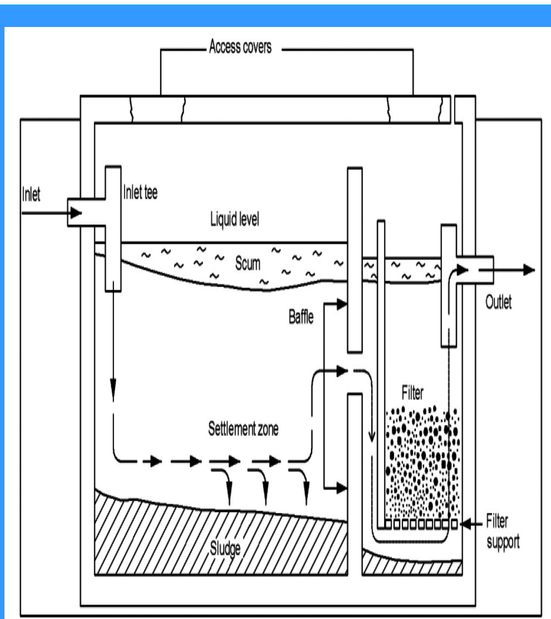
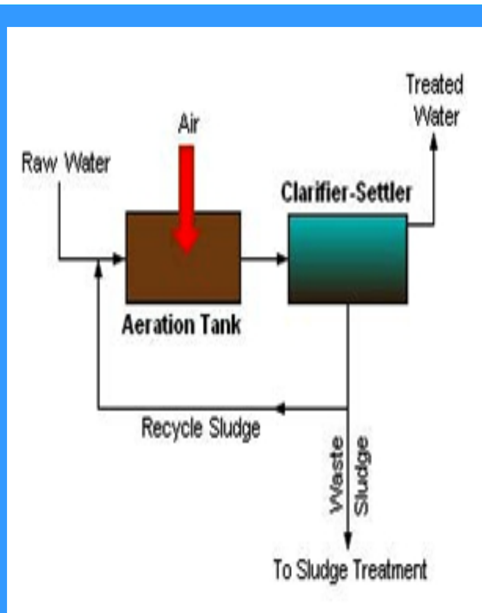
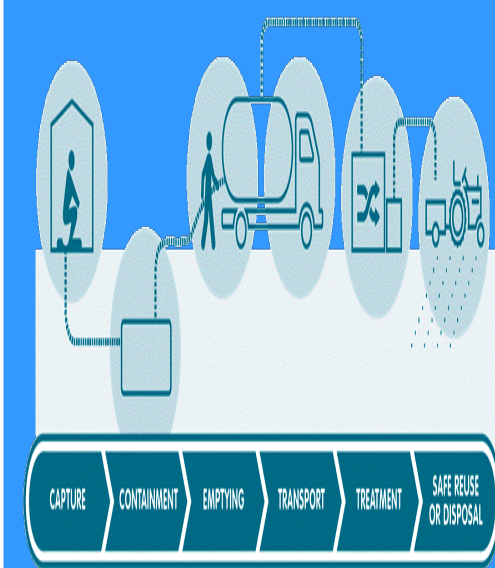
Ministry of Housing and Urban Affairs
Government of India

Swachh Bharat Mission - Urban

Advisory
on
ON-SITE AND OFF-SITE SEWAGE MANAGEMENT PRACTICES







Central Public Health and Environmental Engineering Organisation (CPHEEO)

Ministry of Housing and Urban Affairs
Government of India

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July 2020

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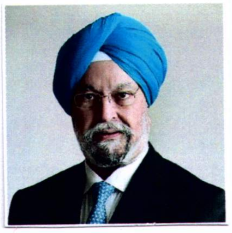
हरदीप एस पुरी
HARDEEP S PURI



सत्यमेव जयते

आवासन और शहरी कार्य राज्य मंत्री (स्वतंत्र प्रभार)
नागर विमानन राज्य मंत्री (स्वतंत्र प्रभार)
वाणिज्य एवं उद्योग राज्य मंत्री
भारत सरकार
Minister of State (IC), Housing & Urban Affairs
Minister of State (IC), Civil Aviation
Minister of State, Commerce & Industry
Government of India

Message

Prior to the outbreak of the Covid pandemic, India was one of the fastest growing economies in the world, and is likely to continue on a similar growth path in the coming decades. At present, India is the 5th largest economy in the world and is slated to be the 3rd largest economy by 2030. By 2050, it is estimated that 50% of the country's population, that is approximately 814 million people would be residing in urban areas. This fast pace of urbanization, coupled with the high growth in economic activities, if not supported with commensurate infrastructure, is bound to compound the sanitation challenges in urban areas.

Approximately 60% of the urban population in India is still dependent on on-site sanitation systems. Since these systems are largely maintained by individual property owners, there is significant scope for improvement in the prevalent levels and standards of sanitation. Further, nearly 70% of water sources are contaminated, with India placed at the 120th position (among 122 countries) in water quality index, according to a study by NITI Aayog conducted in 2018.

Government of India has taken up the challenging task of preventing pollution of fresh water sources and providing piped water connection to the entire population through the "Nal se Jal" initiative under its flagship programme "Jal Jeevan Mission". India is also committed to the United Nation's '2030 Agenda for Sustainable Development' which requires member countries to achieve access to adequate and equitable sanitation and hygiene for all.

In the above context, this Advisory on "On-site and Off-site Sewage Management Practices" is a timely initiative by the Ministry to guide States/Union Territories and other stakeholders on safe and holistic management of sewage and faecal matter. This Advisory will also be of immense help in checking the spread of Covid-19 and other water borne diseases.

I congratulate all the officers of the Central Public Health and Environmental Engineering Organisation (CPHEEO) and the Ministry as well as other stakeholders, who contributed in the preparation and publication of this Advisory.

New Delhi
02 July 2020

(Hardeep S Puri)

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दुर्गा शंकर मिश्र
सचिव
Durga Shanker Mishra
Secretary

सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर

भारत सरकार
आवासन और शहरी कार्य मंत्रालय
निर्माण भवन, नई दिल्ली–110011
Government of India
Ministry of Housing and Urban Affairs
Nirman Bhawan, New Delhi-110011

Foreword

Spurt of economic activities and fast pace of urbanization has compounded the sanitation challenges in urban areas. As of now, around 40% of urban population is serviced with sewerage system and remaining 60% is dependent on sub-optimally regulated on-site sewage management system.

Government of India as well State Governments, hitherto, have been encouraging the cities to put in place conventional sewage management system comprising of sewer networks and sewage treatment plants on whole city basis. However, laying sewer network is cost-intensive and time-consuming project and may not be financially viable in towns and areas having lower population density. Since last few years, States/UTs have prioritized faecal sludge management in areas not covered with conventional sewage systems. This faecal sludge and septage, thus, is being treated and disposed of at the faecal sludge & septage treatment plants and co-treated in sewage treatment plants. In some cases, deep row entrenchment method of land application is also being followed.

This comprehensive Advisory is a tool to further strengthen the policy on sewage management (off-site and on-site) so as to address the complete sanitation value chain in all urban areas at an affordable cost in a time-bound manner.

I congratulate entire CPHEEO team in bringing out this user friendly Advisory on “On-site and Off-site Sewage Management Practices” in a short span of time.

(Durga Shanker Mishra)

New Delhi
July 3, 2020

वी॰ के॰ जिन्दल
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सत्यमेव जयते

स्वच्छ भारत
एक कदम स्वच्छता की ओर

भारत सरकार
आवासन और शहरी कार्य मंत्रालय
निर्माण भवन
GOVERNMENT OF INDIA
MINISTRY OF HOUSING AND URBAN AFFAIRS
NIRMAN BHAWAN

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New Delhi-110011, dated the 20

Preface

Presently, Faecal Sludge and Septage Management (FSSM) is a focus area for States and Urban Local Bodies (ULBs). As conventional sewage system being cost & time intensive, has covered only class I cities, On site Sewage Management alongwith FSSM is affordable and rapid approach to cover remaining population with safe sanitation.

However, with the detailed analysis of various aspects of sewage management, it is clear that sewage can be managed either by on-site methods (septic tank, johkasou and bio-digestive etc.) or off-site methods (WSP, ASP, SBR & MBR etc.). Although, FSSM is an essential component of operation and maintenance of septic tank, the effluent from septic tanks also need to be linked with properly designed soak pit or system of off-site wastewater treatment. This Advisory has discussed in detail on-site sewage treatment methods along with FSSM. Off-site sewage treatment methods have also been explained briefly highlighting its key features, merits and demerits, O&M and comparative cost of various technologies.
This Advisory will facilitate decision makers and planners in selecting suitable methods of sewage treatment and would go a long way in implementing systems of integrated sewage management to ensure that wastewater is safely treated at an affordable cost before discharge into the environment. Detailed technical designs of sewerage systems are given in the Manual on Sewerage and Sewage Treatment Systems released by MoHUA in 2013.

I take this opportunity to thank the CPHEEO team for bringing out this Advisory with clear approach of integrated sewage management in cities/towns. The tremendous efforts by Dr. V.K. Chaurasia, Joint Adviser (PHEE) and his colleagues – Shri Rohit Kakkar, Dy. Adviser, Smt. Sravanthi Jeevan – Assistant Adviser, Shri Sathish Kumar S. – Technical Officer and Shri Vipul Gulati and Shri Sandipan Sarangi, Consultants from Wash Institute is well appreciated. I also acknowledge the efforts of various stakeholders who have taken pain to examine thoroughly the consultative document and shared their suggestions/ comments to enrich this Advisory.
I express my best wishes and hope that the Advisory on On-site and Off-site Sewage Management Practices will go a long way in providing safe sanitation practices in urban areas in a short span of time at an affordable cost.

New Delhi.
3rd July, 2020

V.K. Jindal
(V.K. Jindal)

Executive Summary

The fast pace of urbanization – primarily due to the quest for good quality education, healthcare facilities, job opportunities, rapid changes in lifestyle and growing aspirations in urban areas– coupled with spurt in economic activities has compounded the sanitation challenges in urban areas, as creation of sanitation infrastructure could not keep pace with urbanization. India is signatory to SDGs requiring sustainable sanitation for all by 2030. Contrary to the goal, only 40% of urban population is serviced with sewerage system and the remaining 60% of the urban population is dependent on sub-optimally regulated On-site Sanitation systems.

Government of India as well State Governments, hitherto had been encouraging cities to prepare conventional sewage management plans comprising of sewer networks and sewage treatment plants, on whole city basis. This process although tested and robust but is cost and time intensive. Further, sanitation sector has become a priority, in Government funding, from last few years only. As a result, only about 40 percent of the urban population could be covered with sewerage system. While the current approach remains to provide sewerage system in cities in the long run, of late, States have been encouraging ULBs to cover the hitherto unsewered population with Faecal Sludge and Septage(FSSM) facilities expeditiously. The faecal sludge and septage thus collected is being treated at newly constructed standalone faecal sludge & septage treatment plants (FSTPs) or co-treated at existing STPs in the vicinity. **The contribution of this FSSM in on-site pollution load reduction is hardly 1% of total influent sewage pollution, although it helps in improving biological functions within the septic tanks.** Hence, wholesome on-site sewage/ septage management becomes essential to cover entire population with safe sanitation. However, there are certain alarming issues associated with households covered with on-site sanitation, requiring urgent intervention, as mentioned below;

(i) Poor construction quality of the septic tanks and soak pits in contravention to those specified by Bureau of Indian Standard (IS: 2470).
(ii) Absence of periodic monitoring of functioning of these on-site sanitation systems by owner / ULB/ regulatory department.
(iii) No existing mechanism in place for safe collection, transportation, treatment and disposal of accumulated sludge in septic tanks, which, hampers its treatment performance.
(iv) Unregulated disposal of faecal sludge and septage by unorganized private desludgers in open land/ water bodies without any treatment.
(v) Substantial number of households which have not installed soak pits discharge about 50% of influent pollution load into open environment without any treatment.

This Advisory has shown the way of integrated planning of sanitation in a city comprising of on-site 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. It is clarified that while FSSM is an important element of O&M of on-site sewage management system and essential for its optimal performance, but in no way is it an alternative to conventional sewerage system.

To achieve safe sanitation for all in a short span of time and within available resources, the following key aspects brought out in the Advisory need to be addressed:

(i) Different routes of flow of excreta from a city (Shit Flow Diagram) to be mapped. To safely transport, treat and dispose of excreta, a city sanitation plan to be developed containing short-term and long-term targets.
(ii) City sanitation plan needs to identify priority areas to be covered with sewerage system and

the remaining areas with strengthening of on-site sewage management. It will be a mix of on-site and off-site sanitation systems based on survey of city areas as delineated in the Advisory. As the city grows, sewerage system will keep expanding to cover newly developed areas and on-site based sewage management systems which keep moving outward to cover newly included areas in city limits.

(iii) The present trend of adopting FSSM by States and cities as an alternative to the robust sewerage system, will lead cities nowhere on city sewage management, especially to those cities which are misunderstanding FSSM as an alternative to Sewerage systems. In fact, it is an O&M element of septic tank which handles a portion of household pollution load whether only WC or entire wastewater is connected to septic tank. and is essential for its optimal performance. What is essential is to strengthen the on-site sewage management system to achieve city wide sanitation, its periodic monitoring/ inspection, enforcement of regulations, awareness and discipline in citizens.

(iv) Covering entire urban population with safe sanitation is not too cost intensive as often perceived by ULBs. All that is needed is brilliant planning engaging sector experts and planned mix of on-site and off-site sanitation systems coupled with circular economy concept. It is mindless city-wide planning of sewerage systems in one-go by agencies which had brought sanitation sector in the cities to this juncture. Impatience of authorities to accede reasonable time for survey and robust planning is another factor. Following the approach suggested in the Advisory, a city-wide safe sanitation can be achieved within reasonable time frame of 5-10 years.

(v) Developing a receptive market for usage of end products of sewage treatment/faecal sludge treatment is essential so that the operators are not hesitant in deploying the suitable technologies and are also have no fear of economic losses on their investment.

(vi) Generate awareness among the community towards hazards of poor sanitation and the direct or indirect cost paid by them.

(vii) Building capacity of the urban local bodies and other institutions working on ground is essential so that they understand the facts, ways and means in the right perspective and lead on ground planning and implementation.

(viii) Institutional set up is important at Central / State/ ULB level to achieve city wide sanitation at an economical rate. In its absence the city actually ends up spending more with low sanitation coverage in the city and without significant improvement in hygienic condition of the city.

The Advisory covers all aspects of planning of On-site and Off-site sanitation options including conveyance, treatment and recycle and reuse for implementation. It also contains a Decision-Making Tree for selection of suitable sanitation option for an area and also the comparison of different conveyance and treatment options to suit different set of conditions in cities.

The Advisory has been developed to suit the requirements of ULB officials, decision makers as well as designers and the facts associated with different aspects of city sanitation can be easily comprehended. This will be of immense help to cities in planning to achieve

ODF ++ and Water Plus Certifications which will further help ULBs to improve their rank in Swachh Survekshan at minimum investment. The Advisory is enriched with insights on different procurement models, cross references to various resource documents and several case studies to meet the requirements of ULBs completely while planning city sanitation.

The contents covered in various chapters of this Advisory are summarized in a nutshell chapter-wise below:

Chapter 1 INTRODUCTION: This chapter introduces the current and future challenges of sanitation in urban India. It also underlines the cost of poor sanitation that country is paying. The regulatory framework existing is also briefly highlighted along with Programmatic and Policy initiatives of Governments. It also contains important definitions adopted in this Advisory.

Chapter 2 OBJECTIVES & SCOPE: This chapter highlights the necessity of bringing out this Advisory, intended usage and users. It also outlines the broad objectives along with the scope covered in Advisory.

Chapter 3 CITY SANITATION PLANNING: This chapter deals with the steps required before detailed design begins. In particular, it contains detailed examination the factors that will affect the choice of treatment plant site and procedures for determining the hydraulic, organic, and suspended solids loads on the plant.

Chapter 4 ON-SITE SEWAGE MANAGEMENT: At present about 60% of country population is dependent on one or another form of on- site sewage management system. Since coverage of entire population with sewerage system is still a distinct dream, it is important to strengthen existing on-site sewage management systems to comply with various regulatory disposal norms. The present chapter deals with various types of on-site sewage management systems e.g. Conventional Septic tank with soaking options and other advance systems. It also mentions about their suitability, merits/limitations and O&M requirements for better performance.

Chapter 5 FAECAL SLUDGE & SEPTAGE MANAGEMENT: In the previous chapter, on- site sewage management has been dealt with involving Conventional Septic tank with soaking options and other advance systems. On-site sewage treatment methods invariably generate faecal sludge or septage which need to be safely collected, transported, treated and resuse/disposed of. In recent times, ULBs have gained lot of awareness to manage it safely. This chapter on Faecal Sludge and Septage Management deals with Faecal Sludge and Septage (FS&S) Value Chain with emphasis on the Faecal Sludge &Septage Treatment methods. It also guides on recycle/reuse of treated by-products. Out of three methods of FS&S treatment, two methods namely standalone FSTP and land application have been described in this chapter.

Chapter 6 CO- TREATMENT OF FAECAL SLUDGE and SEPTAGE: The third method of co-treatment of FS&S in STPs is dealt with in this chapter covering aspects like co-treatment and its planning, options of co-treatment at STP, preliminary treatment, FS&S loading at STPs etc. in detail being the prominent method. Additional methods of co-treatment like Bio-methanation, compost and thermal treatment are also covered.

Chapter 7 OPERATION & MAINTENANCE AND MANAGEMENT: This chapter covers O&M of various aspects of FS&S treatment, sanitation value chain and general maintenance of STPs/FSTPs. It also covers institutional set up, capacity building, IEC and private sector participation.

Chapter 8 COMMUNITY BASED SEWAGE MANAGEMENT: This chapter deals with off-site sewage management practices with focus on low capacity community-based conveyance and treatment plants which can be expanded in large size plants also. It also contains important aspects of plants like process, suitability, land requirements, merits/limitations, Capex & Opex and where such plants are working etc. It also contains comparative performance of various wastewater treatment technologies along with comparative O&M requirements of various plants. This chapter will be of immense use to planners not only in planning for sewage based STPs in smaller towns but also for planning localized treatment options for areas not having soak pits after septic tanks.

Chapter 9 FINANCIAL MODELS AND BIDDING PARAMETERS: This chapter attempts to guide planners and decision makers on financial models to operationalize Sanitation value chain. Since, FSSM has picked up in past years and states are planning to implement, three models of operationalizing systems are presented namely (i) Separate service providers for collection and treatment (ii) Service provider for integrated collection and treatment (iii) Hybrid annuity model. These models are supported by eligibility criteria, evaluation criteria, examples of procurement and tenders used to procure such services.

Chapter 10 CONCLUSIONS AND WAY FORWARD: The conclusions presented in a nutshell along with way forward to plan and implement holistic sanitation systems in cities comprising of onsite and offsite expeditiously and economically.

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1. AMRUT: Atal Mission for Rejuvenation and Urban Transformation
2. ASP: Activated Sludge Process
3. BIS: Bureau of Indian Standards
4. BOD: Biological Oxygen Demand
5. COD: Chemical Oxygen Demand
6. CPCB: Central Pollution Control Board
7. DFBOOT: Design, Build, Operate, Own Transfer
8. DO: Dissolved Oxygen
9. DRDO: Defence Research and Development Organization
10. EAP: Extended Aeration Process
11. ERSU: Emergency Response Sanitation Unit
12. FAB: Fluidized Aerated Bed
13. FS: Faecal Septage
14. FSSM: Faecal Sludge and Septage Management
15. FSTP: Faecal Sludge Treatment Plant
16. GeM: Government e-Marketplace
17. GHO: Global Health Observatory
18. GIZ:Deutsche GesellschaftfürInternationaleZusammenarbeit
19. GPS: Global Positioning System
20. GWMC: Greater Warangal Municipal Corporation
21. HRT: Hydraulic Retention Time
22. IARI: Indian Agricultural Research Institute
23. IIT: Indian Institute of Technology
24. LLDPE: Low Linear Density Polyethylene
25. MBBLs: Model Building Bye-Laws
26. MBBR: Moving Bed Biological Reactor
27. MBR: Membrane Bioreactors
28. MLD: Million Litres per Day
29. MoEF&CC: Ministry of Environment, Forest & Climate Change
30. MoHUA: Ministry of Housing and Urban Affairs
31. MPN: Most Probable Number
32. MSW: Municipal Solid Waste
33. NMC: Nashik Municipal Corporation
34. NUSP: National Urban Sanitation Programme
35. O&M: Operation & Maintenance
36. OSS: On-site Sanitation Systems
37. SBM-U: Swachh Bharat Mission – Urban
38. SBR: Sequencing Batch Reactor
39. SDG: Sustainable Development Goals
40. SFD: Shit flow diagram
41. SOP: Standard Operating Procedure
42. SPCB: State Pollution Control Board
43. SPV: Special Purpose Vehicle
44. SS: Suspended Solids
45. STP: Sewage Treatment Plant
46. UASB: Upflow anaerobic sludge blanket
47. UDDTs: Urine Diverting Dehydrating Toilets
48. ULB: Urban Local Body
49. USEPA: United States Environment Protection Agency
50. WHO: World Health Organization
51. WSP: Waste Stabilisation Ponds
52. WSP, World Bank: Water and Sanitation Program

Glossary

Activated sludge Process: An aerobic treatment process in which oxygen and micro-organism concentrations in wastewater are artificially elevated to facilitate rapid digestion of biodegradable organic matter.

Biochemical oxygen demand: A measure of the organic pollutant strength of wastewater.

Blackwater: Wastewater generated from toilets.

Decentralized sewerage system: Implies localized collection and localized treatment of excreta and sullage in micro zones within a major habitation, keeping it in tandem with densification and progressively duplicating it, as and when other micro zones densify.

Dry latrines: All forms of latrines that do not require water for flushing.

Desludging: Removal of sludge or settled solid matter from treatment tanks such as septic/Imhoff tank, interceptor tank or sedimentation tanks.

Disposal: Discharge, deposition or dumping of any liquid or solid waste onto land or water so that it may enter the environment.

Effluent: Any form of wastewater or liquid waste that flows from an operation or activity.

Excreta: Feces and urine.

Faecal Sludge: The accumulated semi-solid or solid portion that settled at the bottom of the septic tank which comprises 20% - 50% of the total septic tank volume is termed as faecal sludge.

Grey water: Wastewater generated from bathing, kitchen and all other household activities except toilets.

Off-site sanitation: A system of sanitation that involves collection and transportation of waste (wastewater either by sewerage or septage/fecal sludge by vacuum truck) to a location away from the immediate locality.

On-site Sanitation: On-site sanitation is a system of sanitation whose storage facilities are contained within the plot occupied by a dwelling and its immediate surroundings. For some systems (e. g. double-pit or vault latrines), faecal matter treatment is conducted on site and also by extended in-pit consolidation and storage. With other systems (e. g. septic tanks or vault installations), the sludge has to be collected and treated off-site.

Pathogens: Micro-organisms such as bacteria, viruses and protozoa that cause disease.

Percolation rate: The rate at which liquids move through soil.

Pit latrine: A form of on-plot sanitation with a pit for accumulation and decomposition of excreta from which liquid infiltrates into the surrounding soil.

Sanitation: Normally sanitation is a broad term and refers to both solid and liquid waste management, however, in this advisory, sanitation is referred to as sewage management only.

Scum: The extraneous or impure matter like oil, hair, grease and other light material that floats at the surface of the liquid, while the digested sludge is stored at the bottom of the septic tank.

Septage: Septage is the liquid and solid material that is pumped from a septic tank, cesspool, or such onsite treatment facility after it has accumulated over a period of time. Septage is the combination of scum, sludge, and liquid that accumulates in septic tanks. Offensive odour and appearance are the most prominent characteristics of Septage. It is a host of many disease-causing organisms along with the contamination of significant level of grease, grit, hair, and debris.

Septic Tank: Septic Tank means a water-tight receptacle which receives the discharge of a plumbing system or part thereof, and is designed to accomplish the partial removal and digestion of the suspended solid matter in the sewage through a period of detention.

Sewage: Combined grey and black water generated from household in the absence or presence of septic tank.

Sewerage System: The underground conduit for the collection of sewage is called Sewer. A network of sewer appurtenances intended for the collection and conveyance of sewage generated from each of the properties to a sewage pumping station for pumping to sewage treatment plant for further treatment and disposal is called sewerage system

Sludge: The settled solid matter in semi-solid condition – it is usually a mixture of solids and water deposited on the bottom of all anaerobic and aerobic sewage treatment systems like septic tanks, oxidation ponds and Activated Sludge plants etc. The term sewage sludge is generally used to describe residuals from centralized sewage treatment, while the term septage is used to describe the residuals from septic tanks.

Soak pit/Soakaway: A pit, typically after a septic tank from where wastewater slowly seeps into the ground through perforated sides and bottom.

Suction truck: A vehicle used for mechanized sludge removal from septic tanks and lined latrine pits.

Wastewater: Liquid wastes from households or commercial or industrial operations, along with any surface water/storm water. Wastewater is a broad term and used for any used water.

Water closet: A pan, incorporating a water seal, in which excreta are deposited before being flushed away using water.

Chapter-1

INTRODUCTION

This chapter introduces the current and future challenges of sanitation in urban India. It also underlines the cost of poor sanitation that country is paying. The regulatory framework existing is also briefly highlighted along with Programmatic and Policy initiatives of Governments. It also contains important definitions adopted in this Advisory.

1.1 BACKGROUND

India is one of the fastest growing economies in the world and this pace of growth is likely to continue in coming decades. At present, India is 5th largest economy in the world and is slotted to be 3rd largest economy by year 2030. Further, Census data 2011 indicates the total urban population of the country at 377.10 million and is projected to touch 600 million by the year 2030. By the year 2050, it is expected that 50% of the country's population at 814 million will be urban. The fast pace of urbanization –primarily due to quest of good quality education, healthcare facilities, job opportunities, rapid changes in lifestyle and growing aspirations–coupled with spurt in economic activities has compounded the sanitation challenges in urban areas. To address the challenges, adoption of both short term and long-term solutions with due leveraging of technology, is need of hour.

India is also signatory to the '2030 Agenda for Sustainable Development', adopted at the Sustainable Development Summit of the United Nations in September 2015.It comprises of seventeen Sustainable Development Goals (SDGs) and 169 associated targets. Of these, 3 SDGs namely SDG No. 6: Ensure availability and sustainable management of water and sanitation for all, SDG No. 11: Make cities and human settlements inclusive, safe, resilient and sustainable, and SDG No. 12: Ensure sustainable consumption and production patterns, are directly related to sanitation sector. This also obligates Government of India as well as State Governments to develop strategies to cover entire population with sanitation facility by year 2030.

To address the sanitation issues in the urban areas, hitherto, primarily sewerage systems have been implemented. These are functioning satisfactorily in many cities across the world including in India, particularly in larger cities having sound financial base. However, in many low and middle-income cities/ towns, installing a comprehensive sewerage system is often not a feasible option due to high capital and O&M cost and availability of adequate piped water supply as a prerequisite. In such cases, a properly managed on-site sanitation system [e.g. septic tank + soak pit] coupled with sanitation value chain offers a feasible and affordable solution. Although, in many cases where soaking arrangements are not available or ineffective, this system unlike sewerage system, may not offer comprehensive solution to grey water/ overflow of septic tanks. Still due to low population density in periphery to core city areas and in smaller towns, this approach improves sanitation and hygiene to a significant extent. Further, to safely manage such grey water/ overflow of septic tanks, localized off-site sewage treatment systems offer economical solution. Above combined approach of on-site & off-site sanitation offers a medium term (5 to 15 years) complimentary plan to sewerage system and is helpful for ULBs to meet regulations on sewage management economically. At later stage, the areas covered under the combined approach of on-site & off-site sanitation, can be increasingly covered with Sewer Networks and STPs, depending on availability of resources.

1.2 Current Sanitation Scenario

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

A recent study of 12 cities in Latin America, Africa, and Asia concluded that around 64 per cent of all households in the 12 cities relied on on-site sanitation (WSP, 2014). Figures from individual cities varied from 51 per cent for Santa Cruz, Bolivia, through 72 per cent for Phnom Penh, Cambodia, 88 per cent for Manila, the Philippines, and 89 per cent for Maputo, Mozambique, to 90 per cent for Kampala, Uganda. Comparison with figures quoted by the World Health Organization (WHO) in the mid-2000s suggests that on-site sanitation coverage is changing slowly (Eawag/Sandec, 2006) and that a high proportion of urban dwellers will continue to rely on on-site sanitation for many years to come.

In India, as per the 2011 Census, 81.4% urban households had toilet facilities within their premises. Out of this, 32.7% households had water closets connected to sewer system and 38.2% households were having water closets with septic tank. However, with construction of about 61 lakh individual household toilets and 5.82lakh Community/Public Toilets seats under Swachh Bharat Mission (SBM-U), the coverage of urban population with toilet facilities has risen to 100%. Though, 60 % of households, in cities with population of more than one lakh (as per 2011 Census), are targeted to be covered with sewerage facilities under AMRUT by 2022, still, as of now, about 60% of the urban population is dependent on On-site Sanitation systems and remaining 40% only are serviced with sewerage system.

Government of India as well State Governments, hitherto had been encouraging cities to prepare conventional sewage management plans comprising of sewer networks and sewage treatment plants, on whole city basis. This process although tested and robust but is cost and time intensive. As a result, only about 40 percent urban population is covered with sewerage system. While the current approach remains to provide sewerage system in cities, in the long run, of late, States have been encouraging ULBs to cover, so far uncovered population with sewerage system, with Faecal Sludge and Septage (FSSM) facilities expeditiously. The faecal sludge and septage so collected is being treated at newly constructed standalone faecal sludge treatment plants (FSTPs) or co-treated at existing STPs in the vicinity.

The contribution of this FSSM in on-site pollution load reduction is hardly 1% of total influent sewage pollution, although it helps in improving biological functions within the septic tanks. Hence, wholesome on-site sewage management becomes essential to cover entire population with safe sanitation. However, there are certain alarming issues associated with households covered with on-site sanitation, requiring urgent intervention, as mentioned below;

(i) Poor construction quality of the septic tanks and soak pits in contravention to those specified by Bureau of Indian Standard (IS: 2470).
(ii) Absence of periodic monitoring of functioning of these on-site sanitation systems by owner / ULB/ regulatory department.
(iii) No existing mechanism in place for safe collection, transportation, treatment and disposal of accumulated sludge in septic tanks, which, hampers its treatment performance.
(iv) Unregulated disposal of faecal sludge and septage by unorganized private desludgers in open land/ water bodies without any treatment.
(v) Substantial number of households which have not installed soak pits discharge about 50% of influent pollution load into open environment without any treatment.

1.3 Poor Sanitation-Cost to Nation

As per the WHO report, 80 % of the diseases in human beings are water-borne and water-related. One of the major reasons for this is pollution/contamination of surface and ground water sources. As per Global Health Observatory (GHO) data acquired by WHO in 2004, India registered a staggering 28,597 human deaths in year 2004 due to diseases out of poor management of Water and Sanitation Hygiene.

Water and Sanitation Program (WSP) of World Bank in its report titled **"Economic Impacts of Inadequate Sanitation in India, 2011"**, estimated the annual economic impact of inadequate sanitation in India at Rs. 2.44 trillion in the year 2006 which is equivalent to 6.4 percent of the country's GDP. Further, the Report states that the urban households in the poorest quintile bear the highest per capita economic losses due to inadequate sanitation, specifically Rs. 1,699 which is 60 percent more than the urban average of Rs. 1,037. The report also indicates that premature mortality and other health-related impacts of inadequate sanitation, were the costliest at US$38.5 billion (Rs.1.75 trillion, 71.6 percent of total impacts), followed by productive time lost to access sanitation facilities or sites for defecation at US$10.7 billion (Rs. 487 billion, 20 percent), and drinking water-related impacts at US$4.2 billion (Rs. 191 billion, 7.8 percent). Further, more than three-fourths of the premature mortality-related economic losses are due to deaths and diseases in children younger than five. Diarrhea among these children accounts for over 47 percent (US $18 billion) of the total health-related economic impacts.

As per Ministry of Health & Family Welfare, official data of 2018, Water Sanitation and Hygiene related diseases registered 69.14 Million cases from 2013 to 2017.

In order to curtail these human and monetary losses, it is necessary to drastically improve the sanitation condition especially the proper treatment and disposal of sewage and faecal sludge and septage in the urban areas.

1.4 Regulatory Framework

Government of India as well as States and ULBs bring out regulations in the sector from time to time. The

Table 1 Treated sewage effluent discharge standards

S.no	Parameters	General norms 1986				MoEFCC Notification, October 2017**	NGT order 2019** (for Mega and metropolitan cities)
		Inland Surface water	Public sewers	Land irrigation	Marine coastal areas		
1	BOD [mg/L]	30	350	100	100	< 30 < 20 (metro cities)	<10
2	COD [mg/L]	250	–	–	250	Not more than 50 (for new STP design)	< 50
3	TSS [mg/L]	100	600	200	100 process water 10% of influent cooling water	< 100 < 50 (metro cities)[2]	< 20
4	TKN [mg/L]	100	–	–	100	Not more than 10 (for new STP design)	< 10
5	NH3-N [mg/L]	50	50	–	50	Not more than 5 (for new STP design)	–
6	Dissolved phosphorus [mg/L]	5	–	–	–	–	<1
7	Faecal coliform [MPN/100ml]	–	–	–	–	< 1000	Permissible < 230

Source: NGT 2019, MoEFCC 1986, 2015 and 2017 & CSE report on Performance study of FSTPs in India 2020 regulations relevant to sewage management are as below.

(i) Central Laws include the Environment (Protection) Act, 1986, the Water (Prevention and Control of Pollution) Act, 1974, Notifications of MoEF&CC and the Municipal Laws from time to time, which provide a framework for control of effluent, sewage and septage discharge. General Discharge standards under EPA 1986 of MOEF&CC along with other norms as notified from time to time are given in Table 1.

1. The standards set in 1986 cover 33 parameters, which are not depicted in this table.

2. Metro cities, all state capitals except for the states of Arunachal Pradesh, Assam, Manipur, Meghalaya Mizoram, Nagaland, Tripura Sikkim, Himachal Pradesh, Uttarakhand and Jammu and Kashmir and the Union Territories of Andaman and Nicobar Islands, Dadar and Nagar Haveli Daman and Diu and the Lakshadweep areas/regions.

** Standards applicable for discharge into waterbodies and land disposal/applications, while reuse is encouraged.

(ii) The provisions of the Bureau of Indian Standards (BIS) (IS:2470) as applicable for Septic tanks, soak pits, cess pools, leach pits, drainage fields etc. are also relevant while strengthening on-site sanitation system.

(iii) The Employment of Manual Scavengers and Construction of Dry Latrines (Prohibition) Act, 1993 puts a ban on dry latrines, i.e., latrines with no water-seal or flushing mechanism, and the employment of persons for manually carrying human excreta. This was supplemented with the Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013 by which "hazardous cleaning" in relation to sewers and septic tanks was also banned. The law now provides that manual cleaning of sewers and septic tanks, if necessary, may be carried out only in very controlled situations, with PPE and adequate safety precautions, and in accordance with specific rules and protocols for the purpose.

(iv) The Government has also laid down standard e.g. IS 11972 – 2002: Code of Practice for Safety Precautions to Be Taken When Entering a Sewerage System. This standard lays down guidelines for selection of sewer-person and safety measures against gas hazard, infection with a view to provide some basic guidance for selection of employees for sewer cleaning and proper job instructions for safe working in a sewerage system.

1.5 Initiatives Taken by Government of India

Several initiatives have been taken by Government of India to achieve decent sanitation in the urban areas of the country. These initiatives may be broadly classified into

(i) Programmatic initiatives

(ii) Policy initiatives

Some of these prominent initiatives are given below:

(i) Programmatic initiatives

- Swachh Bharat Mission – Urban (SBM-U): The Swachh Bharat Mission –Urban (SBM-U) was launched by the Government of India on 2nd October 2014 covering all statutory cities/ towns with a stated aim to provide access to sanitary toilet facilities to the entire urban population and to eradicate the problem of Open Defecation from the country. Creation of the massive number of additional toilets in the past five years had increased the need for systems for collection, conveyance and treatment of the sewage generated from these toilets.

As per recent estimates, urban areas of 36 states/UT, and 4,320 cities have become ODF, and remaining states / cities are on track to become ODF very soon. Additionally, a variety of innovative initiatives such as Swachh Survekshan, ODF / ODF+ / ODF++ / Water+ protocols are being practiced under SBM.

- Atal Mission for Rejuvenation and Urban Transformation (AMRUT):The Atal Mission for

Rejuvenation and Urban Transformation (AMRUT), a Centrally Sponsored Scheme, is under implementation focusing on creation of basic urban infrastructure including sewerage and septage management in 500 cities/towns in the country.

(ii) Policy initiatives

- National Urban Sanitation Programme (NUSP), 2008: The Ministry of Housing and Urban Affairs had formulated the "National Urban Sanitation Policy (NUSP)" in 2008. The NUSP envisages preparation of state sanitation strategies by states, and city sanitation plans (CSPs) by cities. The overall goal of the NUSP is "to transform Urban India into community-driven, totally sanitized, healthy and liveable cities and towns." The specific goals include awareness generation and behaviour change; open defecation free cities; and integrated city-wide sanitation. Under NUSP, Ministry had published and adopted Service Level Benchmark (SLB) for various components of water and sanitation sector.

- Manual on Sewerage and Sewage Treatment Systems, 2013: Ministry of Housing and Urban Affairs has published 'Manual on Sewerage and Sewage Treatment Systems' in 2013. Separate chapters have been allocated for decentralized sewerage system and onsite sanitation, wherein, the different methods of decentralized sewerage and onsite sanitation systems are discussed in detail.

- National Policy on Faecal Sludge and Septage Management (FSSM), 2017: National Policy on FSSM was published by Ministry 2017 with main objective to set the context, priorities, and direction for, and to facilitate, nationwide implementation of FSSM services in all ULBs such that safe and sustainable sanitation becomes a reality for all.

The Policy set specific milestones in order to achieve the target of total sanitation throughout the country. According to the policy, States and ULBs have to develop and issue respective FSSM Policy and Plans. Many States have already developed or modified their FSSM Strategies in line with the National FSSM Policy and have initiated to work in order to achieve the targets set in the National Policy.

- Standard Operating Procedure (SOP) for Cleaning of Sewers and Septic Tanks, 2018: Ministry had published the 'Standard Operating Procedure (SOP) for Cleaning of Sewers and Septic Tanks' in November, 2018. The set of procedures to be followed while cleaning the sewers and septic tanks its cleaning frequency and the the use of personal protective & cleaning equipment are discussed in detail.

- Advisory on Emergency Response Sanitation Unit (ERSU) 2019: Ministry of Housing & Urban Affairs (MoHUA) had published an Advisory on Emergency Response Sanitation Unit (ERSU) 2019. The advisory deals with the technical and managerial interventions for ensuring safety during sewer and septic tank cleaning.

- Various Advisories on Sanitation: Ministry had published various Advisories in the field of sanitation from time to time to guide the States/UTs about the various technological advancements or to showcase the best practices followed across the country/world.

Chapter-2

OBJECTIVES & SCOPE

This chapter highlights the necessity of bringing out this Advisory, intended usage and users. It also outlines the broad objectives along with the scope covered in Advisory.

2.1 Objectives

This Advisory primarily focuses on broad technical know-hows and helps in decision-making needs of ULBs and other stakeholders. It is not a design manual but a guide for planners to evaluate and consider the available options of on-site and off-site sewage management practices. Emerging FSSM including the treatment options of Faecal Sludge and Septage is also covered.

The main objectives of this Advisory are to:

i. Strengthen on-site sewage management practices to cover entire urban population with safe sanitation facilities, specially the unsewered 60% urban population, entailing moderate infrastructure budget.

ii. Facilitate ULB officials and other stakeholders with the basic knowledge of the on-site and off-site sewage management techniques and to empower them to take decisions on suitable technology/ approach, suiting to the requirements of particular ULB.

iii. Detailed guidance on periodic desludging of septic tanks and treatment of Faecal Sludge and Septage using various available methods.

iv. Facilitate ULBs for faster procurement of services/ products by way of preparing and providing model tender documents, concession agreement etc.

v. Improves health as the poor sanitation inflicts several health hazards.

vi. Help ULBs meet forthcoming challenges during implementation of various programmes and missions of States/GoI.

vii. Help the urban areas in the Country to achieve Target 6.2 of Sustainable Development Goals (SDG)- requiring India to achieve access to adequate and equitable sanitation and hygiene for all by 2030.

2.2 Scope

This Advisory inter allia covers the following;

(i) On-site sewage management techniques along with their key features, merits and demerits, capital as well as Operation and maintenance costs.

(ii) Norms on safe containment, collection and transportation of Faecal Sludge and Septage in urban areas.

(iii) Standalone treatment of Faecal Sludge and Septage and/or its co-treatment in other feasible options like Sewage Treatment Plants, Bio-methanisation plants or Thermo-Mechanical Treatments.

(iv) The off-site (community based) sewage treatment options with their merits and demerits, requirements of land for its set up and capital as well as Operation and maintenance costs.

(v) Reuse/recycle of treated by-products of Septage/ Sewage in the true spirit of circular economy.

(vi) Procurement of services including concession agreement

Chapter-3

CITY SANITATION PLANNING

This chapter deals with the steps required before detailed design begins. In particular, it contains detailed examination the factors that will affect the choice of treatment plant site and procedures for determining the hydraulic, organic, and suspended solids loads on the plant.

3.1 The Planning Process

For coverage of entire urban population with safe sanitation facilities, city sanitation planning is an important step. City sanitation planning reflects actionable priorities suiting to the ULBs particularly on technological and cost options. The City Sanitation Plan preparation broadly involves the following elements.

1. Identifying planning area to cover with safe sanitation facilities
2. Existing sanitation coverage
3. Characteristic of Sewage and Faecal Sludge & Septage
4. Identifying the excreta flow routes in city/town
5. Identify existing Sewage Treatment plants/ Solid waste Plants within the city or in nearby city suitable for co-treatment.
6. Identify available lands for setting up new processing facilities on standalone/ shared basis.
7. Identifying the availability/ constraints of funds
8. Decision making tree to select one of the two feasible options viz onsite & offsite
9. Factors to be considered in Technology choices
10. Plan to operationalize Sanitation Value Chain
11. Procurement of goods & services
12. Reuse of the reclaimed water from treated sewage/septage and conditioned sludge that are hygienically safe
13. Consultation with the stakeholders to evolve a complete acceptance of physical, financial and managerial aspects
14. Collaboration with other planning agencies at local, state and national levels to ensure co-ordination in allocation of priorities and resources
15. Institutional Set up for planning, Implementation, ICT based monitoring and O&M
16. IEC and enforcement of regulations

3.2 City Sanitation Plan Preparation

The planning process elements are briefly elaborated to help in preparing sound City Sanitation Plans.

3.2.1 Identify planning area

Planning should always be information-based and should start from an assessment of the existing situation. Rapid assessment, based on existing records, field observation, and conversations with service users and providers, can provide useful information on existing facilities and services. It will help to identify areas requiring more detailed investigation prior to detailed design.

The first task will be to determine the planning area. This will be influenced by physical realities, in particular, existing settlement patterns and administrative boundaries. It should be determined in consultation with local government and service providers.

3.2.2 Existing sanitation coverage

The objective of this is to gather information about the coverage and quality of existing services to clarify the key problems to be addressed and priority locations for improvement. In most settlements, investments in sanitation will already have been made, whether by government agencies, households or others. The condition and functionality of these facilities will have a strong influence on the options for improvement.

The data pertaining to existing services may include information on existing water supply services (including daily consumption per household) can be used to estimate daily wastewater production, Current levels of service (household and shared facilities),including approximate household coverage and number and location of community or public toilets, Data pertaining to types of on-site sanitation system serving households, for example, leach pit or septic tanks, Waste collection and conveyance such as existing sewerage infrastructure, coverage of sewerage and proportion of households with household connections, Fecal sludge and septage collection services (ULB / Private / both), coverage, frequency of servicing and infrastructure in terms of no and sizes of trucks with service providers, charges levied for desludging services etc. Off-site wastewater treatment and reuse, wastewater treatment location and types of wastewater treatment infrastructure (if any exists). Discharge or reuse locations where wastewater and fecal sludge is disposed or reused.

The outcome from this should be a clear understanding of the problems to be addressed, both in terms of location and type, at the household, neighborhood and city levels. It should also be clear which locations require new infrastructure or services and which are suitable for upgrading.

3.2.3 Characteristic of Sewage and Faecal Sludge & Septage

To customize the design of treatment options, it is important to study the characteristics of sewage and faecal septage in the service area. The characteristics of sewage and faecal septage depend on socio-economic & geographical factors. It also depends on the methodology of sampling; period of time over which samples are taken and sample size. Samples of septage can be drawn from septic tanks and tested for arriving at design values of FSTPs/ STPs for designing these systems. However, where desludging is being done using desludging vehicles, the representative sample may be taken from desludging vehicle itself.

The characteristics of sewage can be determined as per procedure mentioned in IS code 3025 of BIS. The main characteristic parameter BOD varies from 100 mg/l to 300mg/l in Indian conditions. For typical values of various other parameters like COD, TSS, PH and Nitrogen etc., the Manual on Sewerage and Sewage Treatment Systems, 2013 may be referred.

A typical comparison of characteristics of faecal

Table 2 Characteristics of faecal sludge and comparison with tropical sewage

	Sewage	Septage	Public Toilet Sludge
Characteristics	Tropical Sewage	Low Concentration (Well Stabilized)	High Concentration (Mostly Fresh)
COD (mg/L)	500–2,500	10,000	20,000–50,000
COD/BOD	2:1	5:1–10:1	2:1–5:1
NH4–N (mg/L)	30–70	1,000	2,000–5,000
TS	1%	3%	3.5%
SS mg/L	200–700	7,000	30,000
Helminth eggs	300–2,000	4,000	20,000–60,000

Source: Co-treatment of Septage and Faecal Sludge in Sewage Treatment Facilities, Dorai Narayana (2020)

Table 3 Characteristics of various kinds of domestic wastewaters

Parameters	Grey water	Black water	Septic Tank Effluent*	Septic Tank Effluent**	Mixed Wastewater***	Sewage
BOD (mg/L)	100-300	600-1000	300-600	80-160	150-400	250-400
COD (mg/L)	200-500	1000-2000	600-1000	200-400	300-600	500-800
TSS (mg/L)	100-300	800-1200	300-500	200-400	150-350	600-1000
Fecal Coliforms (MPN/100 ml)	102 -103	106 -107	105 -106	103 -105	104 -105	105 -107
Total Coliforms (MPN/100 ml)	102 -103	107 -108	106 -107	104 -106	105 -106	105 -107

Source: MoDWS, 2015

**(Treating Black water only)*
*** (Treating Grey water + Black water)*
****Septic Tank Effluent & Grey water*

septage with sewage is given in **Table 2**. The comparison of various types of waste water, septic tank effluents etc. are also given in **Table 3**. for the purpose of waste water treatment planning for household grey water and effluent of septic tank finding way into drains. It is clear from the table that characteristics of sewage and faecal sludge and septage are quite different and special care and technical interventions needed for co-treatment of faecal sludge and septage with sewage in STPs.

Note: These concentrations are analyzed on-site, the values could be 20-40 % lower at the STP site due to settling, biodegradation etc. process in the wastewater collection system depending on the climatic conditions, type and length of the collection system etc.,

In case of faecal septage, although a great level of variation is observed in the values of the parameters like BOD. In majority of cases, it varies in the range of 500 mg/l to 3000 mg/l in India. It is strongly advised to carry out the field test of influent septage to arrive at specific values of BOD, COD and other parameters for design of FSTPs, as the characteristic parameters may vary from city to city. The method of testing sewage/septage is given in IS code 3025. However, in absence of specific values of influent BOD, the same may be considered in the range of 1500 – 2000 mg/l for design purposes of FSTPs.

3.2.4 Shit Flow Diagram: A City Sanitation Planning tool

A first step towards providing adequate sanitation services in urban areas is to identify the existing faecal matter flow routes from origin till its final disposal. It is also important to identify the strengths and weaknesses of existing system, if any, right from containment to emptying, transport, treatment and safe disposal till resource recovery.

A Shit Flow Diagram (SFD) or excreta flow diagram is a tool to readily understand and communicate how the excreta flow through a city or town. SFD is an innovative way to engage sanitation experts, political leaders and civil society in coordinated discussions about excreta management in a city. It also shows how excreta generated in a city are or not contained/ processed as it moves from defecation to disposal. Further, it highlights the resulting challenges, and works as an advocacy tool to support decision-making on city sanitation planning. The sewage and faecal sludge & septage service value chain primarily consists of the following components:

i. Containment
ii. Emptying of faecal matter
iii. Transportation of the emptied sludge/septage/ sewage
iv. Safe treatment of the collected sludge/septage/ sewage
v. Safe disposal/recycle/reuse of the environmentally stable end product

A typical Shit Flow Diagram of a city depicting safe/ unsafe management of excreta is given below:

3.2.5 Existing STPs and SWM Plants

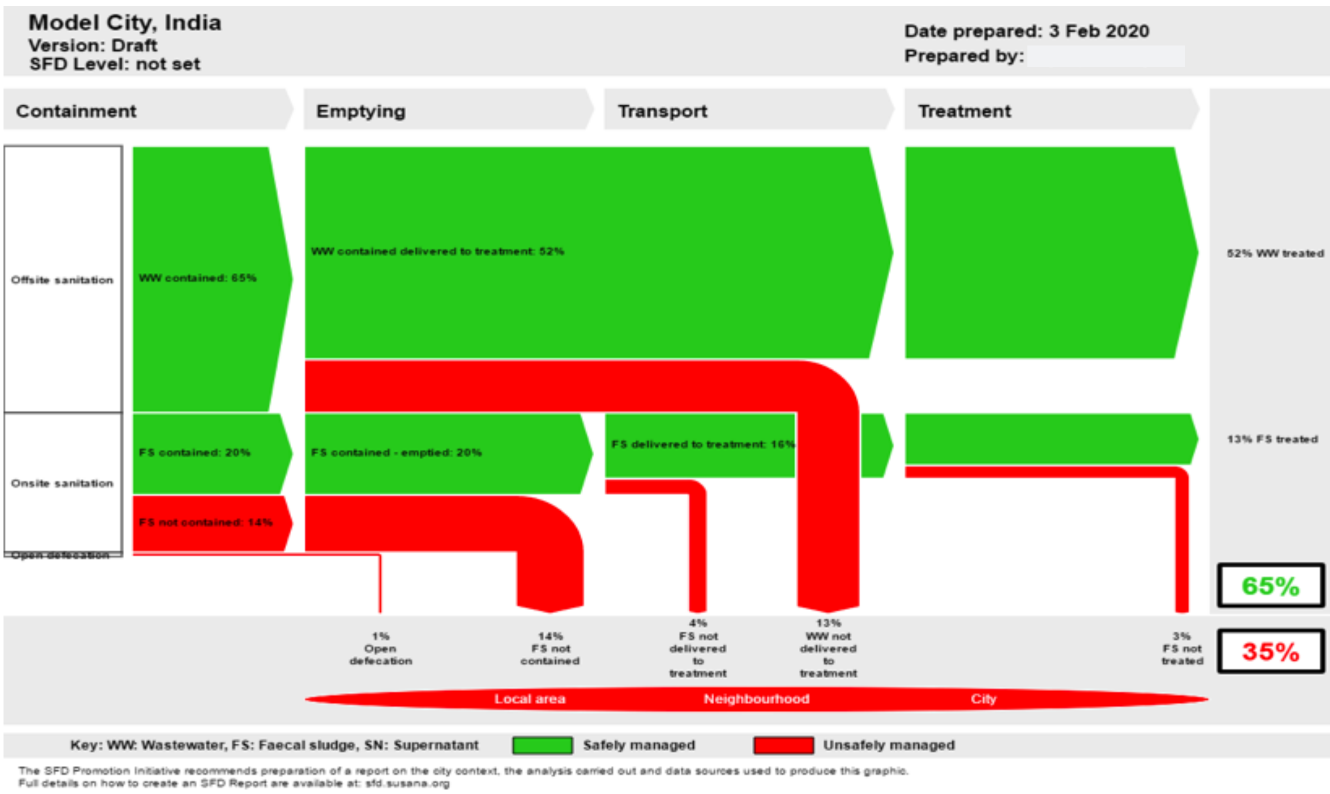
The data regarding the existing STPs such as Location and number of STPs, Technology adopted, Mechanical and Electrical equipment available with details about capacity, Assess condition & efficiency of Mechanical & Electrical equipment, Power bill amount, availability of space in the STP, staff for maintenance, expenditure head wise, Influent quality and effluent quality, process quality after different units, are to be collected and analyzed. The data thus collected would help in analyzing the gap in treatment capacity available and capacity required and also if co-treatment of sludge maybe taken up in the existing STPs.

Also, details of Solid Waste Management Plants such as location, kind of processing unit (wet waste processing unit such as compost plant, bio-methanation plant), capacity of the unit etc. This data would be essential to take up co-treatment of sludge along with the wet waste (organic waste) for production of compostable matter, bio-gas and other derivables.

3.2.6 Land Availability to Set Up STPs/FSTPs

Land availability: Projects are often delayed because of non-availability or high price of land. ULBs should identify the land bank for treatment facility. It is important to ensure sufficient land is set aside for setting up STPs/FSTPs and its infrastructure at the earliest opportunity and embedded into the local planning scheme. Failure to incorporate sufficient land requirements in the planning scheme can result in

Figure 1: A typical Shit Flow Diagram of a city depicting safe/unsafe management of excreta



Tool for generating SFD graphic for any city/town may be downloaded from URL: https://sfd.susana.org/data-to-graphic significantly more expensive and difficult to operate infrastructure to achieve the same performance outcomes. ULBs should also explore the possibility of developing faecal sludge and septage treatment facilities near solid waste dumping sites or already existing sewage treatment plants in order to streamline disposal processes: effluent from FSTPs may be treated at an STP, and the treated sludge may be co-composted with solid waste

Measures to be taken while planning for Faecal Sludge Treatment Plant

Identification of Faecal sludge and septage treatment site is crucial for effective implementation of septage management plan. Following parameters to be taken into consideration before finalization of treatment sites:

i. Distance of treatment site: Distance from emptying to delivering and accessibility of the treatment site are major issues. The transport of relatively small faecal sludge volumes on congested roads over long distances in large urban areas is financially unfeasible. A site that is too far away implies fewer trips per day, less revenue and more fuel costs to private operators.

ii. Reliability of electricity: It is also important to assess the availability and reliability of electricity if treatment technology has mechanical operated parts; as in case of fluctuations it will increase treatment time and will affect optimal utilization of treatment capacity.

iii. Neighborhood: A treatment site may generate objectionable odours. For this reason, it should be located at an appropriate distance from the residential areas and communities should be consulted during the process of designating land for a treatment plant.

iv. Geological Parameters: Assessment of existing geological conditions on site including groundwater table, type of soil, flooding risk is always recommended to ensure that the structure can be safely constructed and sludge will not enter the environment through either porous soil or frequent floods.

Treatment plant locations will depend on their service areas, which, in turn, will depend on the degree to which treatment provision is to be decentralized. A decentralized approach to treatment will result in reduced haul distances for both untreated faecal sludge and septage and the useful end-products of treatment. Conversely, it will increase labour requirements for the operation and maintenance of treatment facilities. Where operational skills are limited, the need to deploy the workforce over several sites will mean that decentralization will work best with fairly simple technologies. Regardless of theoretical considerations, factors such as the availability of government land will often govern the choice of treatment plant location.

3.2.7 Availability of funds

A preliminary assessment of the cost of a technological option involves an estimation of capital and operation and maintenance costs, and a consideration of the options available for project financing, cost sharing, and revenue generation. The latter is important if operation and maintenance is to be sustained.

It is important to recognize the potential costs, including hidden operational costs associated with staffing and other overheads. All components of a sanitation system should be considered in the costing, including those relating to off-site sewers and wastewater treatment where applicable.

In addition, recurrent costs are those incurred for the operation and maintenance of facilities, including management overheads. They will vary greatly according to local conditions; for instance, the cost of operating and maintaining a sewer is likely to be much higher in flat areas with poor solid waste management than in an area with good gradients and adequate waste collection services.

Operational, maintenance, and rehabilitation costs should take into account the routine cleaning of sewers/drains and waste disposal; Purchase of equipment and materials, maintenance of facilities, for instance, public toilets, and so on; and spare parts and replacement costs.

As financial analysis involves an estimation of the actual amount of money paid and received by the project over a period of time, it is necessary to make adjustments to take into account the impact of inflation on each component where considered to be significant. Differing inflation rates may apply to different components and it should be applied to both expenditures and revenues.

Life cycle costing takes into account capital and recurrent costs and the need to replace infrastructure at the end of its life cycle. A spreadsheet can be developed showing the relevant costs and revenues for each technology over a given time period, and used to help identify the most cost-effective option.

Thus, keeping view of the above components involved in planning of the project, necessary arrangements maybe taken up by the ULBs for uninterrupted cash inflow and availability of funds. Unavailability of funds due to various reasons would result in incomplete projects and inefficient Operational & maintenance

There are various financing mechanisms and they can be grouped into several categories, including subsidies and/or grants, public–private partnerships (PPP), Output based aid (OBA), micro-financing or loans, partnerships etc. The ULB may propose any one of them or use cash reserves available with them for continuous availability of funds.

3.2.8 Decision Making Tree: On-site Vs Off-site Sewage Management

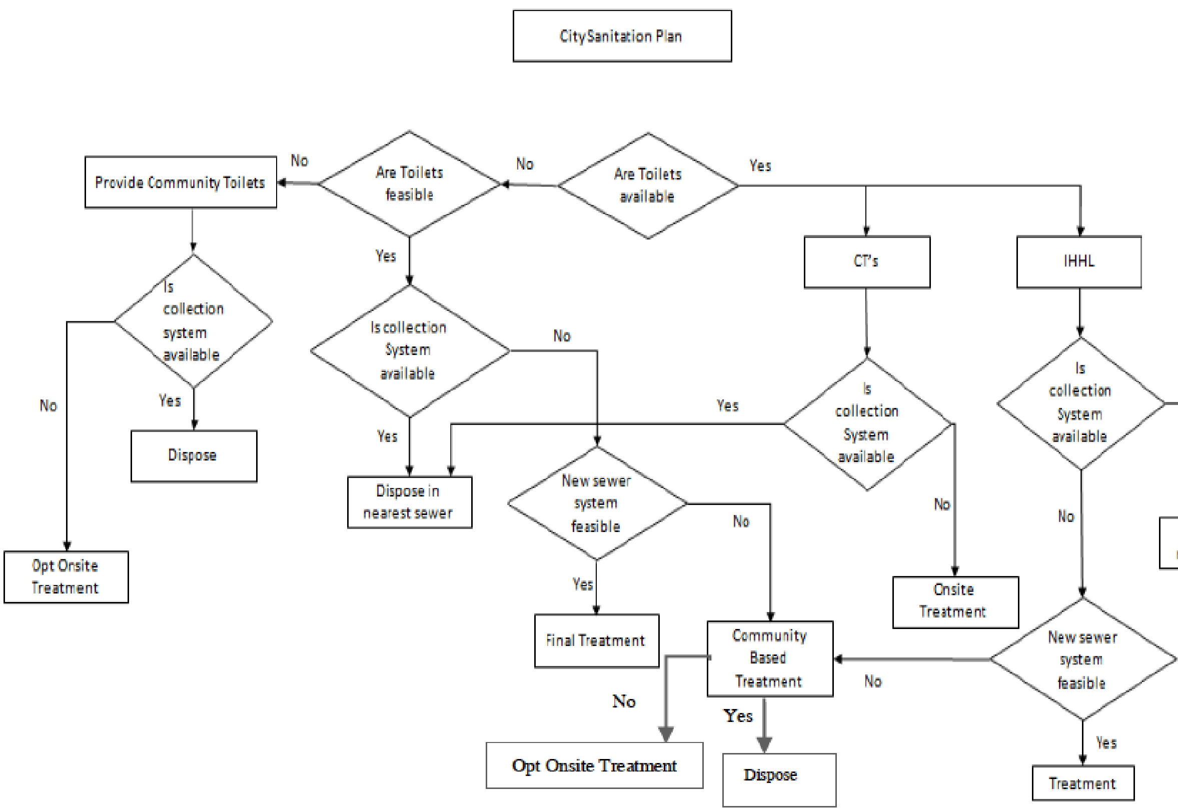
For identified gaps in city sanitation, based on SFD, appropriate sanitation options can be selected out of following two options using the Decision Tree logic:

(a) On-site Sewage Management Systems-within individual's property premises

(b) Community based (Off-site) Sewage Management Systems- for a group of individual properties

A decision tree logic is provided below for selection of appropriate technology option for a given population and location of treatment plant.

Figure 2: Decision Tree Logic



3.2.9 Technology Choices

Technology assessment requires information on the following aspects of each technology:

- land requirement;
- power requirement;
- knowledge and skills required for its operation, maintenance, and repair;
- adequacy of the supply chain for the materials and spare parts that it requires;
- overall cost, including capital and discounted recurrent costs;
- its operational cost;
- environmental impact, particularly any local impact on air or water quality.
- predicted inflow and characteristics of the influent or faecal sludge
- soil characteristics and topography
- seasonal and climatic variations;

Choices between more and less mechanized treatment technologies should take account of the management requirements of each technology, including the skills required to operate the technology and monitor its performance, the supply chains required to ensure the availability of spare parts, and the dependence of the technology on difficult tasks that are required at infrequent intervals.

Choices will also be influenced by costs, particularly recurrent costs. Where financial resources are limited, it may be best to select technologies with lower operational costs, even if their discounted cost is more than that of technologies with high operational costs.

3.2.10 Sanitation Value Chain

Step by step approach: Operationalizing Faecal Sludge and Septage Management

Emptying & Transportation: Transport describes the movement of sludge across the service chain from individual septic tanks and latrines to municipal or regional treatment facilities. Currently, these services are largely unregulated/sub-optimally regulated, particularly in smaller cities and towns. ULB's must take on two tasks: first, they must regulate operators by establishing a system of licensing, which will facilitate the enforcement of health and safety standards and the prevention of open dumping; second, they must design a plan to conduct a system of scheduled emptying in which every containment facility is emptied at least every three years (with more frequent emptying for public accommodations, community/ public toilets, and the like). This scheduled emptying will be contingent on having completed a detailed survey of individual containment facilities, and so may not be operationalized immediately; nevertheless, ULBs shall develop plans to do so.

ULBs must take the following steps

(i) Determine how many households use on-site containment systems and ascertain how much sludge they can contain in order to determine the amount of sludge that will be emptied every year (presuming a three-year emptying cycle for individual households and more accelerated cycles on an as-assessed basis for public and commercial facilities).

(ii) Determine how many septic tanks /pits are emptied annually and what volume of sludge is disposed of at present by looking at actual on-ground practices.

(iii) Determine the average price per emptying (and accounting for how it may differ based on volume and containment facility location) that operators are charging.

(iv) Use the above data to determine as to how many trucks would be needed if septic tanks were emptied on a three-year basis and minimum 3-5 trips per day is performed and design a database for maintaining a register of containment facilities that are emptied.

(v) Create a registration system for private truck operators which permit them to legally empty septic tanks within the ULB. However, these permits will require that they adhere to safety and hygiene standards both in emptying and disposal, establish certain regulated tariffs for emptying septic tanks and latrines, and require the use of receipts to track emptying and disposal. Pursuant to this, ULBs should establish a system for penalizing trucks that operate without valid permits/licenses.

(vi) ULBs should mobilize enough vehicles, either through public or private means, to support a three- year emptying system. This should be done in line with the growth in demand for emptying services, so that trucks are not left underutilized.

Treatment, Disposal, and Reuse: ULBs must not dispose the faecal sludge /septage collected from septic tank/pits without any treatment and ULBs must comply with CPCB and SPCB norms before disposal of septage. ULBs should assess the load of septage and assess the requirement of capacity for treatment plant. ULBs should first try and assess the possibility of setting up faecal sludge treatment facilities at the solid waste treatment/disposal site or at sewage treatment plants within the city or utilizing co-treatment, pending the advice and recommendations of the appropriate engineering authorities. In particular, the state recommends co-locating purpose-built infrastructure, i.e. building faecal sludge treatment plants next to either sewage treatment plants or solid waste management plants, in order to gain advantage from synergies in operation and maintenance (effluent from FSTP can go to STP, or output of FSTP can be co-composted with solid waste, etc.).

Reuse/disposal refers to the methods in which products are ultimately returned to the environment, as either useful resources or reduced-risk materials. The treated septage can be used as a soil enricher or as filling material at construction sites. ULB should carry out primary assessment for availability of market and demand for reuse.

3.2.11 Procurement of goods & services

Majority of items of onsite sanitation systems procured by individual house owners, however, ULB may prepare and upload necessary guidelines on their website regarding engaging trained masons and various material and fixture regarding toilet/septic tank/soak pit. Method for engaging service provider for feacal sludge management is explained above and necessary guidance on engaging contractor is given in Chapter-9. For offsite sewage management facilities, for procurement methods are well set and requisite procurement documents can be accessed from various State Government websites.

3.2.12 Reuse of the Reclaimed Water / Sludge

Reuse and recycling of domestic wastewater eases the pressure on freshwater resources and provides a solution to the problem of discharge of wastewater into the environment. Recycled water can provide a defined quantity and quality of water that, with some management controls, can be made suitable for a wide range of uses including irrigation, pisciculture and toilet flushing. The standards for treated sewage for reuse are mentioned in Table 7.19 of the CPHEEO Manual on Sewerage & Sewage Treatment Systems 2013.

Properly treated sludge can be reused to reclaim parched land by application as soil conditioner, and/or as a fertilizer. Deteriorated land areas, which cannot support the plant vegetation due to lack of nutrients, soil organic matter, low pH and low water holding capacity, can be reclaimed and improved by the application of treated septage.

Reuse of treated sludge for agriculture application should comply with the standards notified for compost from time to time and MSW Rules. The use of sludge and the precautions / procedure thereof are mentioned in clause 6.10.2 of the CPHEEO Manual on Sewerage & Sewage Treatment Systems 2013.

3.2.13 Consultation with the Stakeholders

A stakeholders' meeting uses a variety of activities to stimulate and nurture open discussion on the issues under investigation, which in this case could be sanitary conditions in the community and priorities for improvement. Participants include representatives of public and (where relevant) private sector providers of water supply and sanitation services.

In small- and medium-size towns, stakeholders' meetings are best organized at the ward or zonal level. A neutral place with adequate space, as opposed to the offices of the public service provider, is appropriate for the meeting. To the extent possible, participants should include representatives of:

- Service delivery agencies, including managers, engineers, and social development staff (if any).
- Relevant social intermediaries (nongovernmental organizations, community-based organizations), if any.
- Other relevant institutions, for example, schools where improvements to school sanitation are envisaged.
- Other specialist workers in water and sanitation-related functions, such as masons or community health workers involved in hygiene promotion.

3.2.14 Coordination with Agencies

Co-ordination among water boards / PHEDs / Jal Nigams / ULB as the case may be for exchange of knowledge, best practices etc. Intra-departmental coordination for permissions like incase of ground water department, Pollution control boards etc.

Collaboration with other planning agencies at local, state and national levels to ensure co-ordination in allocation of priorities and resources.

Collaboration with NGOs for IEC activities, PHE agencies for technical guidance in upkeep of on-site and off-site sewage management facilities maybe looked into during the planning stage.

3.2.15 Institutional Set Up

Accessing institution setup is a key factor in preparation of city sanitation plan. If the institutional setup is weak, the sanitation value chain would be adversely underperforming. The main focus of the ULB should be:

a) Capability of existing local authority through accessing whether the number of personnel available in the ULB are sufficient or new people are to be brought onboard. Strengthening of the existing organization structure.
b) Revenue collection and reliability of the ULBs have to be accessed and implementation of ICT based monitoring and O&M need to planned for on-site and off-site sewage management facilities.
c) Capacity building needs for the personnel working in the ULB have to be met, by organizing workshops, training etc. for all the employees in the ULB.
d) Public Private Partnership should be explored if the ULB doesn't have the financial capability.

3.2.16 IEC and Enforcement of Regulations

Behavior change is now seen as an essential component of sanitation programs, whether to improve the uptake of sanitation solutions, hygienic practices in households or, indeed, in the institutions responsible for sanitation programming.

Information Education Communication (IEC) is used for generating awareness. It means process of working with individuals, communities & societies to develop communication strategies to promote positive behaviour that are appropriate to their settings.

Behaviour Change Communication (BCC) is used taking another step forward - enabling action. It means provide a supportive environment that will enable people to initiate and sustain positive behaviour

IEC/BCC activities play a very important and strategic role in the area of public health. Strategic IEC/ BCC programs use a systematic process to understand people's behaviour and influences. A successful IEC/ BCC plan would help in refuting myths and misunderstandings prevalent in the society and will lead to a demand for the various health services being provided, thus bringing about a behavioural change among individuals and the community at large

While planning the ULBs should aim to connect the programs to the people by educating and mobilizing the masses through Information Education and Communication (IEC) and to encourage individuals of society to adopt healthy behaviours. The ULB should have a dedicated IEC team which is responsible for overseeing the planning, implementation, monitoring, and evaluation of all IEC activities related to on-site and off-site sewage management.

The ULB/IEC cell should have decentralized planning and subsequent implementation of the activities by coordinating the process of development of State and District IEC action plans from bottom up. IEC materials like posters, stickers, pamphlets, leaflets, banners etc. are to be produced and are to distributed to health centers in all districts. Other activities such as wall-paintings and hoardings at important sites are to be carried out from time to time throughout the ULB. The ULB/IEC cell should also be engaged in health education and spreading awareness through mass media such as local newspapers, television channels and radio.

Integration of the IEC activities would improve overall coordination, more cost effective and timely utilization of funds, avoid duplication of resources, and strengthen planning, implementation and feedback.

The ULB need to set up regulatory mechanisms by itself or by an independent agency for setting standards, monitoring performance, adjusting tariffs, etc. for on-site and off-site sewage management.

The ULB should plan to ensure the compliance of all the existing regulations like Water (Prevention and Control) Act, 1974, Environment (Protection) Act, 1986, Solid waste Management Rules, 2016, Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013 and their Municipal Bye-laws by all stakeholders.

The ULBs can formulate their own plans in enforcement of these regulations, such as penalizing household for indiscriminate dumping of faecal matter, defecating in the open, not complying to BIS standards while construction of septic tanks, defaulters (payment of taxes), not complying to regular desludging of septic tanks, households engaging labour for manually cleaning septic tanks.

Summary of Planning process for setting up a FSTP for treatment of Faecal Sludge and Septage is given in the planning chart at Figure 3. Following the similar planning process, planning can be done for on-site and off-site sewage management sewage including STPs etc.

In subsequent chapters, the step-by-step description of following sewage and faecal sludge & septage management options, suiting to the requirements of ULB officials, are given:

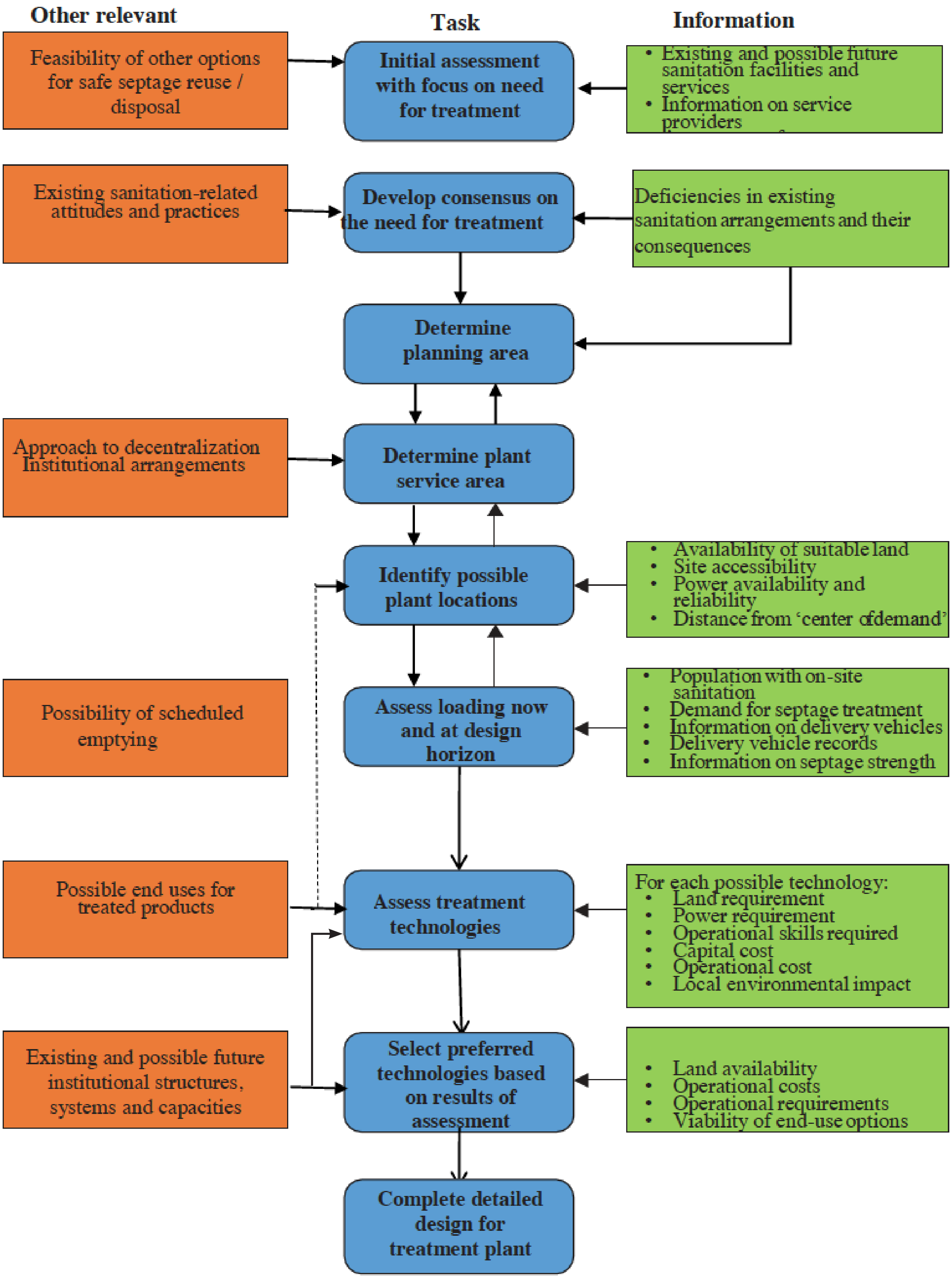
(i) On-site sewage treatment systems along with desludging mechanism of faecal sludge & septage its treatment and recycle/ reuse of byproducts

(ii) Co-treatment of faecal sludge and septage in Sewage Treatment Plants, Bio-methanisation plants or Thermo-mechanical treatment plants.

(iii) Off-site/Community based/ localized sewage conveyance, its treatment systems and recycle / reuse of by-product.

Planning process chart

Figure 3: Steps in the planning process



Chapter-4

ON-SITE SEWAGE MANAGEMENT

At present about 60% of country population is dependent on one or another form of on- site sewage management system. Since coverage of entire population with sewerage system is still a distinct dream, it is important to strengthen existing on-site sewage management systems to comply with various regulatory disposal norms. The present chapter deals with various types of on-site sewage management systems e.g. Conventional Septic tank with soaking options and other advance systems. It also mentions about their suitability, merits/limitations and O&M requirements for better performance.

4.1 On-Site Sewage Management Systems

The premises or properties of individuals that are not served by piped sewer systems can adopt on-site sewage treatment systems. The on-site sewage treatment systems treat sewage within the premises of its generation and are also termed as non-sewered sanitation. They can be broadly categorized as below:

i. Conventional Septic tank with soaking options like soak pit, dispersion trenches

ii. Improved Septic tank

a. Up-Flow Anaerobic Filter

b. Package septic tank-Contact aeration type system

iii. Johkasou Systems-Advanced On-site Sewage Treatment Systems and similar systems

iv. Bio-Digester

The salient features of the On-site Sewage treatment options are briefly described below. The sludge generated in the process of on-site sewage treatment system can be collected and processed in nearby sludge handling facilities like those converting sludge into compost or biogas or safe disposal in deep row trenches. These processes are further elaborated subsequently under Chapter 5 that deals with Septage Value Chain, which primarily focuses on emptying of faecal sludge and septage from on-site containment, its safe transportation, treatment and disposal.

4.1.1 Conventional Septic tank with soaking options

Septic tank combined with soak pit is the most common type of on-site sewage treatment system that is currently practiced in various non-sewered areas.

The salient features of Conventional Septic tank like what is it? where it is applicable? its mode of operation, operation and maintenance requirements, additional infrastructure, limitations and risks, management arrangements and tentative cost etc. are given along with combination of different soaking arrangements and process flow diagrams.

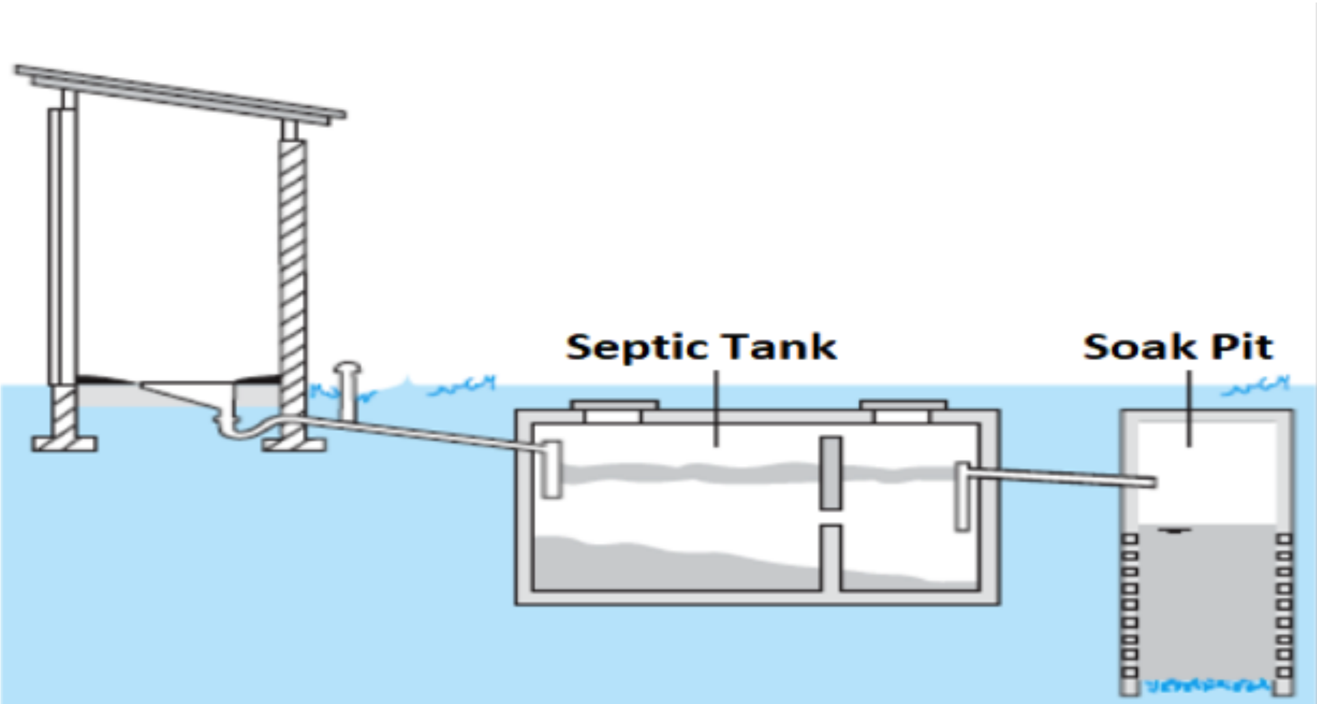
What is a Septic Tank?

(i) A septic tank is a buried chamber that collects and stores domestic sewage (usually blackwater and in some cases grey water as well) and partially treats it under anaerobic conditions. For better performance, grey water should not be allowed to flow in septic tank.

(ii) Effluent from septic tank should be discharged to an on-site infiltration system like soak pit or drain field as shown below in Fig 4. In practice, due to space constraints, as well as, lack of awareness, many premises do not have soaking arrangement and thus, they discharge pathogenic effluent directly into open drains posing a public health risk.

(iii) The standard septic tank design incorporates two chambers. Some septic tank designs adopted in India have three chambers. Most of the treatment takes place in the first chamber.

Figure 4: A schematic diagram of septic tank with soak pit



(iv) A well-managed septic tank would be able to remove about 50–60 percent of the biological load in the sewage. Further, a well-designed soakpit can further remove bacterial load to discharge standards.

(v) Where soaking arrangement is not feasible, the alternative options of upflow anaerobic filter and biological filters (planted gravel filter or constructed wetland) like may be used.

The technical specifications for detailed design of septic tank and soak-pit including upflow anaerobic filters and biological filters are contained in IS Code 2470:1985 (PART I & II) and may be referred to. A schematic diagram of septic tank combined with soak is given below:

Processes within a septic tank and soak pit

(i) Solids settle in the septic tank and digest anaerobically. This reduces sludge volume and enables overflow effluent to infiltrate into the ground in soak pit without clogging the leaching system.

(ii) Sludge settles in the tank and digests anaerobically over time, releasing methane, carbon di oxide and other gases.

(iii) Overflow from septic tank is spread over soak pit or drain field for further treatment and filtration while percolating below ground.

(iv) Septage must be removed from septic tank periodically and transported off-site for treatment prior to recycle/reuse/disposal.

Table 4 recommending the size of septic tank up to 20 users is given for reference.

Note:

a) The capacities are recommended on the assumption that discharge from only WC will be treated in the septic tank

b) A provision of 300 mm should be made for free broad.

c) The sizes of septic tank are based on certain assumption on peak discharges, as estimated in IS: 2470 (part 1) and while choosing the size of septic tank exact calculations shall be made.

Operation and maintenance

(i) Responsibility for operation and maintenance lies with the owner of the property.

(ii) Municipal utility or private contractors are required for periodic desludging of septic tanks and to ensure safe treatment and disposal of septage at a designated facility like Faecal Sludge & Septage Treatment Plant (FSTP) or Sewage Treatment Plant (STP).

Table 4 Recommended size of septic tank up to 20 users

No. of Users	Length, m	Breadth, m	Liquid Depth, m	
			For cleaning interval of 2 years	For cleaning interval of 3 years
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

Source: As per Manual on Sewerage & Sewage Treatment Systems, CPHEEO, 2013

Where are septic tanks suitable?

(i) Septic tank combined with soak-pit is widely used to provide on-site sewage treatment for individual homes, clusters of houses or institutional buildings where there is no sewerage network.

(ii) This system is appropriate for peri-urban settlements or less dense urban areas where installation of sewerage system is not viable.

(iii) Normally associated with pucca [permanent] houses for middle- and higher-income households.

(iv) For soak pits to function, soil conditions must be suitable for infiltration of effluent from septic tanks. A micro-wetland can help through increased evapo-transpiration losses and moisture uptake. Sullage must not be discharged into a septic tank.

Limitations and Risks

(i) The main disadvantages of septic tank and soak pit system are space and cost requirement particularly for the soak pit or drain field. In majority of cases in urban areas, the soak pit is not constructed and instead the common practice is to discharge effluent from septic tank directly into an Open / closed drains.

(ii) Septic tanks often receive more sewage than designed capacity. As a result, the retention time in the septic tank is insufficient and the soak pit becomes hydraulically overloaded. This means that the septic tanks needs to be desludged regularly, but more commonly the households bypass the soak pit and connects the overflow directly to a surface water drain.

(iii) Shock loadings and disturbance of settling zones caused by large inflows from grey water, floods, storms etc. can affect the treatment efficiency of the septic tank and cause excess solids to flow into the soak pit impairing its efficiency.

(iv) The containment structures are often not constructed according to the BIS standards and are oversized most often found to be having higher capacities than required. This is driven with the household's intention to empty the tanks at lesser frequency. However, constructing large size septic tank and lesser frequency of emptying hardens the sludge at bottom and makes it difficult to remove by suction vehicles. This eventually leads to break-open the septic tank and clean the bottom which is often inconvenient and costlier compared to emptying at recommended frequency.

(v) The units are often not lined from the bottom which poses serious threats to the groundwater quality in the areas of high ground water table. Such design errors affect the treatment capacity of the system and likely contributes to the higher pollutant loads in the effluent.

How much does it cost?

(i) Capital costs: A conventional septic tank and soak pit constructed from brick or concrete is a considerable household investment, but cheaper options are available, made from prefabricated plastic or concrete rings. Costs range from Rs. 15,000–20,000.

(ii) Operating costs: The cost is around Rs. 500 per annum considering desludging frequency every third year.

For detailed design and construction of septic tank and soaking arrangements, methodology described in

"Chapter 9: On-site sanitation in Manual on Sewerage and Sewage Treatment Systems" published by Ministry in Nov 2013 maybe referred to.

In regard to the emptying and transportation of the faecal sludge and septage, the set of procedures to be followed for cleaning of septic tanks along with the frequency of emptying and other details like equipment/machineries/vehicles to be used etc. are discussed in detail in Ministry's "Standard Operating Procedure (SOP) for Cleaning of Sewers and Septic Tanks, 2018". SOP may be downloaded from url:

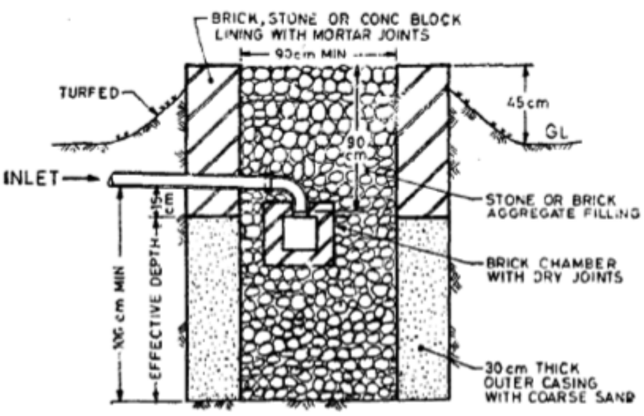
http://cpheeo.gov.in/upload/5c0a062b23e94SOPfor cleaningofSewersSepticTanks.pdf

The emptying and transportation of the faecal sludge and septage is elaborated in detail in subsequent sections.

Soak Pits

(i) Soak pits are cheap to construct and are extensively used.
(ii) They need no media when lined or filled with rubble or brick bats.
(iii) The pits may be of any regular shape, circular or square being more common.
(iv) Minimum horizontal dimension of soak pit should be 1 m, the depth below the invert level or inlet pipe being at 1 m. The pit should be covered and the top raised above the adjacent ground to prevent damage by flooding.
(v) When water table is sufficiently below ground level, soak pits should be preferred only when land is limited or when a porous layer underlies an impervious layer at the top, which permits easier vertical downward flow than horizontal spread out as in the case of dispersion trenches.

Figure 5:Soak pit without lining



Dispersion Trenches

Dispersion trenches consist of relatively narrow and shallow trenches about 0.5 to 1 m deep and 0.3 to 1 m wide excavated to a slight gradient of about 0.25%. The effluent from the septic tank is led into a small distribution box from which several such trenches could radiate out. While proposing dispersion trenches, the factor like permeability of soil, ground water table depth and low lying area should be kept in mind and utmost care should be taken to prevent any threat to public health and environment.

4.1.2 Improved Septic tank

Improved septic tanks namely (i) up-flow anaerobic filter and (ii) Package septic tank -Contact aeration type system is basically improvement over conventional septic tank following anaerobic and aerobic digestion methods respectively. Addition of these improvements in septic tank improves quality of treated effluent and can be successfully used in cases where ground water table is high or permeability of the soil is very low.

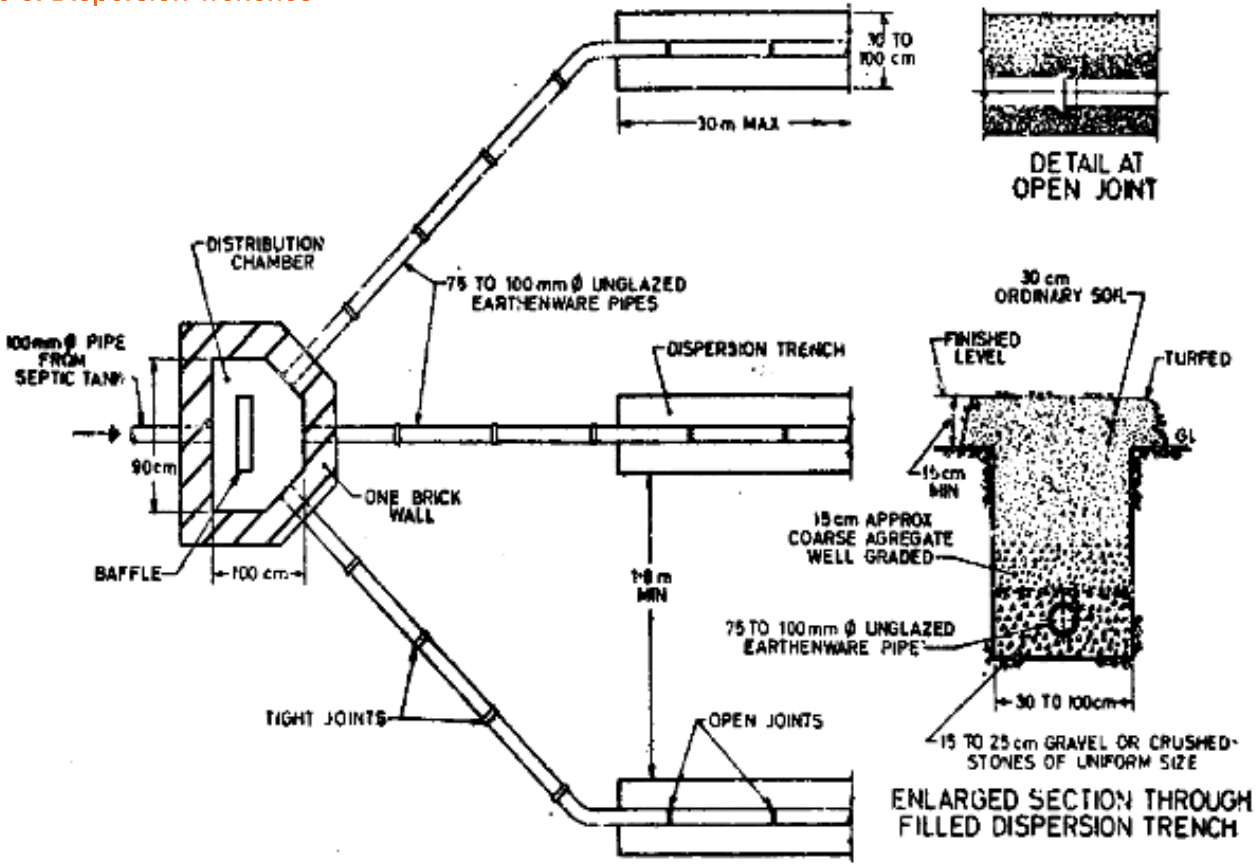
Salient points of both these interventions in these septic tanks are given along with process details, its suitability and limitations.

4.1.2.1 Up-Flow Anaerobic Filter

What is the process that takes place?

- An anaerobic filter is a fixed-bed biological reactor. It is a submerged filter with stone media or half broken chamber well burnt bricks by hand and the septic tank effluent is introduced from the bottom.
- The microbial growth is retained on the stone media, making possible higher loading rates and efficient digestion.
- The up-flow anaerobic filter can either be a separate unit or constructed as an extended part of septic tanks. Dissolved organic matter and non-settleable solids are filtered and anaerobically digested by the

Figure 6: Dispersion Trenches



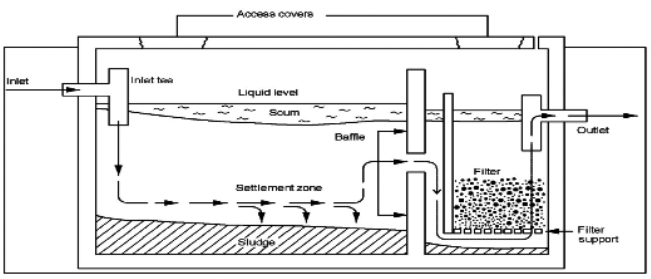
bacteria in the biofilm attached to the filter media.

- The final effluent from the up-flow filter will come out at least 30 to 45 cm above the ground level. At this location an elevated mound of sand can be constructed as a dispersion mound and flowering small plants can be grown for evapo-transpiration.

Where is it suitable?

- The up-flow filter can be successfully used for secondary treatment of septic tank effluent in areas where dense soil conditions, high water table and limited availability of land preclude soil absorption or the leaching system for effluent disposal.
- Anaerobic filters are widely used as secondary treatment in household black or grey water systems and to improve the solid removal compared to septic tanks or anaerobic baffled reactors.
- Since anaerobic filters work by anaerobic digestion, they can be designed as anaerobic digesters allowing recovering the produced biogas. Multi-chamber septic tank system prevents sludge carryover.

Figure 7: One-unit anaerobic Filter integrated in the second chamber of a septic tank



Advantages

BOD removals of 70% can be expected. The effluent is clear and free from odour. This unit has several advantages viz, (a) high degree of stabilization; (b) little sludge production; (c) low capital and operating cost; and (d) low loss of head in the filter (10 to 15 cm) in normal operation.

Limitations

During times of rainfall, it will be necessary, to provide a temporary cover to prevent direct rainfall over the dispersion trench.

4.1.2.2 Package septic tank -Contact aeration type system

What is package septic tank?

Package septic tank -Contact aeration type system is an improvement of the septic tank in which a contact aeration tank is provided after the septic tank. It is developed in line with well-established Japanese on-site treatment systems called Johkasou.

This type of package on-site treatment system is made up of LLDPE (Low Linear Density Polyethylene) and can be installed easily in a very short time. It consists of two chambers, i.e., settling and contact aeration with pall ring media.

A schematic diagram of packaged septic tank--contact aeration type system is given below:

What is the process that takes place ?

The first chamber works as a septic tank, where settleable solids are settled down and further degraded anaerobically at the bottom zone.

Second stage is high specific surface area (100 m2/m3), fixed film plastic media to retain high mass of aerobic microorganism to degrade the organic matter in the sewage aided by continuous diffusion of controlled air supply from a blower.

Where package septic tank suitable?

In cases where space is a constraint and regulations require high degree of treatment, this Package septic tank -Contact aeration type system may be of immense use.

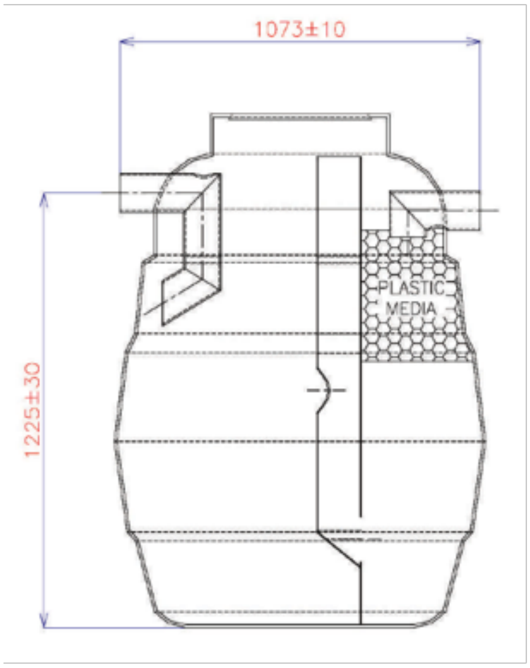
The high specific surface area not only prevents clogging, but also provides intensive contact between the sewage and the fixed film aerobic bacteria for the fast degradation of organic matter.

The treatment performance may be possible to be enhanced to 80-95% for BOD and SS removal. Treated water can be used for various recycling purposes suiting requirement of specific industry or for irrigation in agricultural fields.

4.1.3 Johkasou Systems-Advanced Onsite Sewage Treatment Systems

Johkasou Systems-Advanced On-site Sewage Treatment Systems and similar other advance packaged systems are also available as a decentralized wastewater treatment solution. Brief of Johkasou is given below.

Figure 8: Illustrative configuration of an integral septic tank and contact aeration unit



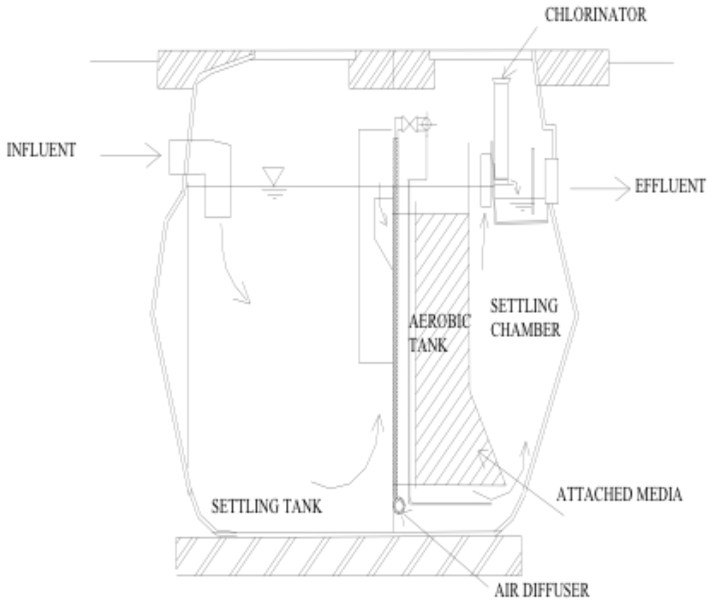


Figure 9: Illustrative configuration of a Johkasou Systems Unit

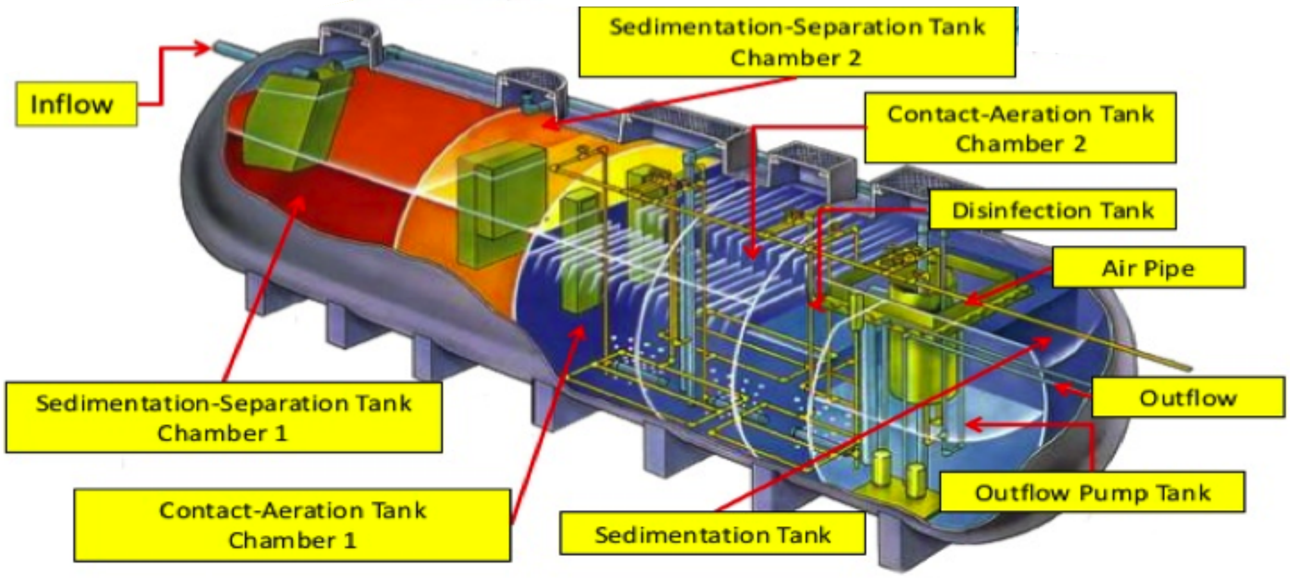


*Image courtesy of Japan Education Center of Environmental Sanitation

What is Johkasou Systems?

Johkasou is an on-site compact sewage treatment plant. This is developed in Japan and adopted by households/ group of households not connected with sewerage system. This is installed in Aizawl, Mizoram and few places around Chennai.

It is usually installed underground as a single compact tank. There are five functional chambers namely, sedimentation, anaerobic, aeration, storage and disinfection in a tank.

Various types and sizes of Johkasou units are available from small residential units to large commercial units. A schematic diagram of Johkasou Systems is given below:

What is the process that takes place?

This is a complete sewage treatment for those houses and localities which are not connected with centralized and decentralized sewerage system. It works on the principle of anaerobic and aerobic combined biological treatment process.

Johkasou treatment system consists mainly of pre-treatment, main treatment, advanced treatment (if necessary), and disinfection processes.

- Pre-treatment process: This process removes insoluble substances that are difficult to decompose biologically by means of sedimentation, floating, and screening. In the large-scale system, a flow equalizer is planned for stabilizing the biological treatment.
- Main treatment process: The main treatment process biologically removes BOD-related contaminants by aerobic treatment and removes nitrogen by combination of anoxic and aerobic treatment. The system employs a sedimentation tank for solid-liquid separation in most cases, but use of a membrane separator in place of the sedimentation tank makes it possible to downsize the system and to improve the quality of treated sewage further.
- Advanced treatment process (to be installed if necessary): This process removes COD-related contaminants and phosphorus from the biologically treated sewage by means of flocculation sedimentation, sand filtration, activated carbon absorption, and dephosphorization.
- Disinfection process: This process disinfects E. coli and other bacteria to make effluent water safer.

Where package septic tank suitable?

- Little topographic limitation
- Invaluable contribution to maintaining sufficient water in small river and aquatic environments near inhabited areas.
- Less vulnerable to earthquakes and other disasters

Advantages

- Short installation time and early realization of the effects
- Johkasou-treated water and sludge are easy to reuse

Limitations

- High Initial Investment Cost
- Uninterrupted Power Supply required
- Periodic Operation and Maintenance

4.1.4 DRDO Bio-Digester

DRDO has developed a Bio-Digester to suit various climatic conditions and treat biodegradable faecal matter as shown in Fig no.10 below.

Key Features

- Anaerobic microbial inoculum
- Cold tolerant microbial consortium
- Required one-time inoculum charging
- Immobilization matrix for retaining higher microbial mass for survival in adverse conditions.
- Specially designed tank for efficient biodegradation
- Suitable for mobile and stationary platforms
- Permits use of toilet cleansing agents
- Tailor made in respect to number of users, materials, situation and condition.

Different Models of Bio-digester

- Microbial Inoculum (Cold-active)
- High Altitude Model
- Glacier Model
- Railway Model
- Plain Area Model

Figure 10 DRDO Biotanks showing different chambers and a completely covered biotank

Advantages

- Wide applicability
- Minimizes water consumption
- Maintenance free
- Customized & easily adoptable
- Effluent water recyclable
- Organic waste Reduction: > 99%
- Pathogen reduction: > 99%
- Environment-friendly & cost-effective
- Suitable for any geo-climatic condition

Current Application

- Hundreds of such bio-digesters have been installed at various locations in J&K, Sikkim and Arunachal Pradesh.
- Lakhs of stainless steel made bio-digesters are in operation in different trains of Indian Railways. It is planned to install bio-digesters in all trains in the future

Note: Based on a study carried out by IIT Madras and another team of experts constituted by the Ministry, concluded that the performance of Bio-Digester is not much superior than Septic tanks in ordinary field conditions.

4.2 Limitations of On-site Sewage Management Systems

On-site sewage management systems are spread across various premises and its O&M lies with owners who are often least aware about its periodic requirement of O&M. They often and periodicity of desludging. In majority of cases soak pits either do not exist or silted badly to perform any function. ULBs/ regulatory agencies too do not monitor its functioning. Due to this, sludge deposited in Septic tanks creating a situation where septic tanks/ soak pits etc. overflow creating unhygienic condition in the area. These alarming issues are also highlighted in para 1.2 under current scenario of sanitation. This requires urgent desludging of tanks and its safe treatment and disposal. These aspects are dealt with in Chapters 5-7. In cases where Soak pits are absent and effluent from septic tanks finds its way into drains or open land, to treat such sewage, suitable treatment options are described in Chapter 8.

Chapter-5

FAECAL SLUDGE & SEPTAGE MANAGEMENT

In the previous chapter, on- site sewage management has been dealt with involving Conventional Septic tank with soaking options and other advance systems. On-site sewage treatment methods invariably generate faecal sludge or septage which need to be safely collected, transported, treated and reused/ disposed of. In recent times, ULBs have gained lot of awareness to manage it safely. This chapter on Faecal Sludge and Septage Management deals with Faecal Sludge and Septage (FS&S) Value Chain with emphasis on the Faecal Sludge & Septage Treatment methods. It also guides on recycle/reuse of treated by-products. Out of three methods of FS&S treatment, two methods namely standalone FSTP and land application have been described in this chapter.

5.1 Faecal Sludge & Septage Management

Faecal Sludge and Septage Management (FSSM) assumes significance in Indian scenario as about 60% households are dependent on on-site sanitation systems. As a part of routine maintenance of these on-site systems, Faecal Sludge and Septage is generated.

Septage from a septic tank of a family of 5 persons with once in three-year frequency of emptying, accounts for only about 1% of pollution load reduction of waste water (justification in Box 1) that is entering into the septic tank. If periodic emptying is not done, it impairs the treatment ability of septic tank, which accounts for about 50% of pollution load reduction of passing waste water. As such contrary to the prevailing perception, FSSM is not a low-cost sewage treatment alternative to cost intensive off-site sewerage system, but an O & M activity of septic tank which is part of on-site sewage management systems. Since FS&S possess strong polluting capacity and can harm humans and environment alike, there is necessity to manage it properly till its safe disposal/end-use. Cost of poor sanitation to nation is humongous which further necessitates the proper management of Faecal Sludge and Septage collected from onsite sanitation systems (OSS) like septic tanks and leach pits.

Proper management of Faecal Sludge & Septage collected from onsite sanitation systems can be done following FS&S value chain as given below. To eliminate the problem of open discharge of Faecal Sludge and/or Septage into the environment, the component of FS&S treatment is explained in detail in foregoing paragraphs. A brief guidance on recycle/ reuse of treated by-products are also given in the end of this chapter along with some useful case studies.

5.2 Faecal Sludge & Septage Value Chain

FS&S value chain begins with the user interface i.e. toilets (Individual Toilets, Community & Public Toilets) followed by the containment systems, emptying, transport, treatment and ends at reuse/disposal. Once properly managed, domestic FS&S is a resource. A valuable soil conditioner, FS&S contains nutrients that can reduce reliance on chemical fertilizers for agriculture.

The figure below describes the prevailing FS&S value chain under FSSM.

FSSM system entails transactions and interactions among a variety of people and organizations at every step in the FS&S value chain. It involves the household level users, the collection and transport companies, operators of treatment plants, and the final end users

Box 1

Scenario I: Share of pollution load reduction at FSTP, as % of Influent raw sewage in Septic tank connected only to water closet (black water only):

Ex: Pollution load handled by a FSTP plant as % of Influent raw sewage in Septic tank in a city of 1 lakh population.

(1) Considering once in 3 year emptying and treatment cycle.
(2) No of houses to be emptied and treated per day in FSTP = (100000/5)/3/365 = 18 houses
(3) Septage to be emptied from each septic tank (Standard size of 1.5mX0.75m X1.0m (excluding free board)) = 1.1 cum
(4) Representative BOD* of septage = 2000 mg/l
(5) Sewage volume from Water Closet entering per day in septic tank per family of 5 persons @ 150 liter (as per Manual, 30 liter per capita per day for flushing)
(6) Representative BOD of influent sewage (as per Manual) = 1290 mg/l
(7) Overall Percent (%) of pollution load handled due to septage treatment =

[18(houses) X 1.1 Cum per house) X 2000(rep BOD load)]X[100]/ [18 (houses) X 0.15 Cum per house per day) X 1290 (rep BOD load)X (3 year cycle) X(365 day per year)]

= [2200] X [100]/ [211883]
= 1 %

Scenario II: Share of pollution load reduction at FSTP, as % of Influent raw sewage in Septic tank (black & grey water both):

Ex: Pollution load handled by a FSTP plant as % of Influent raw sewage in Septic tank in a city of 1 lakh population.

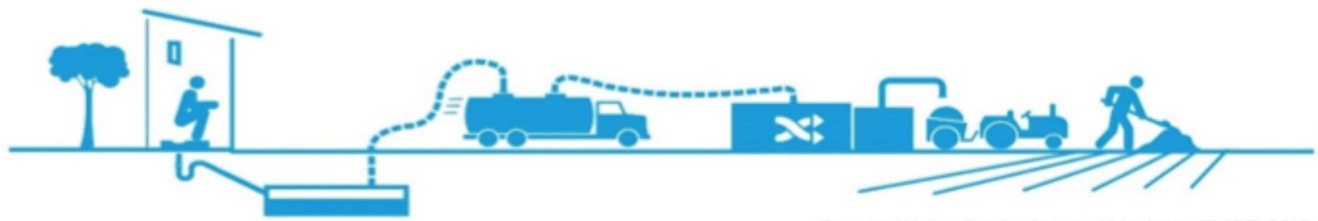
(1) Considering once in 3 year emptying and treatment cycle.
(2) No of houses to be emptied and treated per day in FSTP = (100000/5)/3/365 = 18 houses
(3) Septage to be emptied from each septic tank (Standard size of 1.5mX0.75m X1m (excluding free board)) = 1.1 cum
(4) Representative BOD* of septage = 2000 mg/l
(5) Sewage volume entering per day in septic tank per family of 5 persons @ 500 liter
(6) Representative BOD of influent sewage = 300 mg/l
(7) Overall Percent (%) of pollution load handled due to septage treatment =

[18(houses) X 1.1 Cum per house) X 2000(rep BOD load)]X[100]/ [18(houses) X 0.5 Cum per house per day) X 300 (rep BOD load)X (3 year cycle) X(365 day per year)]

= [2200] X [100]/ [164250]
= 1.3 %

*In anaerobic digestion in septic tanks, more than 80% of bio-degradable organic material is digested within first forty days and remaining organic material also keeps on degrading subsequently.

Figure 11: FS&S Value Chain



Source: Water, Sanitation and Hygiene, BMGF, 2010.

CONTAINMENT	EMPTYING	TRANSPORT	TREATMENT	REUSE / DISPOSAL
Human waste is contained in an on-site system, possibly together with grey water. Waste is partially treated due to the time it is contained, and is known as faecal sludge or septage depending on the system used.	The system is emptied, typically by a desludging vehicle truck with a vacuum mechanism.	Faecal sludge or septage is transported safely in a closed vehicle truck.	Faecal sludge and or septage can be treated either at a Faecal Sludge Treatment Plant (FSTP), or co-treated with sewage at a Sewage Treatment Plant (STP).	The treated waste can now be safely reused or disposed.

of treated byproducts. Different elements of FS&S value chain are briefly mentioned above along with steps to be taken for their desired performance.

5.2.1 Containment

On-site sanitation systems in urban India largely consist of double leach pits and septic tanks. A study by Center for Science and Environment 2019 in some cities of Uttar Pradesh shows that majority (about 80%) containment systems are often not connected to functional soak pits. Situation in other cities in the country is no different. These units are often poorly constructed and tend to leak and overflow in the open environment creating unhygienic conditions and leading to spread of diseases. The size of tanks is often oversized with intention to avoid frequent emptying. O & M of soaking arrangements is seldom done.

Effective steps, as given below, should be taken to ensure that these septic tanks (containment systems) do not pollute the environment.

- Periodic Audit of toilet facilities: To ensure proper containment and reduce pollution, ULBs need to identify type of onsite sanitation systems that these cities have. In case they have septic tanks, whether these are connected to soak pits or not. ULBs also need to undertake a GIS based survey of all toilet facilities with requisite information on the status of containment systems and keep on updating data. The updating data can also be linked to the property tax assessment that carried out in all cities every 4 years.
- Standardization of Containment Construction: Often, due to lack of awareness, monitoring and enforcement, people tend to build oversized tanks, to avoid frequent emptying. ULBs need to strictly enforce BIS standards of containments system in new/ reconstructed dwellings as part of the building plan approval process. The ULBs can also empanel and train masons to construct toilets including containment systems according to BIS standards. ULBs can also educate people about their existing septic tanks and soak pits and encourage them to refurbish the same in accordance of BIS standards.
- Wherever feasible, ULB's may encourage the households to connect their, septic tanks to settled/ small bore sewer networks, laid for this purpose. If such sewer network is not available, effluent from septic tank may be brought to a well-designed and

maintained soak pit and septic tank should undergo desludging periodically. Wherever conventional sewerage system is available, sewage from houses should directly reach to it and no septic tank should exist in between.

- In case where no sewerage system exists and there is no space for soaking arrangements as well, in such situations, overflow effluent from septic tank may be collected in well-lined road side drains as an interim measure. Efforts should be made to convey this effluent to a suitable place for off-site treatment through decentralized waste water treatment plant using Interception and Diversion of these drains.
- Soak pits should be properly designed and maintained. ULBs should also highlight the necessity of converting all toilets into improved facilities as explained in chapter 4.

5.2.2 Emptying of Containment and Transportation

Emptying: Faecal Sludge and Septage needs to be emptied periodically so that septic tank/ leach pit doesn't get filled and overflow in the open environment. While the national guidelines recommend emptying of on-site sanitation containment units periodically every 2-3 years using mechanical means, due to lack of dedicated operators and/or effective monitoring at local level, informal sector workers are still found to be engaged in emptying some units manually, although manual emptying is prohibited by law.

Periodic/Scheduled desludging: To regulate periodic/ scheduled desludging, ULBs need to maintain database on onsite sanitation systems and also to develop a zone-wise annual timetable for Periodic/ scheduled desludging for the city at an interval of 2-3 years as prescribed by guidelines. This database will help ULBs in planning procurement/empanelment of suitable number of desludging vehicles for desludging of septic tanks in the city. The Periodic/scheduled desludging of containment should be carried out by licensed operators only and facility of desludging should be available on call basis also. The cost of desludging can be included in the property tax/user charge collected by the ULBs. Also, ULB may put up a system/framework in municipal bye laws for penalizing house owners, if found engaging labour for manually emptying the septic tanks/ leach pits in contravention of laws.

In addition to the above, the following challenges of desludging need to be addressed for efficient functioning of system:

- Lack of monitoring mechanism to check engagement of informal sector
- Insensitivity in citizens on containmentemptying cycle need to be overcome to ensure that citizens demand for its desludging in 2-3 years. At present, in many cases, there is no schedule for desludging. Tanks are desludged when fully filled.
- Solidification of faecal matter in septic tanks leading to overfilling of tanks and consequent discharge of effluents with faecal matter.
- Septic tanks are often placed under toilets, or sealed/ cemented over, making access to it difficult which dis-incentivizes their frequent cleaning.
- Lack of adherence of safety protocols, as outlined under regulatory framework, while manual emptying of septic tanks in unavoidable circumstances.

Transportation: There are various types of sludge/ septage carrying vehicles. The most recommended vehicle for sludge removal is by using vacuum tankers. The vacuum tankers can be either mounted on a truck chassis or tractor. The desludgers can also have Jetting Machine to clear solidified sludge inside the septic tanks. These desludging vehicles can be procured from GeM Portalhttps://gem.gov.in/swachh-bharat-mission

Many ULBs have been using vacuum tankers but owing to non-existence of proper FSSM mechanism, household owners or commercial spaces, in many cases, relied on easily available private sector unregulated operators or in some cases on manual cleaning through informal sector. In such instances, the collected faecal septage is disposed of indiscriminately and illegally either into the drains/ sewer manholes/open fields or the water bodies. Hence, there is a considerable need to regulate desludging operations by ULBs including empanelling private service providers.

5.2.2.1 Empanelment of registered private service providers

ULBs should empanel and register private GPS enabled desludging vehicles and service providers in their jurisdiction. Registration will help the ULBs to monitor the activity of the desludging machines and prevent unregulated discharge of collected septage in open environment. Where private operators are not forthcoming or are in inadequate number, the ULBs can themselves procure desludging vehicles and sub-contract the operation and maintenance of the vehicle to a third party. Wherever needed, ULBs should provide training to private desludging operators on the MoHUA SOP for the purpose and ensure that safety gears are used by them.

5.2.3 Faecal Sludge and Septage Treatment

The basic objective of treatment is to render the material treated safe for either end use or disposal to the environment. Septage and faecal sludge treatment processes aim to do this by 'stabilizing' faecal waste, converting it from its untreated condition, in which it is unpleasant, unstable, high in pathogens, and has a high oxygen demand, to products that are stable, low in pathogens, and have a low oxygen demand.

While selecting a particular technology for treatment of faecal sludge and septage, factors like the characteristics of the material to be treated, land requirement, site conditions, buffer zone restrictions, hauling distances, power requirement, skill, overall cost, operational cost,the proposed arrangements for end use/disposal of the products of treatment, regulatory requirements and likely impact on environment etc. should be kept in mind.

Generally, the following three methods of treatment are adopted for faecal sludge and septage:

1. Land application
2. Co-Treatment at wastewater treatment plants (WWTPs)
3. Independent Faecal Sludge &Septage Treatment Plants (FSTPs)

Overview of approaches along with advantages and disadvantages of these options are presented in Table below.

As per USEPA, 1994, land application of Faecal Sludge & Septage is reported to be most common means of septage disposal in the United States and is an economical alternative. Unfortunately, availability

Table 5 Overview of Approaches to Septage Treatment and Disposal

Method	Description	Advantages	Disadvantages
Land application	Septage is applied to sites infrequently visited by the public. Stabilization to reduce odour, pathogens and vector attraction may be encouraged or required by the state. Land Application may be by hauler trucks or other vehicles to apply septage to the land surface, or by specialized equipment to inject septage beneath the soil surface. However, Land application will be permitted where State has come out with Land application guidelines for Fecal Sludge and is duly approved by State Pollution Control Board/ other concerned department.	• Simple, Economical • Recycles organic material, nutrient to the land. • Low Energy use	• Need for holding facility during periods of frozen or saturated soil • Need for relatively large, remote land area
Treatment at WWTPS	Septage is added to plant headworks, upstream manhole, or sludge handling process for co-treatment with sewage or sludge. Septage volumes that can be accommodated depend on plant capacity and types of unit processes employed	• Most plants are capable of handling some septage • Centralizes waste treatment operations	• Potential for plant upset if septage addition not properly controlled • Increased residuals handling and disposal requirements
Treatment at Independent Septage Treatment Plant	A facility is constructed solely for the treatment of septage. Treatment generate residues which must be disposed of.	• Provides regional solution to septage management	• High Capital and Operational & Maintenance (O&M) Costs • Requires skill levels for operation

of suitable land with adequate buffer separation from residential areas is limited in many urban and suburban areas and the public is often concerned about the odor and health impacts of such practices. However, this is an acceptable option in towns having less than 50,000 population provided land application is practiced as per the guidelines of State Government devised to safeguard public health. Disposal at an existing WWTP is a viable and economical option if the plant is reasonably close to the source and has adequate facilities to handle the FS&S. Independent Faecal sludge &Septage treatment plants are the costliest of the three categories and also requires skilled management for optimum results. Municipalities generally consider them only if the first two options are not technically or economically feasible.

Treatment of Faecal Sludge &Septage at independent FSTPs and through Land applications are covered in coming sections in this chapter. The Co-treatment of Faecal Sludge and Septage in STPs is described in next Chapter.

5.2.3.1 Independent Faecal Sludge and Septage Treatment Plants

In lower- and middle-income countries, the general lack of sewer networks and sewage treatment brings to fore the on-site sewage management systems. To ensure efficient functioning of on-site systems, independent faecal sludge and septage treatment will usually be the preferred option.

General Treatment Process

In most of the independent faecal sludge and septage treatment plants (FSTPs), the following units are adopted:

These units of treatment are briefly explained below.

(i) Pre-Treatment Unit

Pre-treatment unit, depending on characteristics of FS&S and its quantity, involves preliminary treatments like coarse screen, grit chamber, fine screen, Fat Oil and Grease (FOG) removal and stabilization.

All treatment plants should provide for reception and coarse screening of influents. In case of large FSTP of capacity more than 250 KLD, separate units like Fine

Figure 12: Treatment Scheme

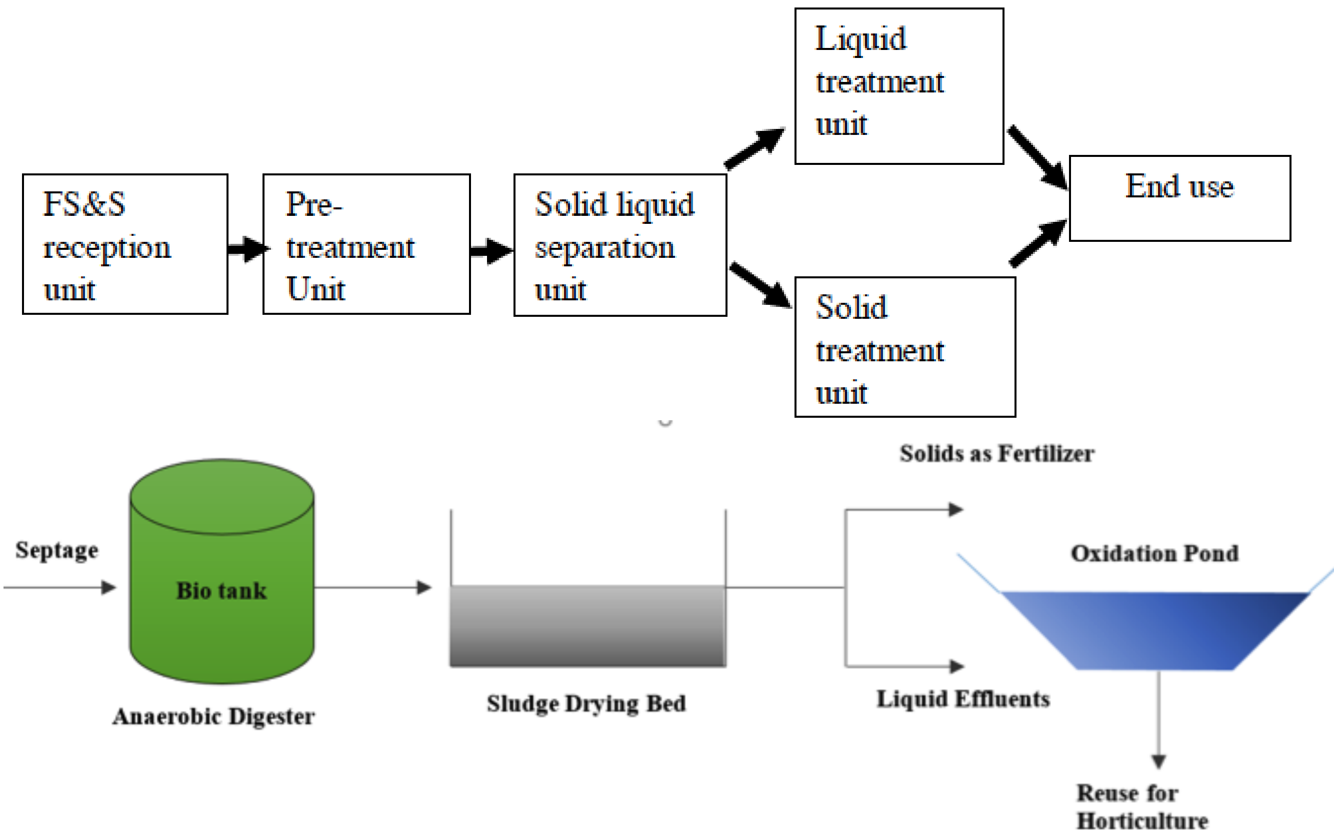
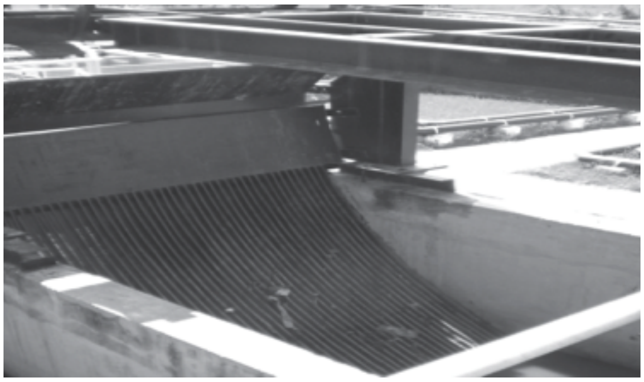


Figure 13: Curved screen with rotating raking mechanism.



Source: (Kevin Tayler, 2018)

screen and grit removal also becomes necessary. For such large plants normally mechanical solid Liquid separators are economical. Other preliminary treatment requirements will be dependent on local conditions, characteristics of Septage and the technologies used at later stages in the treatment process. Where a plant receives both faecal sludge and septage, it will often be appropriate to make separate arrangements for each type of influent.

Septage Stabilization

Septage taken from septic tanks and wet leach pits will normally offer limited scope for further digestion. In contrast, material taken from frequently emptied cess pits and public toilet vaults is likely to be poorly stabilized, with the result that it smells unpleasant and has poor settling characteristics. For such material, stabilization will be desirable to reduce odours, control vectors, improve settleability, and reduce the unpleasant working condition with handling of fresh waste in subsequent treatment processes. Stabilization will be particularly important if either a treatment plant is located within or near a community or downstream treatment steps require a high amount of handling by operators. Stabilization options include lime stabilization, aerobic digestion, composting and anaerobic digestion.

Lime stabilization

Pre- treatment of septage with lime is carried out in this unit to raise pH level of septage. Lime stabilization facility controls odour, vector and facilitates pathogen destruction. Lime stabilization involves adding and thoroughly mixing lime (alkali) with each load of faecal septage to ensure that the pH is raised to at least 12 for at least 30 minutes. Lime addition could be done at any of these three points:

i) to the desludger vehicle before the faecal septage is collected,

ii) to the hauler truck while the faecal septage is being collected, or

iii) to a septage storage tank where septage is discharged from a desludger vehicle.

In land application options of Septage later in this chapter further details are given.

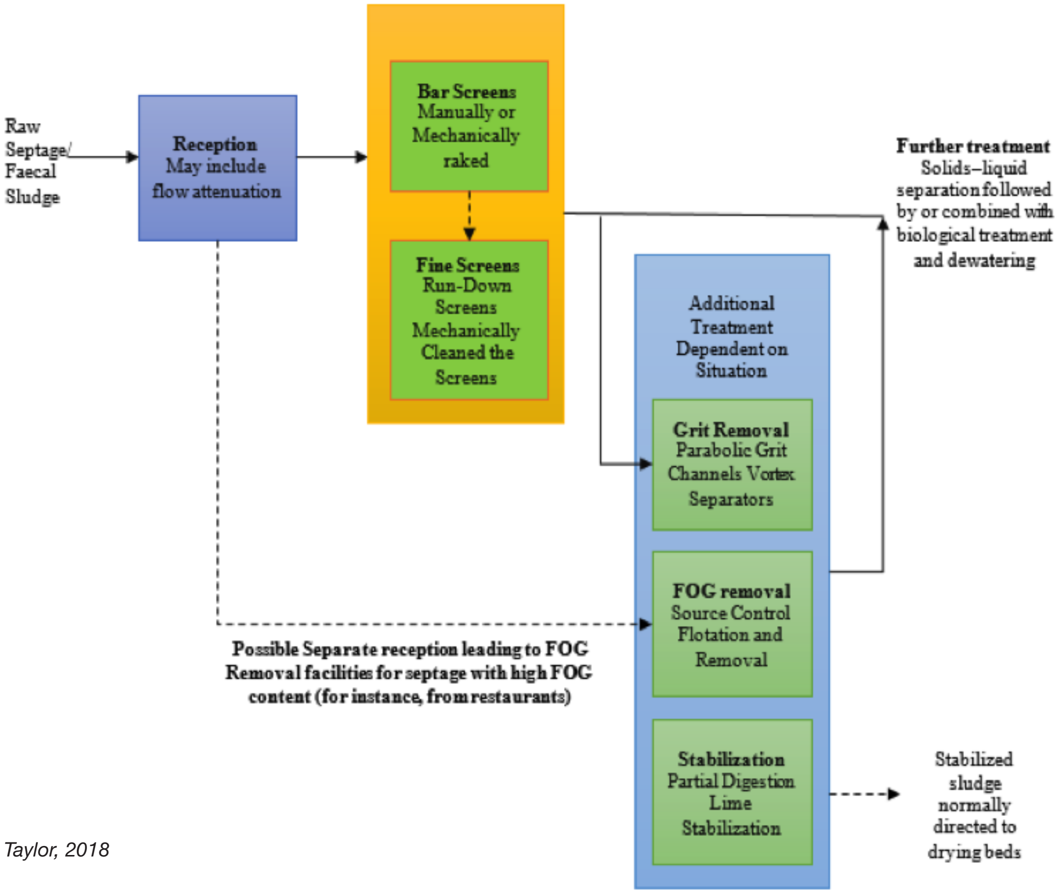
(ii) Solid – Liquid Separation unit

The septage after lime dosing is pumped to suitable dewatering system like Settling tank/ Unplanted drying bed/ Planted drying bed or mechanical dewatering machines like screw press, Centrifuge, Belt Press or Filter Press etc. Polyelectrolyte can be added to increase the dewatering efficiency of the machine. Overview of technologies currently used in lower and medium income countries for solids–liquid separation are as under:

- Imhoff tanks: Designed to combine solids–liquid separation in an upper compartment with digestion of settled solids in a lower compartment;
- Settling-thickening tanks: Rectangular batch-loaded tanks that allow solids to settle while supernatant water continues to liquid treatment facilities;
- Sludge drying beds: Separate solids and liquid through evaporation, settling, and filtration;
- Anaerobic ponds: which combine solids–liquid separation with reduction of the organic loads;
- Mechanical dewatering Machines: Common types include belt filter presses, which use filter cloth attached to filter plates to retain sludge, and screw presses, which retain sludge within a cylindrical sieve.

The solids and liquid so separated are treated in two different streams viz. liquid treatment stream and solid treatment stream.

Figure 14: Overview of reception and preliminary treatment requirements



Source: Kevin Taylor, 2018

(iii) Liquid treatment unit

The liquid residual / pressate / filtrate / supernatant from dewatering system can be discharged for further biological treatment. Treatment modules for liquid components are: Integrated Settler, Anaerobic Baffled Reactor (ABR) with filter chambers, Unplanted/ Planted Gravel Filter (PGF) and Percolation pit etc. Depending upon the volume of load to be treated and land available, the mechanized methods like ASP, MBBR etc. can also be used.

(iv) Solid treatment unit

The dewatered sludge can be sent for further drying or composting prior to reuse as organic fertilizer. These treatment modules for solid components in FSTPs normally consists of Feeding Tank (FT) with screen chamber to remove floating matter/ large size material etc, Stabilization Tank (ST) to degrade undigested fecal matter specially from PT/CT in large cities and Unplanted Sludge Drying Bed (SDB) for drying & digestion. It can also be further treated adopting methods like Composting, Vermi-composting, Thermal Drying &Palletization and Incineration method etc. In case of cold regions/ high rainfall regions Green House Solar Drier Roof may also be provided.

For the treatment of both separated liquid and solid portions, various combinations of treatment technologies used in 12 FSTPs in India are given in Table 6. The performance of these plants is available in CSE report on FSTPs 2020, “Performance Evaluation- How Faecal Sludge Treatment Plants are Performing”.

However, depending on technology adopted, this flow diagram keeps on changing from plant to plant. Further, some plants are more mechanized in nature where as others are non-mechanized.

For better understanding of FSTPs, the requirements of land, Capex and Opex etc. for a 27 KLD Faecal Sludge Treatment Plant (FSTP) at Dhenkanal is given below;

Total Land Area: 2.5 acres

Capital Cost: 2.9 Crore

Table 6 Combinations of treatment technologies used in 12 FSTPs in India

S.no	FSTP location	Technology	Description	Post treatment
1	Bhubaneswar, Odisha	Decentralized wastewater treatment system (DEWATS)	Settler, anaerobic baffled reactor (ABR) and planted gravel filter(PGF)	No tertiary treatment
2	Dhenkanal, Odisha	Decentralized wastewater treatment system	Unplanted sludge drying bed (USDB), ABR and PGF	Tertiary treatment using sand filter and activated carbon filter
3	Jhansi, Uttar Pradesh	Decentralized wastewater treatment system	Planted sludge drying bed (USDB), ABR and PGF	No tertiary treatment
4	Karunguzhi, Tamil Nadu	Decentralized wastewater treatment system	Unplanted sludge drying bed (USDB) and PGF but without ABR	No tertiary treatment
5	Ketty, Tamil Nadu	Decentralized wastewater treatment system	Planted sludge drying bed (PSDB) and PGF but without ABR	No tertiary treatment
6	Adigaratty, Tamil Nadu	Decentralized wastewater treatment system	Planted sludge drying bed (PSDB) and PGF but without ABR	No tertiary treatment
7	Leh, Ladakh	Decentralized wastewater treatment system	Planted sludge drying bed (PSDB) and PGF but without ABR	No tertiary treatment
8	Unnao, Uttar Pradesh	Decentralized wastewater treatment system	Screw press technology for solid–liquid separation, integrated settler, ABR, PGF	Tertiary treatment using sand filter, activated carbon filter and UV radiation
9	Warangal, Telangana	Package STP and pyrolysis	Anaerobic, anoxic, aeration and sedimentation zones	Tertiary treatment using sand filter, activated carbon filter and chlorination
10	Tenali, Andhra Pradesh	Moving bed biofilm reactor (MBBR)	MBBR, tube settler and clarifier	Tertiary treatment using sand filter, activated carbon filter and chlorination
11	Kalpetta, Kerala	Tiger bio-filter technology	Anaerobic digestion followed by two stage vermin-filtration	Tertiary treatment using sand filter, activated carbon filter and chlorination
12	Bharwara, Uttar Pradesh	STP co-processing	Upflow anaerobic Sludge blanket (UASB), pre-aeration tank, polishing pond	Tertiary treatment using chlorination

O&M Cost: 27 lakhs per annum

However, depending on technology adopted and extent of mechanization, the requirements of land, Capex and Opex etc. keep on varying to great extent. Case studies of some functional FSTPs are given at Annexure I along with the list of FSTPs in some cities with its capacity, Capex and Opex.

5.2.4 Recycle and Reuse

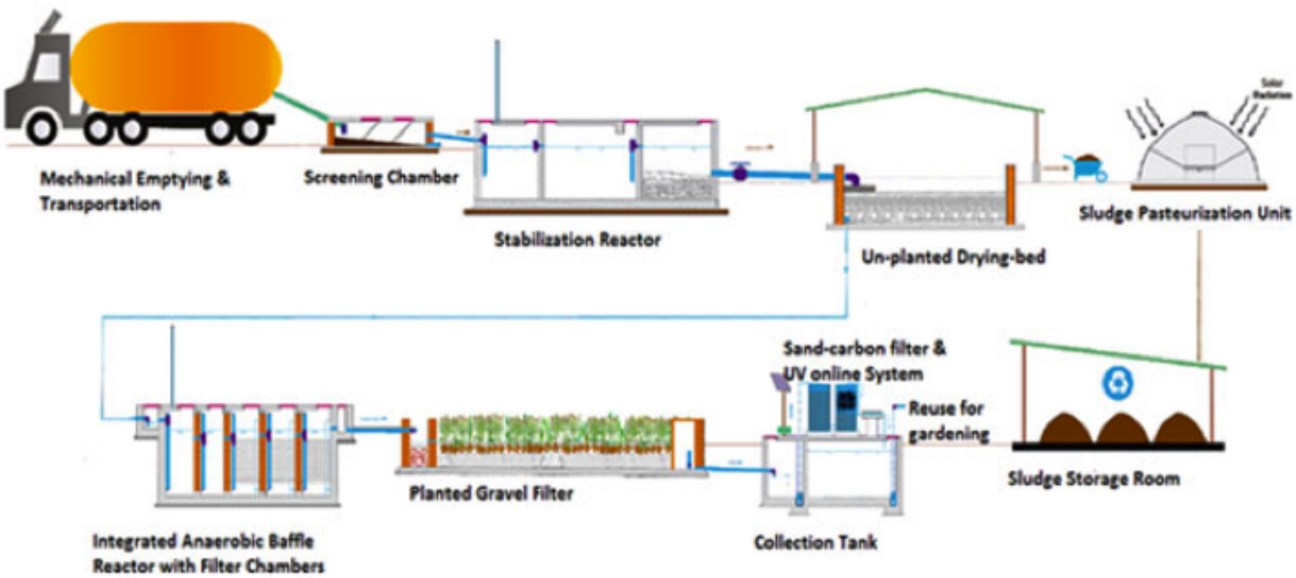
Treated Faecal Sludge & Septage (liquid portion and dried/ composted solid sludge) can be improved/ enriched and reused for agriculture/ horticulture purposes after fulfilling prevailing application standards in the State/UT. It can be processed into the following end products depending on the technology utilized and other surrounding conditions.

i. Composted portion is used in agriculture/horticulture to act as soil conditioner and as a fertilizer.
ii. The anaerobic digestion of faecal septage produces a mixture of gaseous compounds, commonly referred to as 'biogas', which in turn can be used as a fuel after removing the hydrogen sulfide to avoid corrosion.

Photographs and schematic flow of the FSTP is given below.

Figure 15: Photographs of the FSTP plant

Figure 16: Schematic Diagram of the FSTP



iii. The treated effluents are commonly used for irrigation, flushing and other non-potable uses. It can also be used for aquaculture and growing planktons or aquatic plants such as duckweed, water spinach, or water mimosa as the nutrients can increase their growth.

iv. The dewatered faecal sludge can be used as an alternative fuel in the cement industry.

5.3 Standards for Recycling and Reuse

Standards for disposing off the solid and liquid portion of the treated faecal septage has been discussed under regulatory framework and also in the following paragraphs.

5.3.1 Agricultural application

Treated Sewage and Sludge can be used for agricultural application purposes. Properly treated sludge can be reused to reclaim parched land by application as soil conditioner, and as a fertilizer in agriculture. For the usage of dewatered septage/sludge in agriculture fields, it should satisfy the following criteria of Class A Bio solids of US EPA either by lime stabilization, solar drying and or composting.

- Faecal coliform density of less than 1,000 most probable number (MPN) per gram of total dry solids,
- Salmonella sp. density of less than 3 MPN per 4 g

The concentrations of potentially toxic elements in arable soils must not exceed certain prudent limits as notified by Pollution Control Board from time to time within the normal depth of cultivation as a result of sludge application. Further, it will be applied as per SOP specialy developed for this purpose through trained agency or vehicle operator.

Given the relatively small volume of liquid effluent produced by septage treatment plants, and the difficulty of producing an effluent that meets the notified disposal norms, a good option for disposal of the liquid effluent will be to use it locally for irrigation of trees and other crops that require minimal worker contact.

5.3.2 Effluent Discharge Standards

The treated wastewater effluent can be applied to agricultural application ensuring that the general standards for the discharge of environmental pollutants as prescribed by regulatory authority i.e. CPCB/SPCB from time to time are duly met with. For co-composting of faecal sludge, it has to comply Fertilizer Control Order from Ministry of Agriculture from time to time.

5.4 Land Application

This method is most simple, economical and without requirements of skilled O & M. among the three methods of Faecal Sludge and Septage Management mentioned above. In India not much work is done in this area particularly on regulatory norms for field application. However, being a feasible option in India, Centre/States/ULBs may come out with regulatory requirements and detailed guidelines for this economical & less technology intensive septage management through land application.

Based on extensive research work done by United States Environment Protection Agency (USEPA), it has come out with guidelines in 1994, according to which the Septage may be applied to the following “nonpublic contact sites” subject to Centre/States/ULBs regulatory requirements:

- Agricultural fields
- Forest land
- Reclamation sites

To reduce vector attraction, USEPA, 1994, has come out with the following three options for domestic septage application to non-public contact sites:

- Subsurface injection.
- Incorporation (surface application followed by plowing within 6 hr).
- Alkali stabilization (pH of 12 or greater for 30 min prior to application).

Ministry guidelines on Deep Row Entrenchment Method, 2020 makes it safe as far as vector attraction is concerned.

Increased concern about the public health risks and due to lack of adequate regulations and discipline, many developed countries have either ban or severely restricted the use of untreated and partially treated faecal matter on land. However, land disposal is still practised in many lower & middle-income countries, with minimal regulation. However, Land application will be permitted where State has come out with Land application guidelines for Fecal Sludge and is duly approved by State Pollution Control Board/other concerned department. This can be a preferred method in towns less than 50000 population due to surrounding rural areas

5.4.1 Methods of Land Application of Faecal Sludge & Septage

USEPA has identified three broad options for land disposal:

i. Land spreading,

ii. Sub-surface incorporation,

iii. Deep row entrenchment

5.4.1.1 Land spreading

Land spreading is the simplest option but usually lead to problems with pathogens, flies, and other vectors. Also, land is not available all the time for spreading. This leads to the preference of second method of sub-surface incorporation, with sludge ploughed into the land immediately after discharge. This has potential to enhance the fertility of soil but again land is not available all the time for incorporation. Deep row entrenchment method is safe and already under in practice in many parts of world including in India. This can be practices in various parts of country throughout year as stand alone or in combination of other two methods. It is advised that states develop standard operating procedures for these methods in consultation with SPCBs and other concerned departments to minimize public health risks.

In this approach, septage is pre-treated (minimum of screening) during discharge into a holding mixing tank by adding lime and stabilizing it to pH 12 for 30 min, and then sprayed onto the land surface using commercially available sludge application equipment. Lime stabilization reduces odors and potentially eliminates the need to incorporate the septage into the soil.

In the simplest application method, a hauler truck applies septage by opening a valve and driving across the land application site. A splash plate or spreader plate improves septage distribution onto the soil surface. The septage should be discharged through a simple screen or basket located on the truck between the outlet pipe and the spreader plate, which prevents non-degradable materials such as plastics and other objectionable trash from being applied to the soil. Collected trash should be lime stabilized and sent to a sanitary landfill.

Small rural land application operations where little environmental or human health risk is likely to occur may find this approach acceptable. However, a transfer or storage tank must be available when sites are inaccessible due to soil, site, or crop conditions.

5.4.1.2 Sub-surface Application

In this method, a special liquid-waste application vehicle that removes screened septage from a holding tank and injects it on or below the soil surface. If the septage is incorporated into the soil by ploughing within 6 hours of application, lime stabilization may not be required.

5.4.1.3 Deep Row Entrenchment method

Smaller towns which does not have any Sewage Treatment Plant (STP)/ standalone Faecal Septage Treatment Plant (FSTP) within the ULB or in vicinity can manage their faecal septage through Deep Row Entrenchment (DRE) method as an immediate temporary measure or even on long term basis with due safeguards. Deep Row Entrenchment consists of digging deep trenches, filling them with septage and covering them with soil. Some states like Odisha and Karnataka have attempted it. A guidance note being practiced by Government of Odisha is placed at Annexure II.

The following precautions to be take in Deep Row Entrenchment

i. Site should be far away from surface water body.

ii. Site should be far away from high water table areas.

iii. Sites should have low probability of inundation.

iv. The approach is redundant during monsoon season.

v. Installation of CCTV cameras at the site for monitoring.

Space Requirement

Space requirement is very minimal and over the time, the same land can be again used once Septage/ sludge in trenches gets stabilized.

Retention Time

The detention time of the sludge in each trench shall be kept as 90 days minimum and the used trenches shall be closed at the end of the same day.

Design of DRE Facility

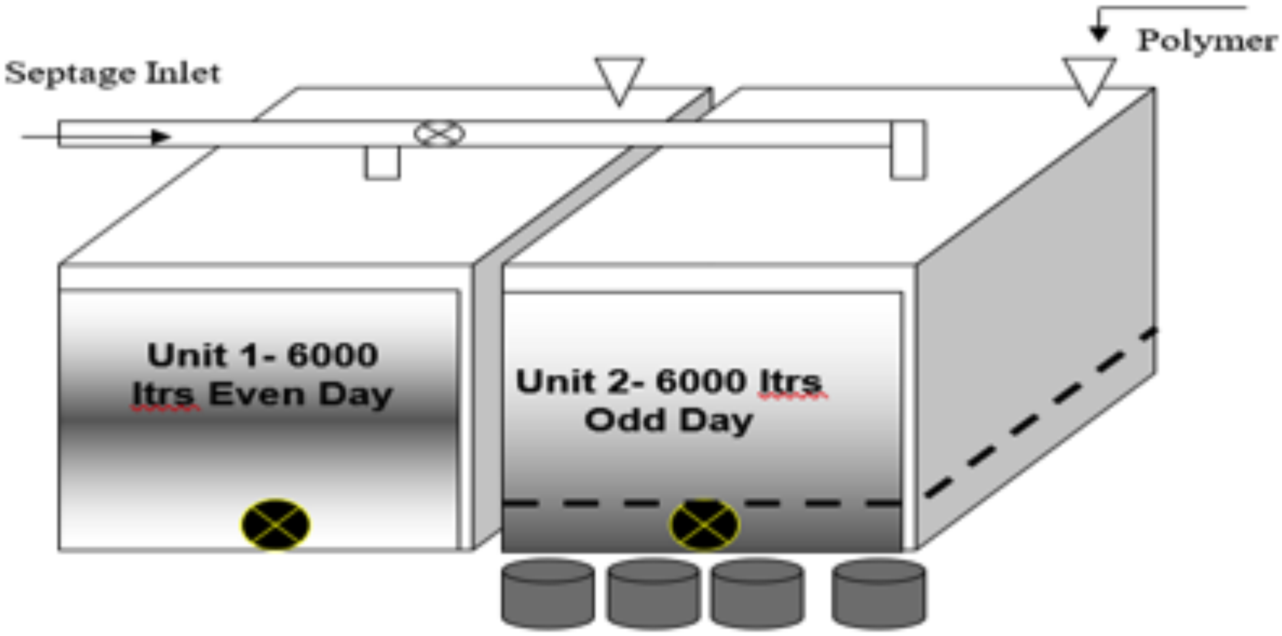
(a) Septage Holding cum Thickening tank

A Covered RCC tank with retention time of 2 days. The tank is preceded by a Screen to remove coarse and floating matter. A typical design for 20,000 population is mentioned below:

Volume- 2x 6000= 12,000 liters= 12 M3 say 3m x 3m x 1.5m (including free board) in two parallel chambers.

If possible, a simple polymer/ admixture addition and stirring arrangement should be provided (to enhance solid-liquid separation).

Figure 17 Septage holding Tanks



Sludge Removal- After 48 hrs of settling, the bottom 10% volume in the tank, along with the scum layer on top, to be removed as Faecal Sludge. This sludge can be stored in barrels and conveyed to the DRE pit on wheel barrows/ tractor.

The remaining 90% liquid portion will be conveyed to the planted constructed wetland / reed bed or to a suitable pond or can be provided to desirous farmers who can put this to appropriate use as Pathogen content is very high.

It may be noted that Septage is not to be put in trenches as the leachate will pollute the underground. Instead, only thickened sludge should be put in trenches.

(b) Design of Reed Bed for BoD removal

Total Volume of separated faecal liquid- 90% of 6000 liters/day (= 5.4M3 or 5400 liters/ day) : 5400 liters= 54 person equivalent (pe)

At 2.5m2/ pe, Total Area required = 2.5 x 54= 135 m2 or a patch of 15 m x 9 m dimension.

(c) Sludge Management in Trenches/ Deep Rows

Total Volume of Sludge = 0.6 M3/day

Dimension of Deep Row Pit

A pit of 1.5 M depth and 1.2 m x 0.5m is excavated manually or using a tractor accessory.

The sludge is emptied into the pit to a height of 1.0 M and the pit is covered back with 50 cm thick top soil.

This small strip of land (0.5m wide) can be ULB-owned such as along the outer town roads (within the road reserve). Trees can be planted under social afforestation programme. Or alternatively, barren and fallow lands can be revived by the nutrient rich sludge. A barbed wire fence should be provided for 4 weeks to keep animals away.

(d) Management of Grey Water Stream-

Total Grey Water expected to be released- 20000x 80 liters/ person= 1.6 Million Liters

Preferably discharged through small bore sewers or covered drains and collected for treatment, locally but that is not an element of DRE.

Advantages

For small population of 20,000 or less where no other option is feasible, and area is thinly populated, these trenches can be constructed in remote areas and trees can be planted on the top which benefit from the organic matter and nutrients that are slowly released from the septage.

Important factors to consider are soil type and porosity, ground water depth, proximity to drinking water sources, and background nutrient concentrations.

Disadvantages

Suitable land may not be easily available and there may be resistance from nearby residents.

5.4.1.4 Odour Control

Odours are a concern during and after septage application. A well-managed operation that incorporates lime stabilization, subsurface injection, or surface application at or below agronomic rates, however, creates minimal odor emissions.

5.4.1.5 Method of Lime Stabilization

Septage can be stabilized by adding sufficient lime or other alkali to raise the pH to 12 for a minimum of 30 min. Typically, this requires lime (as CaO or quicklime) of 2.4 to 3.0 kg per 1,000 L of septage, although septage characteristics and lime requirements vary widely.

Whether lime is added to the septage desludger truck or to a holding/mixing tank, the pH must be measured to ensure that pH 12 is achieved and maintained for 30 min and subsequently in the recommended range 10 to 13.

5.4.1.6Key Elements of O & M

Key elements of a successful operation and maintenance (O&M) program for a septage land application site should include the following:

i. Provision of septage receiving and holding facilities to provide operational flexibility.
ii. Proper septage treatment prior to application as required to meet Centre/States regulatory requirements (need for treatment depends on requirements of application method).
iii. Control of septage application rates and conditions in accordance with Centre/States rules.
iv. Proper operation and maintenance of the application equipment.
v. Monitoring of septage volumes and characteristics, soil, plants, surface water, and ground water as required by Centre/States/ULBs regulations.
vi. Odor control.
vii. Good recordkeeping and retention for at least 5 years.

Chapter-6

CO-TREATMENT OF FAECAL SLUDGE AND SEPTAGE

Out of three methods of FS&S treatment, two methods namely standalone FSTP and land application has been described in previous chapter. The third method of co-treatment of FS&S in STPs is dealt with in this chapter covering aspects like co-treatment and its planning, options of co-treatment at STP, preliminary treatment, FS&S loading at STPs etc. in detail being the prominent method. Additional methods of co-treatment like Bio-methanation, compost and thermal treatment are also covered.

6.1 Background

Co-treatment of Faecal Sludge and Septage involves treatment of Faecal Sludge and Septage along with other feedstock like Sewage and Organic waste in existing treatment facilities like Sewage treatment plants, Bio-gas plants and Thermal treatment plants. This is a more preferred option for those towns and cities which have existing treatment plants within the city or in nearby (say 25 km away or so) with unutilized capacities. In many European countries this option of co-treatment is widely followed. Denmark has exception to co-treat its 100% Faecal Sludge and Septage in its existing treatment facilities.

In the backdrop of Swachh Survekshan of MoHUA, many cities and towns have attempted to co-treat its Faecal Sludge and Septage in existing waste treatment facilities, often without having deep insights of co-treatment. It is not so simple, as often considered, to desludge Faecal Sludge and Septage in sewer manholes, sewage pumping stations or at STPs and the existing system will take care of it. Without ascertaining the factors like strength of Faecal Sludge and Septage vs sewage, preliminary treatment, equalization, plant loading and source of Faecal Sludge and Septage, the co-treatment is more likely to impair the functioning of existing sewerage system and become counter-productive. Further, these existing plants would need specific retrofitting (desludging platform for vehicles, screening, equalization tank/ stabilization tank and solid-liquid separation chamber etc.), because of wide variation in the characteristic parameters of sewage and septage (Table 2 & 3), to enable efficient co-treatment.

6.2 Co-Treatment of Faecal Sludge and Septage

Co-treatment of faecal sludge and septage is primarily done in sewage treatment plants like Activated Sludge Process (ASP), Sequential Batch Reactor (SBR), Upflow Anaerobic Sludge Blanket (UASB) and Waste Stabilization Ponds (WSP) etc. Faecal sludge and/or septage can also be co-treated in Bio-methanisation plants, compost plants and thermal treatment plants like Incineration, Pyrolysis and Gasification etc.

Further, Sludge (solid content > 5%) generated in an on-site treatment facility can be treated using methods like

(1) delivery to a sewage treatment facility for treatment with sludge generated in the sewage treatment process,
(2) treatment in a special sludge treatment facility,
(3) solar drying on a floor, and
(4) treatment by a mobile dehydrating truck.

Faecal Sludge and Septage co-treatment in ASP is given below in detail. Similar approach may also be followed while co-treating faecal sludge and septage with other STPs like SBR, UASB and WSP etc.

6.2.1 Co-treatment of Faecal Sludge and Septage in ASP

Co-treatment of Faecal Sludge and Septage can be carried out in ASP after ascertaining the following aspects.

ii. volume to be treated and characteristics of Faecal Sludge and Septage particularly COD/BOD and total solids
ii. concentrations of sewage BOD, actual quantity of sewage flows and Spare capacity of STP
iii. Spare capacity of Bio-gas plant for treatment sludge generated at STP

Addition options of Faecal Sludge and Septage in ASP

Following are three addition options of co-treatment of Faecal Sludge and Septage in STP after accounting for the aspects mentioned above.

I. Solid concentration in sludge is very high (>5%) (e.g. septic tank is emptied after a long period say > 5 years and septic tank is full with sludge. This can be decided by vehicle operator based on experience and visible fluid nature of septage.) and volume of sludge is very less than Bio-gas Plant within STP.

Sludge can directly be added to Bio-gas plant for treatment. After anaerobic digestion and gas extraction, digested slurry can be solar dried up/ composted and sent for field application;

or

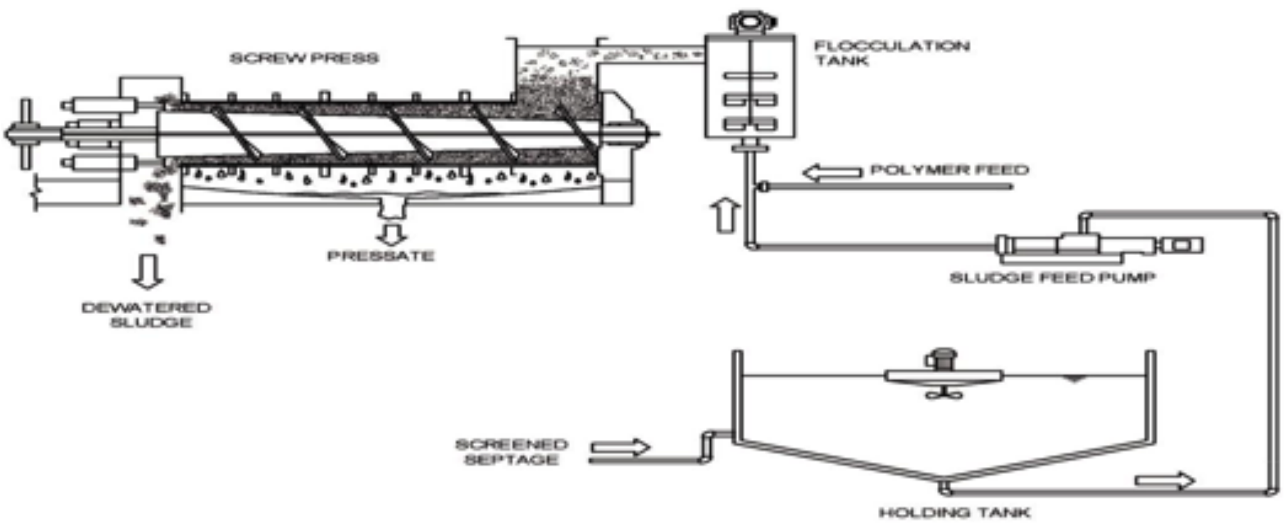
After lime dosing Sludge can be filtered (solid- liquid separation) naturally by spreading over sand/gravel bed or mechanically through screw press or any other mechanical dewatering machine like Centrifuge, Belt Press or Filter Press. Polyelectrolyte can be added to increase the dewatering efficiency of the machine. The liquid residual / pressate / filtrate / supernatant from dewatering machine can be discharged for further biological treatment with influent sewage. The dewatered sludge can be send for further drying or composting prior to reuse as organic fertilizer. Process flow diagram of Screw Press dewatering machine is given below for better understanding.

II. In situations where (a) septic tanks are periodically emptied or (b) most of the population covered with sewerage system with comparatively low number of septic tanks, the thin/ dilute septage with solids less than 2%, can be directly put in STP for co-treatment through sewer maintenance manhole or sewage pumping station located at trunk sewer leading to STP or at inlet of STP provided the volume of septage is very less (< 1%) compared to inflow sewage.

Minimum requirement for this mixing is screening and uniform discharging over some time rather than abrupt discharging. This should be practiced only when source of septage is known along with its characteristics, else, it may impair functioning of sewerage system and be avoided.

III. In normal cases (other than above two scenario),

Figure 18: Process flow diagram of Screw Press dewatering machine



collected Faecal sludge and septage could be added in suitably designed proportion so that characteristics of mixed septage and sewer do not exceed the design sewage characteristics. Normally, the faecal septage volumes are not unduly significant in relation to the full-fledged STP volumes and would seldom exceed about say 3-5% of its sewage quantity. This way, even if the STP is functioning at design capacity, volume wise, will not be a problem to add. Though septage is more concentrated (2 – 4% solids) in its strength than domestic sewage (< 1% solids), its constituents are similar to municipal wastewater. The municipality should monitor the incoming wastewater load to the STP and accept the septage, if the design norms are not violated with the increased load on account of addition of the septage.

In current scenario in India, co-treatment is preferred option due to better control and being economical one. However, in case of the towns/cities where the faecal sludge cannot be treated in the existing/ proposed nearby STPs (within 25 km radius), due to various technical and economic reasons, then it is recommended to design and construct standalone FSTP, as an interim arrangement, till another STP comes up in those areas.

Options of addition of septage and faecal sludge for processing through wastewater treatment plants have the following advantages/ disadvantages (USEPA, 1994).

6.2.1.1 Stepped Approach on planning for Co-Treatment of faecal septage at STP

It will be appropriate to take a stepped approach for implementation of co-treatment process as explained below;

Step 1: Identify the existing / proposed treatment facility sites within the city or a nearby city within 25 km radius or so

Step 2: Assess hydraulic, organic, and solids loadings, treatment efficiency and whether treatment plants meets the outlet parameters

Table 7 Summary of Options for Handling Septage at WWTPs

Methods	Description	Advantages	Disadvantages
Septage Addition to upstream sewer manhole	Septage is added to a sewer upstream of the WWTP	• Simple and Economical due to very simple receiving station design • May provide substantial dilution of sewage prior to reaching the WWTP	• Odour Control near Manhole • May be difficult to control access • Potential for accumulation of grit and debris in sewer • Only feasible with large and treatment plants
Septage Addition to plants headwork	Septage is added to sewage immediately upstream of screening and grit removal process	• Simple and Economical due to very simple receiving station design • Allows control of septage discharge by WWTP staff	• May affect WWTP process if septage addition is uncontrolled or the treatment plant is too small • Increase odour potential at treatment plant
Septage Addition to Sludge handling process	Septage is handled as sludge and processed with WWTP sludge after pretreatment in receiving station	• Reduces loading to liquid processes • Eliminates potential for affecting effluent quality	• May have adverse effect on sludge treatment process such as dewatering • May cause clogging of pipes and increase wear on pumps if not screened and degritted in receiving station • Expensive due to receiving station cost
Septage Addition to both Liquid Stream and Sludge Handling process	Septage is pretreated to separate liquid and solid fractions, which are then processed accordingly	• Provides more concentrated sludge for processing	• Requires increased operations for septage pretreatment at receiving station • Expensive due to receiving station cost

Step 3: Determine Septage receiving and preliminary treatment requirements like screening, stabilization/ equilisation, solid- liquid separation and options for its mixing into influent sewage.

Step 4: Decide the approach to solids–liquid separation and select an appropriate location and technology, if solid loadings is high in septage.

Step 5: Assess options for liquid treatment: Select the most appropriate option of treatment by taking into account the volume and characteristics of the material delivered to the facility, solids–liquid separation, the location, the required effluent quality, and the resource requirements of the various treatment options particularly O&M requirements.

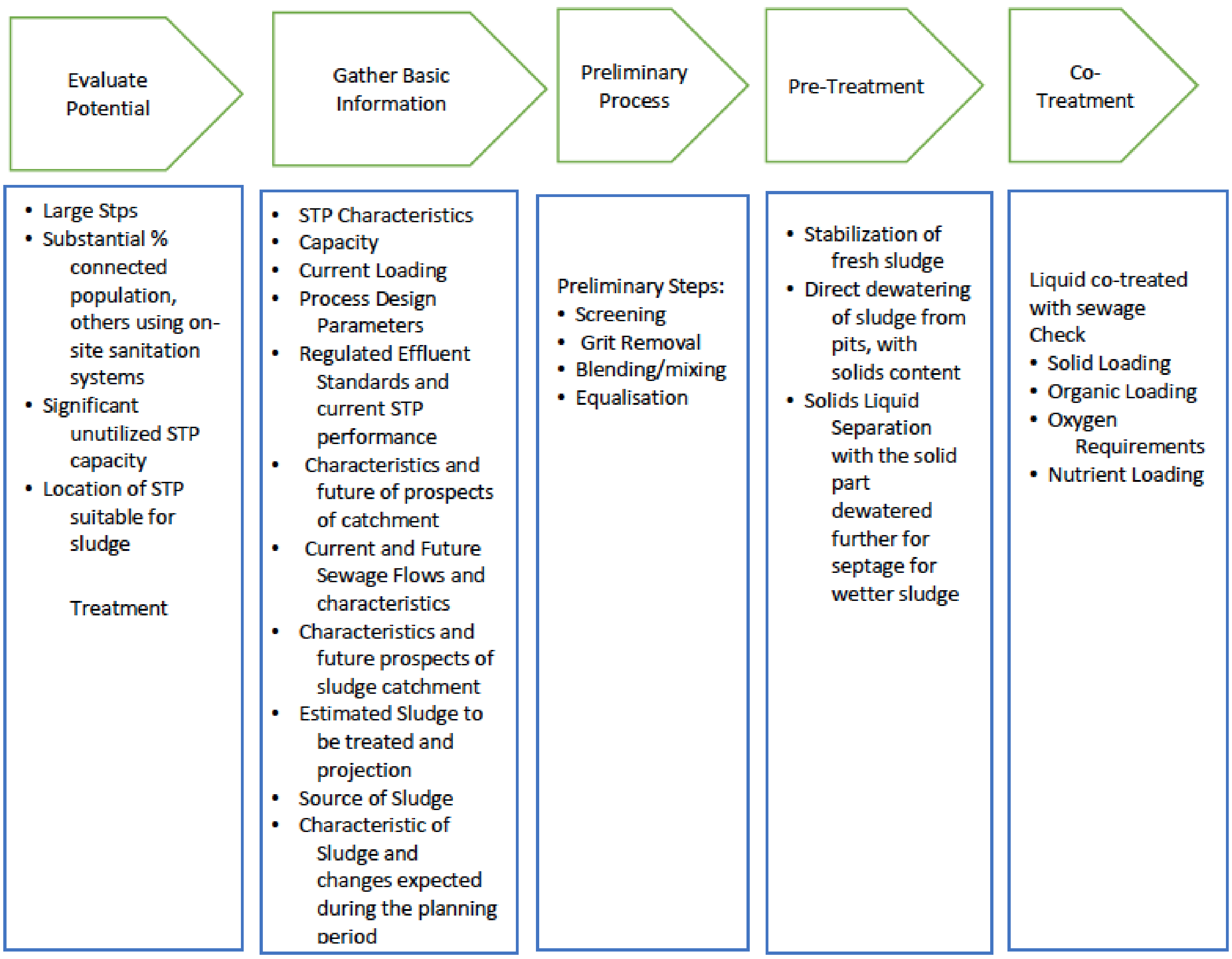
Step 6: Assess solids dewatering requirements and options depending on the characteristics of the solids to be dewatered and the final solids content required.

Step 7: Determine additional treatment required to ensure that treated products are safe and suitable for any proposed end uses like agricultural input

Above steps on planning for Co-treatment are summarized in Figure 19 under evaluate potential, gather basic information, preliminary process, pre-treatment and Co-treatment.

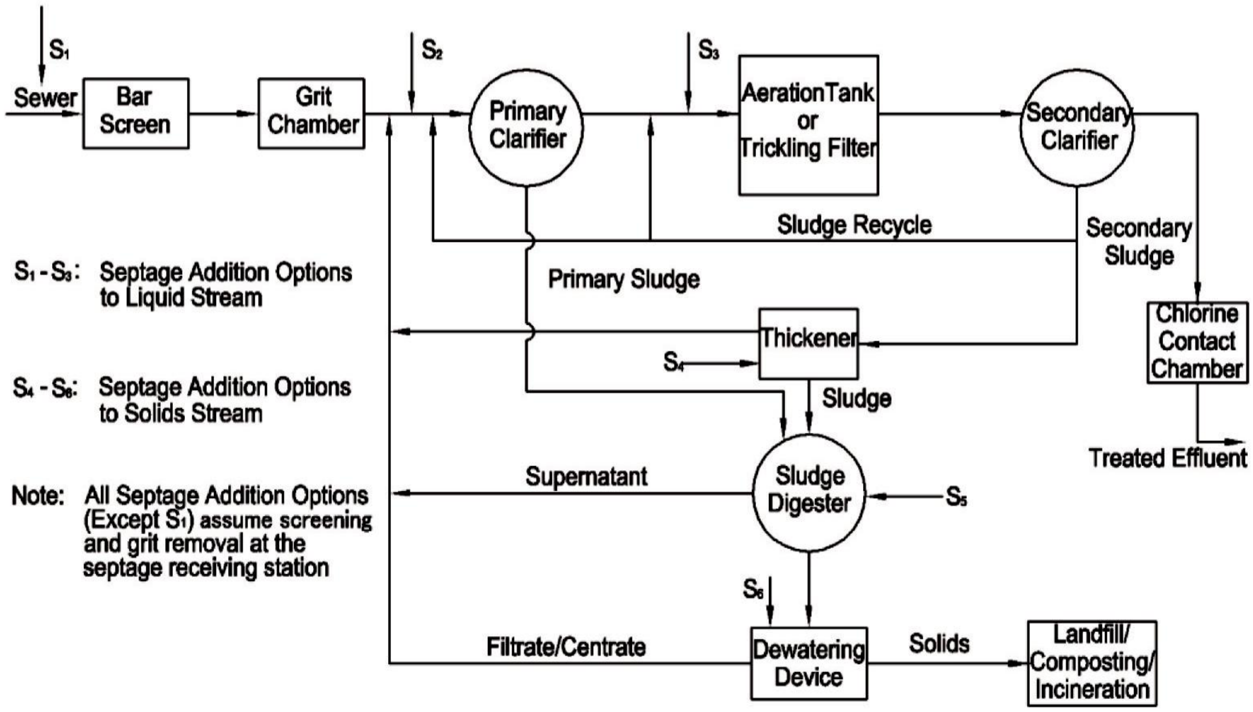
A schematic diagram indicating the options for FS&S mixing into influent sewage is given in Figure 20 for better comprehension. Depending on requirements, the options like reception of septage and preliminary treatment requirements like screening, stabilization/ equalization and solid- liquid separation etc. can be located between S1- S3. Septage with high solids content and sludge can be directly added between

Figure 19: Planning for Co-treatment



Source: Co-treatment of Septage and Faecal Sludge in Sewage Treatment Facilities, Dorai Narayana (2020)

Figure 20: Planning for Co-treatment of FS&S in STPs



Source: Manual on sewerage and sewage treatment (2013), CPHEEO, MoHUA

S4- S6. These units are similar to those described at Section 5.4.1 in Chapter 5 under 'Faecal Sludge and Septage Management'.

However, design processes along with use of end by-products are summarised in technological process chart at Figure 21, Liquid stream waste treatment options are also given in Figure 22.

6.2.1.2 Septage receiving facility

If septage is to be co-treated with sewage, it will be necessary to construct a septage receiving station. Such a station will consist of an unloading area (sloped to allow gravity draining of septage hauling trucks), a septage storage tank, and one or more grinder pumps. The storage tank is used to store the septage so that it can be discharged to the treatment plant.

The septage in storage tank should be properly mixed by mixers, air diffusers for odor control. Discharge of septage upstream is preferable for the removal of grit and screenings. If there are no screening facilities ahead of the septage discharge facility, the septage should be transferred from the storage tank to the treatment plant with grinder pumps. In some cases, this transfer can be accomplished by gravity flow. If the septage is strong and concentrated, it can also be diluted with treated sewage while adding in STP.

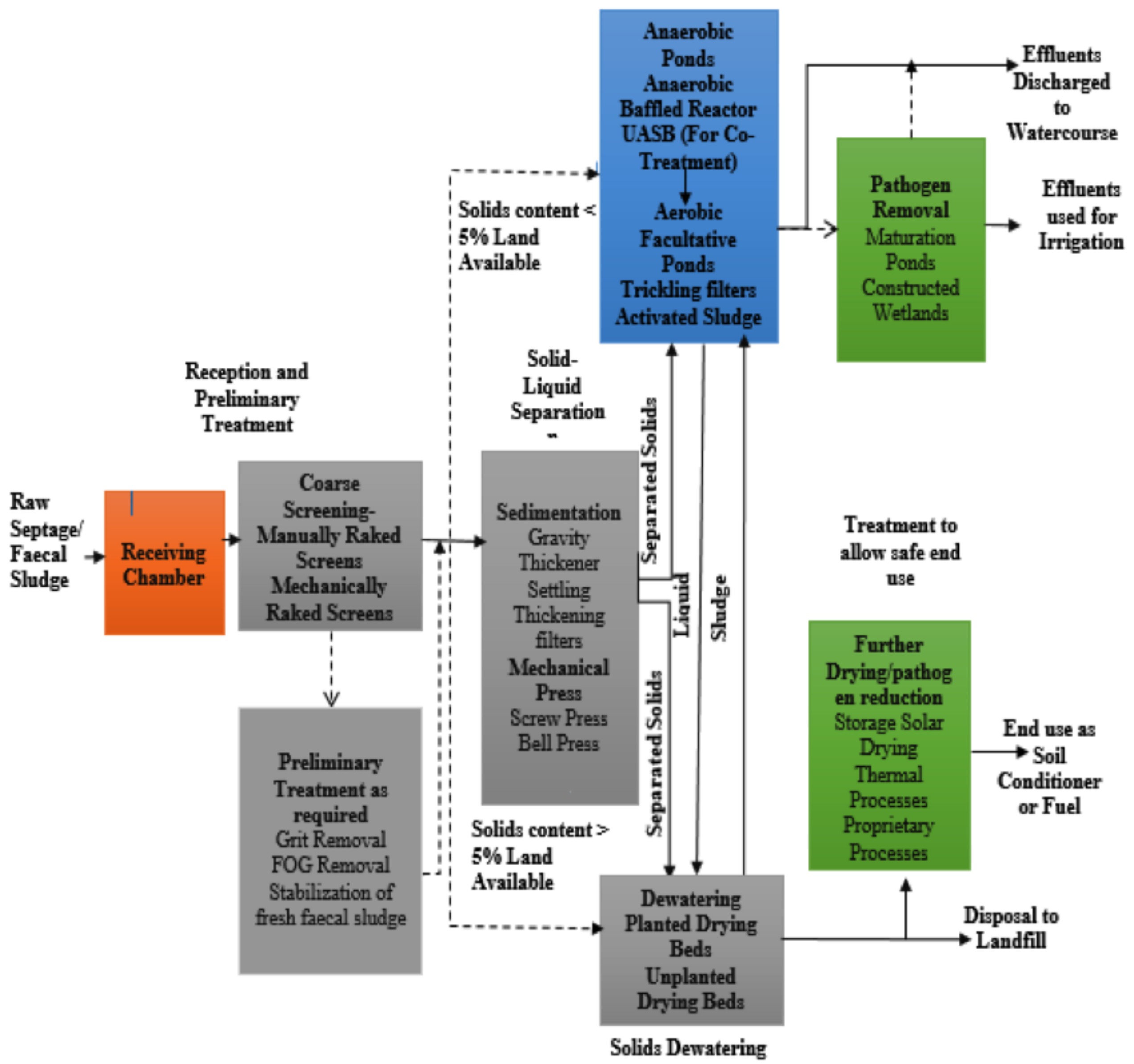
Chemicals such as lime or chlorine can also be added to the septage in the storage tank @ 2.4 kg/1000 litre of septage to neutralize it, render it more treatable, or to reduce odours and treat the septage.

6.2.1.3 Loadings of Septage at STPs

A chart prepared by USEPA is given below for guidance which takes into account the current loadings to the plant compared with its design loadings. If the STPs are working close to the design capacity, additional loads due to disposal of septage will necessitate expansion or upgradation of the STP capacity.

The chart can be used to assess the percent of septage by volume that can be co-treated with influent sewage at STP. For example, if a given ASP

Figure 21: Treatment Processes and Technologies



Source: Faecal Sludge and Septage Treatment: A guide for low- and middle-income countries by Tayler, K. (2018)

with Primary treatment is running at 50% capacity, the percentage of septage loading by volume works out to 1.4% of influent sewage volume (Fig. 24). This is further elaborated through a work out example below:

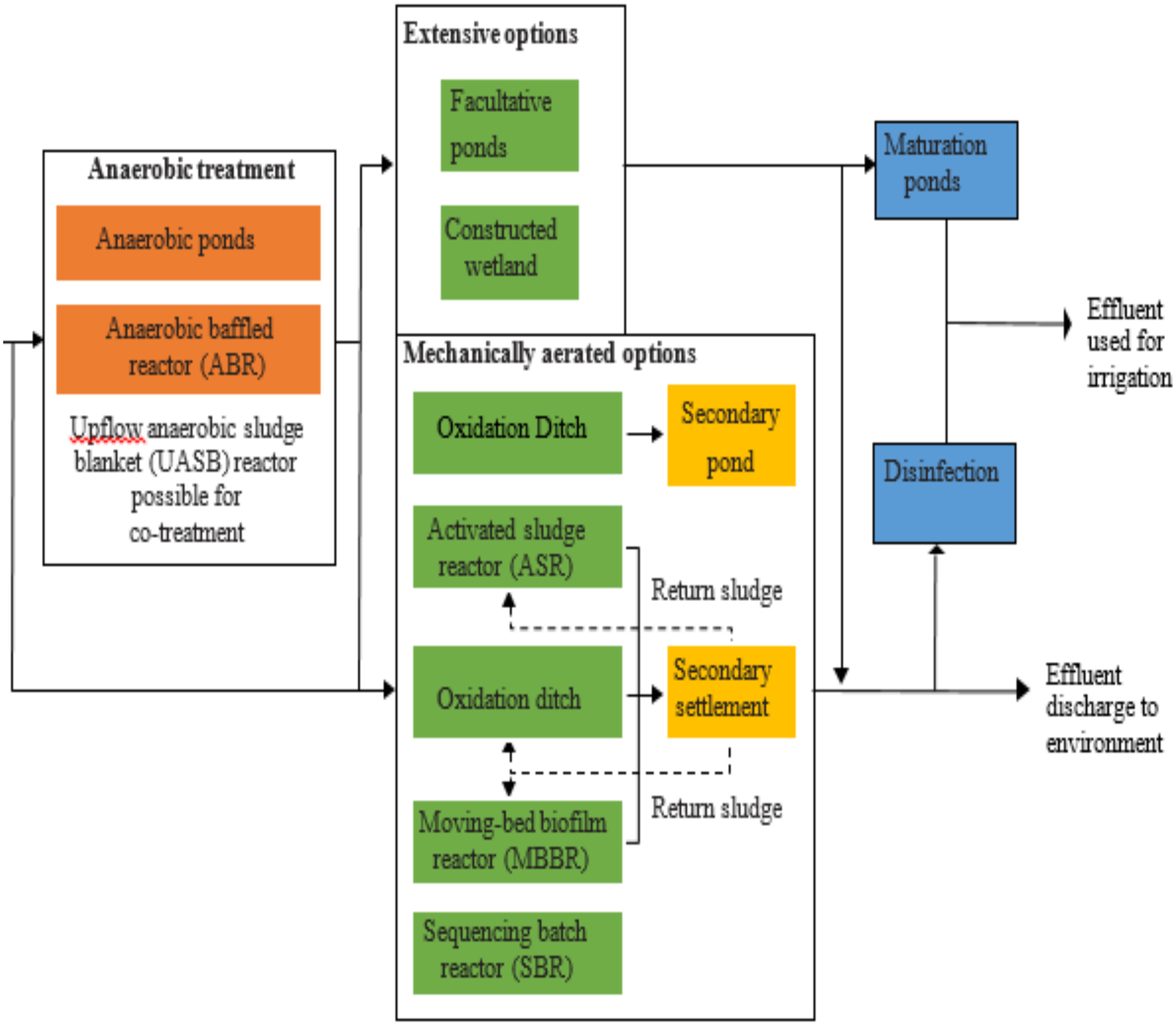
Example: For a city having 5 lakh population. Let's say that present required capacity of STP is 50 mld @ of 100 litre waste generation per capita. However, due to only 50 % sewer connection of houses, the STP is running at 50% capacity i.e. 25 mld. For remaining 50 % population i.e. 2.5 lakh, city intends to implement a Faecal Sludge and Septage management scheme with co-treatment of septage in STP. Considering desludging once in 3 years, the septage to be treated is as worked out below;

No of houses = 2,50,000/ 5 = 50,000

No of houses to be desludged per day = 50000/(300x3) = 56 house per day (assuming 300 working days a year)

Total septage to be desludged per day = 1x56 =56 m3

Figure 22: Liquid stream treatment options



Source: Faecal Sludge and Septage Treatment: A guide for low- and middle-income countries by Tayler, K. (2018).

(Considering @ 1 m3 septage per household)

Percentage of septage vis-à-vis Sewage = 56x100/ 25000 = 0.22%
(< than 1.4% of sewage volume) can safely handle septage)

Further, checking from BOD loading angle
Design capacity of the STP = 50 mld

Actual operating capacity = 25 mld

For sewage load of
300mg/l 200mg/l

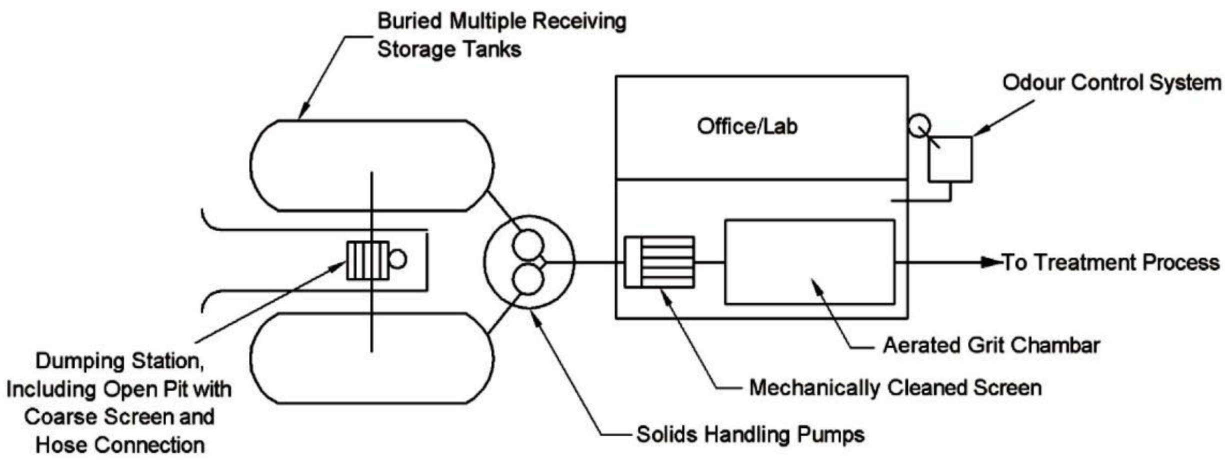
BOD load in to the STP (25 mld × 300 mg/l) = 7500 kg/day 5000kg/day

(assuming sewage reaching is having BOD of 300mg/l as designed. Although, in practice in majority of cases influent sewage has around 200mg/l in India further giving room for enhanced septage loading)

BOD load from septage (0.056 mld × 2,000 mg/l) = 112 kg/day 112 kg/day

Total resulting BOD load = 7500 + 112 = 7612 kg/day 5000 + 112 = 5112 kg/day

Figure 23: Typical septage receiving facility

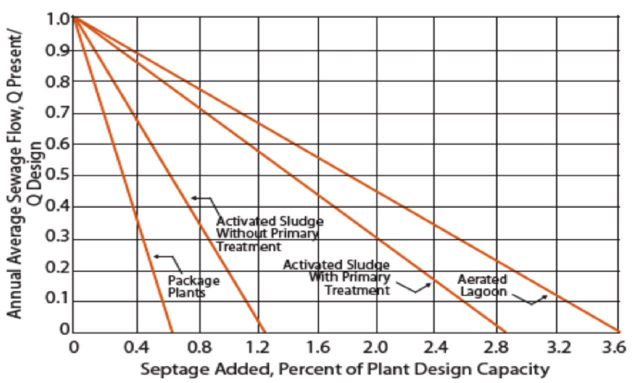


Designed ability of the STP for BOD load= 25 × 300 = 7500 kg/day   25 × 300 = 7500 kg/day

Thus, it may be possible to accommodate the septage as long as the actual flow to STP does not increase. If the spare capacity is available, then it is wiser to opt for this instead of rushing into an Independent Septage Treatment Facility. Yet another option will be to augment or upgrade the STP capacity, which is far simpler so far as the liquid stream is concerned.

Similarly, the planning for potential of co-treatment of faecal sludge and septage can be assessed in sewage treatment plants like Sequential Batch Reactor (SBR), Upflow Anaerobic Sludge Blanket (UASB) and Waste Stabilization Ponds (WSP) keeping in mind their process details.

Figure 24: Allowable septage loadings to a sewage treatment plant having septage-holding tank



Mechanized systems based on activated sludge, extended aeration and their variants can produce good effluent quality but are dependent on a reliable power supply, trained operators, and good performance-monitoring systems. Because of their power requirements, they may be expensive to operate and they are also subject to power outages. They may be considered for larger plants where knowledgeable managers, skilled staff, effective monitoring systems, and reliable supply chains are in place. Operating costs will be reduced if mechanized aerobic treatment is preceded by anaerobic treatment.

Anaerobic processes do not require external energy and have a fairly small footprint. Anaerobic treatment processes that are suitable for treatment of the liquid stream of separated faecal sludge and septage include anaerobic waste stabilization ponds and ABRs. Upflow UASB reactors should be considered for co-treatment with municipal wastewater, but they are unlikely to be a good option for stand-alone faecal sludge and septage treatment. They offer a good option for first-stage liquid treatment, reducing the land and/or power requirements of subsequent aerobic stages.

NOTE: Detailed technical design of various processes may be seen at publication on

(i) Manual on sewerage and sewage treatment (2013), CPHEEO, MoHUA

(ii) Faecal Sludge and Septage Treatment: A guide for low- and middle-income countries by Tayler, K. (2018).

(iii) Co-treatment of Septage and Faecal Sludge in Sewage Treatment Facilities,Dorai Narayana (2020)

6.3 Co-treatment of Faecal Septage in solid waste-based Bio-methanisation Plant

In this treatment, there is microbes driven anaerobic decomposition of organic matter from Faecal Septage to bio-gas. Faecal Sludge and organic solid waste is converted to treated sludge, effluent and bio-gas. Preliminary treatment for FS&S as mentioned in para 5.4.1 can be adopted depending on source of FS&S, quantity and whether fresh or digested.

To start the reactor, active sludge (ex from a septic tank) should be used a substrate. The tank is essentially self-mixing, but it should be manually stirred once a week to prevent uneven reactions. However, once stable state reached, stirring is not essential. Gas equipment should be cleaned carefully and regularly so that corrosion and leaks are prevented. Grit and Sand that has settled to the bottom should be removed once periodically/at least once every year.

Biogas is a mixture of mainly methane and carbon dioxide and the digestate is relatively biologically stable and can be used as a soil conditioner.

Anaerobic digestion has been widely applied in centralised wastewater treatment facilities for the digestion of primary sludge and waste activated sludge. Anaerobic treatment technologies also include upflow anaerobic sludge blanket (UASB) reactors, anaerobic baffled reactors (ABRs) and anaerobic filters. Throughout Asia, the onsite anaerobic digestion of organic solid waste/animal manure with or without the addition of Faecal Sludge is widely practised (Koottatep et al., 2004).

Operating conditions that play an important role in the design and operation of anaerobic digesters includes the parameters like:

- solids retention time (SRT);
- HRT;
- temperature;
- alkalinity;
- pH;
- toxic / inhibiting substances; and
- bioavailability of nutrients and trace elements.

Advantages

- Established and Mature Technology
- Best Suitable for Wastes with high moisture content
- Technology could be optimized for any scale
- Considerate reduction in the emission of greenhouse gases like methane is possible

Disadvantages

- There are concerns with odour and pathogen dissemination from the digestate
- Issues are there in controlling microbial activity if the digester is beyond a certain size.
- Affected by temperature, less efficient in colder climate

6.4 Thermal Drying and Treatment of Faecal Sludge and Septage

6.4.1 Thermal Drying

Thermal drying allows the removal of all types of liquids from Faecal Septage. It has been applied in the management of wastewater sludge for many years, and the technology has been taken up and improved from its original application in other industries (e.g. paper industry). Several types of technologies exist, all based on the ability of evaporating water with heat. The end products are stable and in a granular form allowing easier storage or transport. Direct or indirect thermal dryers are also referred to as convection or contact dryers, respectively.

Thermal drying can be broadly categorized into two categories namely (i) natural solar drying and (ii) heat or electricity supply based drying.

Box 2

Waste to Energy Plant, Nashik, Maharashtra

Scale: Daily 10 to 15 tons of food and vegetable waste from approximately 500 restaurants and 10 to 20 tons of septage from 400 community toilets are collected by trucks and delivered to the plant

Implementing mode: Design – Finance - Build – Own – Operate – Transfer (DFBOOT)

Implementing agency: The Deutsche GesellschaftfürInternationaleZusammenarbeit (GIZ) GmbH

Area: 6000 sq.m, provided by Nashik Municipal Corp (NMC).

Processing Capacity: 30 Tonne/day

Capital Cost: INR 8.02 Crore (INR 6.8 Cr from GIZ and 1.2 Cr from M/s Vilholi Waste Management System

Operational since: December, 2017

O&M: NMC will give INR 5 lakh per annum for management

Power Generation: 3300 kWh/day (the purified bio-gas is sent to a Combined Heat and Power (CHP) unit.

Solar radiation is the cheapest form of thermal energy. Use of solar drying of dewatered sludge is a techno economic solution for sludge drying to be used as manure / soil conditioner in agricultural fields and also in coal furnaces of thermal power plants and cement kilns. Fortunately, this is available plenty in India and reduces the cost of handling the sludge with very minimum skill.

Heat or electricity supply based thermal drying systems require preliminary dewatering if used for sludge that is high in water content. In direct thermal driers, the hot air or gases are mixed with the dewatered sludge, as they pass through it, or are transported with it. In indirect thermal driers, a heat exchanger is used, which allows the heat convection to the sludge. In this case, the heat carrying media is often steam or oil, and does not come in direct contact with the sludge, which reduces the operational need to separate the sludge from the heat carrier. In both cases, the vapor produced by the evaporated water needs to be collected and transported out of the dryer. Gas treatment can be an issue depending on environmental requirements and the odors produced. Indirect thermal dryers produce less contaminated vapor. Various methods of thermal treatment based on heat or electricity supply are explained below.

6.4.2 Thermal Treatment

Thermal drying is followed by thermal treatment which include incineration, pyrolysis or gasification. These are briefly mentioned below;

6.4.2.1 Incineration

Involves the burning of Faecal Sludge at temperatures between 850-900°C. It does not typically take advantage of the potential for resource recovery; however, energy can be captured from the incineration of sludge. For better performance Faecal Sludge needs to be dewatered prior to combustion, but stabilization treatment is not necessary as it decreases the volatile content of the sludge. The process requires very less space and can be designed to be a batch or continuous process. One cycle takes a few hours to complete. Sludge volume is substantially reduced and all pathogens are removed. However, contains potential emission of pollutants, need highly skilled operating and maintenance staff, high capital and O&M costs.

6.4.2.2 Gasification

Gasification involves thermal transformation of organic mass under limited supply of air/oxygen to Syngas. In this technology sludge is converted to Syngas &Biochar. Gasification is suited for dry feedstock and the drying of Sludge is required prior to treatment. It is an energy intensive process and needs to be tested for operational and financial viability under Indian conditions.

6.4.2.3 Pyrolysis

Pyrolysis involves thermal conversion of carbonaceous materials in sludge to produce complex oil in absence of air/oxygen. In this technology sludge is converted to Bio-oil, Pyrolytic Gas and Biochar. Pyrolysis requires trained manpower and has high risk of malfunction if not maintained and operated properly.

Advantage of thermo-mechanical treatment

- Low footprint
- Modular and Scalable
- Bio-safe treatment process for solids and liquids
- No minimum plant capacity required for operation.
- Setup time in 6-7 months from signing of agreements

Disadvantages of thermo-mechanical treatment

- Requires Electricity (Grid / DG)
- Energy Intensive
- High Capital and O&M Cost
- Susceptible to breakdown and malfunctioning
- Skilled manpower

6.5 Co-composting

For dewatered Sludge processing (solid portion), the methods like Co-composting, Vermi-compostingcan also be used which are briefly described.

6.5.1 Composting

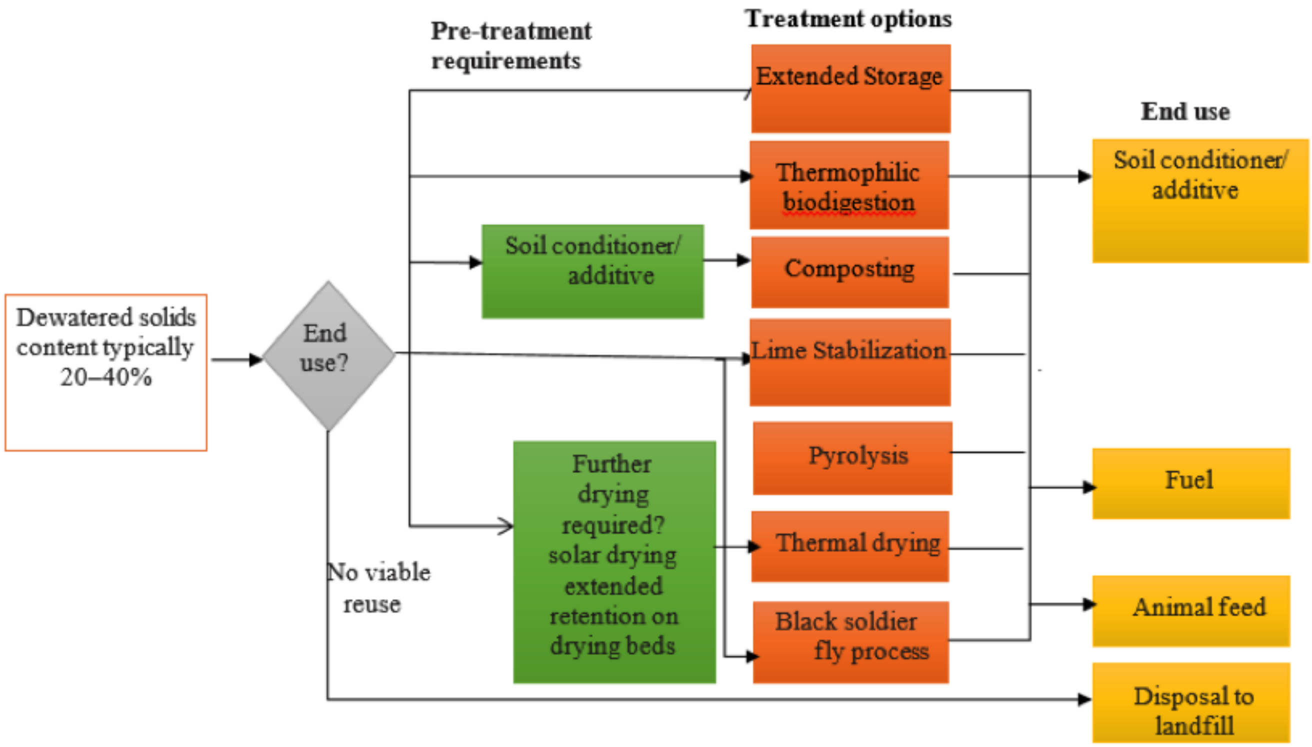
Composting of Faecal Sludge is done together with other waste streams such as municipal solid waste (MSW) following similar procedure of composting as is done for MSW alone. Pathogen reduction is

Box 3

Biochar production from faecal sludge using pyrolysis

To date, most initiatives using pyrolysis to produce biochar or fuel briquettes from faecal sludge have been at the pilot scale. One such initiative is operated by Water for People with support from the Water Research Commission (WRC) in Uganda and involves production of sludge briquettes. Currently the organization is experimenting with two types of small kilns that have previously been used for carbonization of wood: a masonry insulated retort kiln and a metallic kiln. The process involves the following steps: (1) a start-up fuel (wood or charcoal) is burned at the base of the kiln, (2) dried sludge is added until the kiln is full, (3) additional sludge is added as sludge burns down (4–5 hours), and (4) when the fire penetrates the topmost sludge, the unit is air-locked to allow the pyrolysis process to continue overnight. In the final step of the process the carbonized biochar is crushed into fine particles and then blended with a binder such as cassava or molasses. Clay may also be added as a filler to reduce the burning rate of the briquettes, although this may not be necessary as the lack of pit lining means that sludge may already contain a high proportion of filler. Crushed charcoal can be added to increase the energy content of the mixture. After blending and addition of water to increase the moisture content, the briquettes are produced using either a mechanized extruder, screw extruder, hand/ manual press, or honeycomb press.

Figure 25: Overview of end-use and treatment options



Source: Faecal Sludge and Septage Treatment: A guide for low- and middle-income countries by Tayler, K. (2018).

achieved during the composting process through high temperatures, and/or length of time. Co-composting of Faecal Sludge with MSW is best implemented with sludge that has undergone dewatering. Normal composting process takes 30-45 days and yields a safe product useful for agriculture/ horticulture applications. The facility should be located close to the sources of organic waste and faecal sludge to minimize transport costs, but still at a distance away from homes and businesses to minimize nuisances.

Depending on the climate and available space, the facility may be covered to prevent excess evaporation and/or provide protection from rain and wind.
For dewatered sludge, a ratio of 1:2 to 1:3 of sludge to solid waste should be used. Liquid sludge should be used at a ratio of 1:5 to 1:10 of sludge to solid waste. Windrow piles should be at least 1 m high and insulated with compost or soil to promote an even distribution of heat inside the pile.

6.5.2 Vermicomposting

In this method, dewatered faecal sludge is applied to a system inoculated with earthworms whether alone or mixed with food waste. When carried out under controlled conditions, the technology of vermicomposting can lead to a complete removal of coliforms. Process has high space requirement because of being largely a nature-based treatment system. Normal process takes 45 to 60 days to achieve permissible levels of pathogen reduction. The worms can be quite susceptible to toxic components and to be maintained for long time span until matured compost is reached.

Finally, the overview of various treatment options of dewatered solids out of Faecal septage is summarized in the Figure 25 along with their prospective end uses.

Chapter-7

OPERATION & MAINTENANCE AND MANAGEMENT

This chapter covers O&M of various aspects of FS&S treatment, sanitation value chain and general maintenance of STPs/FSTPs. It also covers institutional set up, capacity building, IEC and grievance redressal. Private sector participation is also emphsized.

7.1 Operation & Maintenance

In spite of the large proportion of on-site installations (60%) in urban areas in the country, limited attention has been given so far to its proper construction, maintenance and safe disposal of Faecal Sludge & Septage from septic tanks & pit latrines. These installations are subject to local practices and considerable variations are observed across the country.

In ULBs, septic tanks are often constructed in total disregard to the Standards in force, and are often dramatically undersized/oversized and poor in quality. Septic tanks are frequently installed underneath homes, roads/ lanes due to small lot sizes, thus making access for inspecting or desludging difficult. In many instances, "septic tanks" are constructed in such a way that they are not septic tanks at all, but are instead seepage pits or cesspools. These unlined, earthen receptacles not only perform poorly at treating sewage, but frequently serve as direct conduits to aquifers, resulting in fecal contamination that can impact precious drinking water supplies.

Sanitary workers also work in hazardous conditions having to manually clean on-site pits and tanks without adequate protective gear and equipment. The new legislation prohibits hazardous manual cleaning of septic tanks and sewers, so as to ensure that health and safety of such workers is not compromised.
There is a general lack of awareness among system owners and ULBs about entire sanitation value chain as to how it should be planned, designed, installed, operated and maintained. In several instances, private desludging operators dispose of Faecal Sludge and Septage in open drains/ land degrading environment. Even simplest of STPs/FSTPs do not function properly due to poor O & M and lack of skilled manpower. This has resulted in pollution of the ground and surface water bodies impacting the public health. Limited capacities and resources with ULBs and absence of regulation of maintenance and cleaning of septic tanks and pits are main factors responsible for it.

States and Cities need to develop a strategy for effective management of on-site and localised sewage in line with existing policies like the National Urban Sanitation Policy 2008 and National Faecal Sludge and Septage Management Policy 2017. To ensure that entire sanitation value chain for septage and sewage performs as per desired objectives, following important aspects need to be taken care;

1) Enforcement of regulations to improve on-site and off-site sewage management practices
2) Monitoring of Sanitation Value Chain
3) STP/FSTP routine maintenance
4) Institutional Set up for O & M
5) Capacity Building and Training
6) Availability of O & M funds
7) Information Education Communication
8) Feedback from stakeholders and Grievance redressal

The important aspects of O & M of on-site and off-site sewage management practices are briefly elaborated below:

7.1.1 Enforcement of regulations to improve on-site and off-site sewage management practices

The ULBs need to develop a robust process of enforcement of Regulation to improve on-site and off-site sewage management practices. Several states have formulated specific sanitation policies to address the issue as given at **Annexure IV**.

Further, cities can incorporate in their bye laws, various regulations brought out from time to time by Govt. which is specific to sanitation, in order to strengthen the enforcement of sanitation practices in the city. A sample draft Sanitation bye law is provided on the URL:

http://www.swachhbharaturban.gov.in/writereaddata/Draft%20Sanitation%20Byelaws.pdf?id=08qsqye2vvuhbdry

States and ULBs can also develop protocols for the enforcement of different laws and regulation to improve sanitation like prevention of manual scavenging, discharge of sewage in open environments like water bodies. The bye laws can have stringent penalties for non-compliance.

(i) Standardization of Septic tanks: At present, there is no uniformity in design and construction of Containment Systems like septic tanks which leads to leakage of septage into ground water or discharge in open environments. ULBs should strictly enforce BIS standards of containments system in new/ reconstructed dwellings as part of the building approval process. If sewer network is not available, effluent from septic tank may be brought to well designed and maintained soak pit.

The ULBs can also empanel and train masons to construct toilets according to BIS standards. Alternatively, Cities can also explore the feasibility of small bore systems or tapping of drains to transport septic tank effluent and grey water to the localized STPs and this may also form part of building plan approval.

7.1.2 Monitoring of Sanitation Value Chain

Various aspects of sanitation value chain need to be monitored and kept in tip top condition for desired performance of assets as mentioned below.

i. Periodic Audit of toilet facilities: ULBs should undertake a survey of all toilet facilities to identify the status of containment systems and capture the information in a database. This database will help ULBs in planning, procurement, implementation and empanelment of suitable number of desludging vehicles or interceptor tanks in case of shallow sewers.

ii. Emptying & Transportation: Emptying and Transportation faces following gaps and challenges, which need to be addressed by every local body;

- While the national guidelines recommend emptying of on-site sanitation containment units every 2-3 years, due to lack of dedicated operators or effective monitoring at local level, informal sector workers are still found to be engaged in emptying the units manually, although prohibited by law.
- Emptying needs to be planned by leveraging mechanized solutions like vacuum suction trucks which eliminates the possibility of human contact with faecal matter. Many ULB's have been using vacuum trucks but owing to high costs of emptying, household owners or commercial spaces often rely on much cheaper option of manual cleaning through informal sector which are often found to be disposing off the collected faecal septage indiscriminately and illegally into drains, sewer manholes, and open fields in the outskirts of the town or directly into the water bodies. Hence there exists a considerable need to regularize operations and creating an end-to-end solution.

iii. Truck operators must take the following measures while desludging:

- The septic tanks should not be fully emptied; small amount of sludge of around 1 to 2 inches should be left in the septic tank to facilitate decomposing of incoming faecal waste.
- No fire or flame should be used near the septic tanks as there may be inflammable gases inside septic tanks.
- Proper safety gear (including uniform, tools, and well-maintained vehicles) must be used by the operator

while desludging/emptying the septic tanks/Pits. The rules under the Prohibition of Employment as Manual Scavengers and their Rehabilitation Act, 2013 provide for a comprehensive list of safety gear that should be used while providing these services.

- Operators should clean their surroundings before leaving and after desludging; residents should not find their homes or surroundings dirtier.

iv. ULBs shall take the following steps in order to properly treat faecal sludge.

- Operators shall be forbidden by regulation to dispose of sludge collected from the septic tanks or pits into fields, rivers, nalas, forests, etc. These regulations shall be enforced and violation shall be subject to advertised financial and/or legal penalties. These penalties should come into force as soon as there is a sanitary location for dumping faecal sludge.
- ULB should first assess the possibility of sludge treatment at existing STP in the city or STP of nearby city through appropriate agreements with STP operators and receiving ULBs.
- If STP is not available in the city or nearby that can receive the sludge, then ULB should plan for new faecal sludge treatment facility. Such a new faecal sludge treatment plant should be designed to cater to expected volumes of septage generated in urban local body and if faecal waste is expected from nearby rural areas or ULBs.
- Input quality of the collected septage should be tested at the treatment facility for checking presence of any metal or traces of industrial waste.
- The faecal sludge treatment plant should be operational during working hours only and a responsible person should be appointed in the facility to ensure that no industrial waste is unloaded in these facilities.
- Septage should be reused/disposed of only after it meets the specified disposal parameters.

For holistic planning, implementation and monitoring of sanitation services robust database is often unavailable which otherwise is a very important in planning and making policy decisions. For better planning and optimizing cost and service delivery, it is important to have database at city level, state level and also at national level. This will be helpful for private sector to get clear picture of the sector and invest with low risk.

Quality control of reclaimed water /sludge for Reuse

There should be a clear analysis of potential consumers in an area. This should entail clear understanding of water quality, water scarcity/stress, tariffs, and perception of the community towards water reuse. Industries in water-scarce areas, which often pay huge tariffs for water, might be potential consumers of reclaimed water.

In a nutshell, the measures recommended in Table 8 below need to be monitored by ULBs for optimal performance.

7.1.3 STP/FSTP Routine Maintenance

The overall requirements for any treatment process are that it operates effectively and consistently achieves its design objectives. To achieve it following need to be ensured

i. Treatment capacity matches the load on the plant;

ii. Technology selection takes account of resource availability;

iii. The process design facilitates effective operation;

iv. Management systems support and facilitate operational procedures;

v. Facilities are constructed accurately and to the minimum standards required to ensure effective operation; and

vi. Both managers and operational staff have a sound knowledge of the operational requirements of the treatment process.

vii. Written standard operating procedures(SOPs) are available and are routinely followed by staff.

7.1.4 Institutional Set up for O & M

It is well known that even the simplest technology will fail if it is ineffectively managed. Central Pollution Control Board, 2007 analysis showed that the simplest waste stabilization ponds were among the worst performers. This is bacause that managers assumed

Table 8 Measures Recommended

Stage	Monitoring
Containment	Construction as per prescribed standards by BIS or CPHEEO Construction of the containment by licensed masons and plumbers Overflow from containment is not diverted in open areas or drains Census of the OSS and retrofitting of faulty containment is done. If not done within a timeline, defaulters should be charged
Emptying	Safety standards are followed Legislative provisions like Manual Scavenging Act, 2013 are followed Fixed charges are collected by private or government operators
Transportation	Vehicles are registered with ULBs with transparency Vehicles are well-maintained All vehicles are GPS-enabled so that the route followed and point of disposal can be monitored Septage is disposed in designated disposal or treatment sites
Treatment	Septage characteristics are determined to design the treatment system In case of co-treatment at STPs, design parameters to take additional septage load is checked Effluent resulting from dewatering is treated as per discharge standards Independent septage treatment plants have adequate provisions for vehicle parking Sludge drying beds are emptied regularly
Disposal and end use	Legislative provisions like water pollution and environment protection acts are followed Defaulters are charged or fined as per provisions Quality checks of end products is done before end use Rates of end products are reasonable Treated wastewater overflowing from containment meets prescribed standards of end use for designated purposes

Source: Septage Management, A Practioners Guide, 2017

the low maintenance meant no maintenance. Existing management structures should there fore be assessed at the planning stage in order to identify and address any weaknesses and constraints that might prevent effective operation and maintenance of the plants.

Further, the responsibilities of various personnel must be clearly defined and periodically monitored to ensure efficient functioning of the systems. Advance steps to be taken to ensure O & M funds are sanctioned in time and consumables and spare parts are readily available to ensure uninterrupted functioning of systems in case of breakdown.

7.1.5 Capacity Building and Training

The staff allocated to septage management tasks are often either low-grade employees or contract workers employed on a temporary basis. Many are daily-wage employees with no job security and no pension or sickness benefit rights. Such arrangements are not conducive to the employment and retention of staff members with the knowledge, experience, and skills to operate anything other than the simplest technologies. Where such arrangements exist, planners must make a realistic assessment of the steps that need to be taken to develop capacity before attempting to introduce new and improved treatment processes and technologies. These might include:

Creating new posts within the municipal structure. The scope for doing this will depend on the division of powers between local and higher levels of government.

Introducing new institutional arrangements that provide increased scope for employing the required specialist staff.

ULB need to take the following steps to address the gap in capacity on on-site and localised sewage management practices:

- Training and capacity building of ULB officials and other engaged in the sector
- State level awareness and behavior change campaign

- Create enabling environment for participation of NGOs, CSOs and SHGs.

MoHUA is also encouraging States and ULBs to build capacity of de-sludging service providers on safety norms, safe collection and transportation and safe disposal of faecal sludge.

7.1.6 Availability of O & M Funds

No technology will continue to function if essential operation and maintenance tasks are neglected. Each technology option should therefore be assessed in terms of the ability of existing and possible future management systems to ensure that those tasks are undertaken both promptly and effectively.

To recover O & M charges for smooth functioning and maintenance of STP/FSTP/ emptying & desludging activities. ULBs may develop systems for charging for services that provide mainly public goods. An example from the Philippines is the introduction of small monthly charges, on water bills in some towns in the Philippines to cover the cost of scheduled pit and tank emptying and the associated transport and treatment services. This option has the merit of simplicity but is only possible where most people have a water connection. It might also be possible to add the surcharge to electricity bills or property taxes. Some states in India have explored the second option. Both options pose some administrative challenges: in the case of electricity because it is rarely a municipal responsibility, and in the case of property tax because some properties are exempt from tax. The Maharashtra Government has also suggested the alternative of introducing a new sanitation tax, noting that this would be possible under existing legislation. Cities like Wai and Sinnar collect sanitation tax as a part of property tax and use it to fund for O&M activities along with surplus of property tax as given in Annexure III. Cities like Hyderabad add sewage cess as percent of water supply charges.

The revenue generation can be further boosted up by promoting sale of treated by-products. The sanitation cess/ FSSM cess/ sewage tax as the case may be should also have inbuilt provision to annually increase the charges linked with inflation/WPI.

7.1.7 Information Education Communication

The States/ULBs shall develop appropriate IEC materials and undertake IEC campaigns through print and electronic media, outdoor medium and consultations and workshops targeting the residents to promote adoption of proper toilet designs, construction methods, periodic desludging and safe sanitation practices.

The builders, masons and suppliers of the septic tanks and pits shall be exposed to better designs and better methods of construction. The operators of collection and transportation shall be provided information on standard operating procedures. Non-government Organization (NGOs), Community Based Organizations (CBOs), women's groups and school children shall be extensively involved in undertaking IEC campaigns. Operators and other involved parties shall also develop IEC material and educate communities on safe management of septage.

The IEC plan identifies the steps for:

- Creating the message;
- Producing the materials;
- Launching the outreach activities;
- Monitoring and Evaluation (M&E); and
- Adjusting the message and outreach based on the M&E.

7.1.8 Feedback from stakeholders and Grievance redressal

At each stage of the sanitation chain, monitoring is essential. Any lapse in monitoring means avoidable delays in achieving the goals of the programme and, in extreme cases, may result in the goals of the programme not being achieved. When any services are offered, there are always some issues and challenges associated with them. Customer satisfaction should be the main objective of service providers, In wastewater and Faecal Sludge & septage management, many stakeholders and beneficiaries are involved. It may not be possible to ensure that every one of them is satisfied with the services. Therefore, for appropriate disposal of the complaints with management, a complaint redressal system must be put in place before the services are offered. The mode of the redressal system should vary according to the size of the target area, from a simple register to complex information technology-based systems. Nodal officers must be appointed to dispose of the complaints for each stage of management chain.

Nodal officers should review the complaint and take appropriate action. However, in case the complaint is not addressed or the user is not satisfied, there should be provisions to take the complaint to higher authorities or institutions (e.g. pollution control boards) for appropriate action.

7.2 Private Sector Participation

Private Sector can bring about technical know-how and innovation and operational efficiency in on-site and localised sewage management practices. ULBs should develop operational and financial models to engage the private sector and attempt to make the projects financially viable. ULBs also need to empanel private desludging vehicles, FSTP/STP operators and other service providers in their jurisdiction. The empanelment should be done through a tender basis to maintain transparency and the suitable service providers need to be selected through tender basis. Private sector can be either employed for individual activities like desludging or integrated services. Financial models and bid parameters are discussed in detail in the next section.

Where private operators are not forthcoming/ are in inadequate number, the ULBs can themselves procure desludging vehicles and sub-contract the operation and maintenance of the vehicle to a third party.

Employing private-sector companies to run septage management services through some form of public–private partnership arrangement. The private-sector companies might be responsible for all aspects of septage management or for specific aspects, including septage removal and collection, septage treatment, and the provision of laboratory services.

Chapter-8

OFF-SITE SEWAGE MANAGEMENT

This chapter deals with off-site sewage management practices with focus on low capacity community-based conveyance and treatment plants which can be expanded in large size plants also. It also contains important aspects of plants like process, suitability, land requirements, merits/ limitations, Capex& Opex and where such plants are working etc. It also contains comparative performance of various wastewater treatment technologies along with comparative O&M requirements of various plants. This chapter will be of immense use to planners not only in planning for sewage based STPs in smaller towns but also for planning localized treatment options for areas not having soak pits after septic tanks.

8.1 Off-Site Sewage Management Systems

Off-site sewage management practices can be categorized as centralized or community-based systems. Both categories are similar in nature and a suitable treatment process can be opted in each case considering various factors like availability of land, treated effluent discharge options, Capex & Opex and level of skilled operations etc. In this chapter emphasis is given for Community Based Sewage Management Systems suiting to smaller towns. This comprises of collection and conveyance systems for community-based sewage management along with its safe treatment/disposal/recycle and reuse. In places where due to non-availability of suitable land community-based sewage management systems are not feasible, same approach can be followed for decentralized or centralized systems on modular basis.

Community Based Sewage Management Systems concept implies localized collection, conveyance and treatment of excreta and sullage in micro zones within a major habitation. This depends on densification of locality and progressively keeps on duplicating as and when population in other micro zones get dense.

This type of system advocates that every micro zone owns up its sewage management and cannot expect a faraway habitation to receive and inherit to its future generations. Thus, the provision of both the decentralized collection, conveyance and treatment systems can be made compatible to the pace of development by juxtaposing it with on-site sanitation. State may come out with guidelines mandating apartments having certain number of housing units say 200 houses and more can go for separate community based sewage treatment system.

8.1.1 Collection and Conveyance Systems

The following four types of collection and conveyance systems are recommended for installation of decentralized sewerage system:

(i) Simplified Sewerage
(ii) Small Bore Sewer System
(iii) Shallow Sewers
(iv) Twin Drain System

8.1.1.1 Simplified Sewerage

Simplified Sewerage is defined as “an off-site sanitation technology that removes all wastewater from the household environment.”

Conceptually, it is the same as conventional sewerage, but with conscious efforts made to eliminate unnecessarily conservative design features and to match design standards to the local situation.

The key feature of an in-block system is that sewers are routed in private land, through either back or front yards. This in-block or back-yard system of simplified sewerage is often termed condominial sewerage in recognition of the fact that tertiary sewers are located in private or semi-private space within the boundaries of the 'condominium'.

These simplified sewers are laid at shallow depths, often with covers of 400 mm or less. The minimum allowable sewer diameter is 100 mm, rather than the 150 mm or more that is normally required for conventional sewerage.

The simplified sewerage approach is now widely used.

8.1.1.2 Small Bore Sewer System

Small bore sewer system is designed to collect and transport only the liquid portion of the domestic sewage for off-site treatment and disposal.

The solids are separated from the sewage in septic tanks or aqua privies installed upstream of every connection to the small-bore sewers. Since the small-bore sewer collects only settled sewage, it needs reduced water requirements and reduced velocities of flow.

This system also provides an economical way to upgrade the existing on-site sanitation facilities to a level of service comparable to conventional sewers This in turn reduces the cost of excavation, material and treatment.

Where conventional sewers would be inappropriate or infeasible, this system provides an alternative. This is also called as settled sewerage.

It consists of house connections, interceptor tanks, sewers, cleanouts and manholes, vents and in some cases lift stations also.

Suitability of the System

This system is suitable under the following conditions, where

- Effluent from pour-flush toilets and household sullage cannot be disposed off on-site
- Installation of new schemes is taken up, especially for fringe area
- A planned sequence of incremental sanitation improvements with small bore sewers as a first stage is contemplated.
- Existing septic tank systems have failed or where there are a number of septic tanks requiring the effluent to be discharged, but soil and ground water conditions do not permit such a discharge.

8.1.1.3 Shallow Sewers

Shallow sewers are designed to receive domestic sewage for off-site treatment and disposal. They are a modification of the surface drain with covers and consist of a network of pipes laid at flat gradients in locations away from heavy imposed loads (usually in backyards, sidewalks and lanes of planned and unplanned settlements). For black water, mixed with grey water, small bore is the appropriate and sustainable options for collecting wastewater. Small bore sewer systems are designed to receive only the liquid portion of household wastewater for off-site treatment and disposal.

- It consists of components like the one for conventional sewer system i.e. house connections, inspection chambers, laterals, street collector sewers, pumping stations where necessary and treatment plants.
- Low volume pour flush or cistern-flush water seal toilets are connected to the inspection chamber by means of a 75 mm diameter sewer.
- The laterals are of small diameter (minimum 100 mm) and of stoneware or concrete, which are buried in a shallow trench. They are usually laid at a minimum depth of 0.4 m. Where vehicular loading is present and the invert depth of sewer is less than 0.8 m, a concrete encasement is provided for the sewer.
- The street collector sewer has a usual minimum diameter of 150 mm, however, 100 mm sewers may also be used if hydraulic capacities permit.
- Inspection chambers are provided along the street collector sewers and along the length of the laterals at intervals not exceeding 40 m. Usually one chamber is provided for each house.
- Depending upon the size of interceptor tanks and inflow of wastewater, settled solids should be removed periodically from the interceptor tanks. The effluent from the tank is discharged into the small

bore sewer system, where flow occurs by gravity utilizing the head resulting from the difference in elevation of its upstream and downstream ends.
- Since the small-bore sewer collects only settled sewage, it needs reduced water requirements and reduced velocities of flow.

8.1.1.4 Twin Drain System

This is an integral twin drain on both sides of the road. The drain on house side receives the sewage and the drain on road side is the storm water drain. The advantage is that even if the per capita sewage falls to low quantities, say 28 lpcd as is still there in some cases, where water is scarce this can still be adopted.

The design of the drain with removable cover slabs permits the daily scraping forward of sediments progressively by each house owner in the portion of the drain before his premises to the destination treatment site, something that the other options do not permit that easily.

Since open drain/channel have a higher friction than a pipe, in relatively flat areas, pipe flow could be better. The important design considerations are as follows:

Applicability

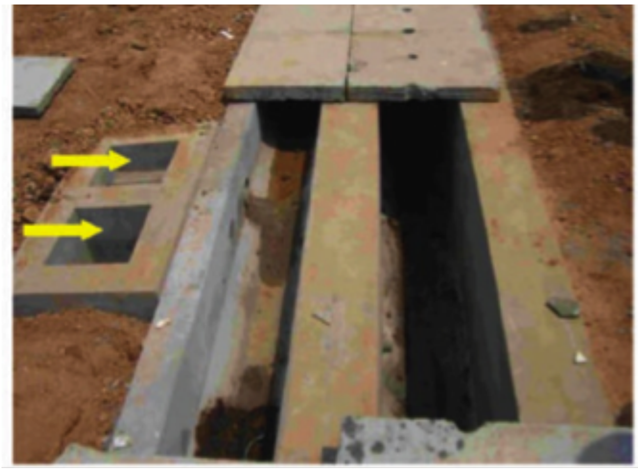
- Suitable for areas having low sewage flows like in coastal fishermen communities
- It is an interim and fast solution of wastewater collection and can be applied in any urban area with lower sewage flow at a reasonable cost.

For detailed design considerations/parameters, Chapter 8: Decentralized Sewerage System of Ministry's Manual on Sewerage and Sewage Treatment Systems, 2013 may be referred to.

8.2 Off-site Sewage Treatment Technologies

A combination of treatment steps is required to remove impurities from the sewage to achieve desired design standards. These treatment steps or "technologies" are breakthroughs, which have evolved after extensive technical research and experience can be grouped into the following.

Figure 26: Twin Drain System



a) Physical Treatment which comprises of Physical Straining, screens, filters, press, centrifugation, sedimentation
b) Chemical Treatment such as Activated Carbon, ion-exchange, Disinfection- Chlorine, ozone or Ultra violet disinfection
c) Bio-chemical treatment which utilizes beneficial microbes to breakdown the waste matter into simpler stable compounds.

For efficient treatment of sewage, the same should be properly screened and allowed to pass through sedimentation process before entering into main bio-chemical process. After bio-chemical process, it is allowed to pass through activated carbon or disinfected before discharge on land or water body. The main bio-chemical processes used for treatment of sewage could be further distinguished on the basis of the characteristics of beneficial micro-organisms involved in treatment as given below:

i) Aerobic processes - the stabilization reaction occurs in presence of air/ oxygen, wherein a certain strain of microbes is prevalent, which help to break the sewage down into simpler stable oxidised end products by combining it with the oxygen available/ supplied to the reactor.

ii) Anaerobic processes - the stabilization reaction takes place in absence of air/ oxygen, where-anaerobic bacteria predominate and the waste is reduced through putrefaction to combine with Hydrogen available in the sewage.

In most cases, sewage treatment is a sequence of processes or a treatment train consisting of a number of technologies, applied on the wastewater, in series. The train is further divided into the pre-treatment steps followed by primary, secondary and tertiary treatment and the disinfection step. Not all steps maybe provided or are distinguishable in a particular treatment plant. The popularly used treatment technologies are given below:

a) Waste Stabilisation Ponds (WSP)
b) Activated Sludge Process (ASP)
c) Extended Aeration Process (EAP)
d) Sequencing Batch Reactor (SBR)
e) Moving Bed Biological Reactor (MBBR)
f) Fluidized Aerated Bed (FAB)
g) Membrane Bioreactors (MBR)
h) Upflow anaerobic sludge blanket (UASB)
i) Phytorid/Reedbed/Wetland Processes/DEWATS

Many of above-mentioned Technologies are also used for setting up Centralized Treatment facilities either standalone or in parallel modules of multiple capacities.

Details like advantages & disadvantages, capital cost and O&M cost land requirement etc. for above-mentioned technologies are briefly mentioned below for the benefit of ULBs and to help them make decisions regarding suitability of technology.

8.2.1 Waste Stabilization Ponds

A Waste Stabilization Pond is a properly designed pond for receiving wastewater for its treatment. The ponds can be used individually, or linked in a series for improved treatment. There are three types of ponds, (1) anaerobic, (2) facultative and (3) aerobic (maturation), each with different treatment and design characteristics. Photograph of a WSP plant along with a process diagram is given below.

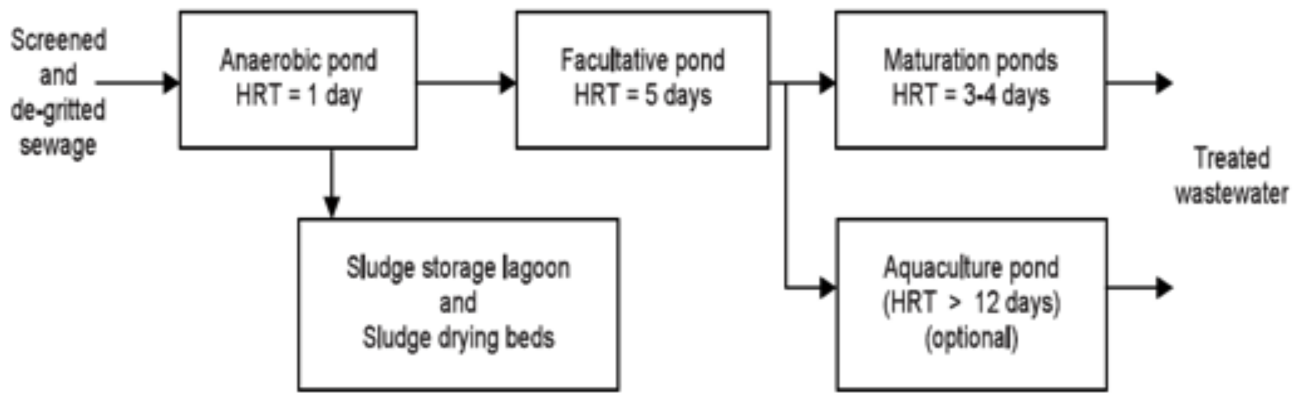
The Process Flow Diagram for Waste Stabilization Pond is given in Figure no 28:

Types of Waste stabilization ponds (natural ponds)
There are three basic types of waste stabilization ponds and these are normally connected in series to provide a two- or three-stage treatment process as mentioned below:

- Anaerobic ponds: Comparatively small and deep (3–4 m) as there is no need for aeration. They receive raw sewage which is treated by anaerobic bacteria, while sludge that builds up in the bottom of the pond is digested by anaerobic micro-organisms.
- Facultative ponds: Shallower (1.5–2 m) with a larger surface area than anaerobic ponds. They consist of an aerobic zone close to the surface and a deeper, anaerobic zone.
- Maturation ponds: Shallow (1–1.2 m) with a large surface area to enable light penetration. They receive treated effluent from the facultative pond and provide tertiary treatment to remove turbidity, pathogens, and nutrients.

Figure 27: Photograph depicting Waste Stabilization Pond

Figure 28: Schematic Diagram -Waste Stabilization Pond



Key features of the technology

(i) Simple to construct, operate and maintain

(ii) Does not involve installation of expensive and electro-mechanical equipment

(iii) Operates on a combination of solar energy and natural forces and thereby has very low O&M costs

(iv) Extremely robust and can withstand hydraulic and organic shock loads

(v) Effluents from maturation pond and safe for reuse in agriculture and aquaculture

Performance

(i) Can reliably produce high quality effluent with low BOD, SS, Fecal Coliform and high DO levels

(ii) BOD reduction of the order of 80% and more

(iii) Suspended solids reduction is somewhat less due to possible overflow of algae

(iv) Coliform reduction could be up to 6 log units

(v) Total nitrogen removal between 70-90%

(vi) Total phosphorus removal between 30-45%

Specific requirements

(i) In case of unlined ponds, soil and geo-hydrological survey during planning stage to assess risk of groundwater contamination

(ii) Sulphate concentration in raw wastewater under 300 mg SO4/L to avoid odour nuisance

(iii) Spraying to prevent fly breeding may be required at various times of the year.

Land requirement

0.80-2.3 hectares/MLD. 3-4 times the land requirement for ASP.

Energy requirement

10KWh (units)/ML treated

Capital costs

About Rs.1.1 Crore per MLD capacity for lined ponds. The cost substantially varies with different type of WSP i.e lined, unlined and also as per geographical location.

O&M Costs

Rs.2.5 lakhs/year/MLD installed capacity. Much lower than ASP to TF.

Advantages

(i) The inherent simplicity of construction offers low cost technology option

(ii) High quality effluent at least operating costs

(iii) Low skill requirement for operation of the plant

(iv) Fish yield from aquaculture ponds around 4-7 tonnes/ha/year

Disadvantages

(i) Large land requirement

(ii) High cost of lining

(iii) Likelihood of odour nuisance and mosquito breeding in poorly maintained WSPs

(iv) If unlined, likelihood of groundwater contamination in porous and fractured strata

Applicability

(i) Suitable under warm Indian climatic conditions

(ii) For areas with easy availability of land

(iii) In areas with social preference for aquaculture

(iv) In areas with low, unreliable or expensive power supply

Cities where working

WSP based plants are working in plenty in various parts the country i.e in Vrindavan in Uttar Pradesh, Mysore in Karnataka and various cities including Kolkata in West Bengal. Salient features of a plant working in Ozhukarai, Puducherry is given below:

Name of the ULB: Ozhukarai (M)
State/UT: Puducherry
Capacity: 125 MLD
Year of Commissioning: 2004
Area: 28000
Capex: 12 crore
Estimated Opex: 35 lakhs per annum

8.2.2 Activated Sludge process

The activated sludge process (ASP) uses microorganisms to feed on organic contaminants in wastewater, to reduce the concentration of the biodegradable components of waste. In principle all ASP consists of three main components: an aeration tank, which serves as bio reactor; a settling tank ("final clarifier") for separation of activated sludge solids and treated waste water; a return activated sludge (RAS) equipment to transfer settled activated sludge from the clarifier to the influent of the aeration tank. Photograph of a ASP plant along with a process diagram is given in Figure no 30.

Key features

An Activated Sludge Plant involves:

(i) Wastewater aeration in the presence of a microbial suspension,
(ii) Solid-liquid separation following aeration,
(iii) Discharge of clarified effluent,
(iv) Wasting of excess biomass, and
(v) Return of remaining biomass to the aeration tank.
(vi) Proven and tested for more than 7-8 decades all over world
(vii) Several modifications/advances possible to meet specific requirements

Performance

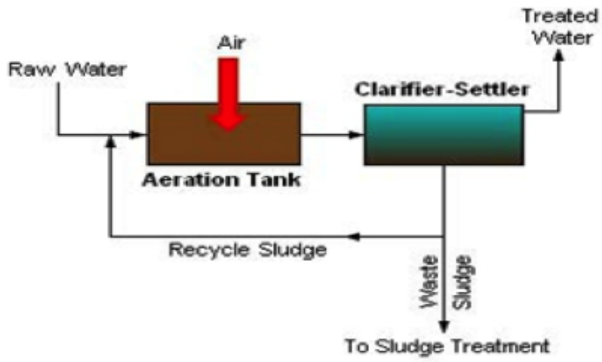
Very good performance in terms of BOD and SS. Treated effluent can most often satisfy the current Indian effluent discharge standards. Performance is critically dependent on sludge settling characteristics and design of secondary clarifier. Sludge settling characteristics are typically influenced by bio-flocculation which in turn depends on growth rate of micro-organisms. Growth rate is generally controlled by controlling biological solids retention time/food to micro-organism ratio.

Specific requirements

(i) Un-interrupted power supply for aeration and sludge recirculation
(ii) Maintenance of biomass concentration in the aeration tank and proper settling in the secondary clarifier.

Figure 29: Photograph of Activated Sludge Process Plant

Figure 30: Schematic diagram for Activated Sludge ProcessProcess Plant



Dos and don'ts

(i) Carefully monitor the reactor sludge levels and sludge withdrawal

(ii) Regular painting/coating of corrosion susceptible materials/exposed surfaces

Land Requirement

0.15 -0.25 hectares/MLD installed capacity

Energy Requirement

180-225 KWh(units)/ML treated

Capital Cost

The capital cost is around Rs.2.1 crore per MLD capacity. Approximately 55 % cost is of civil works and remaining 45% is for electrical and mechanical works.

O & M Costs

The O&M costs based on the data collected from various Indian plants is around 12.5 lakhs/year/MLD installed capacity.

Operation and Maintenance

(i) Careful monitoring and control of sludge quantity in the aeration tank

(ii) Regular maintenance of aeration and recycle system

Advantages

(i) Performance is not significantly affected due to normal variations in wastewater characteristics and seasonal changes

(ii) Less land requirements

Disadvantages

(i) High recurring cost

(ii) High energy consumption

(iii) Performance is adversely affected due to interruption in power supply even for a short period

(iv) Foaming, particularly in winter season, may adversely affect the oxygen transfer and hence performance

(v) Requires elaborate sludge digestion/drying/disposal arrangement

Applicability

The most widely used option for treatment of domestic wastewater for medium to large towns where land is scarce

Cities where working

ASP based plants are working in plenty in various parts the country like Agra, Lucknow & Kanpur in Uttar Pradesh, Bengaluru in Karnataka and Chennai in Tamil Nadu etc. Salient features of a plant working in Vellore, Tamil Nadu is given below:

Name of the ULB: Vellore
State: Tamil Nadu
Capacity: 1.2 MLD
Year of Commissioning: 2018
Area: 5.75 acres
Capex: 8.45 crore
Estimated Opex: 26 lakhs

8.2.3 Extended Aeration

- Extended aeration is a method of sewage treatment using modified activated sludge procedures. It is preferred for relatively small waste loads, where lower operating efficiency is offset by mechanical simplicity.
- It is a major modification of Activated Sludge Process and is generally considered as a stand-alone development.
- In extended aeration process the raw sewage goes straight to the aeration tank for treatment. The whole process is aerobic. This simplification implies longer aeration time which has earned for the process the name "extended aeration".

- The BOD removal efficiency of the extended aeration process is higher than activated sludge process which makes it especially desirable to use where it is to be followed by tertiary treatment for reuse.
- This is also often followed in combination of ASP or USAB etc. where further improvement in treated effluent quality is required especially for its recycle and reuse purposes.

8.2.4 Sequential Batch Reactor

The Sequencing Batch Reactor (SBR) is an Activated Sludge Process designed to operate under non-steady state conditions. An SBR operates in a true batch mode with aeration and sludge settlement both occurring in the same tank. The major differences between SBR and conventional continuous-flow, activated sludge system is that the SBR tank carries out the functions of equalization aeration and sedimentation in a time sequence rather than in the conventional space sequence of continuous-flow systems. Photograph of a SBR plant along with a process diagram is given below.

Key Features

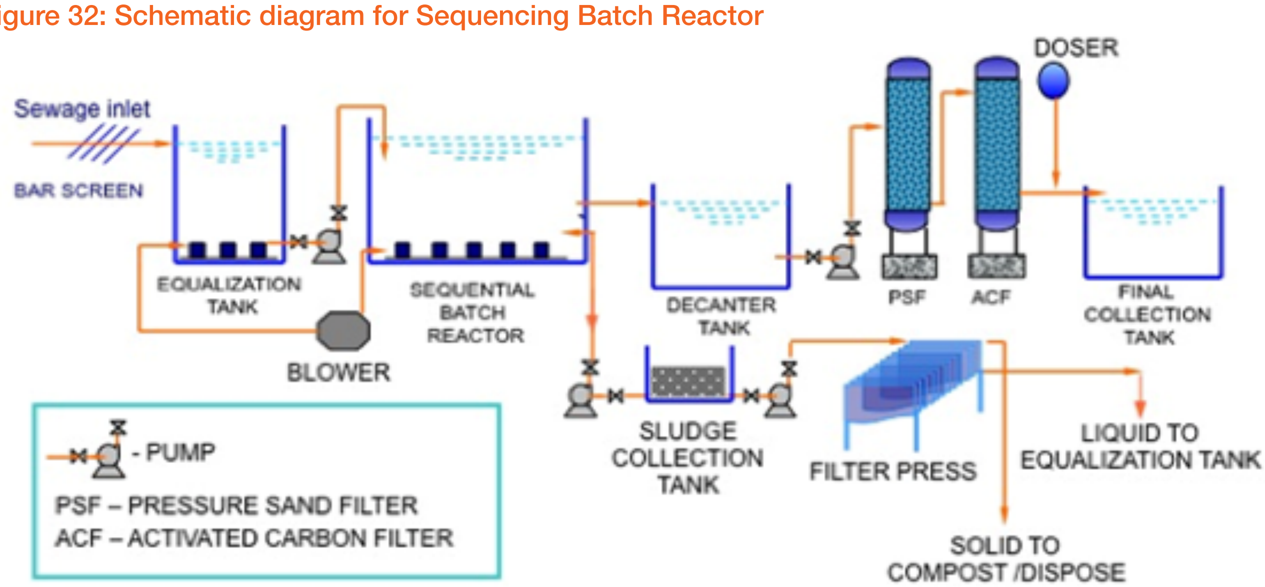
(i) SBR operates by developing mixed culture of bacteria (biomass) which is effective for removal of BOD, COD and nutrients commonly found in wastewater.

(ii) SBR functions as equalization tank, aeration tank and clarifier within single reactor.

(iii) For large quantities of wastewater flow (more than 500 cubic meters /day) two or more reactors are utilize in predetermined sequence of operation.

Figure 31: Aerial photograph of a SBR plant

Figure 32: Schematic diagram for Sequencing Batch Reactor



Performance

i. Pollutant removal efficiency of SBR System is higher for Nitrogen and Phosphate

ii. SBR system can remove heavy metals such as Zn, CU, Pb with organic pollutants and Nitrogen

iii. BOD removal efficiency is generally 85 to 90 %

Land Requirement

0.03 hectares per MLD

Capital Cost

Around Rs. 2.5 Crore per MLD capacity. Theper MLD cost varies depending on capacity and geographical location.

O & M Costs

Around 17 lakhs per annum/MLD.

Energy Requirement

153.70 kWh(units)/d/MLD

Advantages:

(i) Offer consistent effluent quality to desired limits;

(ii) Designed to minimize operation & maintenance cost;

(iii) Eliminates return activated sludge piping;

(iv) Excellent effluent quality

(v) Smaller footprint because of absence of primary, secondary clarifiers and digester

(vi) Recent track record available in large applications in India also

(vii) Biological nutrient (N&P) removal

(viii) High degree of coliform removal

(ix) Less chlorine dosing required for post disinfection

(x) Ability to withstand hydraulic and organic shock loads

Disadvantages

(i) Comparatively high energy consumption

(ii) To achieve high efficiency, complete automation is required

(iii) Highly skilled operators needed

(iv) No energy production

(v) Uninterrupted power supply required

Applicability

Ideal for treatment of wide range of domestic and industrial waste water at flow ranging from few thousand liters to millions of liters per day.

Applicable in areas where there is a limited amount of space is available. Also, older wastewater treatment facilities can be retrofitted to an SBR because the basins are already present.

Cities where working

SBR based plants are working in plenty in various parts the country like Varansi in Uttar Pradesh, Delhi, Bengaluru in Karnataka etc. Salient features of a plant working in Coimbatore, Tamil Nadu is given below:

Name of the ULB: Coimbatore (M Corp.)
State: Tamil Nadu
Capacity: 70 MLD
Year of Commissioning: 2011
Area: 13.94 acres
Capex: 55 crore

8.2.5 Fluidized Aerated Bed (FAB)

An aerobic process in which wastewater flows vertically upwards through a filter bed of lightweight inert media at a sufficient velocity to 'fluidize' the bed. A bacterial biofilm develops on the media particles and treats the wastewater as it passes through. Photograph of an SBR plant along with a process diagram is given on next page.

The Process Flow Diagram for Fluidized Aerated Bed is given in Figure no. 34.

Key features of the technology

(i) A compact and robust system involving extended aeration process with submerged aeration.

(ii) Biomass growth on fluidized bed of plastic media enabling retention of biomass and long solid retention time in the reactor leading to low 'food to micro-organism ratio and higher organic removal

(iii) Two stage biological oxidation

(iv) Flexibility in handling organic load by adjusting quantity of fluidized media

(v) Treatment scheme excluding primary sedimentation and sludge digestion

(vi) Reactors up to 5 m deep enabling low land requirements

(vii) Tube settlers again offer space economy

(viii) Ability to withstand limited organic overload

Specific requirements

(i) Special grade plastic proprietary media custom made for offering high specific area

(ii) Diffused aeration system

(iii) Submerged stainless steel screens at the outlet of FAB reactors to prevent media overflow

(iv) Tube settlers for compact clarifier

Options

(i) Addition of coagulant and polyelectrolyte for compact plants

(ii) Treatment of chlorination

(iii) Sludge treatment through thickener and bag filter press or drying beds

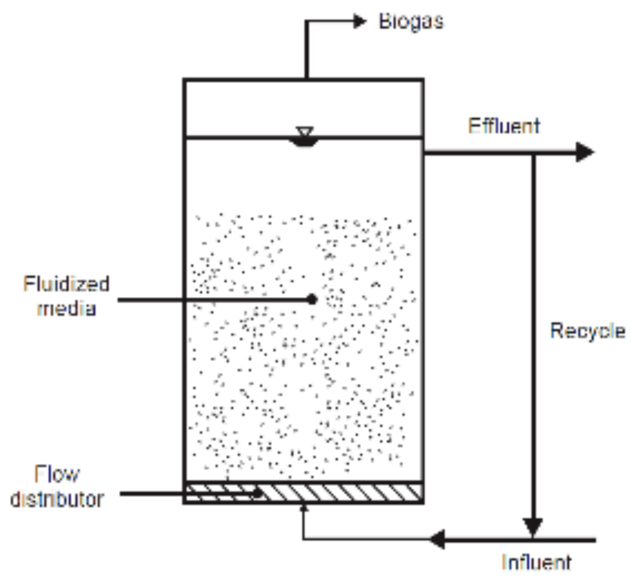
Land requirement

0.06 hectare per MLD installed capacity. Much lower than ASP

Energy requirement

Between 99 to 170 kWh(units)/ML sewage treated. Slightly lower than ASP.

Figure 34: Schematic diagram for Fluidized Aerated Bed



Capital costs

Around Rs.2.2 crore per MLD installed capacity which is higher than ASP. The plastic media constitutes about 30% of the plant cost.The per MLD cost varies depending on capacity and geographical location.

O&M Costs

Rs. 21.4 lakhs per year per MLD installed capacity. About 50% higher than ASP.

Performance

(i) High BOD removal with effluent concentration under 10 mg/L

Figure 33: Photograph of a FAB plant

Figure 35: Fluidised Aerated Bed

(ii) High suspended solids removal with effluent concentration under 20 mg/L
(iii) Faecal coliforms removal of the order of 2-3 on log scale at FAB-2 stage

Dos and don'ts

(i) Effective multistage self-cleaning screens required to prevent choking of FAB reactor outlets
(ii) Adequate sludge storage facility of sludge drying beds to be provided

Other Aspects

(i) Requires effective multi-stage screens to prevent chocking of submerged screen at FAB outlet and tripping of system due to plastic bags and pouches
(ii) Calibration of treatment capacity by adding or removing plastic media within 10-50% range
(iii) Possibility of chocking at FA outlet due to fluidized media. Requires effective air flushing valve to prevent tripping of the system
(iv) Blockage of media in case of excess biomass growth or low hydraulic loads
(v) Longer shutdowns may lead to septic conditions
(vi) Restarting after a long shutdown may take long to stabilize
(vii) Uncertainty regarding durability of media under varying climatic conditions
(viii) Lack of availability of additional quantity of media which is a proprietary item may cause operational difficulties

Advantages

(i) Exclusion of primary treatment step of sedimentation
(ii) Deep reactors enabling small space requirements
(iii) Ability to effectively treat dilute domestic wastewaters
(iv) Elimination of the need for sludge recirculation and monitoring of MLSS in the reactor
(v) Capacity to handle shock loads
(vi) Low head loss in the fluidized filer bed
(vii) Low and stabilised sludge production eliminating the need for sludge digestion
(viii) Simple and reliable operation
(ix) Absence of odour and improved aesthetics
(x) Absence of emission of corrosive gases

Disadvantages

(i) Reliance on patented filter media
(ii) Reliance on flocculants, polyelectrolyte and chemical disinfectant (Optional)
(iii) Requires skilled manpower
(iv) Choking of reactor due to floating plastic matter

Applicability

The FAB technology-based system is particularly applicable for:

(i) Small to medium flows in congested locations
(ii) Sensitive locations
(iii) Decentralized approach
(iv) Reliving existing overloaded STPs

Cities where working

FAB based plants are working in plenty in various parts the country like Chandigarh, Renukoot in Uttar Pradesh, Delhi, Pimpri Chinchwad, Pune in Maharashtra etc. Salient features of a plant working in Lucknow, Uttar Pradesh is given below:

Technology: Fluidized Aerated Bed
Name of the ULB: Lucknow
Capacity: 42 MLD

8.2.6 Moving Bed Bio Reactor

Moving Bed Bio-Reactor (MBBR) processes improve reliability, simplify operation, and require less space than traditional wastewater treatment systems (ASP).

MBBR technology employs thousands of polyethylene biofilm carriers operating in mixed motion within an aerated wastewater treatment basin. Each individual bio carrier increases productivity through providing protected surface area to support the growth of heterotrophic and autotrophic bacteria within its cells. Moving Bed Bio-Reactor systems deliver a flexible, cost-effective, and easy-to-operate means

Figure 36: Photograph of a Moving Bed Bio Reactor plant

to address current wastewater requirements and the expandability to meet future loads or more stringent discharge requirements within a compact design. Photograph of a MBBR plant along with a process diagram is given in Figure no 36 & 37.

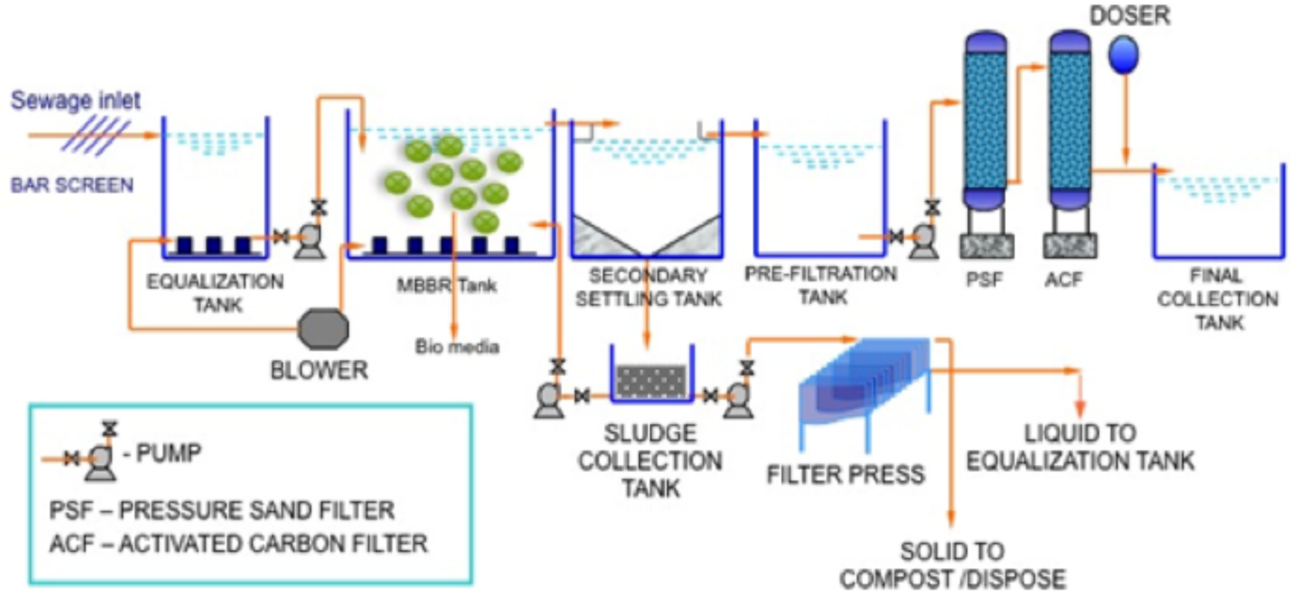
Land requirement

0.05 hectare per MLD
Energy requirement
282 kWh(units)/ML sewage treated

Capital costs

Around Rs.2.3 Crore per MLD capacity.The per MLD cost varies depending on capacity and geographical location.

Figure 37: Schematic diagram for Moving Bed Bio-Reactor



O&M Costs

Around 9.6 lakhs per annum/MLD.

Advantage

(i) Perfect Wastewater Solution for Space Constraints
(ii) Easy to Use for Inexperienced Plant Operators
(iii) Resistant to Shock Loads
(iv) Works Quickly With a Low Hydraulic Retention Time
(v) Compact Design – A fraction of the size of ASP
(vi) Expandable – Capacity could be easily upgraded by increasing the biofilm carrier
(vii) No Return activated sludge stream required
(viii) High Response to shock load
(ix) Minimal maintenance of MLSS
(x) Moving Bed Biofilm Reactor needs less space since there is no primary clarifier and detention period in reactor is generally 4-5 h.
(xi) Ability to withstand shock load with equalization tank option
(xii) High operator oversight is not required

Disadvantage

(i) Manual monitoring
(ii) Skilled experts
(iii) Insects
(iv) Escaping carriers
(v) High operating cost due to large power requirements Not much experience available with larger capacity plants (>1.5 MLD)
(vi) Skilled operators needed
(vii) No energy production
(viii) Effluent quality not up to the mark in India
(ix) Much less nutrient removal
(x) Designed criteria not well established

Applicability

The MBBR technology-based system is particularly applicable for:
(i) Small to medium flows in congested locations
(ii) Sensitive locations
(iii) Decentralized approach
(iv) Reliving existing overloaded STPs

Cities where working

MBBR based plants are working in plenty in various parts the country like Panchkula in Haryana, Vishakhapatnam in Andhra Pradesh, Tharangambadi in Tamil Nadu etc. Salient features of a plant working in Ahemdabad, Gujarat is given below.

Name of the ULB: Ahmedabad
State: Gujarat
Capacity:1 MLD
Year of Commissioning: 2016
Area: 1000 sqmtrs
Capex: 2.12 crore
Estimated Opex: 18 lakhs per annum

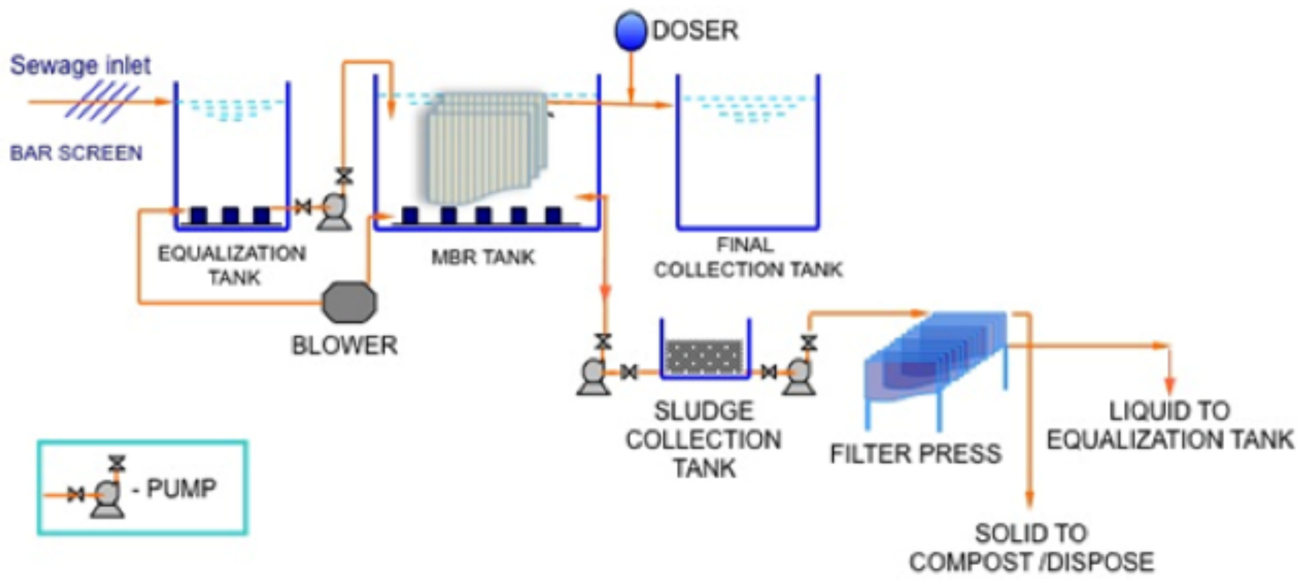
8.2.7 Membrane Bioreactors

Membrane Bioreactor is a systems integrating biological degradation of waste products with membrane filtration. They have proven effective in removing organic and inorganic contaminants as well as biological entities from wastewater. Membrane bioreactor is the combination of a membrane process like microfiltration or ultra-filtration with a suspended growth bioreactor, and is widely used for municipal and industrial wastewater treatment.

The MBR system are available as Integrated Submerged Type & External Module Type and the advantages include good control of biological activity, high quality effluent free of bacteria and pathogens, smaller plant size, and higher organic loading rates. Photograph of a MBR plant along with a process diagram is given below.

Figure 38: Photograph of Membrane Bio-Reactor Plant

Figure 39: Process Flow Diagram for Membrane Bio-Reactor Plant



Land requirement

0.05 hectare per MLD

Energy requirement

305kWh(units)/ML sewage treated

Capital costs

Around Rs.6.5 crore per MLD capacity. The per MLD cost varies depending on capacity and geographical location.

O&M Costs

About Rs.42 lakhs per annum per MLD capacity.

Advantages

(i) Low hydraulic retention time and hence low foot print (area) requirement
(ii) Less sludge production
(iii) High quality effluent in terms of low turbidity, TSS, BOD and bacteria
(iv) Stabilized sludge
(v) Ability to absorb shock loads

Disadvantages

(i) High construction cost
(ii) Very high operation cost
(iii) Periodic cleaning and replacement of membranes
(iv) High membrane cost
(v) High automation
(vi) Fouling of membrane
(vii) No energy production

Applicability

The MBR technology is applicable for:
(i) Where land is a constraint
(ii) High Quality Treated Effluent is required
(iii) To meet the industrial water requirement out of treated sewage.
(iv) ULB should financially well off
(v) Continuous power supply is available

Cities where working

MBR based plants are working in plenty in various parts the country like Rahimatpur in Maharashtra, Delhi, Udaipur in Rajasthan, Bengaluru in Karnataka etc. Salient features of a plant working in Ahemdabad, Gujarat is given below:

Name of the ULB: Greater Hyderabad Municipal Corporation
State: Telangana
Capacity: 12 MLD
Year of Commissioning: 2018
Area: 1.6 acres
Capex: 24 crore
Estimated Opex: 63.48 lakhs per annum

8.2.8 Upflow Anaerobic Sludge Blanket

Upflow anaerobic sludge blanket technology also known as UASB reactor is a methane-producing digester, which uses an anaerobic process and forming a blanket of granular sludge and is processed by the anaerobic microorganisms. UASB reactor is based on the so-called three-phase separator, which enables the reactor to separate gas, water, and sludge mixtures under high-turbulence conditions. Wastewater flows upwards through the blanket and is processed (degraded) by the anaerobic microorganisms. The upward flow combined with the settling action of gravity suspends the blanket with the aid of flocculants. Photograph of a UASB plant along with a process diagram is given below.

Key features

(i) No mechanical components or external energy requirements in the reactor, therefore, process not vulnerable to power cuts

(ii) No primary treatment; suspended solids in the wastewater serve as carrier material for microbial attachment

Figure 40: Photograph of Upflow Anaerobic Sludge Blanket

(iii) Recovery of gas with high calorific value

(iv) Low sludge production

(v) Relatively simple routine operation and maintenance

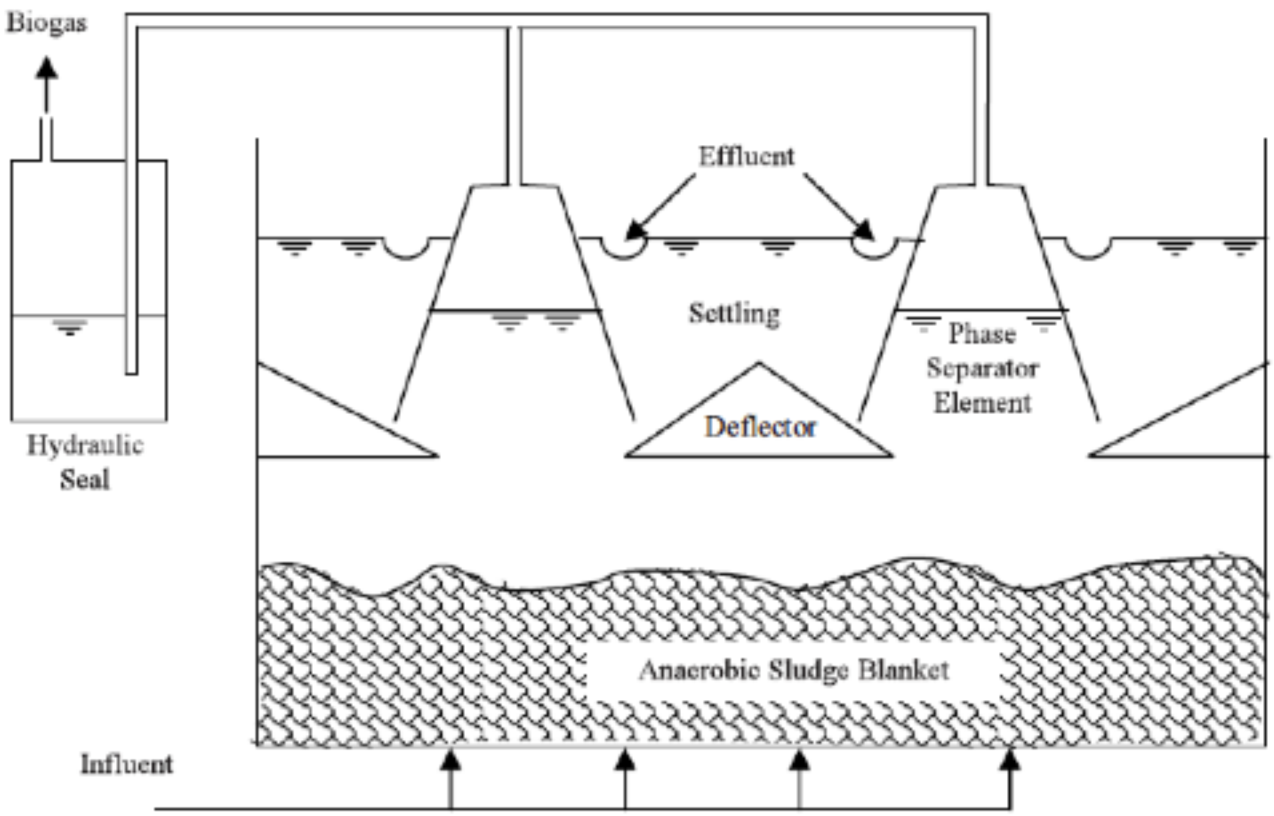
(vi) Biological activity can be restarted without any external seedling or special care after interrupted

Specific Requirements

(i) Use of anti-corrosive materials/paints on exposed surfaces

(ii) Frequent cleaning/de-sludging of distribution/vision boxes and influent pipes

Figure 41: Schematic diagram for Upflow anaerobic sludge blanket Sludge Blanket



(iii) Skilled supervision during start-up and for control of biomass levels within the reactor
(iv) Post treatment of the UASB effluent is invariably required
(v) Control of toxic materials and sulfates in the wastewater is required for efficient operation

Mode of operation

(i) The upward motion of gas bubbles produced during anaerobic digestion causes
(ii) Turbulence that enables mixing without mechanical assistance. Baffles at the top of the reactor allow gases to escape but prevent outflow of the sludge blanket.
(iii) No external energy requirements in the reactor, thereby the process is not vulnerable to power cuts.
(iv) Can bring down BOD of domestic wastewater to 70–100 mg/l and suspended solids as low as 50–100 mg/l, but removal of nitrogen and bacteria is poor.

Additional treatment requirements

(i) Pre-treatment: Screening and de-gritting but no other form of primary treatment is required.
(ii) Post-treatment: Like other anaerobic treatment technologies, UASBs only provide partial treatment and rarely meet discharge standards unless appropriate post-treatment is provided. As yet, only a waste stabilization pond system has been found to be an appropriate post treatment option.
(iii) Sludge production and treatment: Relatively low sludge production with good dewatering characteristics. Requires thickening, drying, and safe disposal.

Operation and maintenance requirements

(i) Careful monitoring and control of the reactor sludge levels and sludge withdrawal.
(ii) Frequent cleaning or desludging of distribution or division boxes and influent pipes.
(iii) Removal of scum and floating material from the settling zone.
(iv) Control of the flow rate is difficult for small units.
(v) Prevent mixing of industrial effluents with toxic elements and sulfates or sulfides.

Land requirement

0.2-0.3 hectares per MLD installed capacity. Comparable to that of ASP

Energy requirement

10-15 KWh (units)/ML treated. Much less tan ASP or TF, but more than WSPS.

Capital Costs

Around Rs.1.8 crore per MLD capacity. The per MLD cost varies depending on capacity and geographical location.

O&M Costs

Around Rs. 3.6 Lakh per annum per MLD capacity

Advantages

(i) Sludge handling is minimized
(ii) Power supply interruptions have minimal effect on plant performance
(iii) Cab absorb hydraulic and organic shock loading

Disadvantages

(i) Long start-up and high initial oxygen demand of effluent during this period may cause oxygen depletion in receiving water bodies.
(ii) Sensitive to seasonal temperature variations and low removal efficiency in winter.
(iii) Release of corrosive and odorous hydrogen sulfide and ammonia in the air.
(iv) Sludge washout from the reactor can result in instability leading to deteriorations in treatment performance and very high BOD and total suspended solids in the effluent.
(v) In general, cannot meet the desired effluent discharge standard unless proper post treatment is adopted, which in turn may make the treatment scheme energy intensive or may require large land area
(vi) Effluent is anoxic and invariably exerts substantial initial/instantaneous oxygen demand which may have adverse impact on receiving inland water bodies or when used for irrigation
(vii) Stability in performance is questionable unless sludge wash out is prevented

(viii) Fecal and total coliform removal is poor

(ix) Aesthetically the effluent has poor acceptability due to its black color

(x) Exploitation of biogas generated is unsustainable during domestic sewage treatment

Applicability

(i) Best suited to higher strength wastewaters: blackwater and industrial wastewater, but can also treat lower strength domestic wastewater.

(ii) Appropriate for medium-size wastewater treatment plants.

(iii) UASBs need less land than aerobic systems but require follow-up treatment to achieve comparable performance in terms of COD/BOD removal.

(iv) The suitability of this technology may be doubtful as a stand-alone secondary treatment option

Cities where working.

UASB based plants are working in plenty in various parts the country like Mathura-Vrindavan, Ghaziabad in Uttar Pradesh, Agartala in Tripura, Vijayawada in Andhra Pradesh etc. Salient features of a plant working in Vijayawada, Andhra Pradesh is given below:

Name of the ULB: Vijayawada (M. corp.)
Capacity: 20 MLD
Year of Commissioning: 2016-2017
Area: 3-4 acres
Capex: 20 crore
Estimated Opex: 10-15 lakhs per month

8.2.9 Phytorid/Reedbed/Wetland Processes/ DEWATS

Phytorid/Reed beds also known as constructed wetlands, planted horizontal gravel filters, subsurface flow wetlands or root zone treatment are engineered natural treatment systems that use fast growing plant species to assimilate dissolved organic impurities. A combination of physical settlement, photosynthesis, uptake by plants, degradation by bacteria in the root-zone, and filtration bring about improvement in wastewater quality.

There are various types of reed beds for different treatment applications. Horizontal sub-surface flow systems are most appropriate for domestic wastewater treatment whereas vertical flow is used for dewatering of sludge and treatment of septage. Commonly used plants are cattails, bulrushes and reeds, with Phragmitesaustral is being ideal due to its extensive root system. Photograph of a Wetland plant along with a process diagram is given on next page.

Mode of operation

(i) Reed beds mimic the treatment that occurs in natural wetlands by relying on plants and a combination of naturally occurring biological, chemical, and physical processes to remove pollutants from the water.

(ii) Treatment is mostly anaerobic as the layers of media and soil remain saturated and unexposed to the atmosphere.

(iii)The main role of the plants is to transport oxygen via their roots into the filter media though the roots also reduce clogging of the filter.

Operation and maintenance requirements

(i) Operation and maintenance requirements are simple but essential to ensure system performance. They include removal of excess weed, occasional scraping of the top layer of filter media, and removal of the floating scum layer, plastic and other debris.

(ii) Insect and odour problems should not be a problem as long as the wastewater remains under the gravel and sand. Otherwise, insecticide spray should be used to control mosquitoes and other insects.

(iii) Inlet and outlet structures should be cleaned periodically. The filter media will eventually become clogged and should be changed every 8 to 15 years.

(iv) Plants need to be harvested.

Additional treatment requirements

(i) To prevent clogging of the media, wastewater must be pre-treated to reduce suspended solids. For this reason, reed beds are best used for secondary treatment following primary treatment in a sedimentation tank, septic tank, baffled reactor or other form of anaerobic treatment.

(ii) Sludge production is relatively low as solids are retained in or on the reed bed.

Management arrangements

Although the process is natural, constructed wetlands are complex systems that require specialist knowledge and technical expertise to ensure sustained performance.

Land requirement

0.16-0.18 hectares per MLD installed capacity.

Energy requirement

Negligible

Capital Costs:

Around 3 Crore per MLD. Theper MLD cost varies depending on capacity and geographical location.

O&M Costs:

Rs 3 Lakhs per Annum/MLD

Advantages

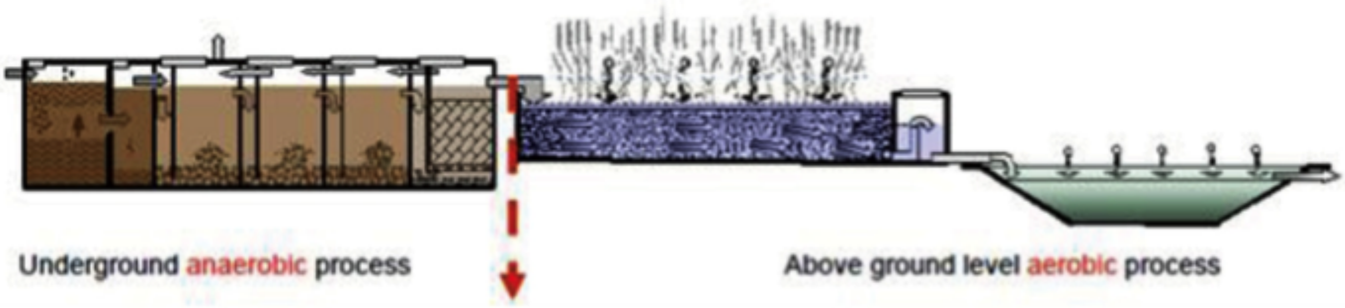
• Simple to construct and operate and maintain
• Low operating and maintenance cost
• Self-sufficiency, ecological balance, and economic viability is greater
• Possibility of complete resource recovery
• Good ability to withstand hydraulic and organic load fluctuation

Disadvantages

(i) Careful design is required to ensure that the filter media is of appropriate grain size and quality.
(ii) Reed beds require a large amount of space, up to 5 m2 per person, depending on conditions, and are therefore not always appropriate in urban areas.
(iii) Odour caused by ponding on the surface, blockages in inlet pipe work and problems with drainage at the outlet can result in the development of septic conditions in the reed bed.
(iv) A blocked or overloaded reed bed can cause the wastewater to rise above the surface, which may result in problems with mosquitoes or other insects.
(v) Large evaporation loss of water
(vi) Not easy to recover from massive upset
(vii) If liner is breached, groundwater is impacted
(viii) Effluent quality may vary with seasons
(ix) No energy production
(x) No nutrient removal
(xi) Odor and vector nuisance

Figure 42: Photograph of Wetland process

Figure 43: Schematic diagram for Reedbed/Wetland Process



(xii) Loss of valuable greenhouse gases to the atmosphere

Applicability

(i) Reed beds provide secondary and tertiary treatment and can treat a wide range of wastewaters, septage, and faecal sludge of varying strengths and composition.

(ii) They are suitable for pre-treated (pre-settled) domestic or industrial wastewater with a COD content less than 150–200 mg/l (BOD 70–90 mg/l) and are generally good at handling intermittent and variable flows.

(iii) The most common use is to provide additional or advanced treatment of wastewater from homes, businesses, and small communities. The technology is also well-suited for hotels, campsites, resorts, and recreational areas.

Cities where working

Phytorid/Reedbed/Wetland Processes based plants are working in plenty in various parts the country like Powai Mumbai in Maharashtra, WAPCOS office premises, Gurgaon and Shahadra in Delhi. Salient features of a plant working in IARI, PUSA in Delhi is given on next page.

Name of the ULB: Delhi
Capacity: 2.2 MLD
Year of Commissioning: 2012
Area: 1.2 Hectares
Capex: Rs.1.2 crore
Estimated Opex: Rs.1,335 per annum

These treatment technologies have been discussed in detail in Ministry's Manual on Sewerage and Sewage Treatment Systems, 2013. Therefore, the same may be referred for further information on suitability, designing and maintenances of these technologies.

8.3 Brief performance of various wastewater treatment technologies

The performance of various Decentralized wastewater treatment technologies is given in Table 9 below. Further, the performance of various wastewater technologies in Ganga Basin as carried out by consortium of 7 IITs can be seen at URL: **https://nmcg.nic.in/writereaddata/fileupload/16_31_003_EQP_S&R_02.pdf**

Table 9 Performance of various wastewater treatment technologies are also given in below for selecting a suitable technology

S.No.	Process	Effluent Quality	Coliform Removal	Nitrification Denitrification	Phosphorus Removal	Process Reliability	Land Use	Ease of Operation	Ease of Maintenance	Energy recovery	Electrical demand	Capital Cost	Track Record	Typical Capacity Range (MLD)
1	ASP	G	G	P	P	VG	G	G	G	VG	A	A	VG	AF
2	EA	VG	G	P	P	VG	A	VG	VG	P	P	G	G	SF
3	MBR	VG	VG	P	P	G	VG	P	P	P	P	P	P	SF
4	MBBR	VG	VG	P	P	P	G	VG	P	A	P	A	G	SF
5	SBR	VG	VG	VG	VG	G	VG	G	G	P	A	A	G	AF
6	UASB	A	A	P	P	G	G	A	VG	G	A	A	G	AF
7	WSP	A	P	P	P	P	P	A	VG	P	VG	G	A	AF
8	CW	P	P	P	P	P	P	A	P	P	VG	G	P	AF

Source: Guidelines for Decentralized Wastewater Management Prepared by MoUD Centre of Excellence, Indian Institute of Technology Madras – Chennai, India for Ministry of Urban Development, Government of India

Abbreviations-

ASP-Activated Sludge; EA-Extended Aeration; MBR-Membrane Bio Reactor; MBBR-Moving Bed Biofilm Reactor; SBR-Sequencing Batch Reactor; UASB-Up flow Anaerobic Sludge Blanket; WSP-Waste Stabilization Pond; CW-Constructed Wetlands; VG-Very Good; G-Good; A-Average; P-Poor.

8.3.1 Comparative Capital and O&M cost of various wastewater treatment technologies

The comparative Capital and O&M cost of various wastewater treatment technologies of smaller capacities (towns less than 100,000 population) along with its land requirement is given in Table 10.

Table 10 Comparative capital and O&M cost of various wastewater treatment technologies of smaller capacities

Parameter	WSP	ASP	SBR	FAB	MBBR	MBR	UASB	CW
Capital Cost (per MLD) (Rs. In crore)	1.1	2.1	2.5	2.2	2.3	6.5	1.8	3
O&M Cost (per anuum/ MLD) Rs. In Lakhs)	2.5	12.5	17	21.4	9.6	42	3.6	3
Energy Requirement kWh(units)/MLD	10	180-225	153.70	99 to 170	282	305	10-15	Negligible
Land Requirement (hectare/MLD)	0.80-2.3	0.15-0.25	0.03	0.06	0.05	0.05	0.2-0.3	0.16-0.18

Source: The above-mentioned capital and O&M cost as well as the land requirements per MLD is worked out based on analysis carried out by Compendium of Sewage Treatment Technologies by IIT Kanpur and also data collected from various cities.

Chapter-9

FINANCIAL MODELS AND BIDDING PARAMETERS

This chapter attempts to guide planners and decision makers on financial models to operationalize Sanitation value chain. Since, FSSM has picked up in past years and states are planning to implement, three models of operationalizing systems are presented namely (i) Separate service providers for collection and treatment (ii) Service provider for integrated collection and treatment (iii) Hybrid annuity model. These models are supported by eligibility criteria, evaluation criteria, examples of procurement and tenders used to procure such services.

9.1 Financial Models and Bidding Parameters

To guide Urban Local Bodies, three financial models and bidding parameters are given below for guidance. There may be a number of similar models that cities can evolve and work to procure services.

Model I: Separate service providers for collection and treatment

Part 1

- ULB to notify charges for cleaning of Septic tanks on cubic meter basis to be payable to empaneled service provider.
- ULB to empanel service provider to empty septic tank and discharge to FSTP/STP on fee basis to be collected from users.
- ULB may or may not pay some portion of charges towards emptying septic tank.

Part 2

- Grant component for setting up of FSTP/STP for different scenarios/percentage
- FSTP operator charges for treatment and safe disposal of per cubic meter of septage
- Desludgers may or may not pay to plant operator for desludging septage.

Model II: Service provider for integrated collection and treatment

Part 1

ULB to notify charges for emptying of Septic tanks on cubic meter basis to be payable to empaneled service provider.

Part 2

- Grant component for setting up of FSTP/STP for different scenarios/percentage
- FSTP/STP operator charges for treatment and safe disposal on per cubic meter/MLD of septage.

Model III: Hybrid Annuity Model

Part 1

ULB to notify charges for cleaning of Septic tanks on cubic meter basis to be payable to empaneled service provider.

Part 2

- Grant component of 40% (progress linked) for setting up of FSTP/STP for different scenarios/percentage
- Remaining 60% grant over ten years period based on satisfactory performance along with O&M charges on per cubic meter/MLD.

An example of emerging Hybrid Annuity Model is given in Box 4

Box 4

Under the Project, two methods of evaluation of financial bids have been followed

Method 1

The only criterion for evaluation and comparison of Financial Proposals is the Bid Price. Each bidder will have to mention the four parameters in the bid.

a) the Bid Project Cost (calculated based on the state schedule of rates)
b) the O&M Charges for the first yearafter COD;
c) the Guaranteed Energy Consumption for each year of the O&M Period; and
d) the Land Requirement /Based on the above 4 components quoted by the Bidders in the Bid Price Sheet, the Bidder shall calculate the Bid Price using the following formula:

Bid Price = Bid Project Cost + (O&M Charges x 5 years) + Power Charges+ Land Price

Method 2

The method uses weighted averages to calculate the Final score for the project. The Technical proposal is dependent on multiple factors and is calculated as a weighted average.

The lowest Financial Proposal (FM) will be given a financial score (SF) of 100 points. The financial scores of other Proposals will be computed as follows:

SF = 100 x FM/F
(F = amount of Financial Proposal)

Proposals will finally be ranked according to their combined technical (ST) and financial (SF) scores as follows: S = ST x Tw + SF x Fw

Where S is the combined score, and Tw and Fw are weights assigned to Technical Proposal and Financial Proposal, which shall be 0.70 and 0.30 respectively

The Selected Bidder shall be the first ranked Bidder (having the highest combined score). The second ranked Bidder shall be kept in reserve and may be invited for negotiations in case the first ranked Bidder withdraws, or fails to comply with the requirement.

9.2 Bid Document Framework

9.2.1 Eligibility Criteria

S No.	Eligibility Criteria	Documents to be submitted
1.1	FINANCIAL QUALIFICATION The firm, and the Lead Member in case of a Consortium, to be a company registered under the act of 1956/2013 and in existence at least for 5 (five) years at the end of preceding financial year, i.e., 20-- - --.	Copy of Certificate of Incorporation.
1.2	The firm, and the Lead Member in case of a Consortium, to have declared net profit at the end of preceding financial year, i.e., 20-- - --.	Copy of the balance sheet / auditor certificate.
1.3	The Bidder to have a minimum average annual turnover of INR ----- (in word) crore in the last 5 (five) consecutive financial years preceding the Bid Due Date and in case of a Consortium, the cumulative average turnover of all the Members of Consortium would be reckoned.	Audited balance sheets / Auditor's Certificate.
1.4	Minimum Net Worth of INR ----- (in word) crore at the end of preceding financial year, i.e., 20-- - --and in case of a Consortium, the criteria has to be satisfied as per the share of each member of the Consortium in the equity capital of the SPV. In case any of the Bidders is the Lowest Bidder in more than one Package and the Authority decides to award, subject to Clause 3.3.6, more than one Package to such Bidder(s); the Bidder(s) should have minimum Net Worth corresponding to the number of Packages awarded to them. For the sake of clarity and by way of illustration, if 2 (two) Packages are awarded to one such Lowest Bidder(s), then the minimum Net Worth of such Bidder(s) shall be INR ---- (in word) crore at the end of preceding financial year. i.e., 20-- - --.	As certified by a Chartered Accountant.
2.1	TECHNICAL QUALIFICATION The firm to have prior experience and expertise in developing and/or designing and constructing and operating waste water / septage management /waste to compost / Bio-methanation projects in India. The Bidder should have commissioned at least one project _______of the above specified in the last 5 (five) years. In case of Consortium, the criteria can be complied by any one Member of the Consortium for project development experience and the other for O & M experience. To claim design and construction experience /operations experience, the entity claiming the experience should have been appointed/ hired directly by the relevant government /private entity for execution/operations. Any subcontracting work shall not be considered.	Copies of firm orders / contract along with Certificates, if any, issued by Government Organizations / Municipal Corporations or their equivalent / private entities to demonstrate its experience of developing / commissioning and operating the project in the last 5 (five) years.

9.2.2 Evaluation criteria

S No.	Evaluation of Financial and Technical Qualifications	Max. Marks	Documents to be submitted
1	Experience in developing and/or designing and constructing and operating waste water / septage management / waste to compost / Bio-methanation projects in India for at least ---- (in word) years: 1. 1 (one) project: 30 marks; and 2. More than 1 (one) project: 40 marks; In case of Consortium, the criteria can be complied by any one Member of the Consortium for development/designing and construction of the project and the other for O & M experience. To claim relevant development and/or designing and constructing / operations experience, the entity claiming the experience should have been appointed/hired directly by the government /private entity for project execution / operations. Subcontracting will not be considered.	40	Photocopies of project completion / commissioning certificates, any other relevant documents / certificates should be established. The details should cover Bidder experience in development of the facility.
2	Average annual turnover from any projects dealing with waste water / septage management /waste to compost / Bio-methanation projects in India in the last ---- (in word) years: 1. Turnover of minimum INR ___ - 10 marks; 2. Turnover of INR ______ to ____-15 marks 3. Turnover >______– 20 marks. In case of a Consortium, the combined turnover of all the Consortium Members shall be taken into consideration.	20	Auditor/CA certificate.
3	Proposed processing technology option clearly outlining the technical and other advantages of the proposed option along with the business plan and the methodology of Project development. Evaluation of methodology for carrying out proposed task (weight-age) assigned in %) 1. Technical plan including identification of risks and mitigating plan: 10%; 2. Bio-solids output indicators: a. Removal of Helminths eggs and pathogens: 5%; b. Lowering of moisture content: 5%; 3. Range of influent characteristics the designed plant can handle: 10%; 4. Range of characteristics ofEffluent discharged.10% 5. Plan on reuse of treated effluent 16% 6. Ease of operations & maintenance 10% 7. Organization & staffing: 8%; 8. Change management: 5%; 9. Hazard risk management: 8%; and 10.Less land requirement due to technology advantage-20%.	40	To be submitted in the format of appendix III of this RFP. Additionally, Bidders whose Bids were declared responsive in accordance with Clause 3.2 and who also meet the criteria set out in Clause 2.2.1 have to give a presentation before Technical Advisory Committee.
Total		100	

Model Tender documents are available on www.swachhbharaturban.gov.in for further reference. Also CEPT University has developed/ compiled various business models for faecal sludge and septage management that can be seen at URL: https://pas.org.in/Portal/document/UrbanSanitation/uploads/Financing_and_business_models_for_FSSM_an_executive_summary_on_the_landscape_study_of_four_Indian_states.pdf

Chapter-10
CONCLUSIONS AND WAY FORWARD

The conclusions presented in nutshell along with way forward to plan and implement holistic sanitation systems in cities comprising of onsite and offsite expeditiously and economically.

10.1 Conclusions

The spurt in developmental activities coupled with fast pace of urbanization is giving rise to sanitation challenges in urban areas in our country and is bound to further worsen if adequate steps are not taken in time. As of now only about 40 percent of urban population is covered with sewerage system and remaining 60 percent is serviced on onsite sanitation facilities. In the areas, where sewerage system is yet to come, States are encouraging ULBs to expeditiously cover it by putting in place a mechanism for desludging of septic tanks periodically linked with adequate treatment of Faecal Sludge and Septage either at standalone FSTPs or through co-processing in STPs. This is in spite of fact that FSTPs so installed takes care of only around 1% of influent sewage pollution load.

This Advisory has shown the way of integrated planning of sanitation in a city comprising of on-site and off-site sewage management systems. It has identified interventions for optimal performance of on-site systems and subsequent progressive coverage of on-site systems with off-site systems as and when necessity arises. FSSM is an important element of O&M of on-site sewage management system and essential for its optimum performance, but in no way an alternative of conventional sewerage system. However, the integrated vibrant approach comprising on-site and off-site sewage management brought out in Advisory provides space and freedom to plan sanitation facilities in a city according to availability of resources over time.

The Advisory has covered all aspects of planning of On-site and Off-site sanitation options including conveyance, treatment and recycle and reusefor implementation. It also contains a Decision-Making Tree for selection of suitable sanitation option for an area and also the comparison of different conveyance and treatment options to suit different set of conditions of cities. Advisory is developed to suit the requirements of ULB officials, decision makers as well as designers and the facts associates with different aspects of city sanitation can be easily comprehended.

Finally, the Advisory is enriched with insights on different procurement models, it cross refers various resource documents and also contains several case studies to fully meet the requirements of ULBs while planning city sanitation.

10.2 The way forward

To achieve safe sanitation for all in short span of time and within available resources, the following key aspects brought out in the Advisory need to be addressed;

(i) Different routes of flow of excreta from a city (Shit Flow Diagram) to be mapped. To safely transport, treat and dispose of excreta, a city sanitation plan to be developed containing short-term and long-term targets.

(ii) City sanitation plan needs to identify priority areas to be covered with sewerage system and the remaining areas with strengthening of on-site sewage management. It will be a mix of on-site and off-site sanitation systems based on survey of city areas as delineated in the Advisory. As the city grows, sewerage system will keep expanding to cover newly developed areas and on-site based sewage management systems which keep moving outward to cover newly included areas in city limits.

(iii) The present trend of adopting FSSM by States and cities as an alternative to the robust sewerage system, will lead cities nowhere on city sewage management, especially to those cities which are misunderstanding FSSM as an alternative to Sewerage systems. In fact, it is an O&M element of on-site sewage management system and is essential for its optimal performance. What is essential is to strengthen the on-site sewage management system to achieve city wide sanitation, its periodic monitoring/ inspection, enforcement of regulations, awareness and discipline in citizens.

(iv) Covering entire urban population with safe sanitation is not too cost intensive as often perceived by ULBs. All that is needed is brilliant planning engaging sector experts and planned mix of on-site and off-site sanitation systems coupled with circular economy concept. It is mindless city-wide planning of sewerage systems in one-go by agencies which had brought sanitation sector in the cities to this juncture. Impatience of authorities to accede reasonable time for survey and robust planning is another factor. Following the approach suggested in the Advisory, a city wide safe sanitation can be achieved within reasonable time frame of 5-10 years.

(v) Developing a receptive market for usage of end products of sewage treatment/faecal sludge treatment is essential so that the operators are not hesitant in deploying the suitable technologies and are also have no fear of economic losses on their investment.

(vi) Generate awareness among the community towards hazards of poor sanitation and the direct or indirect cost paid by them.

(vii) Building capacity of the urban local bodies and other institutions working on ground is essential so that they understand the facts, ways and means in the right perspective and lead on ground planning and implementation.

(viii) Institutional set up is important at Central / State/ ULB level to achieve city wide sanitation at an economical rate. In its absence the city actually ends up spending more with low sanitation coverage in the city and without significant improvement in hygienic condition of the city.

ANNEXURE - I
CASE STUDIES–FAECAL SEPTAGE MANAGEMENT PRACTICES

I. International Practices: Malaysia

In Malaysia, as of 2006, 94 percent of the country has access to improved sanitation. Malaysia increased the number of households with sewerage connections to 73 percent in 2005. For the remaining households connected to septic tanks, federal law requires them to desludge the tanks every three years, and 50 percent of households with septic tanks now participate in scheduled desludging. Malaysia nationalized sewerage services in 1993, transferred all wastewater assets to the federal government, and offered services through a single, private concessionaire, Indah Water Konsortium (IWK).

As of 2005, within IWK's service area, there are an estimated 1.2 million individual septic tanks, serving around 5 million people or about 27 percent of the population and the rest 73 percent is connected to the sewerage system. Since national policy requires real estate developers to construct adequate wastewater infrastructure to serve their resident populations, the private sector has constructed roughly 70 to 80 percent of the country's wastewater infrastructure, including over 3,600 communal septic tanks. The liquid effluent from these tanks, however, continues to overflow and empty into storms drains and waterways, contributing to water pollution nationwide. In response, Malaysia has adopted a national policy to gradually reduce the number of septic tanks in the country through urban redevelopment. Effective from 2008, IWK is not responsible for providing scheduled desludging service of septic tanks. Under the Water Services Industry Act 2006, owners of premises with septic tanks are responsible for the maintenance of the septic tanks.

The treatment of septage is in several ways depending on the area's density and service demand. In rural areas, sludge may be buried in trenches sited on dedicated areas or in between trees on plantations of non-edible products. In medium-density communities, IWK treats septage at its sewage treatment plants by dewatering the septage in IWK's gravity-based or mechanized mobile dewatering units or sludge drying beds, and then recycles the drained effluent back into the sewage treatment system. In highly urbanized areas, IWK has constructed three centralized sludge treatment facilities for northern, central and southern regions of Peninsular Malaysia. At the same time, the country is also planning to build advanced sewage treatment facilities that will incorporate centralized sludge treatment technology. These systems more quickly dewater larger volumes of septage. Malaysia does not use its stabilized sludge for edible crops, as septage is often dewatered along with sewage in the sludge drying beds, and sewage sometimes contains high levels of chemicals. In 2000, about 98 percent while the remainder was disposed of as landfill cover, mining cover, or land reclamation. As landfill capacity diminishes and land prices increase, IWK is conducting research and development on alternative reuse options, such as vermin-culture.

II. National Practices

a) Greater Warangal Municipal Corporation

Warangal has a population in excess of 8 Lakhs and is the 2nd largest city in Telangana. Warangal is the first city in India to introduce and implement faecal sludge management (FSM) regulations.

The city does not have sewerage system and depends only on on-site sanitation. About 77 percent of households have access to safe sanitation of which 59 percent have access to septic tanks and remaining 18 percent have access to pit toilets. The design and construction of toilets was not regulated and most

were insanitary pit toilets (typically comprising both single and twin pits) and septic tanks (in many cases without soak pits) discharging directly to open drains. GWMC addressed the multi-faceted FSM challenge by introducing FSM regulations and septage management guidelines derived from provisions and specifications on septage management in various national level guidelines and regulations. GWMC formalized FSM regulations and supporting operative guidelines by issuing a council resolution on 25th March 2016, making Warangal the first city in India to introduce a comprehensive FSM regulatory framework. The objective of the regulation and guidelines was to promote a comprehensive and integrated approach to FSM and septage management covering collection, storage, desludging, transportation, treatment, disposal and reuse.

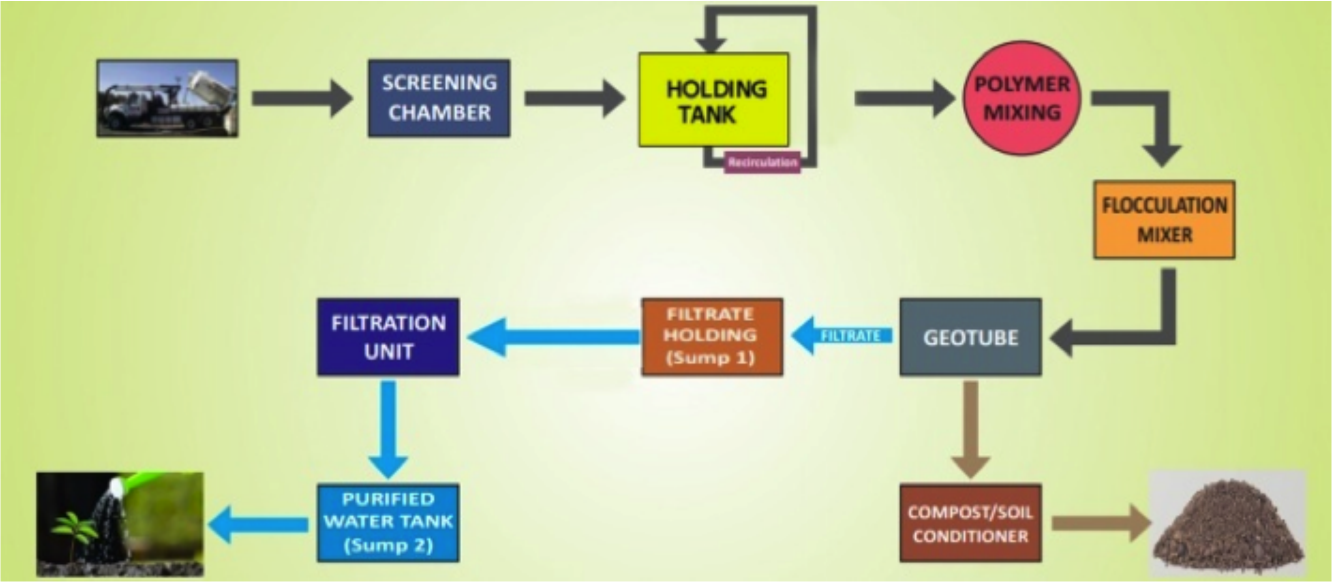
The city government through FSM regulation has successfully introduced:
(i) Licensing and training of masons (as toilet builders) to ensure toilets are built to design specifications,
(ii) Site inspection by the sanitation team prior to issuance of building plan approval,
(iii) Licenses to operate mechanized desludging and service level agreements with private operators,
(iv) Usage of personal protective equipment by the desludging operators,
(v) A mobile app in the vernacular language for record keeping on desludging,
(vi) A dedicated helpline for citizens seeking support with FSM operations,
(vii) Awareness campaigns on safe FSM and scheduled desludging
(viii) Two treatment plants to cover the whole city,
(ix) Adoption of improved designs of septic tanks for households, as well as the use of advanced septic tanks and DEWAT systems by institutional and bulk consumers such as hotels, colleges and apartments,
(x) Conversion of insanitary latrines to sanitary latrines Real time recordkeeping of desludging with built-in alerts for the next desludging cycle combined with a comprehensive property database is being developed will enable scheduled desludging of septage in the future.

In summary, Warangal City has introduced several innovative processes and solutions (S-line, co-treatment of faecal sludge and municipal solid waste, FSM tracker, GPS systems in desludging trucks etc.) to operationalize FSM regulation.

For treating the faecal septage, a Sanitation Eco-park has been created by the local administration wherein two independent faecal septage treatment plants have been sited. The first plant is based on thermal technology and the other is on geo-bag technology based.

The thermal technology based FSTP is of 15 KLD capacity. Septage is then pumped up to a Dewatering Unit wherein the solid liquid separation takes place. The resultant sludge through this process is 25% solids which imply that the volume is reduced by 10 times from the influent septage. The separated liquid stream is then treated in Moving Bed Biological Reactor (MBBR) based treatment plant. Whereas, the Solid fraction is conveyed to a pyrolysis plant. Here the solids are heated to 700-800 degree Centigrade and a bio char with about 20% moisture is obtained.

The geo-bag technology based FSTP is of 10 KLD capacity. Initially, the sludge/septage is screened at the inlet screening chamber. The septage is taken into holding tank where it resides for about 1 day. The homozinised septage is then conveyed through pipes to a polymer dozing chamber after which it is pumped into the Geo-bags. This is an innovative alternative process where septage is anaerobically treated inside a large HDPE tube which permits the liquid to trickle out through its surface and is then collected through a system of underdrains. Hence solid-liquid separation occurs and the solids are retained in the bags. Thus,



this is a kind of Anaerobic drying bed where the disadvantages such as flies, rodents and vermins as well as odour problem is reduced. The material of the tube enhances heating of its contents and thus thermal disinfection is also induced to an extent.

Management of Liquid stream- The water (filtrate) is then subjected to treatment involving pressure sand filter followed by activated carbon filter. The final filtration process happens with ultrafiltration unit for achieving the desired characteristics of water for reuse as per the norms. The treated liquid stream is consumed in the plant site itself.

Management of Sludge Solids- The retained solid in the Geo tube are dried under sun for 6-8 weeks. In the interim, the Geo-bags are taken out of the under-drain area when water stops trickling out of the bag. A lifting machine (JCB) is used for this purpose. A fresh Geo-bag is now placed in the under-drain area. The original Geo- bag is then placed outside the area and is ripped open to allow its contents to further dry out for a few days more. The bio solids are then broken down and pulverized for packing into 25kg bags. The treated bio solid is reported to be free from any pathogens and is used for soil conditioning, amendment and for agriculture use.

b) Faecal Sludge Management in Odisha

As per Census 2011, only 2.5% of Odisha's population had access to sewer networks and the rest 97.5% of the population was dependent on pits and septic tanks. Odisha State initiated working towards a more managed faecal sludge collection system in 2015 when the state procured 86 cesspool desludging vehicles. These vehicles were offered on lease to desludging operators with a condition to follow formal collection and transportation procedures. All the vehicles are live tracked and users are asked to fill forms for desludging along with payment of user fee per operation.

State went on to publish State Urban Sanitation Policy and Strategy in year 2016 and simultaneously septage management was included in AMRUT Scheme. State

Process Flow Diagram of FSTP Facility

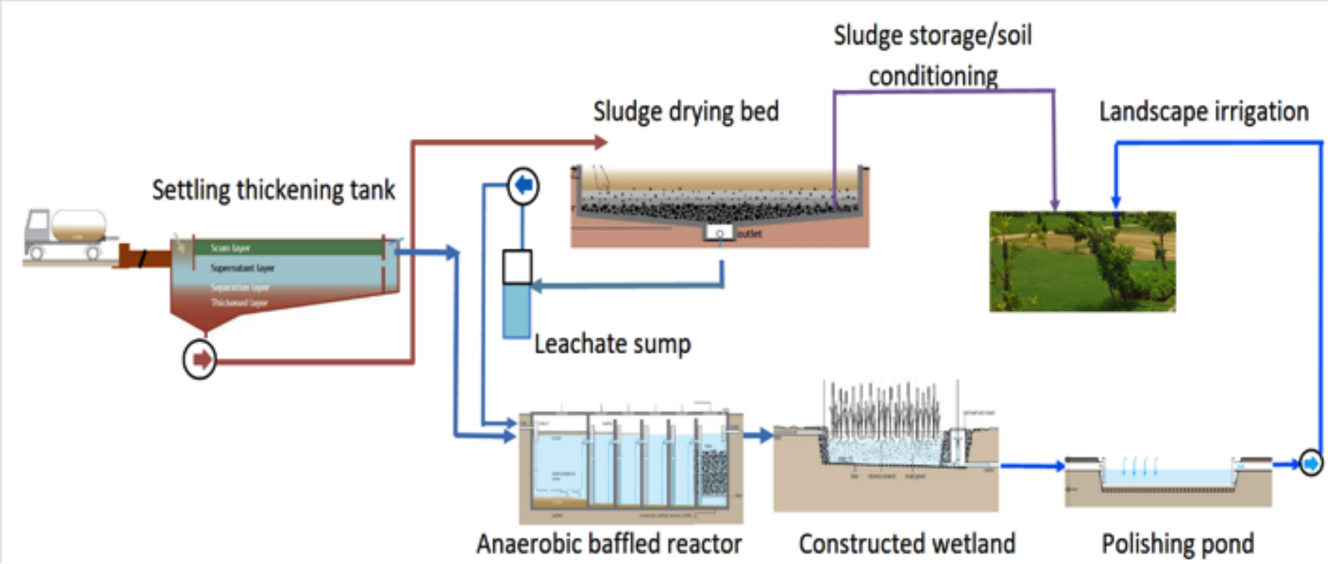


Table 11 FSTPs installed/under construction in Odisha

Sl. No.	Name of the city/ town	Technology	Plant Capacity (KLD)	Project Cost (Rs. Cr.)	Population benefitted	Per capita cost (Rs.)
1	Baripada	Not Available	50	2.54	1,25,000	203
2	Berhampur	DEWATS	40	2.76	1,00,000	276
3	Bhubaneswar	DEWATS	75	3.59	1,87,500	191
4	Puri	Co-treatment in STP	50	1.73	1,25,000	138
5	Rourkela	DEWATS	40	2.25	100,000	225
6	Sambalpur	DEWATS	20	1.93	50,000	386
7	Dhenkanal	DEWATS	27	2.85	67,500	422
8	Cuttack	Not Available	60	2.20	1,50,000	147
9	Balasore	Not Available	60	2.92	1,50,000	195
10	Angul	Not Available	18	2.53	45,000	562

also involved a Technical Support Unit (TSU) to better manage the technical aspects.

As a result, the following 6 FSTPs were commissioned in year 2018 in various urban centres in the State. Their operations and maintenance were also outsourced on PPP Model to private partners through extensive bidding mechanism.

Apart from the above new FSTPs, 2 already installed and functional STPs were selected for co-treatment of septage. Further, the State Government is scaling up the faecal sludge and septage management services in in all 114 ULBs of the State.

c) Wai Municipal Council

Wai is a small town situated at foothills of Western Ghats in Maharashtra along the River Krishna with an area of about 3.6 sq.km. and with population of about 42,000 (36,025 as per Census 2011). It receives about 1000 mm rainfall over 4-6 months in a year. On May 30, 2018, Wai Municipal Council became the first city in India to start a Scheduled Desludging service.

The Faecal Septage Treatment Facility is located alongside the Municipal Solid waste Management Facility and has been operational for about 24 Months. The Facility consists of 70 KL holding cum equalization

tanks (4 cylindrical Containers) which receive septage conveyed by haulage Vehicles. The influent septage passes through a coarse screen at inlet of the tanks to remove large and floating debris.

Septage is then pumped up to a Dewatering Unit (mechanical filter press) installed on the upper storey of a double stacked shipping container. Here, a polymer is added to improve solid liquid separation. The resultant sludge through this process is 25% solids which implies that the volume is reduced by 10 times from the influent septage.

The separated liquid stream is conveyed to a modified Moving Bed Biological Reactor (MBBR) based treatment plant, which is preceded by an anaerobic step. The plant has a design capacity of 70 KLD. The secondary treated water is passed through a pressure sand filter and an activated carbon filter for tertiary treatment. The water is finally conveyed to an Ultra-violet unit for disinfection. The water is used locally in the plant itself and also stated to be used for Gardening and greening of public places in the city.

The Solid fraction is conveyed to a conveyor belt pyrolysis plant which has been placed in the lower shipping container. The solids are heated to 700-800 degree Centigrade and a bio char with about 20% moisture is obtained. Agriculture briquettes are used to flare the pyrolysis plant. It was stated that a large amount of thermal energy/ heat is produced from this process and which is used internally for power generation for the plant, and also pasturisation and drying. The bio-char is dumped as an inert material in low lying areas in vicinity of the plant.

d) Capex and Opex of some of the plants are given in table below:

S.no	City	Technology	FSTP Capacity (in KLD)	Total Capex (in lakhs)	Total Opex per annum (in Lakhs)	Per KLD Capex (in Lakhs)	Per KLD Opex (in Lakhs)
1	Warangal	Pyrolysis	15.00	110.00	13.80	7.33	0.92
2	Devanahalli	DEWATS	6.00	110.90	5.33	18.48	0.89
3	Phulera	DEWATS	20.00	239.50	3.30	11.98	0.17
4	Jabalpur	MBBR	50.00	50.23	8.56	1.00	0.17
5	Bhubaneshwar	DEWATS	75.00	167.90	12.06	2.24	0.16
6	Puri	Co-treatment	50.00	73.90	13.09	1.48	0.26
7	Leh	Planted Gravel Filter	12.00	52.20	7.66	4.35	0.64
8	Tenali	MBBR	20.00	20.00	5.53	1.00	0.28

ANNEXURE-II
DEEP ROW ENTRENCHMENT [DRE] ADOPTED IN THE STATE OF ODISHA

In Odisha, currently, only 10 cities have access to safe treatment facilities for faecal sludge and septage. While 30 new treatment facilities are under construction and 46 are under different stages of tender evaluation and tendering, more facilities are coming up to ensure 100% coverage of safe treatment for all ULBs of Odisha. Construction time for these facilities is a minimum of nine months.

In consonance with the provisions contained under the FSSM Regulations, 2018, faecal sludge may only be disposed safely at a designated site. In absence of treatment facilities, Deep Row Entrenchment [DREs] provide an interim solution for safe disposal. Also, during the nine months of construction to ensure safe disposal of the faecal sludge and septage, Odisha has implemented DRE method in the ULBs across the State as a temporary measure.

GoI have formulated the principle that ULBs with a population of less than 20,000 may use DRE as a temporary intervention to certify themselves as ODF++.

In order to ensure that there is no contamination of ground water / adverse effect due to DREs, the guidelines / criteria adopted for selection of suitable sites for DREs has been indicated below:

S. No.	Site selection criteria
1.	Site above high flood level (HFL)
2.	Site not prone to water-logging
3.	Water table deeper than 15ft from bottom level of the trench
4.	Minimum distance from water body – 45 ft
5.	Soil type – porous
6.	Site terrain – flat
7.	Distance between nearest habitation and site - 200m minimum
8.	All weather road accessibility for cesspool emptier vehicle
9.	Compatible to adjacent and neighbouring properties usage
10.	Distance of site from town centre < 15km
11.	GPS tagging of DRE site

Testing protocols for DRE sites post implementation:
(i) Boreholes up to aquifer depth in the eight directions (North, East, South, West, North-east, North-west, South-east, South-west) 3m from the DRE site.
(ii) Sampling and testing of groundwater from the boreholes to assess contamination due to DREs.
(iii) Minimum two samples (one during dry season and one during wet season) to be collected and tested per borehole during a year.
Parameters to be tested:
(i) pH
(ii) Total Solids (TS), mg/L
(iii) Total Volatile Solids (TVS), as % of TS
(iv) Chemical Oxygen Demand (COD), mg/L
(v) Biochemical Oxygen Demand (BOD), mg/L
(vi) Total Nitrogen (TN), mg/L
(vii) Total Kjeldahl Nitrogen (TKN), mg/L
(viii) Ammoniacal Nitrogen (NH4-N), mg/L
(ix) Nitrates (NO3-), mg N/L
(x) Total phosphorus (TP), mg P/L
(xi) Faecal coliform, cfu/100 mL
(xii) Helminth eggs, Numbers/L

If any drastic change in the characteristics of groundwater between two opposite directions, e.g., East-West, North-South, etc. are observed, the disposal at that DRE site to be immediately, stopped and covered with soil. This drastic variation indicates improper implementation of DRE.

If contamination is found, new DRE site should be identified and executed.

Some images of DRE sites enclosed.

Polasora NAC

Digapahandi NAC

ANNEXURE-III
SCHEDULED EMPTYING SERVICE IN WAI AND SINNAR, MAHARASHTRA

Wai and Sinnar are cities from Maharashtra, where the former city is located at the foothills of Panchagani and latter city is located near Nashik. Wai is a holy town and Sinnar is a fast growing industrial town. The current population of Wai is around 43,000 and for Sinnar it is around 72,000. Both the cities have been recently declared ODF++ by MoHUA.

Before the cities implemented scheduled emptying, most of the septic tanks were cleaned only once in 8 – 10 years or when they became completely full and overflowed. Since households did not bear the environmental cost of infrequent cleaning until the tanks overflowed, they treated cleaning of septic tanks more as an emergency solution, rather than as a regular maintenance service. In addition to this, septic tank cleaning services were being provided by the council vehicle against a fee for providing this service. Also there were no septage treatment facilities in Wai and Sinnar and septage was being dumped with solid wastes.

To resolve this, both the councils implemented the FSSM plan in the city, where emptying service would be provided more as a scheduled service like the SWM D-D collection service rather than a demand-based service that HHs raise request for. Under this scheduled emptying service, all the septic tanks in the city would be emptied once in 3 years and the collected septage would be treated at a dedicated septage treatment facility. In order to carry out scheduled emptying, both councils signed an exclusive contract for 3 years with a private operator, where payments are done on annuity basis and based on performance of the operator. While planning the emptying service, the city was divided into 3 zones as per the citywide database on toilets and septic tanks. The private operator has stationed 2-3 trucks in each city to desludge ~ 2000 and ~4000 septic tanks annually in Wai and Sinnar respectively. Also a mobile based system called SaniTab was set up to capture the actual information of onsite sanitation system and to monitor the performance of private sector.
To treat the septage, a treatment facility of 70 KLD capacity has been set up on the land allocated by Wai and Sinnar council which is around 4-5 kms away from the city centre. The Wai FSTP is funded by a donor and the Sinnar FSTP is funded by council own funds. The operations of both these FSTPs are done by a private sector.

For financing the O&M cost of scheduled emptying service, both the cities has levied a sanitation tax as a part of property tax. This tax as well as transfer from property tax is being used to finance the O&M cost of these activities that are being carried out by the private sector. Also to ensure regular payments to the private sector for the FSSM services, the city has opened an escrow account wherein as per escrow agreement and the contract document the council puts fund in the Escrow Account to create a Contract Fees Reserve Fund (CFRF) and maintains a minimum balance of three month's payment to the Contractor. In this way it ensures regular payment to the private sector.

ANNEXURE-IV
LIST OF STATES FORMULATED SPECIFIC SANITATION POLICIES

List of States Formulated Specific Sanitation Policies

S. No.	Name of the State/UTs/ ULBs	Title of the Document	Year of Release
1.	Andhra Pradesh	Faecal Sludge and Septage Management Policy and Operative Guidelines for Urban Local Bodies	2018
2.	Chhattisgarh	Policy on Faecal Sludge and Septage Management	2017
3.	Gujarat	Faecal Sludge and Septage Management Policy	2017
4.	Karnataka	Operative Guidelines - Septage and Faecal Sludge Management for Urban Local Bodies	2015
5.	Kerala	State Sanitation Strategy	2015
		Brahmapuram Septage plant Guidelines	2015
6.	Madhya Pradesh	State Level Policy for Wastewater Recycle & Reuse and Faecal Sludge Management	2017
7.	Maharashtra	Guidebook for Urban Local Bodies to Implement Septage Management Plan	2016
		Guidelines for Septage Management in Maharashtra	2016
8.	Odisha	Odisha Urban Sanitation Policy	2017
9.	Punjab	Policy & Guidelines for Septage Management in Punjab	2017
10.	Rajasthan	Draft Policy - Faecal Sludge &Septage Management	2018
11.	Tamil Nadu	Operative Guidelines for Septage Management for Local Bodies	2014
12.	Telangana	Policy on Faecal Sludge and Septage Management	2018
13.	Uttar Pradesh	Draft - Guidelines for Faecal Sludge and Septage Management in Uttar Pradesh	2018
14.	Greater Visakhapatnam Municipal Corporation	Faecal Sludge and Septage Management Policy and Operational Guidelines	2017

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NOTES

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Swachhata Pledge

Mahatma Gandhi dreamt of an India which was not only free but also clean and developed.

Mahatma Gandhi secured freedom for Mother India.

Now it is our duty to serve Mother India by keeping the country neat and clean.

I take this pledge that I will remain committed towards cleanliness and devote time for this.

I will devote 100 hours per year that is two hours per week to voluntary work for cleanliness. I will neither litter nor let others litter.

I will initiate the quest for cleanliness with myself, my family, my locality, my village and my work place.

I believe that the countries of the world that appear clean are so because their citizens don't indulge in littering nor do they allow it to happen.

With this firm belief, I will propagate the message of Swachh Bharat Mission in villages and towns.

I will encourage 100 other persons to take this pledge which I am taking today.

I will endeavour to make them devote their 100 hours for cleanliness.

I am confident that every step I take towards cleanliness will help in making my country clean.

Ministry of Housing and Urban Affairs

Government of India