg TSS/d/m²]		Weir loading [m³/d/m]	Side water depth [m]
	Average	Peak	Average	Peak	Average	Average
For activated sludge	15 - 35	40 - 50	70 – 140	210	185	> 3.0 – 3.5
For extended aeration	8 – 15	25 - 35	25 - 120	170	185	> 3.0 – 4.0

Source: CPHEEO, 1993

The table above provides the design values for secondary clarifier. Since the TSS increases in the ASP reactor due to production of sludge, the solids loading rate becomes critical design constraint in case of secondary clarifier. In this case zone settling or hindered settling mechanisms takes place which separates the sludge from the water. The sludge produced in extended aeration has better settling properties as it has undergone partial digestions (stabilization). Thus, the surface loading rate as well as the SLR is less as compared to convention ASP.

Tertiary treatment - Chlorination

- Chlorination is widely used as a disinfection treatment process in STPs
- Forms of chlorine: elemental chlorine (Cl_2), hypochlorite (OCl^-), chlorine dioxide (ClO_2)
- Chlorine demand = chlorine dose – residual chlorine
- Relative effective of chlorine – increases with dosage, contact time, temperature and decreases with pH

Advantages of adopting chlorination

Easy to obtain

Economical

Effective

Easy to apply

Precedence in reacting

Inorganic material (Hydrogen sulphide, Ferrous iron, Manganese, Nitrite)

Ammonia

Organic compounds

At the tertiary stage, the aim here it to disinfect the wastewater so that it fits the discharge standards of treated wastewater. The widely adopted treatment at tertiary stage is chlorination. Chlorine is easy to obtain, it is economical, effective (residual chlorine extends the disinfection even after the water leaves the treatment plant) and its easy to apply as compared to other treatment technologies.

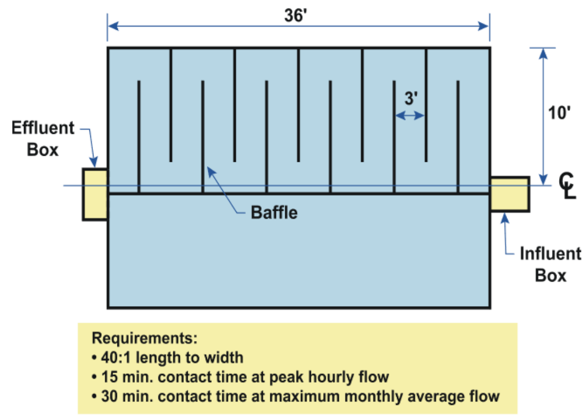
Various types of chlorine are used for disinfecting secondary treated wastewater like chlorine gas, hypochlorite solution and chlorine dioxide tablet. The chlorine dose is calculated based on the chlorine demand and the requirement of residual chlorine. Chlorine first reacts with the inorganic material followed by organic compounds and then finally with the pathogens. Hence, if the secondary treatment is ineffective, then chlorine demand will increase. The relative effective of chlorine increases with the dose, contact time, temperature and decreases with pH. A contact time of 30 min with mixing is recommended for highest effectiveness of chlorine in disinfection.

Design values

Secondary treated water with aerobic biological treatment such as ASP requires:

- Dosage 10mg/L.
- Contact time – 30 min
- Residual chlorine – 1.0 – 1.5 mg/L

Chlorine demand varies with dosage, time, temperature, pH, nature and amount of impurities



Source: PSATS; 2016

Effluent from secondary treatment based on aerobic biological process such as ASP requires following design parameters:

Chlorine dosage of 10 mg/L followed by contact time of 30 min in mixing channel. This leaves approximately 1.0 – 1.5 mg/L residual chlorine in the final effluent of the treatment plant. Depending upon the operation and maintenance of the preceding treatment units the chlorine dosage needs to be varied during the operation of the treatment system.

8.2 Precautions and feasibility checks for co-treatment

Addition of sludge

Addition of sludge leads too:

- increase in solids loading
- increase in organic loading
- increase in pathogens

Parameter	Septage	Sewage	Ratio
TS	40,000	720	55:1
TVS	25,000	365	68:1
TSS	15,000	220	68:1
VSS	10,000	165	61:1
BOD_5	7,000	220	32:1
COD	15,000	500	30:1
TKN	700	40	17:1
NH_3-N	150	25	6:1
Total P	250	8	31:1
Grease	8,000	100	80:1

Source: USEPA Handbook on Septage Treatment and Disposal

In very rare cases, hydraulic loading will become the critical constraint for co-treating faecal sludge and septage with sewage at an STP

Characteristics of septage and sewage vary considerably. It is observed that the septage specifically has higher quantities of solids grease followed by organic pollutant measured by BOD and COD. Septage is also known to contain more nutrients.

Thus, adding of faecal sludge or septage can lead to different impact on different treatment units. Since the quantity of the faecal sludge and septage as compared to the design hydraulic capacity of the plant is insignificant the impact is seen due to increase in solids loading rate, organic loading rate and pathogens.

Primary clarifier

- Solids loading rate is usually not prioritized for design of primary clarifier:
  - Designed for sewage with TSS < 1000 mg/L
  - Flocculant settling principle
- Feasibility check
  - Data needed - diurnal variation of TSS and flow in to the STP
  - Identify the critical time of the day – addition of sludge leads to TSS > 1000 mg/L

The other design parameters are linked to hydraulic loading and hence, they are not critical!

SLR is not prioritized in case of primary clarifier, however, in case if after addition of faecal sludge and septage in the plant, the TSS concentration increase beyond 1000 mg/l then the performance of the clarifier will get affected. A temporary dip in the performance efficiency of primary clarifier can lead to serious consequences on the subsequent treatment units. The effect of addition of the sludge can be seen for upcoming days depending upon the concentration of the sludge.

To mitigate this risk feasibility checks needs to be carried out. For such feasibility check, data needs to be collected from STP operator. Diurnal variation of TSS and wastewater flow in to the STP needs to be studied. Using the graphs, critical time of the day can be identified. It should be noted that during this time, addition of faecal sludge and septage should be avoided.

Activated sludge process (ASP)

- Increase in organic loading will result in:
  - Increase in the F/M ratio in ASP reactor
  - Reduction in SRT
  - Sudden fall in DO level
- Feasibility checks
  - Organic loading rate
  - Aeration capacity

ASP is designed for removal of carbonaceous BOD only.
Thus, addition of sludge might also result in increase of nitrogen in various forms.

General standards for discharge of environmental pollutants

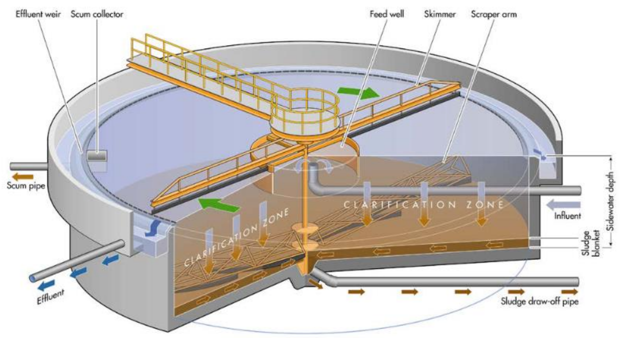
Ammonical nitrogen: 50 mg/L | Total nitrogen: 100 g/L | Free ammonia: 5 mg/L

In the secondary stage, the increase in the organic loading will result into increase in the F/M ratio. This means there is more food for the microorganisms and if sufficient oxygen is available, this will result into increase in the sludge production. Increased sludge production will result into reduction in SRT of the system. This has an impact on the working of secondary clarifier and sludge handling units. In the cases where sufficient aeration is not available, the DO level of the reactor will fall and this will result in to insufficient treatment of wastewater. Since, ASP is traditionally not designed for removal of nutrients, addition of faecal sludge and septage might also result into increase in the nitrogen content of the secondary treated wastewater. This will not only affect the disinfection stage but effluent will not be able to meet the discharge standards.

To mitigate these risks, feasibility checks such as organic loading rate [kg BOD or COD / unit time] and aeration capacity [kg O_2 / unit time] needs to be checked.

Secondary clarifier

- TSS increases significantly after aerobic biological treatment:
  - Solids loading rate is prioritized for design of secondary clarifier
  - Addition of sludge results in an increase in sludge production
- Feasibility checks
  - SLR for average and peak flow



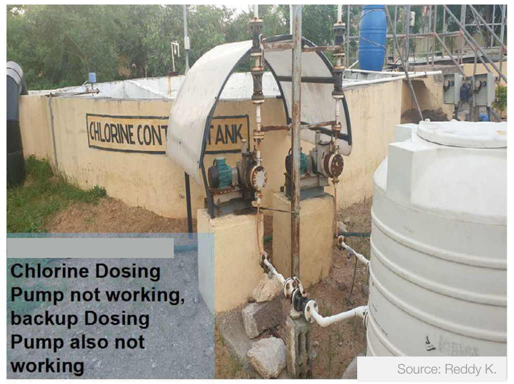
Source: Voutchkov N. , 2020

In secondary clarifier, the solids loading rate is critical because of high TSS content of the effluent of the ASP reactor. Due to increase in the sludge production, the solids loading rate will increase to the clarifier. This might result in to insufficient settling of the sludge in the clarifier, there by leading to its overflow in the disinfection stage. This will not only render the disinfection ineffective, but certain organic compounds are known to react with chlorine to produce stable carcinogenic compounds. The effluent of the plant will not be able to meet the discharge standards.

To mitigate the risk, feasibility check with respect to SLR during average and peak flows needs to be performed.

Chlorination

- Chlorine dosage will not be affected significantly, only if the secondary treatment of sewage is unhampered
- Checks to be performed:
  - Type of chlorine used
  - Method of dosing
  - Effect of chlorination



Source: Reddy K.

If the primary and secondary treatment capacity is adequate to handle the additional load due to co-treatment, then the chlorine dosage will not be affected significantly. However, on ground it is seen that this is the most neglected and ill designed stage of treatment. In most of the cases the chemicals are not procured on time or the dosage is not adjusted or regulated. In most of the STPs, a simple dosing of hypochlorite solution is done through gravity in to the channel leading to the outfall.

To reduce the risk, it is recommended to check the type of chlorine used, the procurement details, methods of dosing and the effectiveness of current practice in reducing the pathogens to discharge standards.

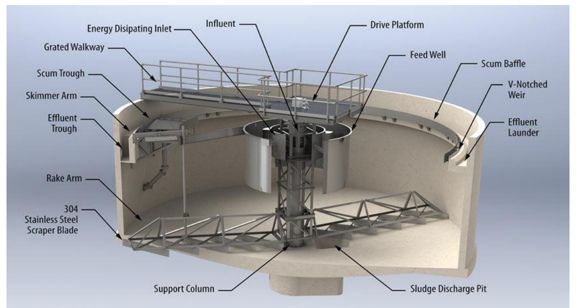
8.3 Mitigating the impact of co-treatment

Primary clarifier

Impact - Increase in primary sludge accumulation

Mitigation measures

- Increasing the RPM of scrapper and skimmer blade
  - Increase the RPM to maximum possible without hampering the sedimentation process
- Increasing the removal of primary sludge
  - Increase the time of operation of pump or replace with a pump of higher capacity



Source: Monroe Environmental

To mitigate the impact of increase in the primary sludge accumulation; following measures are recommended:

1. Adjust the rotations per minute of the scrapper and skimmer blade. Care should be taken that the increase in the RPM should not hamper the flocculation and sedimentation process. This will remove the primary sludge to the sludge sump. Thus, freeing the volume of the clarifier for the incoming solids load.
2. The operation house of the sludge pump will have to be increased. If the capacity of the pump is inadequate to handle the size of the solids or the volume of sludge, then replacing the pump with higher capacity pump is recommended.

Activated sludge process (ASP)

Impact - F/M ratio & DO imbalance

Mitigation measures

- MLSS and MLVSS needs to be increased. Seeding with active sludge or microbial culture is recommended
- DO needs to be improved - increase the operational hour of blowers
- If still insufficient – install extra aerators (surface aerators are recommended)

Impact - Reduction in SRT

Mitigation measures

- This will impact the sludge management infrastructure at the STP
- In most cases, the operational time of the sludge management infrastructure will have to be increased

To handle the imbalance of specific substrate utilization rate (F/M ratio) and the DO of the reactor following measures are recommended:

1. MLSS and MLVSS needs to increase. This can be achieved by seeding the reactor. The recirculation of active sludge can be increased or introduction of microbial culture along with enzymes is recommended.
2. To improve the DO, the operation hours of the blowers need to be increased.
3. When the aeration capacity is not enough, addition of extra aerators is recommended.

The reduction in the SRT of the system can be handled by managing the recirculation of sludge into the ASP reactor. For this real time data collection and careful understanding of ASP process is needed. Alternatively, the excessive sludge can be sent to the sludge handling treatment units where in the units will have to be operated for longer period to accommodate the extra sludge.

Secondary clarifier

Impact - Decrease in performance efficiency

Mitigation measures

- Adding of coagulation & flocculation prior to clarifier
- Adjusting the dosage of coagulant or changing the flocculant
- Converting clarifier into tube settler or lamella plate clarifier

Source: Treatment Plant Operator Magazine

Impact - Change in characteristics of sludge and its production

Mitigation measures

- Sample the sludge and analyze characteristics
- Increase operating hours of the sludge removal pumps

Source: Cooling Tower Filler

In order to mitigate the impact on secondary clarifier following recommendations are made:

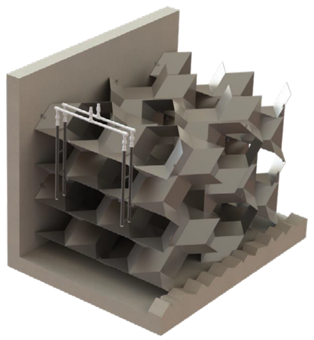
1. If coagulation and flocculation is not part of the process, then this needs to be added before the effluent is sent to secondary clarifier.
2. In case the coagulation and flocculation is already part of the process, the dosage of the coagulant, flocculant or changing the flocculant is suggested. Improved flocculants are available in the market which helps to create larger flocs which settle at a faster rate.
3. The clarifier can be retrofitted with tubes or lamella plates to increase the surface area there by accelerating the settling process.
4. In order to understand the dosage of coagulant, flocculant and the retrofitting, characterization of sludge is important.
5. The operating hours of the sludge pump will help to remove the sludge from the clarifier thereby freeing up volume for incoming higher load.

Chlorination

If the primary and secondary treatment units are restored to their performance efficiency, then disinfection stage will not be hampered largely

Mitigation measures

- Check the chlorine demand and adjust chlorine dose accordingly
- If mixing channel is not provided, then provide one
- Retrofit existing channel to improve mixing



Source: Statiflow

To mitigate the risk and improve the effectiveness of chlorination following recommendations are made:

1. Check the chlorine demand and adjust the dosage accordingly.
2. If mixing channel is not provided, then add a mixing channel. This significantly increases the effectiveness of the chlorination.
3. If a channel exists, then retrofitting using static mixers will improve the mixing.

Summary

- Addition of faecal sludge and septage to liquid treatment stream of an STP will impact the complete treatment chain of the STP
- Proper feasibility check and analysis helps to predict the risk of co-treatment
- Solids loading rate and organic loading rate are major critical constraints as compared to hydraulic loading rate in an STP
- Solids loading rate is important for clarifiers and organic loading rate is important in case of secondary treatment units of an STP
- Proper understanding of ASP process is required for mitigating the risks of co-treatment of faecal sludge and septage in liquid treatment chain of STP

Session

09

Co-treatment in Solid Stream at Sewage Treatment Plant

9. Co-treatment in Solid Stream at Sewage Treatment Plant

Learning objectives

- Understand in detail about the treatment units involved in a sludge treatment stream of an STP
- Learn about the impact of co-treatment and measures to mitigate the impact of co-treatment in the sludge stream of an STP

Contents

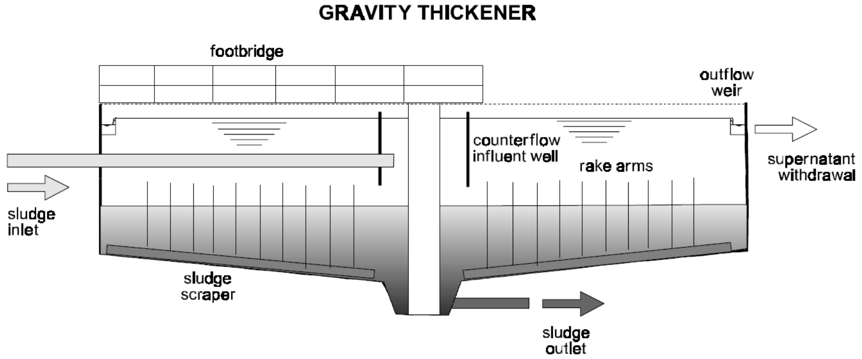
- Treatment units and design criteria
  - Primary treatment stage
  - Secondary treatment stage
  - Tertiary treatment stage
- Feasibility check
  - Gravity thickening
  - Anaerobic digestion
  - Dewatering
- Mitigating impact
  - Gravity thickening
  - Anaerobic digestion
  - Dewatering

9.1 Treatment units in sludge stream

Gravity thickener

Aim: To separate free water from the mix of primary sludge and secondary sludge

Mechanism: Similar to sedimentation tank (secondary clarifier)



Source: Andreoli C. V. et al,; 2007

The solids content of the mixed sludge i.e. primary sludge and secondary sludge is < 3%. Thus, the sludge requires thickening before stabilization. The aim here is to reduce the volume of the sludge, thus reducing the required volume of the anaerobic digester. Significant reduction in the volume is achieved by separating the free water from the sludge. The treatment is based on the physical mechanisms of separation takes place because of difference in the specific gravity of the solids and the water. The picture of the gravity thickener is shown above. The important components of the thickener are: (1) influent well, (2) sludge scraper which also provides necessary flocculation, (3) sludge inlet and outlet provision and (4) outflow weir for drawing out the supernatant water.

Design Criteria

Source of sludge	Type of sludge	Solids loading rate (kgTS/d/m²)
Primary sludge	-	90 - 150
Activated sludge	Conventional	20 – 30
	Extended aeration	25 - 40
Mixed sludge	Primary + Activated sludge	25 - 80

Source: Andreoli C. V. et al,; 2007

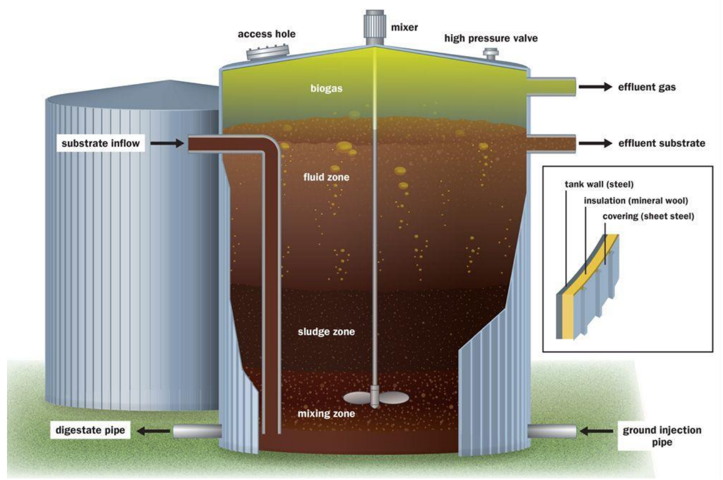
Other design criteria

- Hydraulic loading rate: 20 – 30 $m^3/d/m^2$
- Minimum side water depth: 3.0 m
- Maximum hydraulic detention time: 24 hours

The design criteria for gravity thickener is mainly based on the solids loading rate. The solids loading rate varies for different kinds of sludge and hence, understanding sludge characterization becomes important. It is evident from the information provided in the table that primary sludge has higher dewaterability as compared to secondary activated sludge and hence will require less space for gravity thickening. It can also be seen that the dewaterability of the activated sludge from extended aeration is better as compared to convention activated sludge. The dewaterability of the mixed sludge is dependent on the ratio in which the primary sludge and secondary activated sludge is mixed. The other design criteria are hydraulic loading rate, side water depth and the hydraulic detention time.

Anaerobic digester

- Digestion = Stabilization
- Digestion of organic matter by bacteria in absence of oxygen
- Three stage process:
  - Enzymes break down complex organic compounds into soluble compounds
  - Micro organisms converts first stage products into low molecular weight acids
  - Methane forming organisms convert acids to methane, CO_2 and H_2



Source: Jane Whitney

Anaerobic digester provides stabilization of sludge by digesting the volatile solids using bacteria in absence of oxygen. Anaerobic digestion is a three-stage process: (1) The enzymes break down the complex organic compounds in the soluble compounds. This mainly happens through hydrolysis process. (2) In the second stage the soluble compounds are converted into low molecular weight acids. The formation of acids results in decrease of pH. (3) The methanogenic bacteria converts the acids into more stable products such as methane, CO_2 and H_2. Along with this the digested sludge containing mainly fixed solids and some volatile solids (difficult to digest solids) settle down. The methanogenic bacteria are sensitive to pH and methanation process is affected if the pH of the digester is not around neutral.

Requisites for digestion

- Primary treatment
  - Reduction of fiber, plastics, sand and other inert material
  - Causes frequent breakdowns of pumps and mixers
  - Reduces net volume of the digester and efficiency
- Solids concentration
  - Not recommended: solids concentration < 2.5%
  - Increased using gravity thickeners
  - Desirable range: 4 – 8%
- Inhibiting substance
  - Hydrocarbons, organochlorinated compounds, non biodegradable anionic detergents, oxidizing agents and inorganic cations.
  - Ammonia concentration: 50-1000 mg/L
- Metal
  - Copper, Zinc, Mercury, Cadmium, Chromium, Nickel, Lead
  - Toxicity varies with pH, sulphide & carbonate concentration during digestion process

There are mainly four prerequisites for digestion process: (1) Primary treatment to remove inert material such as fibres, plastics, sand etc. These materials result into frequent breakdown of pumps and mixers and reduces the net volume of the digester. Thus, it reduces the retention time and decrease the efficiency of the digester. (2) Maintaining appropriate solids concentration in the influent sludge. The solids concentration of the sludge is between 4 – 8 %. Thus, sludge thickening is necessary before the sludge is to be sent for stabilization. (3) Removal of inhibiting substances and compounds such as ammonia. There are range of inhibiting compounds which might inhibit the digestion process as they interfere with the chemical and biological processes. Thus removal of these compounds if important as this can have a heavy negative impact on the digester. (4) Removal of heavy metals is necessary as the toxicity of these products vary with the pH, sulphide and carbonate concentration during digestion process.

Design parameters

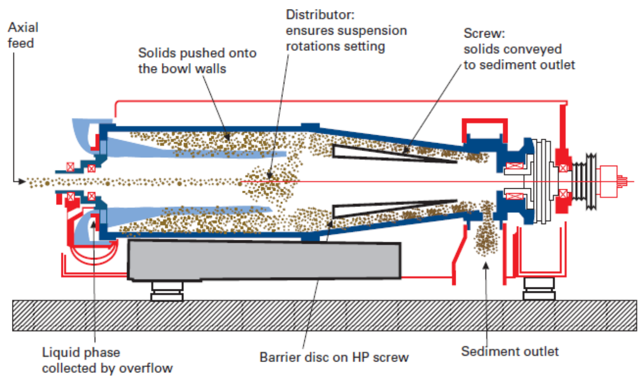
Parameter	Units	Design value
Detention time	(d)	18 – 25
Volumetric organic load	(kgVSS/m³/d)	0.8 – 1.6
Total solids volumetric load	(kgSS/m³/d)	1.0 – 2.0
Influent sludge solids concentration	(%)	4 – 8
Volatile solids fraction in sludge	(%)	70 – 80
Efficiency in total solids reduction	(%TS)	30 - 35
Efficiency in volatile solids reduction	(%VS)	40 – 55
Gas production	(m³/kgVSS destroyed)	0.8 – 1.1
Calorific value of gas	(MJ/m³)	23.3
Digested sludge production	(gTS/inhabitant/day)	38 – 50
Gas production	(L/inhabitant/day)	20 – 30
Raw sludge heating power	(MJ/kgTS)	15 – 25
Digested sludge heating power	(MJ/kgTS)	8 - 15

Source: Andreoli C. V. et al.; 2007\

The design parameters of the anaerobic digester and shown in the table above. The criteria are to be used for designing anaerobic digester to be operated in the mesophilic temperature range that is approximately 35 0C. These value varies significantly depending on the operational temperature range. In most of the cases, the methane produced from the anaerobic digestion is partly used for maintaining the temperature of the digester. This is achieved by heating the influent sludge and providing a heated water jacket around the digesters.

Mechanized dewatering

- Mechanized dewatering:
  - Low area requirement
  - High processing capacity
  - Low CAPEX
- Centrifuge is most commonly adopted mechanized unit, followed by screw press
  - Flow rate: 10-40 L/s
  - Area requirement: 40 m²

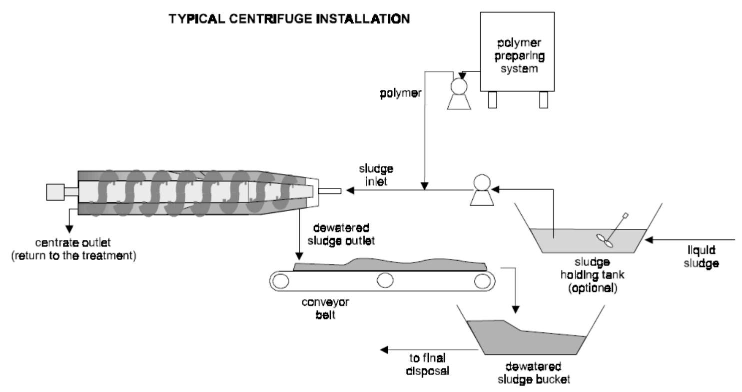


Source: Suez Water Handbook

Dewatering of the stabilized sludge is used to further separate the solids from the liquid in the sludge. Dewatering can be achieved using non mechanized treatment units such as planted and unplanted drying beds but in centralized STPs due to space constraints, mechanized dewatering is preferred. There are options in mechanized dewatering equipment such as centrifuge, screw press, belt press, filter press. The most commonly used unit at STPs is centrifuge. Centrifuge provides continuous dewatering process and is within less time provides sludge cake with relatively higher solids content. In centrifuge, the physical mechanisms of solid liquid separation based on specific gravity is again put into operation. The centrifugal force on the heavier solids particles sends it closer to the rotating bowl and the remaining water is drained out of the equipment using gravity.

Design consideration

- Conditioning system, with polymer tanks, dosage equipment and piping
- Sludge dosing and piping
- Access of vehicles for centrifuge machines
- Area for circulations, ventilation, electric equipment and odour control



Source: Andreoli C. V. et al.; 2007

Conditioning of sludge is required before sending the stabilized sludge for dewatering. The conditioning is mainly done using chemicals which helps to coagulate and flocculate the solids into bigger sludge flocs. The centrifuge should be located inside a well-ventilated room. It is important that the room has wide openings, so there is easy access for the vehicles for easy maintenance of the centrifuge.

Sizing of equipment

- Type of sludge to be dewatered
- Daily sludge flow
- Dry solids concentration

Sludge	TS concentration in cake (%)	Solids capture (%)	Polyelectrolyte dosage (g/kgTS)
Primary raw sludge	28 – 34	95	2 – 3
Activated sludge	14 – 18	95	6 – 10
Mixed sludge	28 – 32	95	6 – 10
Anaerobic sludge	35 – 40	95	2 – 3

Source: Andreoli C. V. et al.; 2007

The sizing or the model of the equipment is usually finalized after consulting an equipment manufacturer or provider. For making an informed decision, following details need to be provided to the manufacturer: (1) type of the sludge to be dewatered, (2) daily sludge flow and (3) dry solids concentration. The solids capture performance remains unaffected if the polyelectrolyte dosage is adjusted accordingly. The final total solids concentration in the sludge depends on the sludge characteristics. If the sludge contains higher amount of bound water (example: activated sludge) then the final solids content of the sludge are relatively less.

9.2 Precautions and feasibility checks for co-treatment

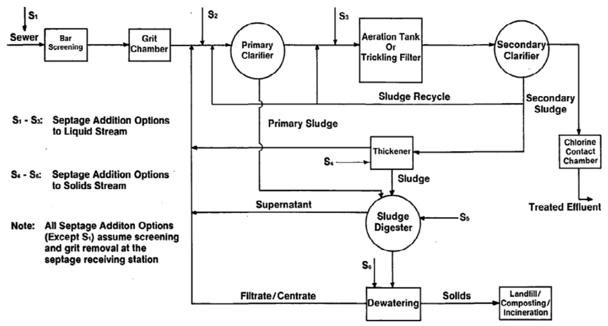
Addition of septage

In liquid stream

- Increase in primary and secondary sludge volume
- Hydraulic loading on the sludge treatment chain will increase
- Characteristics of sludge will change

In sludge stream

- Increase in organic loading
- Increase in solids loading
- Inhibition of treatment process such as gravity thickening and anaerobic digestion



Source: US EPA Handbook on Septage Treatment and Disposal

The addition of faecal sludge and septage at STP can happen in liquid stream and in sludge stream. The impact of both type is different in the sludge treatment stream. In cases where the sludge is added to the liquid stream, the primary and secondary sludge generation will increase. This will result in increase in hydraulic loading rate on the sludge handling unit. The characteristics of the sludge might also vary. However, the advantage here is that prerequisites for anaerobic digestion are already taken care of by the liquid treatment units. In cases, where the sludge is added to the sludge stream, the organic and solids loading will be critical.

Gravity thickening unit

Addition of faecal sludge and septage will result in:

- Increase in solids loading rate
- Poor settleability of faecal sludge
- Reduction in hydraulic retention time
- Hydraulic loading rate

Feasibility check

- Actual solids loading rate < designed solids loading rate
- Faecal sludge to be stabilized before adding to the sludge stream
- Hydraulic loading rate

Septage can be added to the gravity thickener after preliminary treatment
Faecal sludge can be added to the anaerobic digester directly, if it fits the design values (constraints) of anaerobic digester

As a part of the feasibility check, the solids loading needs to be checked. The actual solids loading should be lesser than the designed solids loading rate. Although faecal sludge is known to have higher solids content as compared to the septage and sewage sludge, the organic fraction of these solids is high and hence the solids have poor settleability. The increase in the solids loading rate results into increase in accumulation of thickened sludge, thereby reducing the net volume of the thickener. Thus, HRT gets impacted negatively. It is recommended to add septage to the gravity thickener after preliminary treatment to remove the solid waste and grit which might hinder the settling of sludge. It is recommended to add faecal sludge to the anaerobic digester depending on its characteristics.

Anaerobic digester

Addition of faecal sludge and septage will result in:

- Increased organic loading
- Increases solids loading
- Variation in gas production

Feasibility check

- Actual organic loading rate < designed organic loading rate
- Actual solids loading rate < designed solids loading rate
- Volatile solid fraction in sludge: 70 – 80%
- Ammonia concentration in digester < 1000 mg/L

Faecal sludge and septage might contain higher quantities of digestion inhibiting compounds as compared to sewage sludge

The feasibility check is mainly with organic and solids loading rate. The organic and solids loading rate should be less than the designed rates. The volatile solid fraction in the sludge should be maintained between 70 – 80% for optimizing the methanation rate. Faecal sludge and septage is known to contain higher concentration of ammonia as compared to sewage sludge and hence, this can become a limiting criteria for addition of faecal sludge and septage in sludge treatment stream. Apart from this, higher risk is that of presence on digestion inhibiting compounds. Thus, characterization of the faecal sludge and septage plays a very important role in co treatment at STP.

Mechanized dewatering

Addition of faecal sludge and septage will result in:

- Increases solids loading
- Decrease in efficiency of dewatering

Feasibility check

- Characteristics of sludge
- Solids loading rate
- Efficiency of polyelectrolyte

In an underutilized STP, the hydraulic and solids loading will not be of primary concern. However, the characteristics of sludge might affect the efficiency of polyelectrolyte to flocculate the sludge. This will hamper the dewatering efficiency.

In the case of mechanized dewatering, the feasibility check is with respect to characteristics of sludge, solids loading rate and efficiency of polyelectrolyte. Due to the change in characteristics of sludge, the coagulant and flocculants might need changing or the dosage might need to be adjusted with respect to change in the solids loading. In underutilized STP, the hydraulic and solids loading will not be main concern as this is the last stage of sludge handling. However, dewatering efficiency needs to be changed from time to time.

9.3 Mitigating the impact of co-treatment

Gravity thickening unit

Impact - Increase in thickened sludge accumulation

Mitigation measures

- Increasing RPM of the sludge scraper
  - Increase RPM to maximum possible without hampering the sedimentation process
- Increasing the removal of thickened sludge
  - Increase the time of operation of pump or replace with a pump of higher capacity

Source: Kusters Water

The major impact on gravity thickener is increase in accumulation of the sludge. If this is mitigated, then the further impact on the gravity thickener can be minimized or nullified. For this, removal of the thickened sludge from the thickener is necessary. To do this the RPM of the sludge scraper needs to be increased carefully. Also, the time of operation of the sludge pump to transfer the thickened sludge to digester will have to be increased.

Anaerobic digester

Factors leading to instability			Symptoms	Recommended measures
Hydraulic shock	Organic shock	Toxic load		
Excessive sludge production	Increase in sludge influent	Excessive concentration of heavy metals	Increase in volatile acids concentration	Adjust alkalinity using alkaline solution (Lime)
Very dilute sludge in feeding	Increase in solids concentration	Excessive detergent load	Alkalinity reduction, pH reduction	Lower volatile acids, alkalinity ratio to < 0.5
Digester silting	Change in sludge characteristics	Chlorinated organic compounds in sludge	Increase in volatile acids/alkalinity ratio	Regulate feeding routine
Excessive foam	Too fast digester start up	Addition of oxygen	Reduction of gas production	Raise sludge concentration & restrict industrial influent
Methanogenic organisms wash out	Irregular feeding	Excessive sulphides	Increase in CO2 concentration in biogas	Clean the digester & initiate start up protocol

The impact on the anaerobic digester is the most critical while treating the faecal sludge and septage in the sludge treatment stream at STP. The information given in the table above gives various symptoms which needs to be monitored for early detection of the problem. The mitigation measures are given against each symptom. Maintaining the operational parameters is the key here. Alkalinity adjustment and regulating the feed to the digester is the key. Along with this, in order to increase the methanation rate, temperature of the digester can be maintained at thermophilic range i.e. 35 ^{0}C. This can be done by using the methane gas to heat the water jacket or heat the incoming sludge to the digester. The operator of the STP needs to make informed decision so as to avoid irreversible impact on the operation of the digester. Recommissioning of digester is a costly affair and hence monitoring of highest level is recommended.

Mechanized dewatering

Operational problem	Consequence	Solution
Inadequate material blades	Excessive abrasion	Replace with more resistant material
Rigid feeding pipes	Pipe cracks and joints leaks	Replace with flexible pipes
Grit in the sludge	Excessive abrasion of the equipment	Either review operation or install grit chamber
Higher solids loading	Inadequate dewatering performance	Adjust the polyelectrolyte feed
Excessive vibrations	Destabilization of electric and mechanical parts	Install adequate shock absorbers

Mechanized dewatering is the last stage of sludge treatment at STP in India. Most of the impact of co-treatment of faecal sludge and septage in taken care by the earlier stage and hence not much negative impact is seen on the centrifuge. To mitigate the increase in the sludge, operational hours of the centrifuge will have to be increased. Along with this, solids loading rate and grit are two concerns which need to be monitored. The polyelectrolyte dosage will have to be adjusted according to the solids loading rate.

Summary

- Addition of faecal sludge and septage to sludge treatment stream of an STP will impact only the sludge treatment units of the STP
- Proper feasibility check and analysis helps to predict the risk of co-treatment
- Solids and organic loading rates are the major constraints while adding faecal sludge and septage in the sludge treatment stream of an STP
- Hydraulic loading rate can become a major constraint while adding faecal sludge and septage in the liquid treatment stream of an STP
- Most critical component in an STP is the anaerobic digester; detailed understanding about its operation is required for co-treatment of faecal sludge and septage with sewage at an STP

Addition of faecal sludge and septage to sludge treatment stream of STP will have impact only on the sludge treatment units. The operational expenditure will be less when the sludge is added to the sludge treatment system, as compared to the sludge that is added to the liquid treatment stream. An in-depth feasibility check can help us determine the risk and reduce its impact well in advance. The most important and critical treatment unit is anaerobic digester. Hence, proper understanding about its operation is necessary.

The key take away message here is, addition of faecal sludge and septage in the liquid treatment scheme will have larger impact on the all the treatment units of the STP whereas the addition to the sludge treatment stream will have impact only on the sludge treatment units.

Session

10

Disinfection of Sludge

Learning objectives

- Understand the different treatment technologies for disinfection of sludge and reuse of biosolids
- Learn about the co-composting approach, thermal drying of sludge and thermal treatment of biosolids

Contents

- Treatment objectives
- Co-composting
- Solar drying house
- Thermal Drying
  - Direct thermal dryer
  - Indirect thermal dryer
- Thermal treatment of bio-solids
  - Incineration
  - Pyrolysis

Treatment objectives

To preserve the human and environmental health by eliminating the pathogens or microorganisms

Elimination of pathogens, micro-organisms

Safe handling of bio-solids

Safe end use of dewatered solids or biosolids in agriculture or other applications

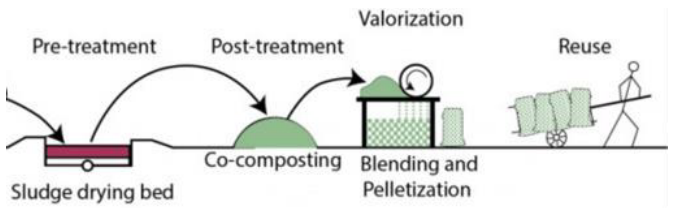
The treatment objectives can be as follows:

- To reduce or eliminate the pathogens, microorganisms and dewater the solids.
- To make it safe for handling of biosolids.
- The safe end use of dewatered solids or biosolids in agriculture, horticulture or other applications.

Co-composting

- C:N Ratio = 20-30:1, Oxygen concentration: 40-60%, Particle diameter < 5 cm
- Advantages: Thermophilic condition = pathogen inactivation
- Limiting factors: Technical and managerial skills required

Source: www.iwmi.cgiar.com



Source: www.wateratleeds.com

Co-composting can be performed on the dewatered sludge. Sludge is rich in nitrogen and if mixed with organic solid waste to achieve C:N ratio of 30 then aerobic composting can be achieved. Thermophilic condition are required for pathogen inactivation and hence care needs to be taken to achieve optimum temperature and maintain oxygen concentration between 40% - 60%. The advantage of the co composting is that it performs drying and pathogen reduction simultaneously and generates an end product with higher value in the market. Limiting factors to practice co composting can be technical and managerial skills along with area required to manage the piles.

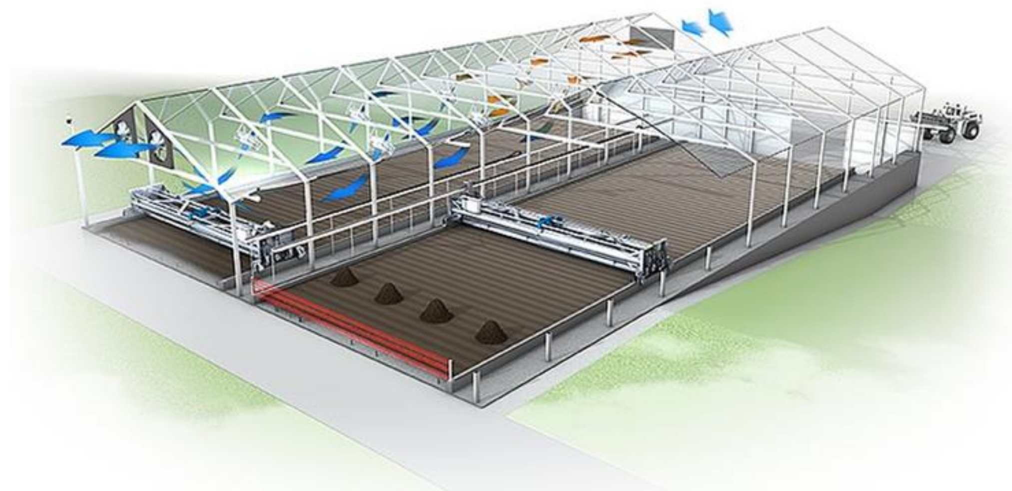
There are two types of co-composting designs: open and in-vessel. In open composting, the mixed material (sludge and solid waste) is piled into long heaps called windrows and left to decompose. Windrow piles are periodically turned to provide oxygen and ensure that all parts of the pile are subjected to the same heat treatment. In-vessel composting requires controlled moisture and air supply, as well as mechanical mixing. Therefore, it is not generally appropriate for decentralized facilities.

Operation and Maintenance:
A well-trained staff is necessary for the operation and maintenance of the facility. Maintenance staff must carefully monitor the quality of the input material, and keep track of the inflows, outflows, turning schedules, and maturing times to ensure a high quality product. Forced aeration systems must be carefully controlled and monitored.

Turning must be periodically done with either a front-end loader or by hand. Robust grinders for shredding large pieces of solid waste (i.e. small branches and coconut shells) and pile turners help to optimize the process, reduce manual labor, and ensure a more homogenous end product.

10.1 Solar drying house

System description



Source: Huber Solar Active Dryer SRT

The slides shows typical solar sludge drying house. Forced ventilation coupled with tilling equipment is used to drive out the moisture at a higher rate from the sludge. The material used for preparing the covering (shed) is such that it allows the solar energy to get inside and get trapped. The solar energy heats up the dry air which absorbs the moisture from the sludge. The moisture laden air is then forced out of the house through the ventilation system.

Performance range

- Solar radiation, air temperature, relative humidity and depth of sludge
- Ventilation flux > Relative humidity
- Initial solid content also affects the solar drying process

SLUDGE
20% solid content
Solar Drying → 7 days
BIO SOLIDS
70-80% solid content

The performance of solar sludge drying is dependent on solar radiations, air temperature, relative humidity of the air and depth of the sludge. The ventilation flux controls the relative humidity and accelerates the evaporation process of moisture from the sludge. The initial water content and depth of sludge also affects the performance of drying. To regulate the depth of sludge and to expose maximum area of the sludge, tilling equipment is used, which tosses and turns the sludge while maintaining the height of the sludge and exposes it to the relatively dry air.

Design criteria

$$E = 0.000461\, R_0 + 0.00101\, Qv + 0.00744\, T_0 - 0.22\, \sigma + 0.000114\, Qm$$

Where;
E: evaporation rate (mm/h)
R_o: outdoor solar radiation (W/m^2)
Q_v: ventilation rate (m^3/ m^2 h)
T_0: air temperature (^{0}C)
σ : dry solids content (kg solids/kg sludge)
Q_m: air mixing rate (m^3/m^2 h)


Solar radiation


Ventilation rate

The evaporation rate can be calculated using the formula given in the slide above.

Design criteria and procedure

- Drying cycle time
  - Solid content of the incoming sludge
  - Evaporation rate
    - Solar radiation, air temperature and ventilation rate
  - Sludge depth
- Sludge depth
  - 150-400 mm
  - Higher depth requires mechanical tilling equipment
- Ventilation rate
  - 150 m^3/m^2.h

The drying cycle time of the sludge depends on the initial solid content, evaporation rate which is dependent on solar radiation, air temperature and ventilation rate and sludge depth. The sludge depth can vary from 150 – 400 mm. However, it is recommended to have tilling mechanisms for higher depths such as 250 mm. A ventilation rate of 150 m3 per square meter area of solar sludge drying house is recommended. However, it is completely dependent on the site conditions and should be adjusted accordingly.

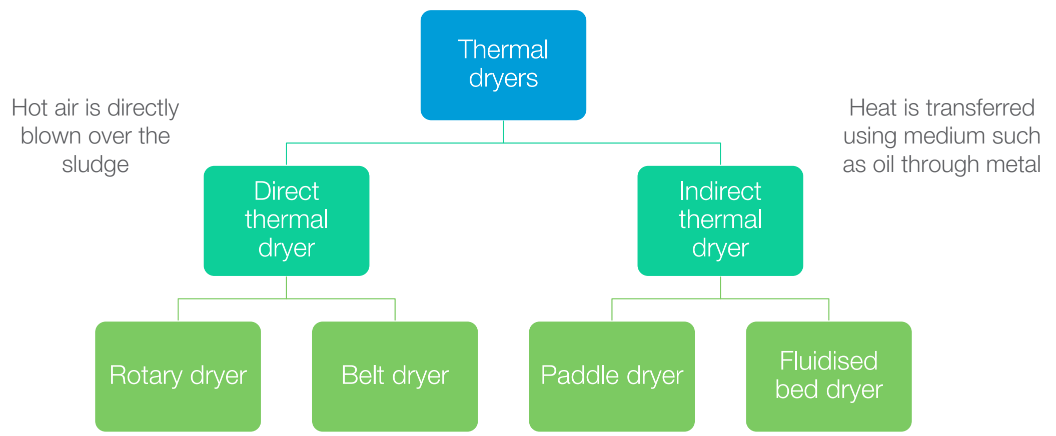
Operational and design consideration

- Requires mechanical equipment and a reliable electricity supply
  - Functioning of ventilation fans
  - Functioning of tilling device
- Number and configuration of drying beds
  - Multiple beds for sequential loading
  - At least one extra bed for ease of maintenance
- Maintenance needs
  - Greenhouse covering needs to be cleaned regularly

Since mechanical equipment is used for forced ventilation and tilling, reliable source of electricity is required for operating the solar drying house. There should be multiple beds especially in places which have high humidity or significant variation in temperature on an annual basis. As a maintenance measure, the covering of the green house should be cleaned on regular basis.

10.2 Thermal drying

System description



The slide shows different type of thermal dryers. There are basic two types- direct thermal dryer and indirect thermal dryer. Direct thermal dryer refers to the process where hot air is used to drive away the moisture. Indirect thermal dryer is referring to the process where heat is transferred using medium such as oil, sand etc.

Performance range

- Initial solid content to be around 60% so that sludge moves through the dryer without sticking
- Dried sludge has solid content of 90-95%

www.suezwaterhandbook.com

In the case of thermal dryer, the initial solid content should be approximately 60%. This is required so that the sludge moves through the dryer without sticking to the walls. The dried sludge in the end has a solid content of 90-95%.

Operational and design consideration

- Thermal dryers have a high energy requirement
  - 4.186 kJ per degree celsius – energy required to heat water
  - 2260 kJ/kg – energy required for vaporization
- Optimised operation - efficiency of more than 80%
- Health and safety considerations
  - More than 95% solid content - dust
- Operator training and skill requirements

Thermal dryers have high energy requirement, since a tremendous amount of energy is required to heat the water and there by vaporise it. However, thermal dryers require significantly less area for processing the sludge. In optimised operation, efficiency of the dryer is more than 80% consistently. Health and safety consideration such as production of dust should be taken into account. Operators need to be trained properly and persons with definite skills are required for operating such equipment.

Design criteria

$$E_{r,e} = \frac{[4.186\,(100 - Ta) + 2260\,(C_i - Cf)]}{\in}$$

Where;

$E_{r,e}$: total energy required for evaporation (kJ/kg of wet sludge)

C_i: water content of dewatered sludge

C_f: water content of the dried sludge

T_a: ambient temperature

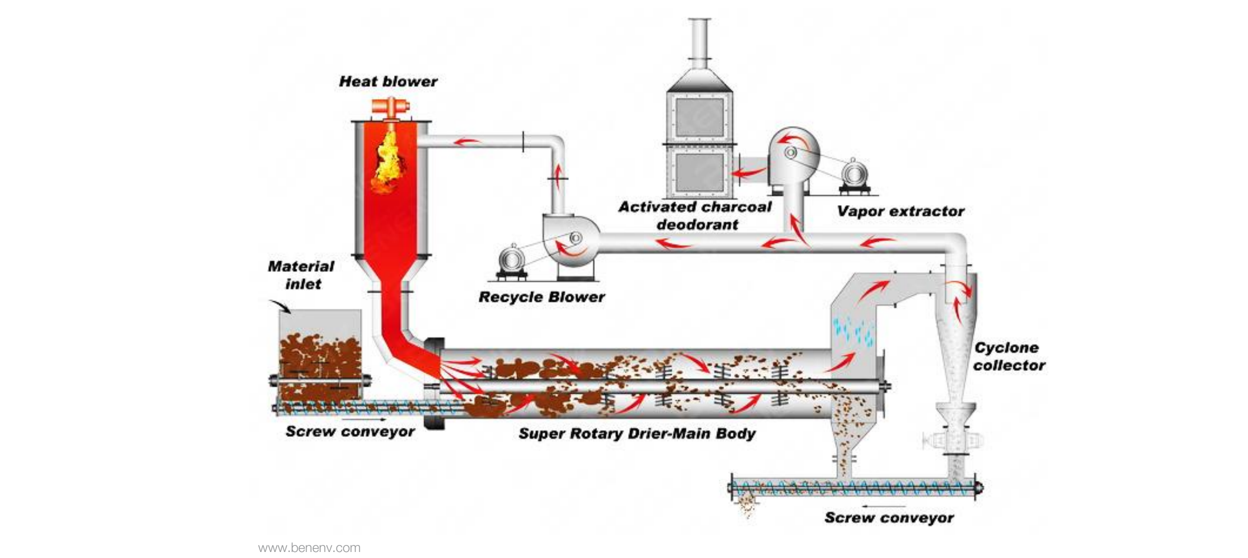
$\in$: efficiency of the drying process

4.186 kJ/kg ^{0}C - energy required to heat water

2260 kJ/kg- energy required for vaporization

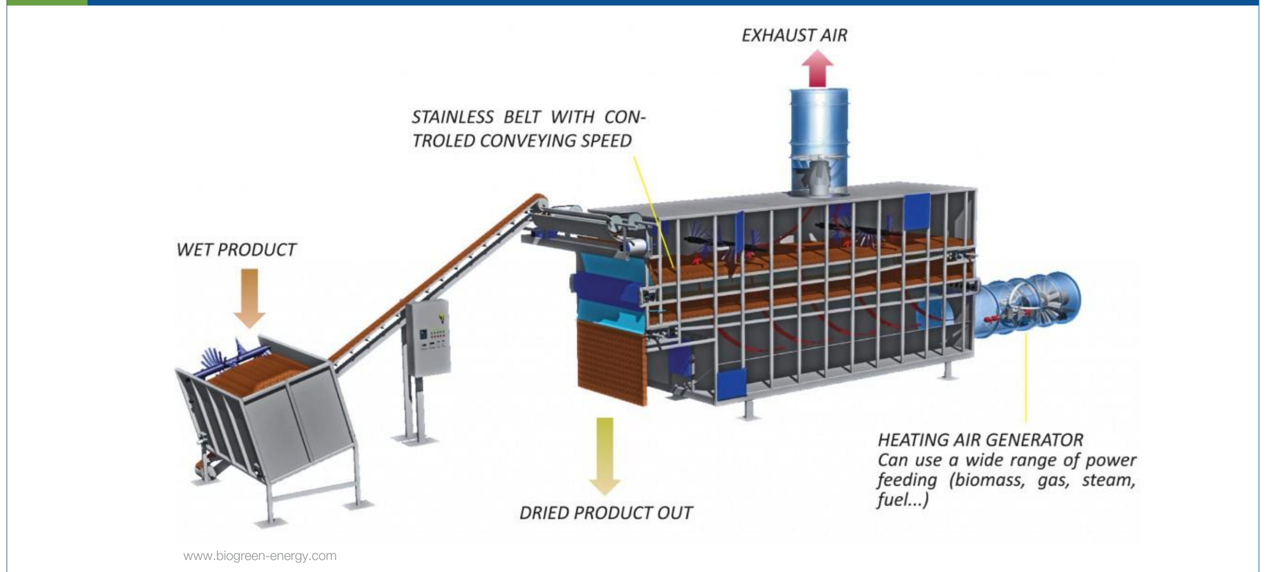
The total energy required for evaporation can be calculated using the formula given in the slide above.

Rotary dryer



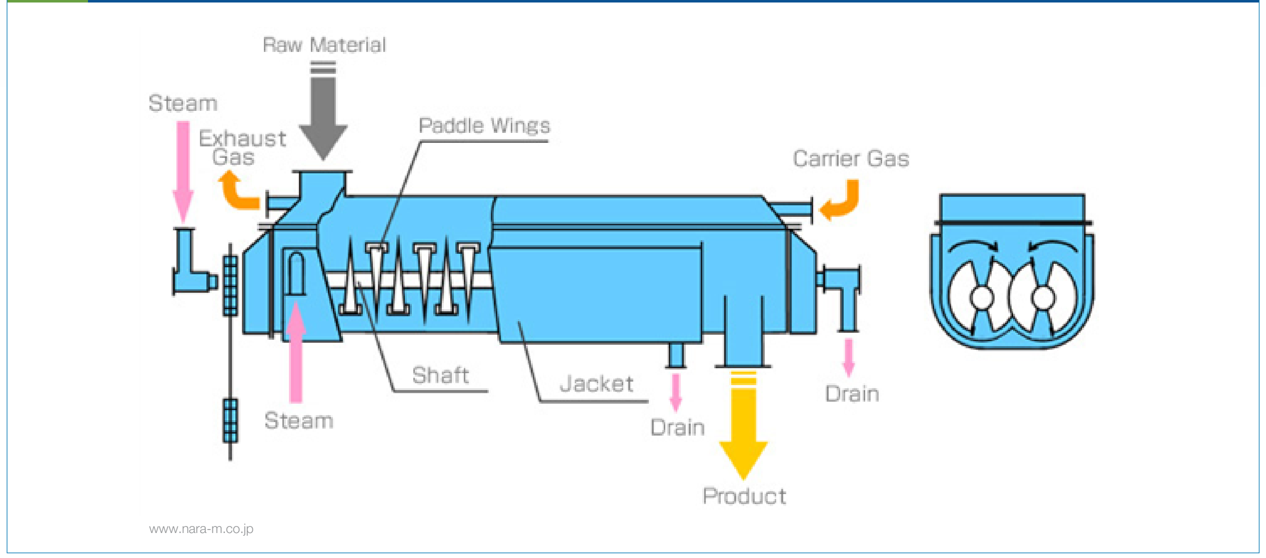
The simplest form of dryer is the direct rotary dryer. This consists of a cylindrical steel shell that rotates on bearings and which is mounted horizontally, with a slight slope down from the feed end to the discharge end. The feed sludge is mixed with hot gases produced in a furnace and is fed through the dryer. As it passes through the dryer, flights (fin-like attachments to the wall of the cylinder) pick up and drop the sludge, causing it to cascade through the gas stream. Moisture in the sludge evaporates, leaving a much dryer material at the discharge end of the dryer. The dried sludge is separated from the warm exhaust gas, part of which is recycled to the dryer while the remainder is treated to remove pollutants and is then vented to the atmosphere.

Belt dryer



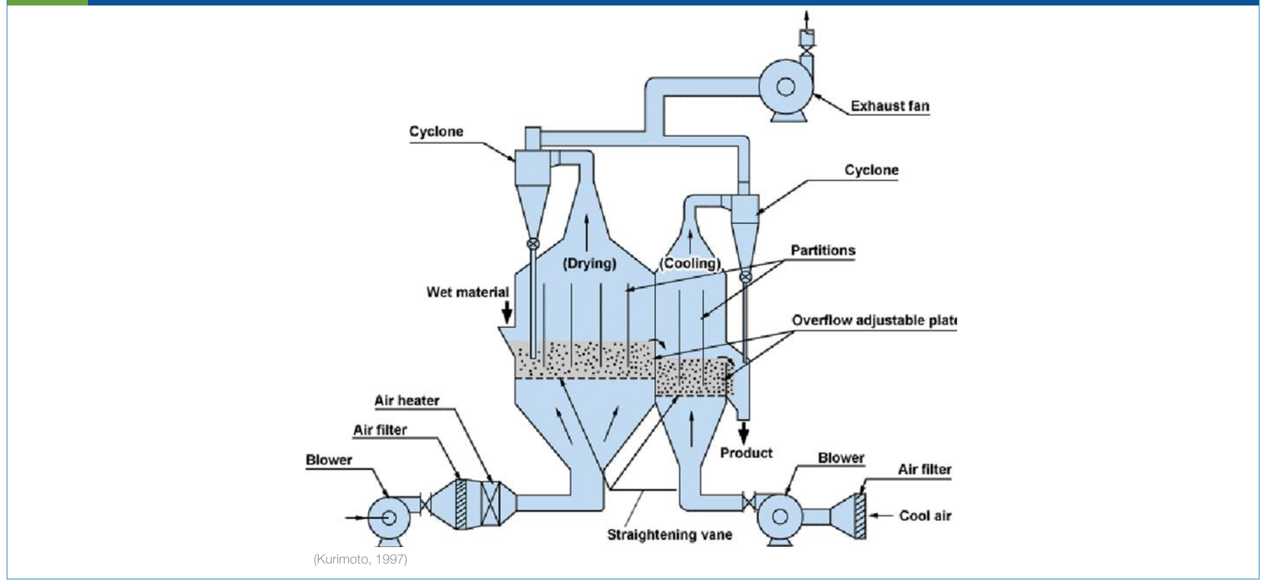
Belt dryers operate at lower temperatures than rotary drum dryers. The heat from the furnace is transferred to a thermal fluid, which heats the air in the dryer. The dewatered cake that is to be dried is distributed onto a slow-moving belt, which exposes a high surface area to the hot air.

Paddle dryer



Paddle dryer has paddle wings which are hollow from inside so that steam can be circulated from it. The paddle system is also encompassed into a jacket which is fed by steam. When raw material is introduced into the paddle dryer, the heat is transferred from the paddles to the sludge. The sludge moves in the forward direction and get churned as it moves ahead. From the other end the dried solids come out of the dryer. Dry air is introduced in the jacket to drive away the moisture laden air out of the dryer.

Fluidised bed dryer

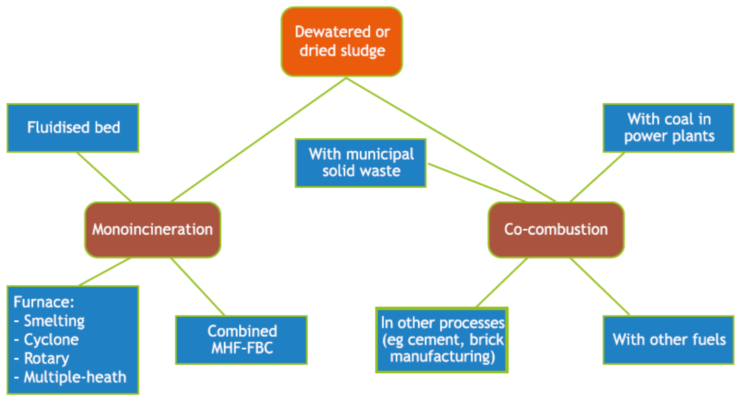


The fluidised beds have been used for drying in Europe and USA since the 1940s to create pellets of sludge. In this case the medium (sand) is heated and kept in fluidised state by introducing hot air in the reactor. The wet sludge in introduced in to the reactor and flash drying takes place. The heated solids are then cooled using cool air before they are taken out of the reactor. Here cyclone de-gritters are used to remove the dust from the hot and cold air coming out of the reactor. Fluidised bed reactor is quite complex to operate and its energy requirement is high too.

10.3 Thermal treatment of biosolids

Incineration

- Complete combustion of organic matter at high temperatures
- Disposal mechanism or way to generate heat or electricity
- Reduces sludge to ash (10% of its initial volume)
- Ash as raw material for construction material



Adapted from Werther and Ogada, 1999

Incineration refers to complete combustion of organic matter at high temperatures. Thus resulting in the ash, which reduced the volume of sludge to 10% of its initial volume. Thus, incineration can be seen as a disposal mechanism for reducing the volume of end product to be disposed or to generate heat or electricity which can be used for various processes. The fly ash which is created as the end product can be used as raw material for making bricks.

Incineration of sludge can be achieved in two ways – mono-incineration and co-combustion. As the name suggest mono incineration refers to incinerating the sludge individually in different types of furnaces. Co-combustion on the other hand refers to incinerating the sludge with some other material such as municipal solid waste, coal in power plants etc.

Energy content

Product	Calorific value (MJ/kg)
Sewage sludge	10-29
Faecal sludge	17
Coal	26

Calorific value of faecal sludge is not as high as sewage sludge or coal

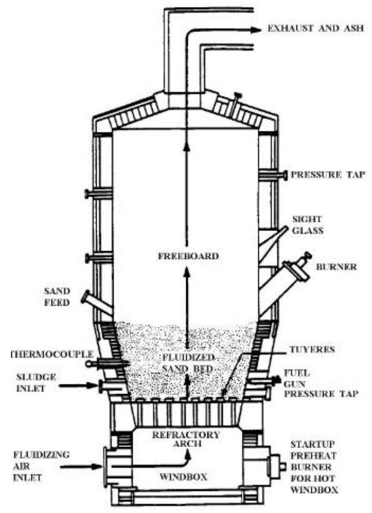
Co-combustion with coal in coal fired plants or cement kilns is better

Financially sustainable only if:

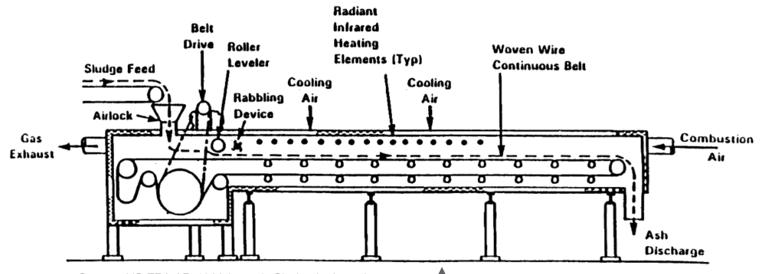
Cost of sludge drying for combustion < financial gains by heat extraction

Energy content in the faecal sludge and septage is quite less as compared to sewage sludge and coal. Hence, faecal sludge alone cannot replace the fuels in the furnaces. It is better to have co-combustion with coal or different fuels such as wood etc in cement and brick kilns. However, it needs to be noted that incineration is only possible when the dewatered sludge is dried with solid content of up to 60% or more. Hence financial viability needs to be checked if the cost of drying the sludge for combustion is less than the financial gains envisioned from the extracted heat.

Types of incinerators



Source: US EPA AP-42 Volume 2, Sludge Incineration



Source: US EPA AP-42 Volume 2, Sludge Incineration

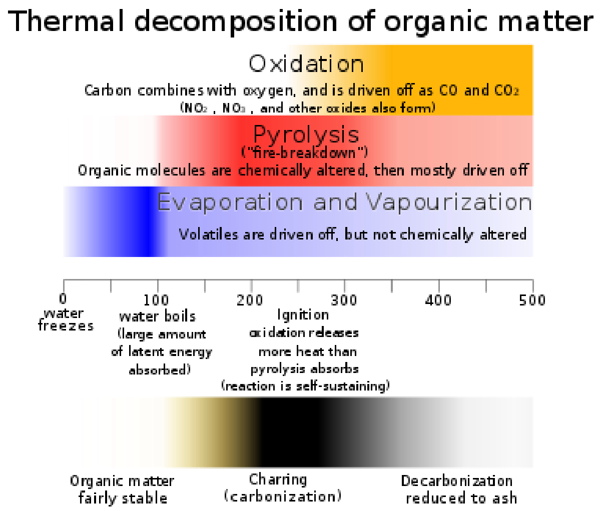
Electric infrared furnace

Fluidised bed incinerator

The slide shows two different types of incinerators. The one on left side is called fluidised bed incinerator and function very similar to fluidised bed dryer, however in this case the temperature is high enough to combust the incoming sludge completely. The other figure is that of electric infrared furnace which uses electrical energy to create heat using infrared heating element. The air is heated with the infrared rays and the hot dry air absorbs the moisture and exits the furnace.

Pyrolysis

- Heating in an oxygen depleted environment
- Temperature: 200 – 500 ^{0}C
- Organic molecule is chemically altered
- Yields carbon based end products such as bio-char, oils and gases

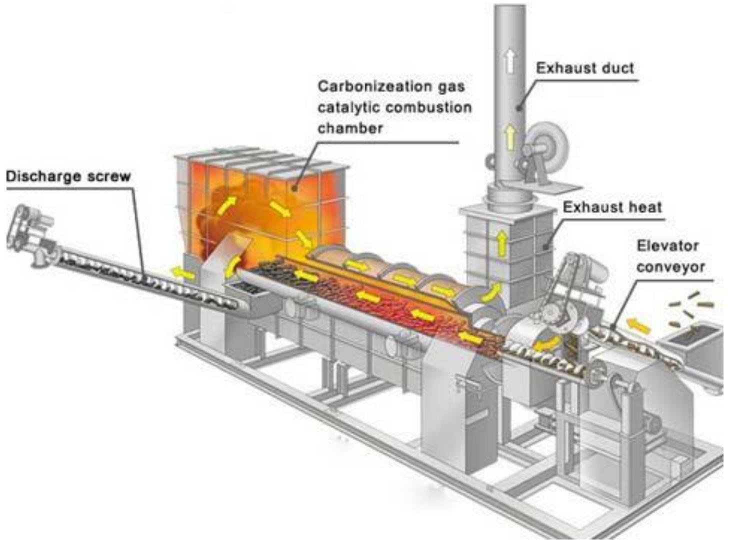


Source: Wikipedia Author: HLHJ

Pyrolysis refers to the stage which is intermediate to combustion. In an oxygen deficient environment and at temperature around 200 – 500 ºC pyrolysis takes place. The organic molecules in the sludge are chemically altered to yield carbon based products such as bio-char, oils and gases. These products can then be used as fuels for completing the combustion process.

Dry pyrolysis

Source: King Tiger Group

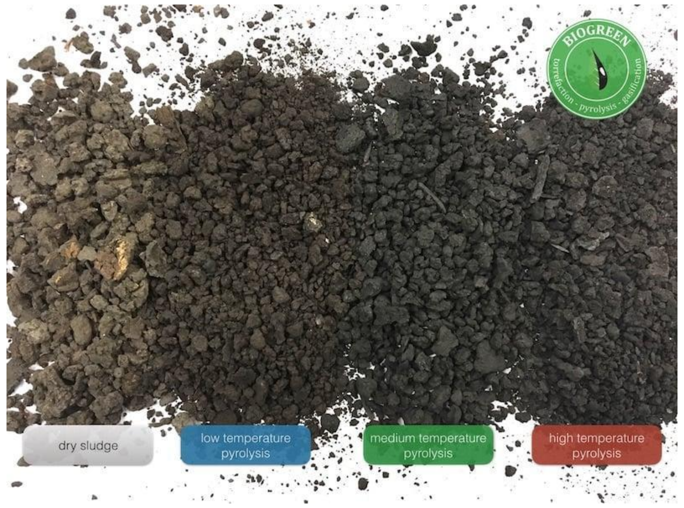


Source: King Tiger Group

Dry pyrolysis refers to a process which is taking place in dry environment. The sludge to be pyrolyzed needs to be dried to the solid content of more than 60%. This is required to avoid sudden drop of temperature in the pyrolizer. The figure on the right shows the complete process from drying to pyrolysis in a skid mounted equipment. The dewatered sludge falls on the conveyor belt and is exposed to hot gases coming from the pyrolysis process. The hot air drives away the moisture and are treated before releasing into the environment. The dried solids then fall into the pyrolizer. In the pyrolizer the dried sludge gets converted into a product called bio-char which is a form of coal. The bio char is removed from the pyrolizer using discharge screw. Thus, it can be seen that there is not physical handling of sludge involved making the complete process bio-safe.

Bio-char

- Fuel in kilns and furnaces
- Should be practiced only if production of char from wet sludge has net positive energy gain
- Soil conditioner
- Improves water retention and aeration, however depletes nutrients



Source: Bio-Green Energy

The slide shows Biochar produced at different temperatures. From the colour it is visible that the degree of carbonization increases from left to right. Production of biochar from dewatered sludge should be practiced only if there is net energy gain is positive. Calorific value of bio char is not as high as coal and hence its acceptability as fuel is less. It can be used for co-combustion in furnaced and coal powered plants. Secondary use of biochar is as soil conditioner. Bio-char is known to improve water retention capacity of the soil and aerates it. However, too much of application of bio-char may also result in depletion of nutrient from plants especially in the cases where inorganic fertilisers are applied over biochar mixed soil.

Hydro-thermal carbonisation

Hydrochar

Ineffective carbonization but the end product is rich in nutrients

Source: G8 International Trading Ltd.

Hydro thermal carbonisation or wet pyrolysis is also one way of tackling dewatered sludge. In this process, the dewatered sludge is subjected to high pressure and temperature by introducing steam in the reactor. Due to the control parameters, the water reaches its critical stage and chemically alters the organic carbon in the solids. Although this process is termed as ineffective carbonization, but the end product is free from pathogens and rich in nutrients. The end product of the process known as hydro char can be used as soil supplement to improve its fertility.

Summary

- Solar drying house requires more area as compared to thermal drying, however the energy required is significantly less
- Thermal drying is more controllable as compared to solar drying, however it is more expensive for implementation and O&M
- Thermal treatment of sludge consists of incineration and pyrolysis of dewatered-dried sludge
- The sludge needs to be dried to increase the solid content to more than 60% for incineration - higher the solid content, better it is for combustion
- Thermal drying equipment do have high CAPEX and OPEX, however provides significant bio safety and reduction in the volume of end product

Case study - videos

- Co-composting of FSS with MSW – Shakhipur Municipality
- Sludge solar dryer
- Rotary sludge dryer
- Belt sludge dryer
- Paddle sludge dryer
- Incineration process animation
- Dry pyrolysis process animation
- Hydrothermal carbonisation

Please find the video links below:

- Co-composting of FSS with MSW – Shakhipur Municipality
- Sludge solar dryer
- Rotary sludge dryer
- Belt sludge dryer
- Paddle sludge dryer
- Fluidised bed sludge dryer
- Incineration process animation
- Dry pyrolysis process animation
- Hydrothermal carbonisation

Notes:

Notes:

Download our latest reports, research briefs
and training modules at:

scbp.niua.org

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.

About SCBP

The Sanitation Capacity Building Platform (SCBP) is an initiative of the National Institute of Urban Affairs (NIUA) to address urban sanitation challenges in India. SCBP, supported by Bill & Melinda Gates Foundation (BMGF) is an organic and growing collaboration of credible national and international organisations, universities, training centres, resource centres, non-governmental organisations, academia, consultants and experts. SCBP supports national urban sanitation missions, states and ULBs, by developing and sourcing the best capacity building, policy guidance, technological, institutional, financial and behaviour change advise for FSSM. SCBP provides a unique opportunity for:

- Sharing and cross learning among the partner organisations, to pool in their knowledge resources on all aspects of urban sanitation capacity building;
- Developing training modules, learning and advocacy material including key messages and content, assessment reports and collating knowledge products on FSSM. Through its website (scbp.niua.org), SCBP is striving to create a resource centre on learning and advocacy materials, relevant government reports, policy documents and case studies;
- Dissemination of FSSM research, advocacy and outreach to State governments and ULBs.

Its strength is its ability to bring together partners to contribute towards developing state sanitation policy, training of trainers and training content development, technical and social assessments, training programme delivery, research and documentation.

National Institute of Urban Affairs

National Institute of Urban Affairs
1st Floor, Core 4B, India Habitat Centre, Lodhi Road, New Delhi - 110003
Phone: 011-24617517, 24617543, 24617595, Fax: 011-24617513
E-mail: niua@niua.org • Website: www.niua.org, scbp.niua.org

CO-TREATMENT OF FAECAL SLUDGE AND SEPTAGE WITH SEWAGE IN SEWAGE TREATMENT PLANT

PART A: PRESENTATION SLIDES