National Institute of Urban Affairs

Decentralised and Non-sewered Solutions for Wastewater Management in Ganga Towns

Learning Notes

TITLE:

DECENTRALISED AND NON-SEWERED SOLUTIONS FOR WASTEWATER MANAGEMENT IN GANGA TOWNS – LEARNING NOTES

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CONTENT

The learning notes are prepared by compiling information sourced from various training modules prepared under Sanitation Capacity Building Platform (SCBP), an initiative of the National Institute of Urban Affairs (NIUA) for addressing sanitation challenges in India.

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About this Handbook

This handbook is an initiative of NIUA to build capacities of urban local bodies (ULB), para state technical agencies, administrators and professionals from the private sector and Non-governmental Organizations. It is meant to be freely used by any can organisation(public or private), national and state level training institutes, AMRUT and SBM Training institutes: for conducting a one to one and a half day basic Orientation Training on Decentralised Wastewater Management with focus on Faecal Sludge and Septage Management (FSSM) within Ganga Towns.

The Handbook presents the key learning elements for the basic training module in a narrative format covering the aspects of: urbanization and sanitation trend in India, wastewater management in ganga basin and challenges, sanitation systems, decentralised sanitation solutions for wastewater management – needs and challenges, decentralised wastewater and septage management technologies and best practices, planning and financing for citywide faecal sludge and septage management, policies and programs for wastewater management in urban areas.

The Handbook has been developed based on the experience of delivering orientation and advance trainings on Integrated Wastewater and Septage Management IWSM) and Faecal Sludge and Septage Management (FSSM) under the umbrella of Sanitation Capacity Building Platform (SCB) anchored at NIUA.

About the Training Module

Title	Decentralised and Non-sewered Solutions for Wastewater Management in Ganga Towns Learning Notes
Purpose	The approach conventionally adopted for managing wastewater and septage in urban areas is predominantly centralised networked systems in the form of sewer networks and Sewage Treatment Plants (STPs). These systems are both CAPEX and OPEX intensive, need large volumes of water to maintain sewage flow within pipeline systems, difficult to implement in brownfield areas, and most importantly requires longer duration for implementation. Even then, 100% coverage of towns/populations by centralised sewerage system may not be feasible given the topographical constraints and un-regulated spatial growth of towns. This inhibits its widespread adoption in all sizes of urban areas. Adopting centralised approach alone for managing wastewater in an urban setting might not eliminate completely the problem of untreated pollution loads entering water bodies like rivers. There is growing acceptance regarding decentralised wastewater management approaches, wherein the focus is on collecting and treating the waste at source or as near as possible to source of generation. Swachh Bharat Mission (SBM) has significantly contributed to reducing open defecation through provision of toilets with on-site containment for faecal matter. Ganga basin is fast becoming ODF and if faecal sludge is not managed properly then instead of reducing contamination, it will further add to Ganga's pollution. Faecal Sludge and Septage Management (FSSM) is a decentralised approach to manage faecal matter that can complement centralised networked systems in reducing the pollution loads entering the river. Decentralised wastewater and septage management solutions have not been a priority for administrators and engineers and has traditionally received less attention. With recent policies and emphasis on dealing of waste from on-site sanitation, direction by central and state governments has provided mandate to ULBs to promote decentralised sanitation. However, the capacities within ULBs and parastatals is limited in this field. This training module aims at building the understanding of city and town officials regarding decentralised solutions for both liquid and solid components of domestic wastewater.
Training module is for	Municipal Commissioners and Executive Officers from Class I and II towns and cities, officials of para state technical agencies, elected representatives and engineers from ULBs within Ganga Basin, Consultants and NGOs dealing in Sanitation.
Learning Objectives	The module aims to convey the following learning: • Decentralized septage, sludge and wastewater treatment solutions are technically sound options for Indian towns and cities, and are not sub optimal solution as compared to centralized sewerage systems • Assessment & planning of both technical and financial for FSSM at the city level

	By the end of the training, participants would be able to understand and appreciate the need and role of decentralised sanitation solutions like FSSM in managing faecal flows, concepts and definitions of centralized and decentralized treatment options, how to calculate and assess the generation of septage in volumetric terms and the cost of treatment using decentralized treatment options. In the long run it will help towns and cities to improve their sanitation, public health status and rankings on Swachh Survekshan; by investing in sustainable and cheaper septage and waste water treatment options.
Duration	1 day non-residential training for approx. 30-40 participants

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1 Urbanisation and Sanitation

1.1 Urbanisation in India

India is urbanizing but the pace and character of is different from countries in other parts of the world. In 2001, the numbers of Census towns and statutory towns were 1,362 and 3,799, respectively, while in 2011, these numbers grew to 3,894 and 4,041, respectively. The growth of population and urbanization has slowed down in the Million Plus cities in the last decade (2001-11), but continues to increase at a fast pace for smaller towns and cities. The number of urban agglomerations in the year 2001 was 384 and increased to 475[1] in 2011.

Table 1: Number of UAs/Towns and Out Growths (OGs)

S. No.	Types of Towns	Number of Towns	
		Census 2011	Census 2001
1	Statutory towns	4,041	3,799
2	Census towns	3,894	1,362
3	Urban agglomeration	475	384
4	Out growths	981	962

Source: Census of India 2011

The total population of India increased from 102.86 crore in 2001 to 121.02 crore in 2011. The urban population in the year 2011 also increased to 37.71 crore from 28.61 crore in 2001. The percentage of urban population in the year 2001 was 27.8% which increased to 31.2% in 2011.

1.2 Urban sanitation and associated challenges

1.2.1 Urban Sanitation

"Sanitation is defined[2] as safe management of human excreta, including its safe confinement treatment, disposal and associated hygiene-related practices. Sanitation pertains to management of human excreta and associated public health and environmental impacts, it is recognized that integral solutions need to take account of other elements of environmental sanitation, i.e. solid waste management; generation of industrial and other specialized / hazardous wastes; drainage; as also the management of drinking water supply (National Urban Sanitation Policy, 2008).

<u>What is the definition of ODF/ODF+/ODF++ City?</u>

ODF – A city / ward can be notified / declared as ODF city or ODF ward if, at any point of the day, not a single person is found defecating in the open[3]. (Ministry of Housing and Urban Affairs, Government of India).

ODF+ – A city/ward can be notified/declared as ODF+ city or ODF+ ward if, at any point of the day, not a single person is found defecating and/or urinating in the open, AND all community and public toilets are functional and well maintained. The cities that have been certified ODF atleast once on the basis

[1] Number of census towns and statutory towns are taken from http://censusindia.gov.in/2011-prov-results/paper2/data_files/India2/1.%20Data%20Highlight.pdf

[2] National Urban Sanitation Policy

[3] Ready-reckoner for "Declaring your City/Ward open defecation free" is available on http://sac.ap.gov.in/sac/UserInterface/Downlaods/IECMaterials/ODF%20Declaration%20booklet.pdf

of the ODF Protocol laid down by MOHUA shall be eligible to declare themselves as SBM ODF+ and apply for certification of SBM ODF+ status, as per the conditions laid down in this protocol document.

ODF++ - A city/ward can be notified/ declared as ODF++ city/ward if, at any point of the day, not a single person is found defecating and/ or urinating in the open, all community and public toilets are functional and well maintained, **AND faecal sludge/septage and sewage is safely managed and treated, with no discharging and/or dumping of untreated faecal sludge/septage and sewage in drains, water bodies or open areas**. The cities that have been certified SBM ODF+ atleast once on the basis of the SBM ODF+ Protocol laid down by MoHUA shall thereafter be eligible to declare themselves as SBM ODF++ and apply for certification of SBM ODF++ status, as per the conditions laid down in this protocol document.

The Government of Maharashtra (GoM) has prepared its own ODF framework and has linked ODF for achieving safe sanitation including safe waste water disposal systems. The ODF+ protocol of GoM talks about managing the entire faecal sludge/septage from on-site sanitation systems as against SBM (U) protocol wherein septage management is covered under ODF++. GoM's ODF++ talks about managing entire septage and wastewater being generated in an urban area.

Table 2 – ODF/ODF+/ODF++ protocol of Government of Maharashtra

	Elimination of OD practices	**Access to toilets**	**Conveyance and treatment of faecal waste**
ODF City	• Not a single person found defecating in the open • No traces of faeces are visible in the city at any time of the day	• All the properties in the city have access to either own toilet or functional community toilet (CT)/ public toilet (PT) • Floating population in the city has an access to sufficient and functional PTs	• All toilets are connected to a disposal system
ODF+ City	• Not a single person found defecating in the open • No traces of faeces are visible in the city at any time of the day	• Atleast 80% of residential properties in the city have access to own toilets • Remaining properties and floating population in the city have access to functional CTs/ PTs	• All toilets are connected to a disposal system • Regular and safe collection, conveyance and treatment of all the faecal matter
ODF++ City	• Not a single person found defecating in the open • No traces of faeces are visible in the city at any time of the day	• At least 95% of residential properties in the city have access to own toilets • Remaining properties and floating population in the city have access to functional CTs/ PTs	• All toilets are connected to safe disposal system • Regular safe collection, conveyance and treatment of all faecal matter and waste water including septic tank effluent and grey water

As per data from SBM(Urban) portal[4], out of the total 4376 ULBs in India, 3909 ULBs have applied for ODF certification and have been inspected. Of these 3909, 3526 ULBs (90%) have been declared ODF whereas 383 ULBs are Non-ODF.

1.3 Urban Wastewater Management

Providing safe wastewater conveyance and treatment systems in cities can be provided by broadly two approaches:

Wastewater management systems can be either conventional centralized sewer systems (also referred to as sewered sanitation) or non-conventional systems including on-site sanitation (also referred to as non-sewered sanitation) and decentralised systems. Centralized systems are usually planned, designed and operated by government agencies which collect and treat large volumes of wastewater for the entire communities. On the other hand, decentralized wastewater management (DWWM) systems treat wastewater of individual houses, apartment blocks or small communities close to their origin. Typically, the decentralized system is a combination of many technologies within a given geographical boundary, namely, onsite systems, low cost collection systems and dispersed siting of treatment facilities.

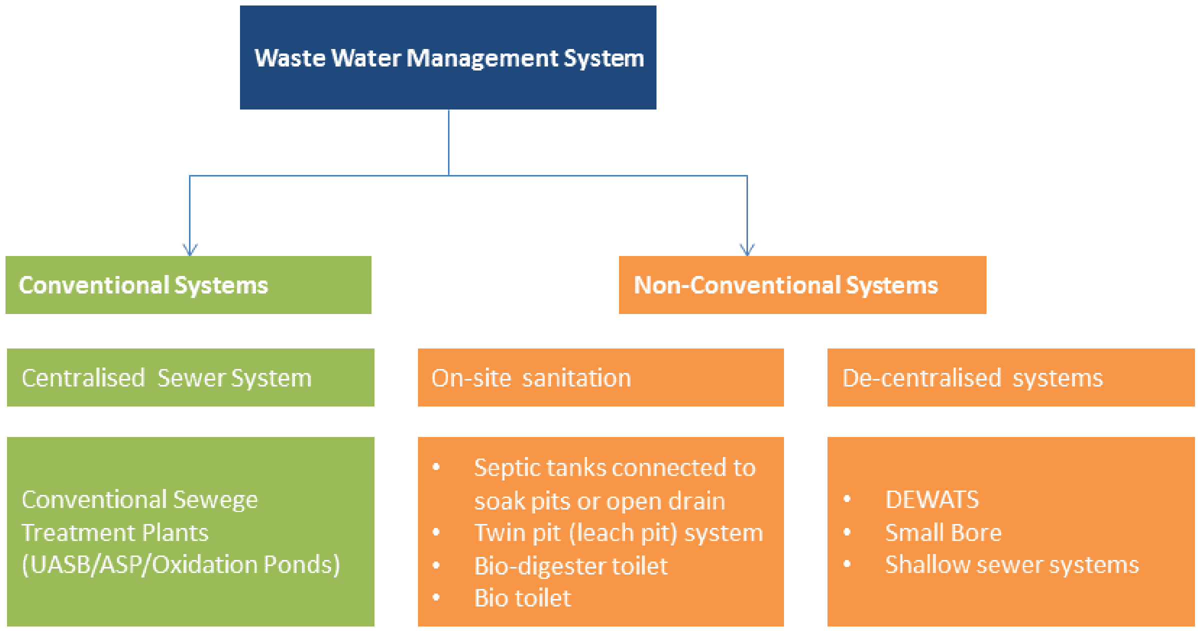


Figure 1 – Types of wastewater management systems

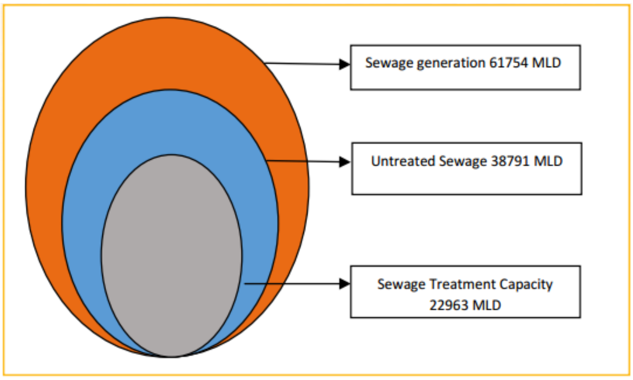
Wastewater treatment systems such as pit latrines, septic tanks, bio-toilet etc., which are used for partially treating wastewater in individual residences or a small cluster of houses, are termed as "On Site Sanitation Systems (OSS)" systems. OSS need not have any wastewater collection system, while a DWWM may have a small sewerage system. It may also be noted that any city or town can have a combination of centralized, decentralized and on-site wastewater management systems, to meet the overall city sanitation. (*Source – Guidelines for Decentralised Wastewater Management, prepared by IIT, Chennai for MoUD, GoI, December 2012*).

[4] Data accessed from portal on 19th July, 2019.

1.3.1 Centralised Wastewater Management (Sewered Sanitation)

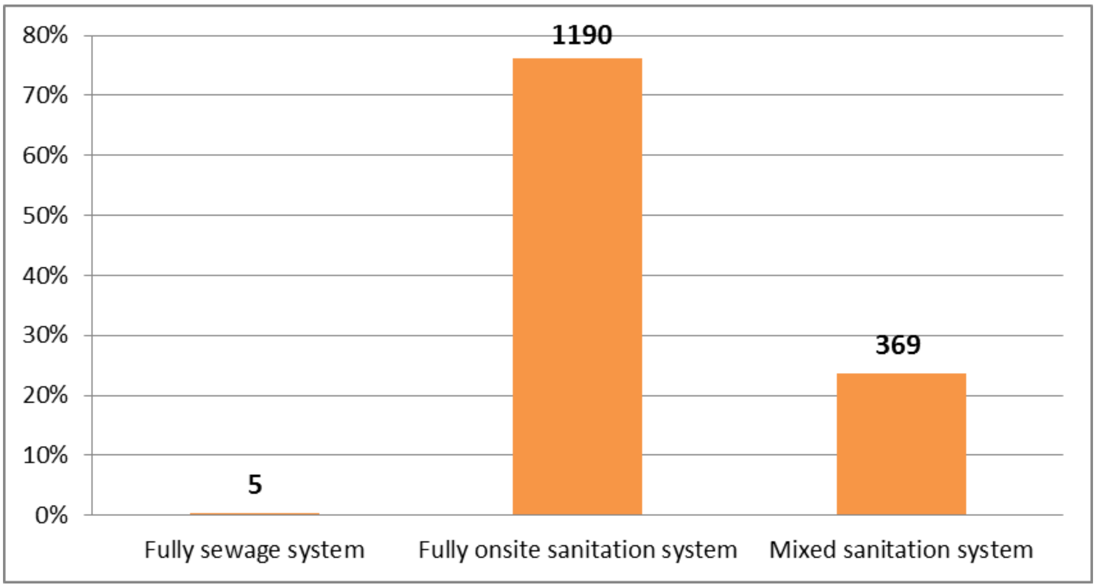
In conventional wastewater management approach, centralised Sewage Treatment Plants (STPs) are set up and all wastewater generated is transported to STPs vis sewer lines. A centralized sewerage is perceived as an underground sewer system to collect the sewage from all over the settlement.

While the conventional sewerage may be a comprehensive system for sewage collection and transport, it also remains as a highly resource-intensive technology. Consequently, high capital cost and significant O&M cost of this system inhibits its widespread adoption in all sizes of urban areas. Conventional centralised sewerage systems require an elaborate infrastructure and large amounts of water to carry the wastes or excreta away. They are resource intensive - that is, they require energy, skilled labour, expensive infrastructure, operation and maintenance. Usually centralized systems are adopted when there are limited challenges in terms of cost, land resources and operative finances in place.



As per the 2011 census, only 38% urban households in India were connected to sewerage systems, where faecal waste is supposed to be conveyed to Sewage Treatment Plants (STPs). The estimated sewage generation in the country was 61,754 MLD and installed capacity for sewage treatment was only 22,963 MLD. However, the treatment utilization at these STPs is only 18,883 MLD (which means approx. only 30% of the total sewage that is generated gets treated). The rest is discharged into nearby water bodies (Central Pollution Control Board (CPCB), 2016). There are 920 STPs in different States/UTs out of which, 615 STPs are operational, 80 STPs are non-operational, 154 STPs are under construction and 71 STPs are under planning stage. (Source: CPCB, 2016).

Figure 2 - Number of cities with different types of sanitation systems in India



Source - CEPT, Based on the SLB data submitted to Government of India (2014)

Wastewater Management in Ganga States

There are 11 states in Ganga Basin with 5 being on main stem of the Ganga River. These states are Bihar, Uttar Pradesh, Uttarakhand, Jharkhand and West Bengal.

An analysis of Ganga basin town shows that only 10% of the sewage is treated and disposed as per standards. As much as 67% households are not connected to any sewerage system and the faecal waste from septic tanks is polluting the ground water, surface water bodies and Ganga river.

The wastewater generated in each ganga state and treatment capacities installed is mentioned in figure above. Across all the states, STPs installed are not adequate to treat volume of wastewater generated resulting in discharge of untreated flows entering water bodies like ponds/lakes and rivers. Bihar State has highest gap (94%) in terms of treatment capacity installed against quantum of wastewater generated. Uttar Pradesh has shortfall of 63% in treatment capacities.

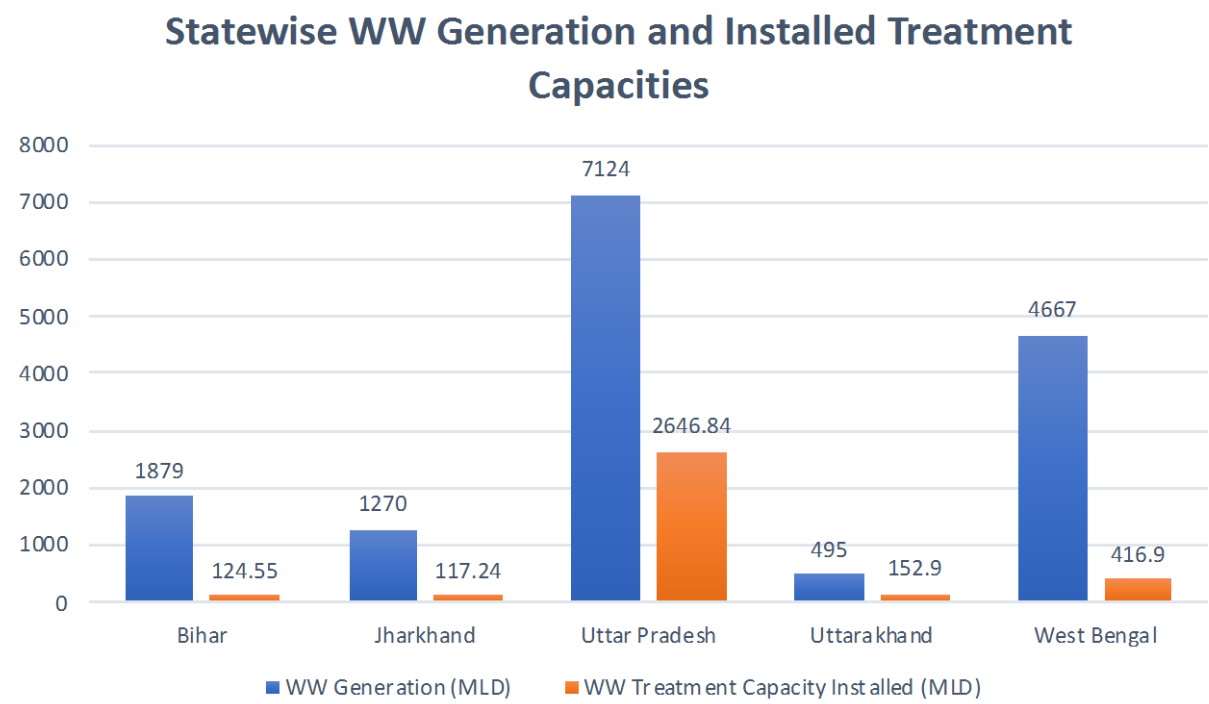
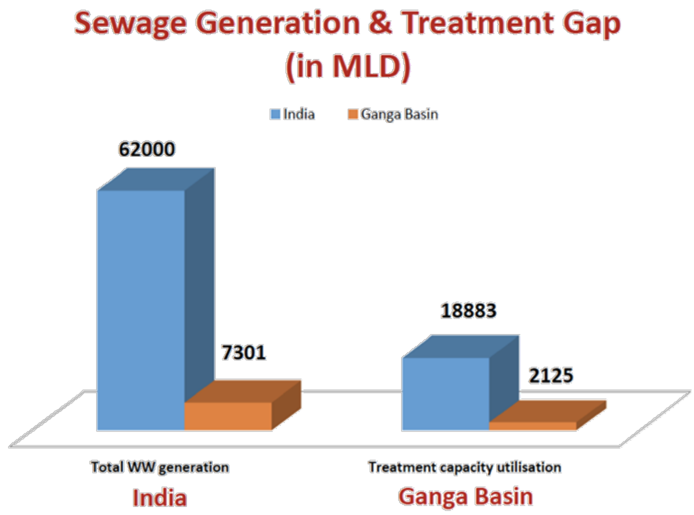


Figure 3 – Wastewater Generation and Installed Treatment Capacities in Ganga States

Source: Ministry of Environment, Forest and Climate Change, GoI, Loksabha unstarred question no. 2541, dated May, 2018.

It is estimated that 11 Ganga basin states generate 12050 MLD (Class I & II towns), whereas 5 Ganga Basin State along main river stem generate 7301 MLD wastewater (across 175 Class I & 102 Class II towns). On the contrary, only 2125 MLD treatment capacities are installed (3313 MLD including 1188 MLD under approval/construction). Considering the same, there is a shortfall of 8737 MLD treatment capacity across 11 Ganga Basin States and 3988 MLD in towns along the main river stem (*Source: CSE, February 2019*). This shows, high volumes of untreated wastewater entering Ganga River causing severe pollution.

Domestic wastewater contributes to 92% of pollution lead entering Ganga river, whereas rest is contributed by industries. However, in terms of organic pollution, domestic wastewater contributes 69%, whereas industries contribute 31%.



Namami Gange – Centre's Flagship Program for Rejuvenation of Ganga River[5]

'Namami Gange' is a flagship program of Union Government initiated in 2014 with a budget outlay of INR 20,000 Crore to accomplish the twin objectives of effective abatement of pollution, conservation and rejuvenation of National River Ganga. The program's vision is to rejuvenate Ganga by restoring the wholesomeness of the river defined in terms of ensuring "Aviral Dhara" (continuous flow) and "Nirmal Dhara" (unpolluted flow), geologic and ecological integrity.

Nirmal Dhara is one of the 7 thrust areas under which actions for reducing pollution entering the river are targeted. Some of the actions are upgrading of existing Sewage Treatment Plants (STPs), creating additional treatment capacities and abatement of industrial pollution, which along with domestic wastewater are major contributors of pollution load.

As of May 2019, 150 projects worth INR 23,130 Crores have been sanctioned for sewerage infrastructure.

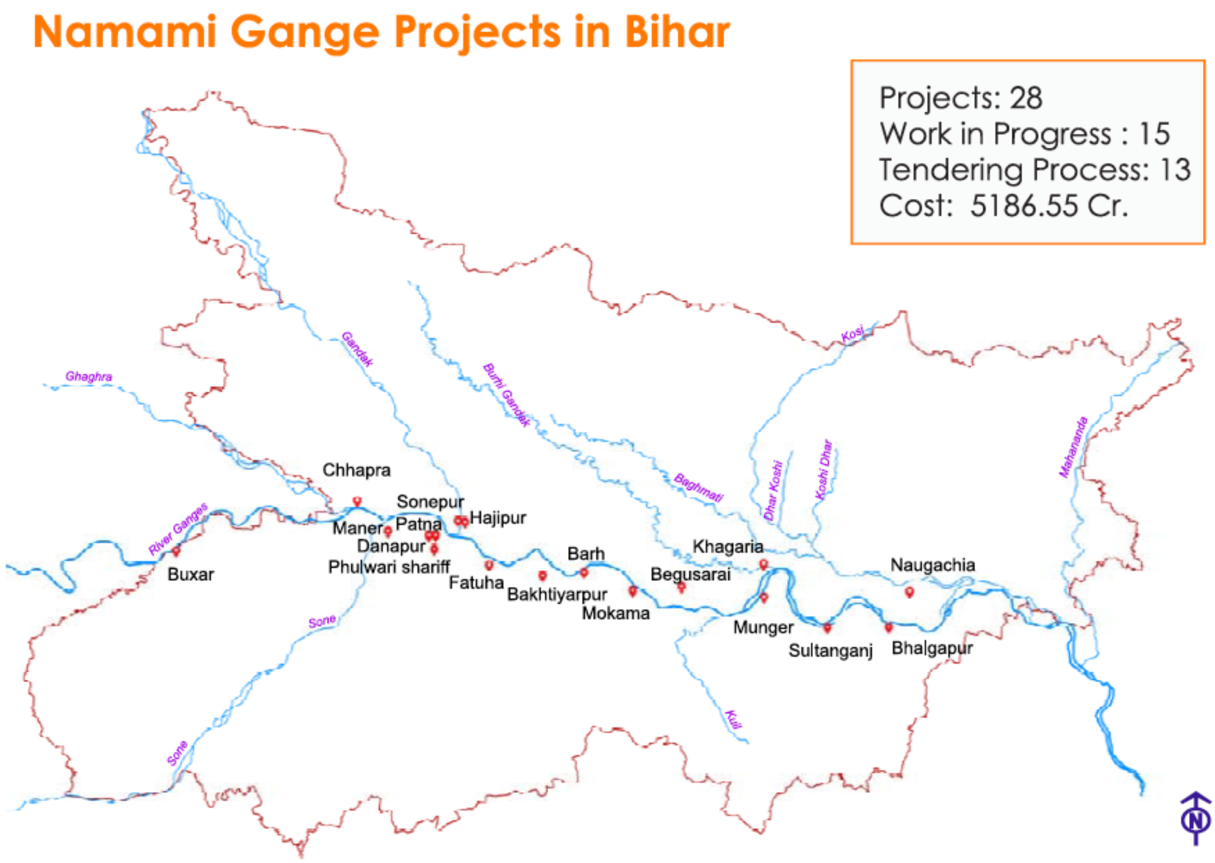
Table 3 – Sewage Infrastructure Projects - Status

S. No.	State	Status as on 31st March 2019				
		Projects	STP Capacity (MLD)	Completed	Work-in-progress	Tendering process
1	Uttarakhand	34	165.28	19	12	3
2	Uttar Pradesh	50	1622.16	13	20	18
3	Bihar	28	619.5	0	15	13
4	Jharkhand	2	15.5	0	2	0
5	West Bengal	22	864.67	3	7	12
6	Haryana	2	145	2	0	0
7	Delhi	11	1384.5	0	9	2
8	Himachal Pradesh	1	1.72	0	0	1
	Total	**150**	**4874.29**	**37**	**65**	**49**

Under this program, until May 2019, 483 MLD of treatment capacity has been created whereas 92 MLD created by rehabilitation of existing STPs. Sewer network of length 2576.28 km has been laid.

[5] All information presented in this section is sourced from "Namami Gange Program – At a Glance", project brochure by NMCG, March 2019

Ongoing/planned actions include creating 3249 MLD of new treatment capacity along with 1022 MLD by rehabilitating existing STPs. Plan also includes laying of another 2394.73 km of sewer network.



In Bihar, a total of 28 projects for creating treatment capacities of 619.5 MLD have been sanctioned, of which projects totaling 257.5 MLD of treatment capacity is under progress, 332 MLD worth projects under tendering and tenders for 30 MLD treatment capacity to be floated.

Centralized Sanitation Systems – challenges

Centralised systems are both CAPEX and OPEX intensive, need large volumes of water to maintain sewage flow within the gravity-based pipeline systems, difficult to implement in brownfield areas, inadequate capacities in designing and maintaining the infrastructure and most importantly requires longer duration for implementation. Even then, 100% coverage of towns/populations by centralised approaches may not be feasible given the topographical constraints and un-regulated spatial growth of towns

a) Network Design Issues:

Typically, each underground sewerage system is designed keeping in mind the population forecast of thirty years and the realization of the sewage volumes to use the designed sewer capacities results in idle volumes and idle expenditures. The underground sewers laid become defunct with time and eventually go into disrepair. This is a non-productive expenditure in a sense, implying that the investment could have been utilized elsewhere.

Scenario 1:

The map to the right shows a typical conventional sewerage with all the sewers discharging to a single STP. There are a few areas that are currently sparsely developed, but yet the sewers are designed for a flow for 30 years. Hence, these sewer lines do not run at optimal capacities, do not have enough water for run off and hence results in silting of sludge in the pipes. There are scenarios where manhole covers are stolen and manholes are reduced to garbage dumps, which leads to choking of the sewer system. The result is that there is a need for a massive rehabilitation program of the sewer system when these areas get fully populated and occupied. A further difficulty is the STP, which is grossly underutilized and the treated sewage quality suffers due to prolonged hydraulic retention.

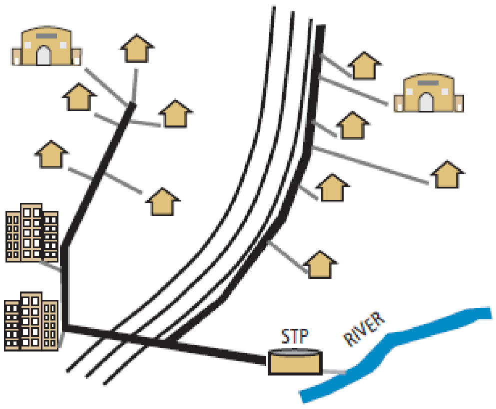


Figure 4 - Centralized Treatment

b) Requirement of adequate water

The CPHEEO manual on sewerage and sewage treatment engineering mentions requirement of at least 100 LPCD of water supply so as to achieve self-cleansing velocities within the sewer system. When sufficient water supply is not provided, solids accumulate and sewer lines get blocked. Many ULBs are not able to ensure this level of water supply but do aspire to implement centralised systems.

c) Achieving household level connections:

Usually, while the investment on laying the sewerage lines is met out of capital grant funding, the cost of individual house level connections is to be met by the house owners. In areas which are currently un-developed, these house service connections get deferred and leading to frequent road cuts as and when the houses are built. There are also instances of illegal connections by HHs which lead to an intensive monitoring and checking regime by the local body. This is another challenge given the limited staff of ULBs.

d) Expensive capex:

According to an estimate, the building of conveyance of one kilometer of sewerage network would range between ₹ 10-40 million and treating 1 MLD of sewage costs another ₹ 10 million through a centralized treatment system, excluding the land cost *(Centre for Science and Environment, 2014)*. Thus one can assume the finances involved in implementing and sustaining centralized systems to treat the huge quantum of sewage.

e) Financial Sustainability of O&M:

A centralized sewer system requires huge capital as well as huge O&M costs. The CPHEEO manual on Sewerage and Sewage Treatment O&M, mentions that about 20 to 40% of total O&M costs are towards O&M staff while 30 to 50% of the cost is incurred on energy charges and the balance amount in repair, replacements and miscellaneous charges. In most of the cities tariffs are so low that they don't even cover the annual O&M. It is estimated that collection costs of waste water to the STP account for more than 60% of the total cost in centralized waste management systems and on-site systems reduce the collection costs to a minimum.

Whereas capital costs are mostly met out of grant funding, the O&M expenses are to be generated by the local body. The revenues generated by taxes and water and sewerage charges are too meagre to even break even in the local body accounts, leave alone increasing the reserve funds.

f) O&M of STPs:

A report by the CPCB on the performance of 152 STPs across the country[6] highlighted that only about 66% of their actual treatment capacity is utilized. Out of the 152 STPs, 30 plants (20%) are non-operational and performance of 28 plants (18%) is not satisfactory in terms of O&M and method of sludge disposal. Treated effluent from 49 STPs (32%) exceeds the BOD standards and with respect to Chemical Oxygen Demand (COD), 7 STPs are violating the general standards of discharge. (Central Pollution Control Board, 2013).

The report concludes that conventional treatment technologies need considerably high demand of energy while natural treatment technology STPs requires fewer staff to operate the system whereas advanced & conventional treatment technology based STPs require large number of skilled professionals. Without adequate finances, ULBs will be stressed to operate and maintain the sewer system which would lead to the deterioration of the useful life of the systems necessitating premature replacement of many system components and hence will also affect overall sanitation. Even after creating such assets by investing millions of rupees, ULBs would be unable to provide the services effectively to the community for which they have been constructed, as they remain defunct or underutilized most of the time.

Adopting conventional centralised approach alone for managing wastewater in an urban setting might not eliminate completely the problem of untreated pollution loads entering the river. There is growing acceptance regarding decentralised wastewater management approaches, wherein the focus is on collecting and treating the waste at source or as near as possible to source of generation. This negates requirement of extensive conveyance infrastructure as required in sewerage system. The waste streams (liquids and solids in wastewater) can be separately treated and also requires relatively simpler technologies for treatment. A city can have a combination of centralised, decentralised and on-site wastewater management system to meet the overall city sanitation.

Swachh Bharat Mission (SBM) has significantly contributed to reducing open defecation through provision of toilets with on-site containment for faecal matter. Ganga basin is fast becoming ODF and if faecal sludge is not managed properly then instead of reducing contamination, it will further add to Ganga's pollution (*CSE, 2019*).

1.3.2 Decentralised Wastewater Management Systems[7]

Decentralized wastewater management (DWWM) systems treat wastewater of individual houses, apartment blocks or small communities close to their origin. Typically, the decentralized system is a combination of many technologies within a given geographical boundary, namely, onsite systems, low cost collection systems and dispersed siting of treatment facilities. Wastewater treatment systems such as pit latrines, septic tanks, DEWATS etc., which are used for partially treating wastewater in individual residences or a small cluster of houses, are termed as "On Site Wastewater Treatment

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[6] Performance Evaluation of Sewage Treatment Plants under NRCD, Central Pollution Control Board, 2013

[7] Source: Guidelines for Decentralised Wastewater Management, prepared by MoUD Centre of Excellence in DWWM Department of Civil Engineering, Indian Institute of Technology Madras, 2012

(OSWT)" systems. OSWT need not have any wastewater collection system, while a DWWM may have a small sewerage system (*IIT Madras, Chennai, 2012*).

In decentralized approach, more than one, small capacity of treatment plant can be set up across the city. It could be in the cluster of residential areas, in commercial areas, at the individual scale or in the industrial areas. Decentralised wastewater treatment solutions include both smaller community scale or individual wastewater treatment module and the management (collection, transport, treatment and disposal) of the contents of non-sewered on-site sanitation systems like single pit latrines, twin pit latrines, septic tanks, holding tanks, aqua privies etc.

Decentralised systems are suitable in situations where community / institutional facility is far away from the existing centralized system, implementing system is unaffordable, topographical constraints in connecting all parts of the towns (specially low lying areas), localities where there is scarcity of freshwater, where there is possibility for localised reuse of treated wastewater and newly developing residential, commercial and institutional areas.

A city or town can have a combination of centralized, decentralized and on-site wastewater management systems, to meet the overall city sanitation

Since decentralised systems aim at providing incremental scaling of infrastructure to optimise investments, these systems are typically designed for 15 years unlike centralised sewage treatment systems that are designed for 30 years.

Advantages of Decentralised Wastewater Management Systems

a) Cost efficient
   - The requirement for the underground sewer system is completely eliminated or partially required (within the settlement area from the Household to the DEWATS system).
   - Lower capital cost and O&M costs, due to absence of complex mechanical as well as electrical systems associated.

b) Environment Friendly
   - Complete absence or lower electric consumption and hence power saving.
   - Due or absence of underground sewer system, negligible possibility of ground water contamination.
   - Odorless, hence can be built within a living habitat also.

c) High user acceptance
   - Minimal O&M needs and costs as lower human resources capacity levels needed.
   - Easy and efficient user involvement and participation (e.g. in decision making and O&M).

d) Flexibility in scale
   - Can be built easily at remotest places, even by regularly skilled labour.
   - Can be built for a scale fit for a HH, cluster as well as community level or a town level.

As in the case of centralised wastewater management systems, DWWMs also have following main components

- Wastewater collection system
- Treatment system, and
- Reuse/disposal system

1.3.2.1 Decentralised wastewater collection system[8]

Simplified sewer systems are cost-effective alternative approaches to overcome the challenges of implementing conventional systems mainly pertaining to costs in laying sewer lines, installation challenges and thereafter maintenance issues. Conventional systems and simplified sewer systems are conceptually the same, with later one focussing on eliminating unnecessary conservative design features and matching design standards to local situation. The whole idea is to simplify the design and reduce the costs for laying the sewer system. Two approaches mentioned below fall under the ambit of simplified sewer systems.

- Shallow Sewer System
- Small Bore Sewer System

Shallow Sewer System

Also referred to as condominial sewerage, is used to convey both blackwater and greywater from a household to an offsite location through sewer lines laid at shall depth for treatment and safe disposal. The design and implementation of this system mainly involves applying design principles of simplified sewers coupled with consultations with users and planning and implementation agencies. The successful implementation of these system is largely dependent on participation of local community, since sewer lines need to cross private property boundaries.

The main feature of this system is that sewers are routed through private land (either in back or front yards of the property). Shallow sewers are usually laid in the front or back yards of the house plots (suited for neighbourhoods with challenging topography or urbanization patterns) or under the pavement (sidewalk).

The system is suitable for (a) high density and squatter settlements (b) newly planned settlements where currently there is no option to dispose household wastewater through conventional sewer system (c) adverse ground conditions and where on-site disposal is not possible and (d) for sullage disposal and where minimum rate of water consumption is 25 lpcd.

A shallow sewer system follows the hydraulic theory of conventional sewerage, however its design assumptions are less conservative. Smaller diameter pipes are used and minimum earth cover could be as low as 0.2 m if less traffic volume expected. Such systems are designed with a planning horizon of 30 years.

The maintenance requirements for the system mainly includes individual households maintaining their interceptor tanks and grease traps, periodical cleaning of inspection chambers and avoiding grit and storm water entering in the collection system.

Pros	Cons
• smaller diameter pipes and shallow inspection chambers resulting in lower CAPEX and OPEX compared to conventional system • system can be built with locally available materials and repaired locally	• requires expert design and construction supervision • suitable only where adequate ground slope available

[8] In this section, conveyance options for transporting wastewater to an off-site for treatment have been discussed. Non-sewered options for on-site sanitation have been discussed under Faecal Sludge and Septage Management

• can be incrementally expanded as per need • cost of construction could be 30 to 50% lower than conventional sewerage depending on local conditions	• frequent clogging of sewers, requires frequent cleaning as solids likely to get deposited because of flat • reluctance by households to allow laying of sewers through their properties

Small Bore Sewer System (Also referred to as Settled Sewer System)

The system is designed to collect only the liquid portion of the domestic wastewater (blackwater & greywater) and transport to on-site or off-site location for treatment and safe disposal. The solids are retained in septic tanks or interceptor tanks at household level before it enters the sewer system. Since the system collects only settled wastewater, the water requirements for transporting the solids and self-cleansing velocities are less. The system is suitable for following conditions:

- where there is no possibility of on-site/off-site effluent disposal from toilets and bathrooms/kitchens
- area where interventions for improvements are incrementally planned by provision of small-bore sewer system first followed by gradual upgradation to full scale conventional system
- where ground and soil conditions do not allow for effluent from on-site systems to be discharged locally

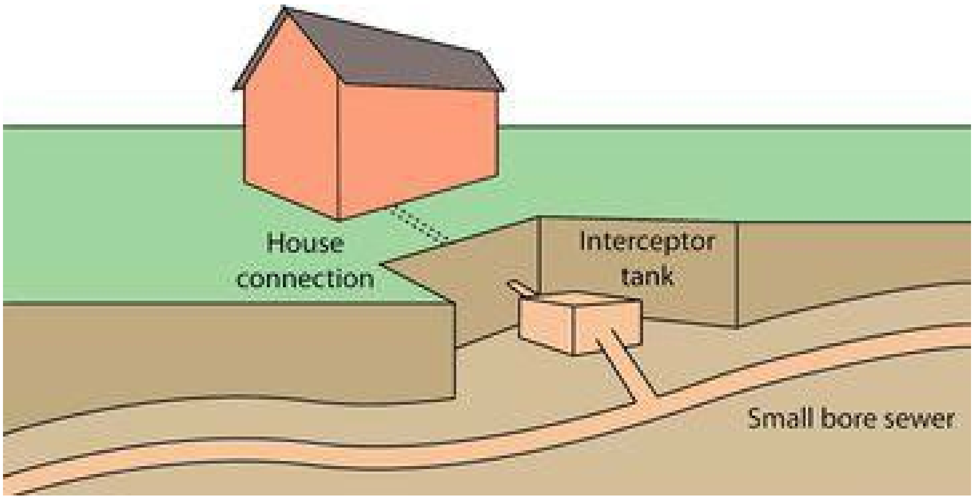

Figure 5 – Schematic diagram of small bore sewer system

The minimum diameter of sewer pipe is 100 mm. The system does not require to maintain strict gradients for self-cleansing velocities. The sewer may be constructed with any profile provided the hydraulic gradient is maintained below the levels of interceptor tanks.

The optimal functioning of this system to a large extent depends on households getting their septic tanks and interceptor tanks cleaned on regular basis. Flushing of sewers is recommended once a year as part of the regular maintenance regardless of their performance.

Pros	Cons
• reduced water requirements for transportation of solids • lesser excavation and construction material cost as compared to conventional system	• regular cleaning of septic/interceptor tanks • requires well-planned maintenance system • mixed experience with the system (limited experience)

Pros	Cons
• treatment requirements are less since solids are already retained on-site • reduced maintenance requirements	• possibility of solids entering sewer system due to illegal connection

Twin Drains

The twin drain system comprises of a integral twin drain on both sides of the road, the drain nearer to the property carrying the septic tank effluent & the grey water and the drain on the road side for storm water and the sewer drains are interconnected to flow out to treatment. This system is in use in coastal areas of Tamil Nadu particularly in Tsunami affected habitations.

1.3.2.2 Decentralised Wastewater Treatment Systems

Compared to household-centered storage technologies (*refer section on Faecal sludge and septage management*), these treatment technologies are designed to accommodate increased volumes of flow and provide, in most cases, improved removal of nutrients, organics and pathogens. The technical and physical criteria for choosing appropriate technology for treatment are as follows;

- Availability of space and other resources (Choice of technology)
- Climate (Temperature affects rate of reactions)
- Ground condition (Flood-prone area)
- Groundwater level and contamination (Cross contamination from tanks underground)

Presently, several treatment options are available and one can choose from these options to find the most appropriate technology for the locality under consideration. Some of the treatment systems are mentioned below:

Waste Stabilisation Ponds

Waste Stabilization Ponds (WSPs) are large, man-made water bodies. The ponds can be used individually or linked in a series of improved treatment. There are three types of ponds, (1) anaerobic, (2) facultative and (3) aerobic (maturation), each with different treatment and design characteristics. For the most effective treatment, WSPs should be linked in a series of three or more with the effluent being transferred from the anaerobic pond to the facultative pond and, finally, to the aerobic pond. Anaerobic and facultative ponds are designed for BOD removal, while aerobic ponds are designed for pathogen removal (see also pathogens and contaminants).

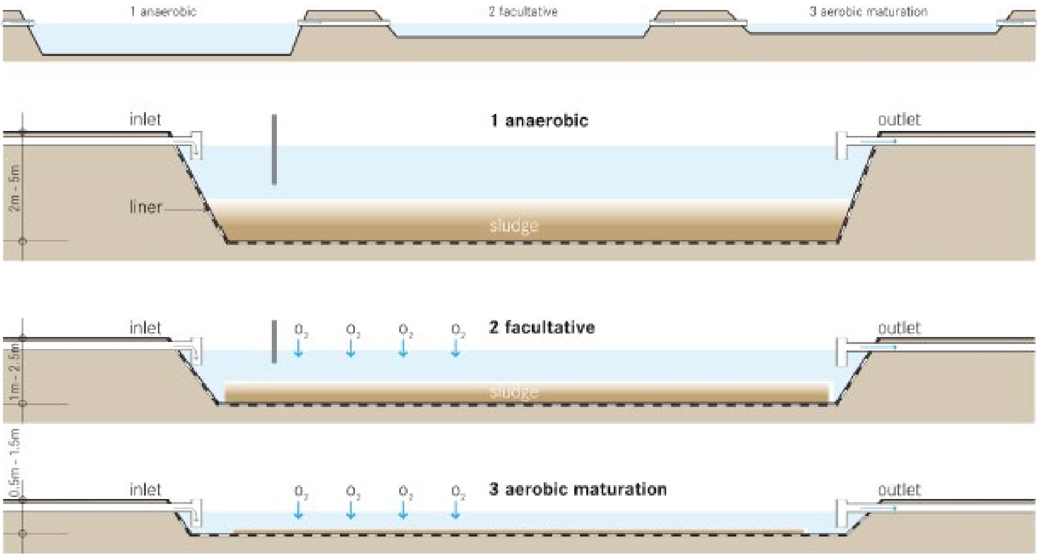

Figure 6 – Schematic diagram of WSP

WSPs are among the most common and efficient methods of wastewater treatment around the world. They are especially appropriate for rural communities that have large, open and unused lands, away from homes and public spaces and where it is feasible to develop a local collection system. They are not appropriate for very dense or urban areas.

Pros	Cons
• Resistant to organic and hydraulic shock loads • High reduction of solids, BOD and pathogens • High nutrient removal if combined with aquaculture • Low operating cost • No electrical energy required • No real problems with flies or odours if designed and maintained correctly	• Requires large land area • High capital cost depending on the price of land • Requires expert design and construction • Sludge requires proper removal and treatmentEffluent and sludge require further treatment and/or appropriate discharge

Upflow Anaerobic Sludge Blanket Reactor (UASB)

The upflow anaerobic sludge blanket reactor (UASB) is a single tank process. Wastewater enters the reactor from the bottom and flows upward. A suspended sludge blanket filters and treats the wastewater as the wastewater flows through it. The sludge blanket is comprised of microbial granules (1 to 3 mm in diameter), i.e., small agglomerations of microorganisms that degrade organic compounds. As a result, gases (methane and carbon dioxide) are released. The rising bubbles mix the sludge without the assistance of any mechanical parts. Sloped walls deflect material that reaches the top of the tank downwards. The clarified effluent is extracted from the top of the tank in an area above the sloped walls.

UASB is not appropriate for small or rural communities without constant water supply or electricity. The technology is relatively simple to design and build, but developing the granulated sludge may take several months. The UASB reactor has the potential to produce higher quality effluent than Septic Tanks and can do so in a smaller reactor volume. Although it is a well-established process for largescale industrial wastewater treatment and high organic loading rates up to 10 kg BOD/m3/d, its application to domestic sewage is still relatively new.

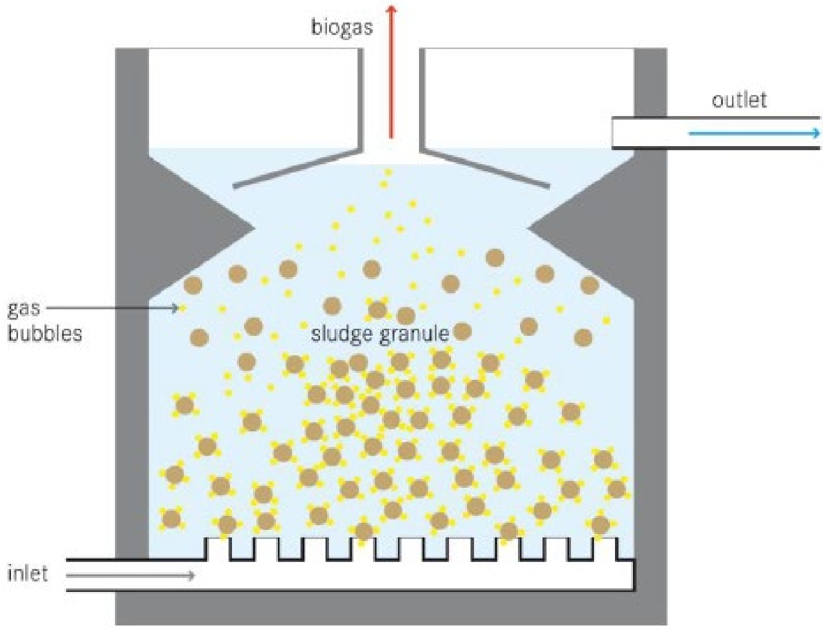

Figure 7 – Schematic diagram of UASB

Pros	Cons
• High reduction of BOD • Can withstand high organic and hydraulic loading rates • Low sludge production (and, thus, infrequent desludging required) • • Biogas can be used for energy (but usually first requires scrubbing)	• Treatment may be unstable with variable hydraulic and organic loads • Requires operation and maintenance by skilled personnel; difficult to maintain proper hydraulic conditions (Upflow, and settling rates must be balanced) • Long start-up time to work at full capacity • A constant source of electricity is required • Not all parts and materials may be locally available • Requires expert design and construction • Effluent and sludge require further treatment and/or appropriate discharge

Activated Sludge Treatment

An activated sludge process refers to a multi-chamber reactor unit that makes use of highly concentrated microorganisms to degrade organics and remove nutrients from wastewater to produce high-quality effluent. To maintain aerobic conditions and to keep the activated sludge suspended, a continuous and well-timed supply of oxygen is required. Different configurations of the activated sludge process can be employed to ensure that the wastewater is mixed and aerated in an aeration tank. Aeration and mixing can be provided by pumping air or oxygen into the tank or by using surface aerators.

An activated sludge process is only appropriate for a Centralized Treatment facility with a well-trained staff, constant electricity and a highly developed management system that ensures that the facility is correctly operated and maintained. Because of economies of scale and less fluctuating influent characteristics, this technology is more effective for the treatment of large volumes of flows. An activated sludge process is appropriate in almost every climate. However, treatment capacity is reduced in colder environments.

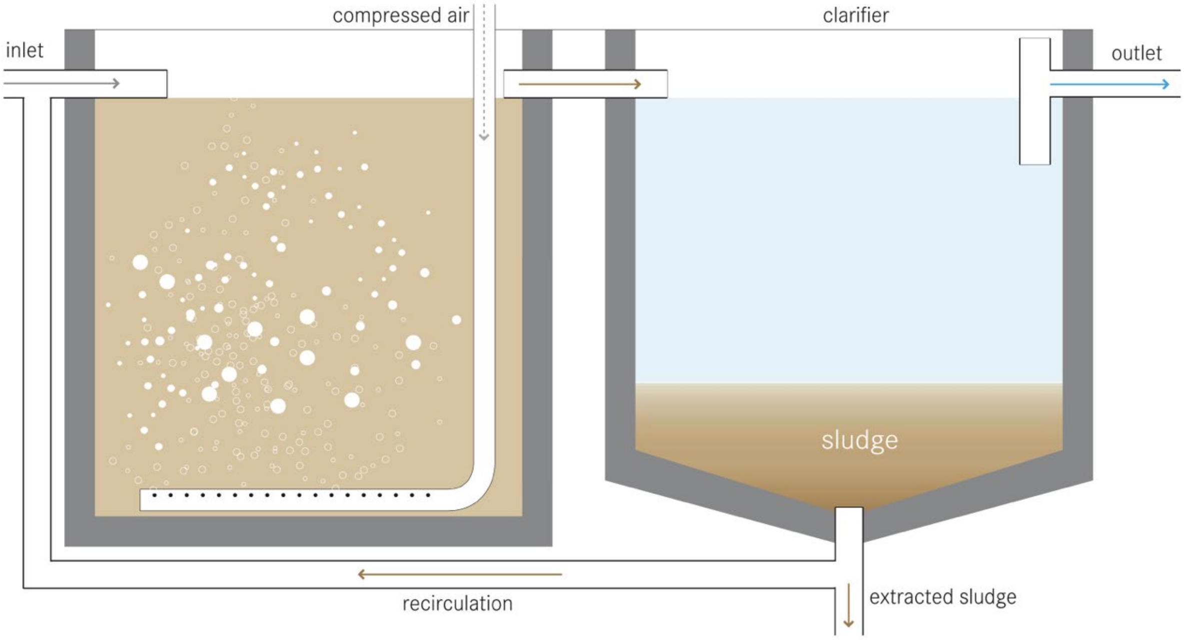

Figure 8 – Schematic diagram of ASP

Pros	**Cons**
• Resistant to organic and hydraulic shock loads • Can be operated at a range of organic and hydraulic loading rates • High reduction of BOD and pathogens (up to 99%) at after secondary treatment • High nutrient removal possible • Can be modified to meet specific discharge limits	• High energy consumption, a constant source of electricity is required • High capital and operating costs • Requires operation and maintenance by skilled personnel • Prone to complicated chemical and microbiological problems • Not all parts and materials may be locally available • Requires expert design and construction • Sludge and possibly effluent require further treatment and/or appropriate discharge

Sequencing Batch Reactor

The Sequencing Batch Reactor (SBR) is a different configuration of the conventional activated sludge systems, in which the process can be operated in batches, where the different conditions are all achieved in the same reactor but at different times. The treatment consists of a cycle of five stages: fill, react, settle, draw and idle. During the reaction type, oxygen is added by an aeration system. During this phase, bacteria oxidise the organic matter just as in activated sludge systems. Thereafter, aeration is stopped to allow the sludge to settle. In the next step, the water and the sludge are separated by decantation and the clear layer (supernatant) is discharged from the reaction chamber

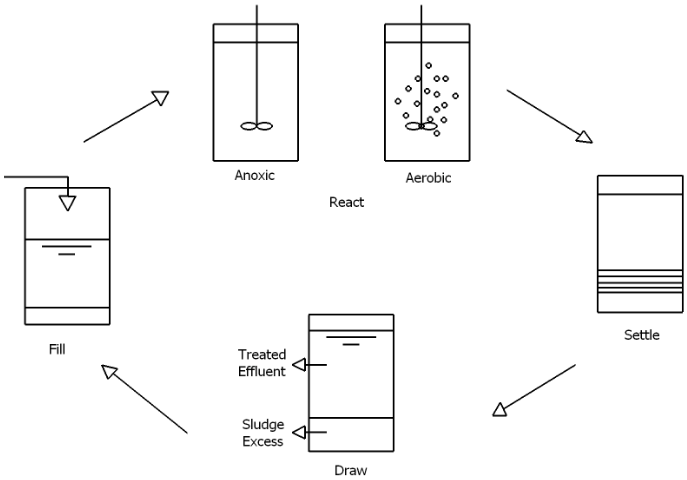

Figure 9 – Schematic diagram of SBR

At least two tanks are needed for the batch mode of operation as continuous influent needs to be stored during the operation phase. Small systems may apply only one tank. In this case, the influent must either be retained in a pond or continuously discharged to the bottom of the tank in order not to disturb the settling, draw and idle phases. SBRs are suited to lower flows, because the size of each tank is determined by the volume of wastewater produced during the treatment period in the other tank.

Membrane Bio-reactor

Membrane Bioreactors (MBR) are treatment processes, which integrate a perm-selective or semi-permeable membrane with a biological process (JUDD 2011). It is the combination of a membrane process like microfiltration or ultrafiltration with a suspended growth bioreactor, and is now widely used for municipal and industrial wastewater treatment with plant sizes up to 80’000 population equivalents. Due to it being a very technical solution; it needs expert design and skilled workers. Furthermore, it is a costly but efficient treatment possibility. With the MBR technology, it is possible to upgrade old wastewater plants.

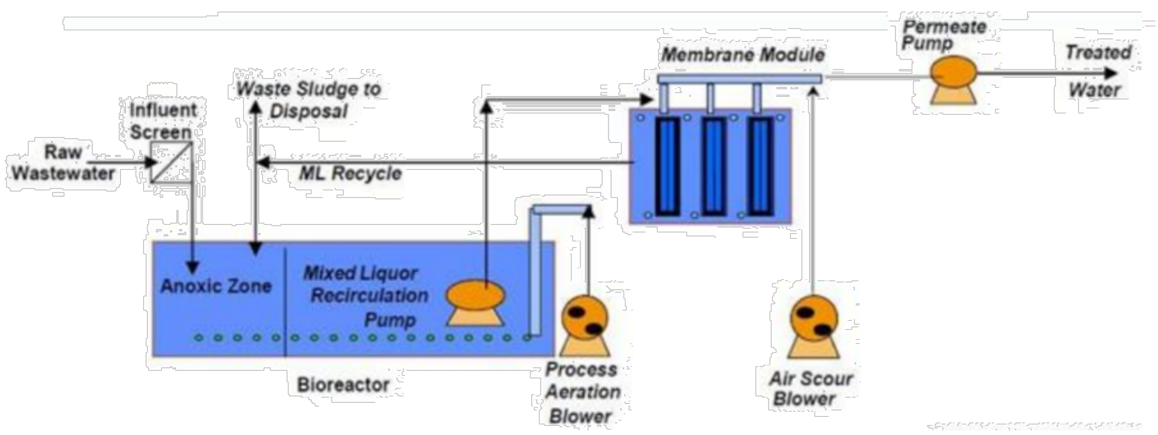

Figure 10 – Schematic diagram of MBR

Capacity/Adequacy	Applicable in conventional wastewater plants.
Performance	High
Costs	High capital and operational costs.
Self-help Compatibility	Low
O&M	Membranes need to be cleaned regularly.
Reliability	High if membranes are maintained correctly.
Main strength	Secondary clarifiers and tertiary filtration processes are eliminated, thereby reducing plant footprint.
Main weakness	High operation and capital costs (membranes)

Constructed Wetlands (horizontal flow)

A horizontal subsurface flow constructed wetland is a large gravel and sand-filled basin that is planted with wetland vegetation. As wastewater flows horizontally through the basin, the filter material filters out particles and microorganisms degrade the organics. The filter media acts as a filter for removing solids, a fixed surface upon which bacteria can attach, and a base for the vegetation. Although facultative and anaerobic bacteria degrade most organics, the vegetation transfers a small amount of oxygen to the root zone so that aerobic bacteria can colonize the area and degrade organics as well. The plant roots play an important role in maintaining the permeability of the filter.

The horizontal subsurface flow constructed wetland is a good option where land is cheap and available. Depending on the volume of the water and the corresponding area requirement of the wetland, it can be appropriate for small sections of urban areas, as well as for peri-urban and rural communities. It can also be designed for single households.

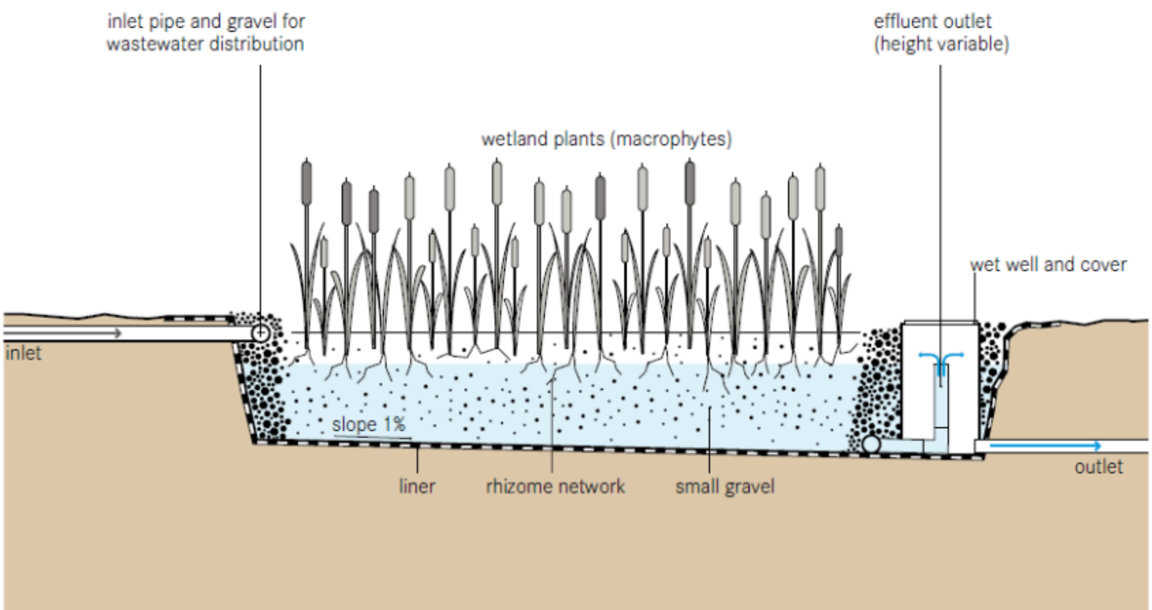

Figure 11 – Schematic diagram of horizontal flow constructed wetlands

Pros	Cons
• High reduction of BOD suspended solids and pathogens • Does do not have the mosquito problems of the Free-Water Surface Constructed Wetland • No electrical energy is required • Low operating costs	• Requires a large land area • Little nutrient removal • Risk of clogging, depending on pre and primary treatment • Long start-up time to work at full capacity • Requires expert design and construction supervision

Aerated Ponds

An aerated pond is a large, mixed aerobic reactor. Mechanical aerators provide oxygen and keep the aerobic organisms suspended and mixed with water to achieve a high rate of organic degradation. Increased mixing and aeration from the mechanical units mean that the ponds can be deeper and tolerate much higher organic loads than a maturation pond (see waste stabilization ponds). The increased aeration allows for increased degradation and increased pathogen removal. As well, because oxygen is introduced by the mechanical units and not by light-driven photosynthesis, the ponds can function in more northern climates.

A mechanically aerated pond can efficiently handle concentrated influent and significantly reduce pathogen levels. It is especially important that electricity service is uninterrupted and that replacement parts are available to prevent extended downtimes that may cause the pond to turn anaerobic.

Aerated ponds can be used in both rural and peri-urban environments. They are most appropriate for regions with large areas of inexpensive land located away from homes and businesses. Aerated lagoons can function in a larger range of climates than Waste Stabilization Ponds, and the area requirement is smaller compared to a maturation pond.

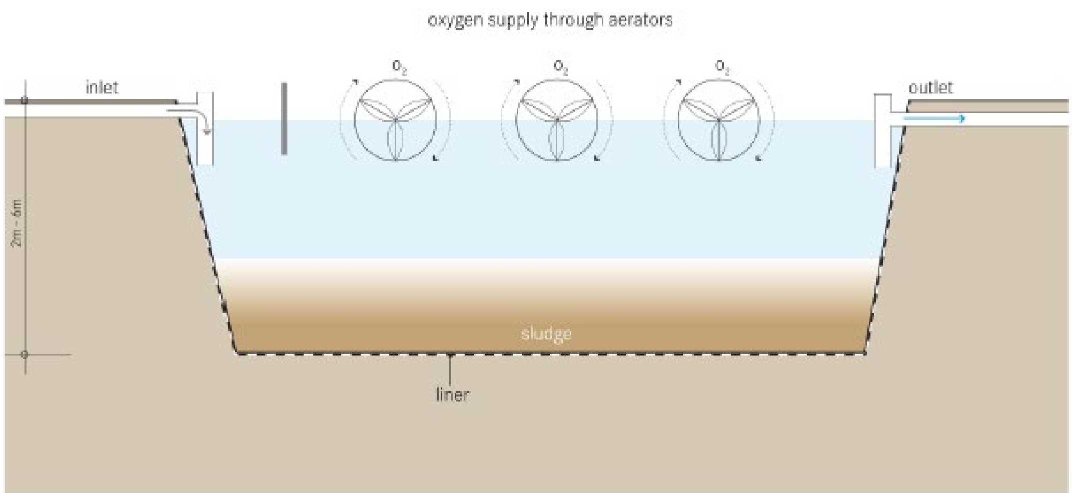

Figure 12 – Schematic diagram of aerated pond (Source: EAWAG, 2005)

Pros	Cons
• Resistant to organic and hydraulic shock loads • High reduction of BOD and pathogens • No real problems with insects or odors if designed and maintained correctly	• Requires a large land area • High energy consumption, a constant source of electricity is required • High capital and operating costs depending on the price of land and of electricity • Requires operation and maintenance by skilled personnel • Not all parts and materials may be locally available • Requires expert design and construction supervision • Sludge and possibly effluent require further treatment and/or appropriate discharge

Decentralised Wastewater Treatment System (DEWATS™)

DEWATS systems are effective, reliable, cost efficient and custom-made wastewater treatment systems, which are perfectly suited for small to medium-size systems at community level and for individual users like e.g. schools, hospitals, or enterprises. The technical options within DEWATS are based on a modular and partly standardized design. Most common DEWATS modules consist of settler, biogas settlers, anaerobic filters, anaerobic baffled reactors, planted gravel filters, anaerobic ponds, and aerobic ponds. However, wastewater treatment plants do not necessarily include all modules. DEWATS systems can be designed for individual needs.

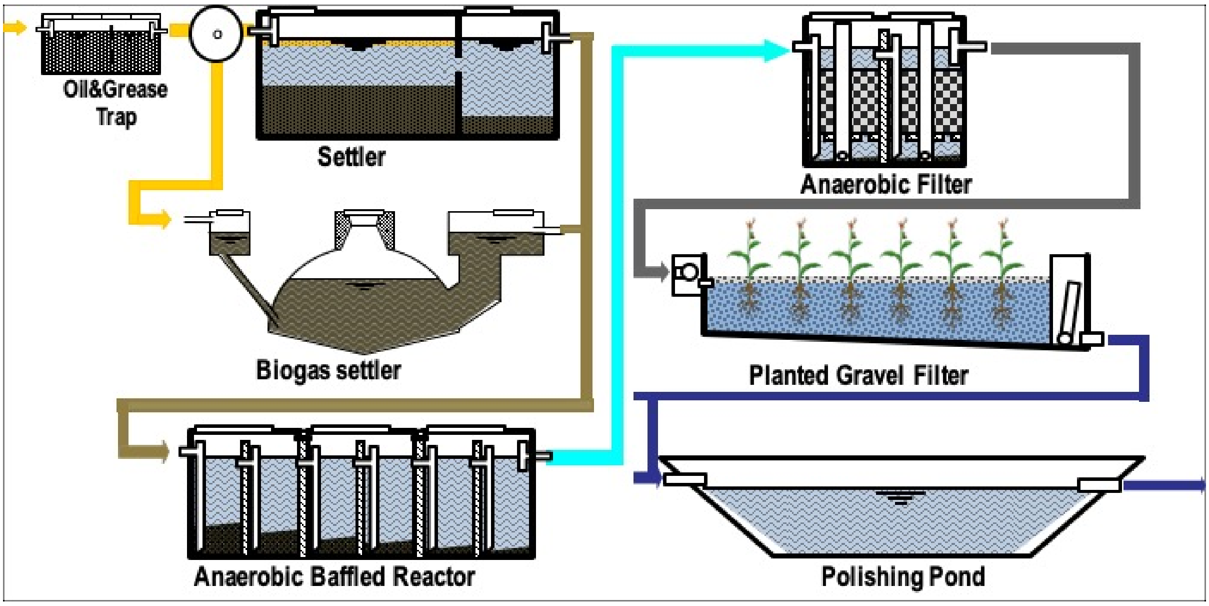

Figure 13 – Schematic diagram of DEWATS modules

Pros	Cons
• Can be applied at various scale (individual, community, cluster) • high treatment efficiency • pleasant landscaping possible • cheap in construction if filter material is easily available • no nuisance of odour • pathogen and nutrient removal • minimal or no energy requirement for treatment process • minimal skill requirement for operation and maintenance • Requires expert design and construction supervision	• high space requirement • requires expert design and construction supervision

Soil Biotechnology (SBT)

In SBT, soil is used as a media for treating the wastewater. SBT is a synthesis process which harnesses the energy, carbon and other elements of the waste and converts them to precious bio-energy products like vegetation, energy, soil, complete bio-fertilizer and water. The SBT is designed to provide the requisite filtration, aeration and bio – chemical processing for removal of toxicity, including Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nitrate, phosphate, suspended solids, colour, odour and bacteria.

In this method, wastewater is pumped or sprayed on the top of the sand bed. The bed consists of cultured soil media, consisting of a layer of boulders, pebbles and sand. The filtering materials are placed over a thick layer of plastic sheets, to prevent seepage loss of wastewater. The wastewater is repeatedly pumped on the top of the soil media using a pipeline network. The treated wastewater, which is collected in the furrows between the soil bund, is finally diverted to a collection well. The collection well also acts as an aeration tank. This water is finally pumped out and used for irrigation. Locally available wild plants are grown on the top of the soil to enhance the treatment process.

SBT can be applied for various scales of operation. The wastewater can be treated in batches, semi – continuous as well as continuous mode as per users requirement. The SBT process effectively removes COD, ammonium, nitrates, SS, bacteria, colour and odour. In this process, no sludge is produced. SBT offers a bacterial removal of approximately 99.99%, thus ensuring a healthier environment without any side effects. It functions at normal temperatures, is energy efficient and economical. SBT has total size flexibility and can be used in both urban and rural areas. SBT designs can be made inside the house and can be site specific. SBT has a low operation and maintenance cost as the system does not require any chemicals and energy is required only for the purpose of pumping.

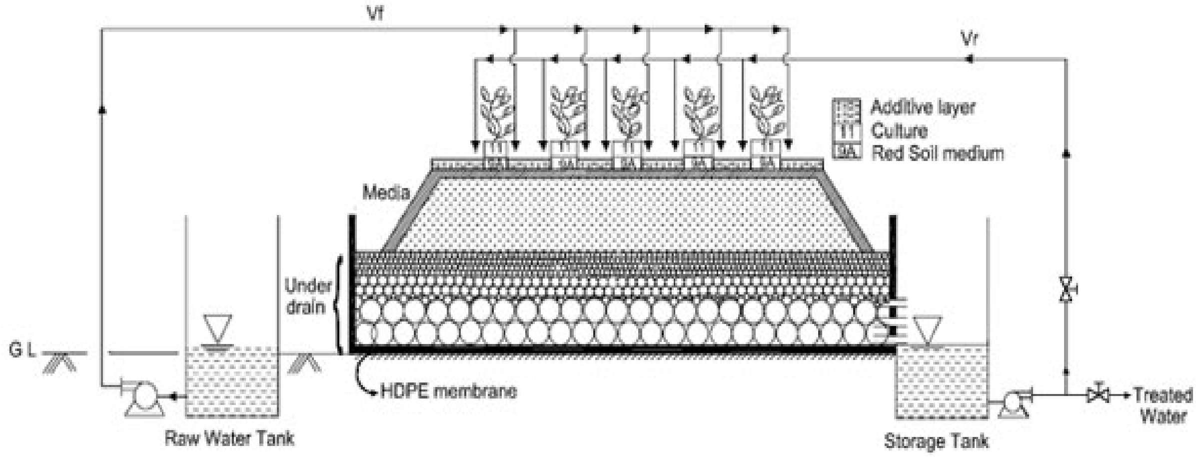

Figure 14 – Schematic diagram of SBT, Source: IIT, Mumbai

1.3.3 Faecal Sludge and Septage Management (FSSM)

Sanitation Value Chain

FSSM refers to the approach towards building a sustainable and environmentally safe infrastructure from containment to end use or disposal of faecal sludge from on-site sanitation systems (OSS). This includes the safe storage, collection, transport, treatment and end-use or disposal of faecal sludge. It is imperative to look at the sanitation market as a value chain where value can be added at each stage. It will, therefore, develop technologies, systems and services which accomplish this at each section of the chain.

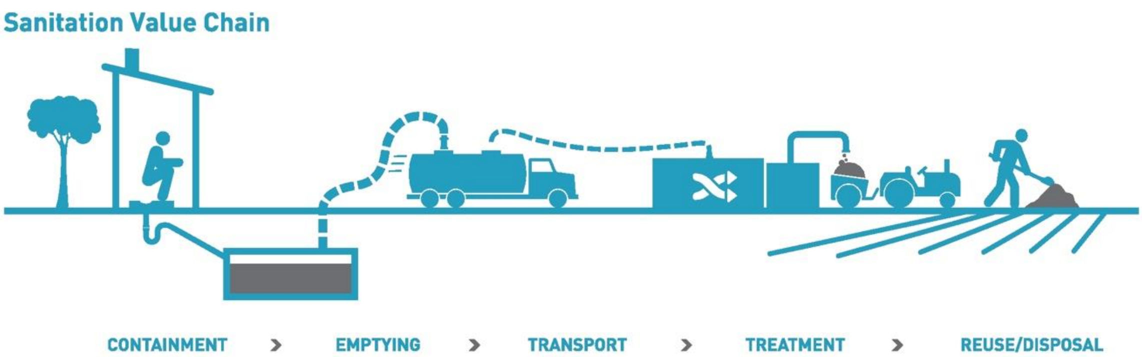

Figure 15 – Sanitation Value Chain (Source – BMGF)

User Interface

User interface explains the type of toilet construction—pedestal, pan or urinal—with which a user comes in contact; it is the way in which the user accesses the sanitation system. In most of the cases, the choice of the user interface depends on the availability of land and water and, also sociocultural factors. Only excreta and black/yellow water and wash water originate at the user interface, and not grey water (grey water is generated from domestic sources).

Collection/Storage/Treatment

Collection/Storage/Treatment explains the collection, storage and, sometimes, partial treatment of products that are generated from the user interface. The treatment that is provided by these technologies is often a function of storage and is usually passive (e.g., no energy inputs). Thus, products that are "treated" by these technologies often require subsequent treatment before use and/or disposal. The collection/storage/treatment component has limited capacity beyond which it cannot function effectively, and needs to be emptied.

Emptying and Conveyance

Emptying and conveyance describes the removal and transportation of FS from one place to another (e.g., septic tank to treatment plant). This becomes necessary when the collection/storage/treatment component has reached its capacity. In developing counties, trucks and small bores are mainly used for the transportation of sludge.

1.3.4 Shit Flow Diagram

A first step towards providing adequate sanitation services in urban areas is to monitor the sanitation service chain, is to identify its strengths and weaknesses, from containment, including emptying, transport, treatment and safe disposal or resource recovery. SFDs can help achieve this by offering a new and innovative way to engage sanitation experts, political leaders and civil society in coordinated discussions about excreta management in their city.

A Shit Flow Diagram (SFD) is an advocacy and decision support tool that summarizes and presents in a concise report what happens to excreta in urban areas. SFDs are a new way of visualizing excreta management in cities and towns. The fate of excreta produced by urban populations across the globe is often poorly understood. Particularly in low- and middle-income countries with rapidly expanding cities, excreta management represents a growing challenge; generating significant negative public health and environmental risks.

Why prepare an SFD?

- An SFD presents a clear picture of how wastewater and faecal sludge management (FSM) services are delivered in a city, and the resulting challenges.
- The SFD is a diagnostic tool that helps to identify the aspects of service delivery where improvements are needed.
- An SFD primarily provides technical and non-technical stakeholders with an advocacy tool to support decision-making on urban sanitation planning and programming.
- Importantly, an SFD does not provide a "shortcut" around integrated sanitation planning, promotion, investment, design, construction, operation and maintenance. These remain very necessary components for implementing successful urban sanitation (Source: https://sfd.susana.org/about/the-sfd)

As per the Census of India 2011, 31.16% of the country was urbanized. Linkages in the sanitation value chain in urban India have been patchy. A shit flow diagram of urban India reveals that only 6.7% of all waste water generated in cities of India is safely disposed[9]. A staggering 93.3% of the waste water is either discharged in the open or agricultural fields or in water bodies. Only 50% of all the waste water is emptied through centralized systems and emptying of OSS systems. Out of this 50%, 34.8% of the waste water is then conveyed to a treatment or disposal site and only 6.6% is treated.

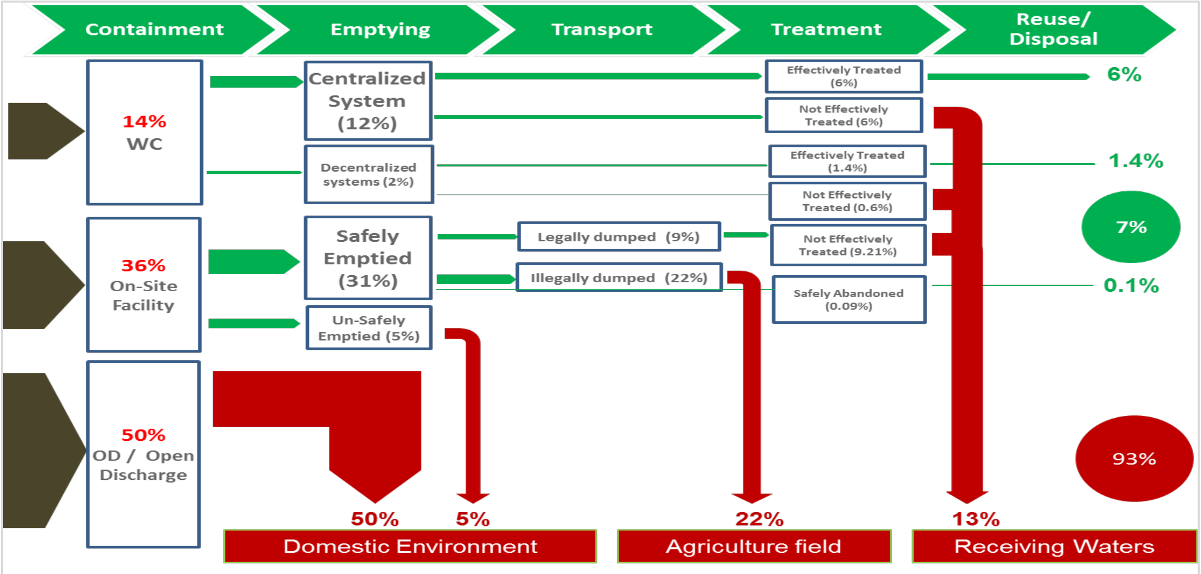

Figure 16 – Shit Flow Diagram (India), Source – Census 2011, Data analysis (CDD Society)

1.4 Urban Sanitation and Policy Context

Sanitation has been at the forefront of urban policy in India in recent times. The need to improve sanitation, however, was realised much earlier. Post-independent India was constantly struggling with its image as the symbol of insanitary living conditions. It was not long before the planning commission noted the magnitude of the problem by identifying the blatant disregard for sanitation in the development of towns by local authorities (First Five Year Plan, 1951). But urban policy on basic services in India traditionally linked sanitation with water supply, largely focusing on sewerage services. The Fourth Five Year Plan (1969-74) acknowledged that the "problems of sanitation require to be dealt with on a long term basis". The Sixth Plan (1980-85)finally recognised that urban development is inescapably connected with the provision of safe water supply and adequate sanitation and stated that the position in regard to urban sewerage and sanitation is even less satisfactory than water supply.

1.4.1 History of Sanitation Efforts and the Shifting Paradigm towards FSSM

Sanitation was included as an agenda item in Government of India's First Five Year Plan (1951-56), but the focus of the Central Government in the fifties was largely on housing and redevelopment of slums. The Slum (Clearance and Improvement) Act was formulated during this period. In the sixties and seventies, urban policy in India began taking a more concrete shape. There was a huge focus on promoting planned development of cities through the implementation of master plans. By eighties, when the 1981 Census revealed that 23.3% of Indian population lived in cities, most cities were characterized by lack of infrastructure, planning and unimproved sanitation facilities.

[9]CDD. (2016). *Faecal Sludge Management in India: Case of Devanahalli.* Retrieved May 2017, from https://smartnet.niua.org

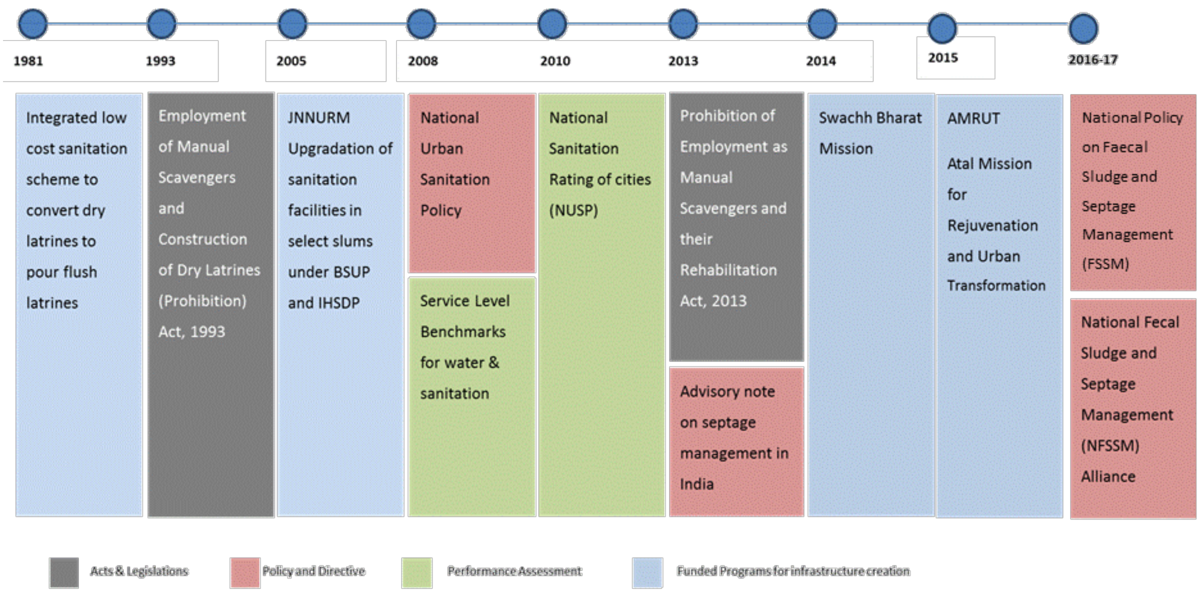

Figure 17 - Initiatives in the sanitation sector in India: A timeline, Source: UMC, 2017

Central government shifted from urban policy to infrastructure development. Sanitation became a prerogative of the local governments only with the passage of the landmark 74th Constitutional Amendment Act in 1992 that recognized cities and towns as the third tier of government through the constitution of ULBs. The Jawaharlal Nehru National Urban Renewal Mission (JNNURM), a massive urban renewal program targeting integrated development of urban infrastructure in 63 identified cities, mandated reforms and preparation of City Development Plans (CDP) that charted out plans by cities as to how they would develop land-use, transport and other basic infrastructure including sanitation. There was provision of funds and focus on creating sewage network and treatment facilities. However, all funds allocated to the sanitation sector were spent on construction of underground sewerage projects[10].

<u>Jawaharlal Nehru National Urban Renewal Mission (JNNURM)</u>

Recognizing the huge infrastructure deficits in Indian cities, the government of India launched JNNURM in late 2005. The programme was meant to infuse capital for infrastructure into select Indian cities as well as initiating a set of urban reforms. The mission focused on 65 selected cities (mostly million-plus), and included two sub-missions: Urban Infrastructure and Governance (UIG), which focused on infrastructure; and Basic Services for the Urban Poor (BSUP), with a focus on shelter for the urban poor. For all other medium and small towns in the country, the Urban Infrastructure Development. Scheme for Small and Medium Towns (UIDSSMT) and the Integrated Housing and Slum Development Programme (IHSDP) were launched with focus areas mirroring those of UIG and BSUP respectively. Sanitation investment went to expansion or retrofitting of sewerage networks, and there is little evidence of funds going to faecal sludge management. Only 6 per cent of the funds went to construction of STPs.

While there was a dedicated fund for the urban poor, it was limited to one-third of the investments. Moreover, most of this funding went to low-cost housing, as opposed to reaching out to larger

[10] Ministry of Urban Development, GoI. (2014, April 29). *Completed Projects.* Retrieved November 21, 2014, from JNNURM: http://jnnurm.nic.in/wp-content/uploads/2014/04/Completed-Projects-29-04-20141.pdf

numbers of urban poor through a range of slum upgrading programmes. JNNURM was designed to enable cities to develop their own priorities on the basis of city-wide planning, and the mission cities were required to submit a City Development Plan before they could access funds. However, most City Development Plans show remarkable similarities in priorities and kinds of projects selected across sectors[11]. While this similarity could be attributed to many factors, one possible constraint could have been that the projects had to be prepared in accordance with Central Public Health and Environmental Engineering Organisation (CPHEEO) manuals– and these listed only sewerage systems, leaving little scope for other technological options. Thus, most investment in urban sanitation in the last decade was directed to networked systems in larger cities. There is little evidence of cities adopting the whole wastewater approach.

National Urban Sanitation Policy (NUSP)

The National Urban Sanitation Policy was launched in 2008. It is remarkable that a policy was actually formulated for urban sanitation, given that there is no matching policy for urban water supply. Along with Indonesia's Sanitation Sector Improvement Programme, the NUSP is one of the few initiatives that has established a broad enabling environment for urban sanitation . The NUSP has several significant features, most of which point to new directions for urban sanitation in India. It recognizes the importance of the entire waste cycle, as well as open defecation free cities, and 100 per cent collection and treatment of waste are explicitly laid out as goals. In a remarkable departure from earlier initiatives, it promotes no particular technological solutions, instead encouraging all kinds of solutions. It also underlines the importance of operation and maintenance of all sanitary installations and facilities. Realizing the vast differences in the cities, it recommends that each state in India prepare a state sanitation strategy, and each city prepare a city sanitation plan.

The NUSP also places the needs of the urban poor right at the centre, highlighting the constraints that might limit their access – legal status, affordability and space constraints. It calls for the urban poor to be provided with sanitation facilities, irrespective of the legal status, and for delinking tenure from service provision. The NUSP addresses most of the priorities laid out in this paper. The biggest policy drawback is the absence of dedicated funding. It has had minimal impact on the nature of JNNURM investments, since the launch/design of JNNURM preceded the NUSP. However, other initiatives have been launched as a result of the NUSP. A rollout of state urban strategies and city sanitation plans as well as some of the initiatives listed below, can at least partly be attributed to the NUSP.

Swachh Bharat Mission (Urban)

The urban component of the Swachh Bharat Mission was launched in 2014 to eliminate open defecation, eradicate manual scavenging as well as implement modern and scientific SWM, generate awareness about sanitation and its linkages to public health, capacity augmentation for ULBs and to create an enabling environment for private sector participation in capex (capital expenditure) and opex (operation and maintenance) (GoI, 2014). The mission is implemented by the Ministry of Urban Development (now Ministry of Housing and Urban Affairs) and is supposed to cover 4,041 statutory towns in India till 2019. At the national level, the infrastructure driven approach started moving towards a holistic, integrated, people centered approach with the release of the NUSP in 2008. The policy moves away from prescribing piecemeal infrastructure solutions such as construction of toilets

[11] Wankhade, K (2012), *JNNURM: An Opportunity for Sustainable Urbanisation*, Indian Institute for human Settlements.

or STPs towards planning and implementing measures related to sanitation in various sectors as a cross-cutting issue.

Key thrust areas of the mission include,

- Elimination of open defecation
- Eradication of Manual Scavenging by converting insanitary toilets to sanitary
- Modern and Scientific Municipal Solid Waste Management
- Effecting behavioural change regarding healthy sanitation practices
- Awareness generation about sanitation and its linkage with public health
- Capacity Augmentation for Urban Local Bodies (ULBs) to create an enabling environment for private sector participation

1.4.2 Emergence of national Faecal Sludge and Septage management (FSSM) policy and expected outcomes

MoUD (now MoHUA) recognised that the end objectives and corresponding benefits of SBM cannot be achieved without proper management of faecal sludge and septage across the sanitation service chain. Further, it is well understood that sewerage coverage will not meet the complete sanitation needs in all areas. According to the data released in the report “Inventorization of Sewage treatment plants, 2015” by the Central Pollution Control Board, out of the 816 municipal sewage treatment plants (STPs) listed across India, 522 are operational (only 64% are functioning), 79 STPs are Non-Operational, 145 STPs are under construction and 70 STPs are proposed. A large number of toilets in India are dependent on on-site sanitation systems. With the increasing number of toilets under SBM, this number is increasing as these toilets have arrangements like septic tanks/pit latrines where sewerage network is not available. A strategy which is a combination of OSS and off-site (decentralised and centralised) must co-exist in all cities and must be given equal attention. Over time the relative proportions of coverage by OSS and off- site systems may change but both will need to be managed well.

In contrast with the large proportion of on-site sanitation systems, limited attention has been accorded to their proper construction, maintenance, management and safe disposal of faecal sludge and septage from such septic tanks and pit latrines. This problem of faecal sludge and septage needed to be addressed in a holistic manner, with a strategy that was appropriate and affordable for all areas, considering the local situation. It also needed suitable regulations, and institutional framework, capacity building and education and awareness among all stakeholders. In response to this, the then MoUD now MoHUA and a host of research and civil society organisations jointly drafted and signed a National Declaration on FSSM on 9th September, 2016 followed by the national FSSM policy launched in February 2017. The key objective of the urban FSSM Policy is 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 in each and every household, street, town and city.

National FSSM Policy

As this Policy is implemented across the country, it is expected to have significant benefits in terms of improved public health indicators, reduced pollution of water bodies, groundwater from human waste, and resource recovery leading to reuse of treated waste and other end products. Some key projected outcomes are:

- Containment of all human waste in 100% of the towns and cities.
- Safe collection and conveyance of human waste to treatment and disposal sites.

- Cost-effective solution for management of human waste through integrated network sewerage, small bore sewerage, and faecal sludge and septage management.
- Clarity among different stakeholders on identifying and implementing best and economically viable sanitation solutions.
- Technical capability among ULBs to effectively implement FSSM.
- Scheduled emptying of septic tanks or other containment systems at an interval of 2-3 years as recommended by CPHEEO Sewerage & Sewage Treatment Manual and the MoHUA Advisory on Septage Management (2013).
- Safe disposal of all collected faecal sludge and septage at designated sites (sewage treatment plants, faecal sludge treatment facilities for safe and scientific disposal, etc.).
- Continuous improvements in efficiency and effectiveness in the entire FSSM chain: containment, collection, conveyance, treatment and disposal.
- Preventing Contamination of water bodies and groundwater from human waste (faecal matter) in all the towns and cities across India.
- Nuisance from faecal sludge reduced to minimum levels, resulting in nuisance-free living space in urban India
- Maximum reuse of treated sludge as fertilizer in farmlands, parks, gardens and other such avenues, reuse of treated sewage, as source of energy where feasible, and any other productive uses.
- Drastic reduction in incidences of diseases due to safe & sustainable FSSM services

Only on-site sanitation facilities and areas served by such facilities would fall under the purview of this FSSM Policy. It does not seek to cover network or conventional sewerage system (including treatment plants) of wastewater/sewage management. However it will address synergies between FSSM and sewerage systems or municipal solid waste (MSW) management, e.g., co-treatment of faecal sludge and septage at sewage treatment plants or co-treatment and management of faecal sludge and septage, and MSW.

The launch of national policy on FSSM has given an impetus to addressing faecal sludge and septage management in cities where sewer systems are not possible or partially possible/available. This has led to awareness to address sanitation challenges at state and city level. Many states like Maharashtra, Odisha, Tamil Nadu, Chhattisgarh, Jharkhand, Bihar, Uttar Pradesh, Rajasthan, Telangana etc. have drafted their own FSSM policies or operative guidelines for ULBs which are aspired to be implemented at city level. The policy has given flexibility to states to assess their institutional framework and drafted their own approach towards FSSM implementation plans. This has led to state specific policies which address their own concerns based on their respective priorities.

States and cities have been urged to include FSSM as part of their AMRUT State Level Implementation Plans. Further, the AMRUT- Sub Mission introduced by MoHUA, specifically focuses on septage management in 500 AMRUT cities across the country. Due to availability of funding from various organizations and multinational agencies, focus is also on research and technical support to the state and cities unlike the conventional capital expenditure funding provision. The national competition of Swachh Survekshan, ODF+/ODF++ protocol launched by the MoHUA and the assessment done for 400 towns to rank the cities based on their cleanliness, sanitation and waste management also has dedicated indicators towards FSSM.

Many state governments have earmarked budget allocation for FSSM (around 100 million USD). Co-treatment is being promoted for more than 900 STPs all over the country. New FSSM mission is being planned for around 600 small towns. The efforts are being made for developing required institutional framework, strengthening local capacities, generating awareness and exploring involvement of private sector at appropriate levels of sanitation value chain. Focus has been also given on technological innovations, monitoring systems, quality assurance as well as introducing gender and social lens including community engagement.

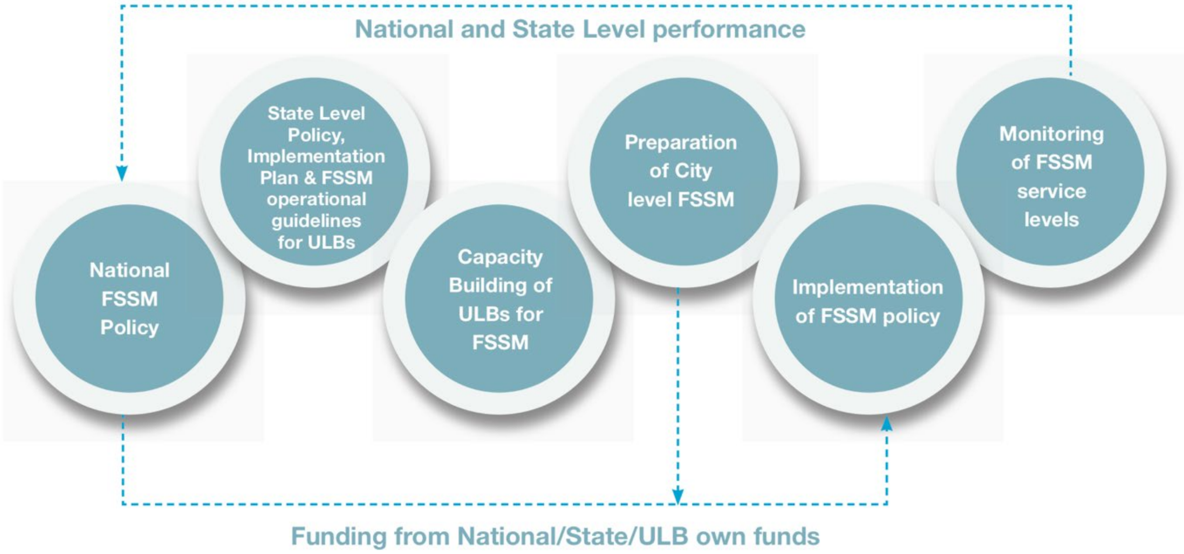

Figure 19 – Implementation process of FSSM policy (Source: FSSM Guidelines, 2016)

Table 4 – Overview of States having FSSM Policy

Sr. No	State	Population in Lakhs	No. of ULBs	Prepared in (Year)	Policy goals/ Objectives	Implementation Approach	Expected Outcomes
1	**Bihar**	1040.99	143	Jun-18	• To set context priorities, direction & to facilitate statewide implementation of FSSM services in all ULBs such that safe and sustainable sanitation becomes a reality for all in each household, street, town and city.	• Stakeholder's identification and engagement. • Baseline information assessment. • Suggest institutional framework, current economic model and business model. • Monitoring and grievance redressed systems. • Awareness generation capacity building for all stakeholders.	• Coverage of adequate sanitation system • Improved Collection efficiency of sanitation system • Adequacy of treatment capacity of sanitation system • Improved quality of treatment of sanitation system • Reuse and recycling and its extent in sanitation system
2	**Chhattisgarh**	255.45	168	Jun-17 (Draft)	• Establish FSSM as a central component in delivery of safe sanitation service. • Ensuring timely collection & treatment, optimum resource recovery, greater awareness and active participation. • Creating and enabling institutional & regulatory framework, innovation in service, delivery and management.	• IEC and stakeholder engagement • Institutional and Regulatory Framework • Partnership Building • Funding and financing • Implementation support and delivery • Monitoring and Evaluation • Capacity Building & training.	• Safe handling and complete containment of FSS during collection, conveyance, treatment and disposal. • Significant reduction in contamination of soil and water • Improvement in public health indicators including morbidity and mortality rates and reduced incidences of water borne diseases. • New opportunities based on cost recovery and profit generating business models.
3	**Gujarat**	604.39	159	2017	• Make all ULBs fully sanitized by 2019 and ensure safe sanitation to all citizens. • Suggest and identify methods, means and resources towards creation of an enabling environment for realizing safe and sustainable FSSM. • Define the roles and responsibilities of key stakeholders for effective implementation of FSSM service in the state. • Without compromising the strict environmental discharge standards, adopt an appropriate, affordable and incremental approach towards achieving these standards.	• By October 2019, all ULBs in Gujarat to mainstream FSSM and achieve the vision of National FSSM policy. • State to provide technical and financial support to ULBs for implementing FSSM in cities. • The ULBs to refer to the standard operating procedure for FSSM provided in guidelines for 'ODF towns' under Mahatma Gandhi Swachhata Mission.	• 100% containment of human waste of town and cities. • Safe collection and conveyance of human waste to treatment and disposal sites. • Cost effective solution for management of human waste through integrated network sewerage, small bore sewerage, and faecal sludge and Septage management. • Scheduled emptying of septic tanks at an interval of 2-3 years • Safe disposal of collected septage at designated site • Maximum use of treated sludge as fertilizer in farmlands, parks, gardens and other such avenues, reuse of treated sewage, as source of energy where feasible, and any other productive uses.

Sr. No	State	Population in Lakhs	No. of ULBs	Prepared in (Year)	Policy goals/ Objectives	Implementation Approach	Expected Outcomes
4	Jharkhand	329.88	45	2017 (Draft)	• To set the context, priorities, and direction for, and to facilitate, statewide implementation of FSSM services in all ULBs such that safe and sustainable sanitation becomes a reality for all in each household, street, town and city.	• A 3-phase approach designed to implement the policy. • To be implemented in the financial year 2017-18, in all the notified Nagar Nigam. • In the financial year 2018-19, to be implemented in all the notified Nagar Parisad • In the financial year 2019-20 it will be implemented in in all the notified Nagar Panchayats.	• Safe containment, collection and conveyance of 100% human waste to treatment and disposal sites. • Scheduled emptying of septic tanks at an interval of 2-3 years and disposal of collected waste at designated sites. • Contamination of water bodies and groundwater from human waste reduced to zero levels in all cities. • Maximum reuse of treated sludge and treated wastewater.
5	Madhya Pradesh	726.26	379	Mar-17	• To make cities and towns totally sanitized, healthy and livable, ensure, and sustain good public health and environmental outcomes for all their citizens. • To ensure improved health status of urban population, especially the poor and under privileged, through the provision of sustainable sanitation services and protection of environment.	• Separate System: Sewerage system to carry domestic sewage while drainage system for storm water. • Water reclamation centers to reclaim water after treatment of domestic sewage. • Grit chamber, Primary sedimentation tank, Reaction Tank, Secondary sedimentation tank, Chlorination Tank followed by sand filtration for treatment. • Reverse osmosis filtration may be used for tertiary treatment.	• Sludge produced from the treatment process shall be processed so that it can be used as a fertilizer and soil conditioner. • Sludge maybe dewatered, thickened and incinerated. Ashes maybe used for land fill
6	Maharashtra	1123.74	392	Feb-16	• To facilitate all ULBs in Maharashtra to prepare an integrated FSSM plan and implement in cities. • This would cover aspects across the service chain of on-site sanitation including safe collection, conveyance, treatment and disposal/reuse of the treated FS. • To provide ULBs with knowledge and procedures of preparing a septage management plan.	• Preparation of plan for septage management • Exploring private sector participation for septage management activities. • Awareness generation and capacity building activities. • Record keeping, reporting (MIS), and monitoring and feedback systems. • Financial Resource mobilization plan	• Converting insanitary toilets into sanitary toilets. Ensuring 100% access to toilets. Prepare database on toilets. • Providing access covers for regular cleaning. Enforcing regulations on septic tanks design. Data base of properties with septic tanks. • Preparing a schedule for periodic cleaning of septic tanks, to ensure that all septic tanks are cleaned at least once in 3 years. • Installing treatment facility for treatment of septage. • Revenue from safe dumping of treated faecal matter and or the sale of septage at a fixed rate.

Sr. No	State	Population in Lakhs	No. of ULBs	Prepared in (Year)	Policy goals/ Objectives	Implementation Approach	Expected Outcomes
7	Rajasthan	685.48	190	2018 (Draft)	• To establish FSSM as a central component in delivery of safe sanitation service by creating a favorable Environment for its effective implementation across all urban areas in a pragmatic, sustainable and participatory manner. • Ensuring timely and safe collection and transport of faecal sludge and septage & complete treatment of all collected waste. • The treatment facility would maximize reuse of treated wastewater and sludge.	• Full scale FSSM with dedicated FSTP to be implemented in cities without centralized network (existing or proposed) and in small and medium towns (Class- III, IV & V except district headquarters). • Partial FSSM with decentralized FSTP or co-treatment at STP shall be implemented in cities with partial coverage of sewerage network. • In large cities where areas are inaccessible to desludging vehicles, decentralized systems shall be adopted.	• Enhancement of sanitation coverage • Environmental improvement, significant reduction in contamination of soil and water (surface and underground) due to human waste. • Safe waste handling and better Public Health • Employment Generation Skilled manpower for FSSM through incremental capacity building program, also evolving opportunities under FSSM as mainstream career prospects for young professionals.
8	Tamil Nadu	721.47	135	Sept-2014	• To decentralize the septage management system and to improve the existing facility. • To ensure that proper design of containment systems • To ensure safe transportation of sludge	• Design and construction of Septic tanks • Septage Transportation • Treatment and Disposal with cluster level FSTP. • STP to have decanting facility designed for septage for 5 year planning horizon • Fees/Charge for Collection. • To have licensed operators for transport • Information Education and Communication	• All septic tanks are constructed as per standard design and all insanitary latrines are converted to sanitary ones • Periodic and safe collection of all sewage generated in the Local Body by residential, commercial institution. • All stakeholders to be given periodical training on safe and best practices in septage management
9	Telangana	351.94	73	Mar 2018	• To establish safe, hygienic and sustainable sanitation systems. • To enable city to capture the wastewater generated from all sources within the city boundaries and treat to the required standard for a clean, healthy and sanctioned city keeping into consideration the public and environmental health outcomes.	• At household, community and ward level with a suitable transport and treatment option, grey water and black water to be collected and treated separately. • The cities shall select the technologies in a manner that the reduction of contaminants in wastewater and septage achieved to the discharge standards.	• Achieve 100% public health and hygiene protection. • Best-designated conjunctive use and management of the water & wastewater resource efficiency, recovery and sustainability.

Sr. No	State	Population in Lakhs	No. of ULBs	Prepared in (Year)	Policy goals/ Objectives	Implementation Approach	Expected Outcomes
10	**Uttar Pradesh**	1998.12	635	Feb-18	• To set context, priorities, and direction for, and to facilitate, statewide implementation of FSSM services in all ULBs such that safe and sustainable sanitation becomes a reality for all in each household, street, town and city.	• Stakeholder's identification and engagement • Task force with collection and analysis of baseline data. • Suggested institutional framework. • FSSM strategy integrated state and city sanitation plans in overall conformity to the national policy. • Monitoring and grievance redressal systems.	• Treatment of adequate sanitation system • Enhanced Collection efficiency of sanitation system • Adequacy of treatment capacity of Sanitation System • Quality of treatment of sanitation system • Extent of reuse and recycling in sanitation system
11	**Odisha**	453.47	114	2017	• Goal is to make all cities and towns in the state very clean, sanitized, safe, healthy and livable, managed by ULBs with active citizen and stakeholder participation.	• Drafting and issuing of sanitation management guidelines for the ULBs - Environmental, Technical standards, public health indicators. • Safety standards for workers. • ULB accountable with regard to service delivery and assets created and managed. • Service delivery could be through agencies contracted by the ULB but all non-household assets would be owned by the ULB with clear lease arrangements for users. • ULB to have key regulatory role over all agencies/ households in the city for outcomes and stipulated process standards, subject to due cognizance of law.	• Urban areas are Open Defecation Free (ODF) and Open discharge free (ODF++) . • Sewage, septage/faecal sludge, and liquid waste is safely managed, treated, and disposed. • Safety standards and guidelines followed in the physical handling and management of waste. • Cities / towns do not discharge untreated waste (water and faecal waste) into the water bodies of Odisha

1.5 Urban Sanitation and Gender

WASH sector literature on gender and sanitation is unfortunately dominated by a limited discourse on menstrual hygiene, the life cycle cost of sanitation and women's' access to toilets.

Gender equity becomes an issue when women and girls lack access to toilet facilities and appropriate hygiene education. Opportunities for learning are lost when children have to spend time collecting water or finding a safe place to defecate or urinate in the open. Many girls may permanently drop out of school with the onset of puberty if the toilet facilities are not clean or do not provide privacy to girls while they are menstruating. Menstruation is a taboo subject in many cultures and can create stigma, shame, and silence among young girls, which often continues into adulthood and perpetuates the cycle of gender inequality.

Women are often vulnerable to harassment or violence when they have to travel long distances to fetch water, use shared toilets, or practice open defecation. Women and girls often wait until nightfall to defecate, which increases the risk of assault. Many choose to 'hold it' or limit their consumption of food and drink to delay the need to relieve them, which can increase the chance of urinary tract infections. The shame and indignity of defecating in the open also affects women's self-esteem, as does a lack of water for washing clothes and personal hygiene[12]. (WaterAid, 2015)

Women are assumed to represent a homogenous category, devoid of caste and class differentiation. The urban sanitation study undertaken by SOPPECOM highlights the issues of how women discriminate among each other (higher caste women objecting to lower caste women using common public toilets) on the basis of caste.

Gender perspective in WASH is possible when women's access to water and sanitation is looked both from the patriarchy at the family, culture, religion and social group level, as well as from the larger perspective of urbanization, dispossession and illegality of slum settlements that impacts women. The Jagori study of water and sanitation in urban slums of Delhi does this well.

The working-classes in Delhi have been subject to a systematic process of dispossession and impoverishment for the last three to four decades. Forcible eviction from slums in Delhi and relocation to the periphery of the city forms the core of this process as most of the evicted work in the informal sector. Such relocation to colonies such as Bawana on the periphery of the city make it impossible for them to continue to attempt to earn sustainable livelihoods. In order to understand the impact of eviction on people's livelihoods, action research, since 2004, has been undertaken in Bawana. The abysmal conditions of water supply in the area and the fact that the burden of filling water falls on women and young girls have been noted by Menon Sen & Bhan in "Swept off the Map: Surviving Eviction and Resettlement in Delhi" (2008: Jagori & Yoda Press).[13]

Within a slum or a poor urban settlement, women whose caste and class are among the lowest in the social hierarchy, usually the rag pickers or those employed in manual scavenging work, suffer the most in terms of denial of sanitation services and payment for work done.

The most studied aspect of women and sanitation (not gender and sanitation), is the women's access to public toilets and how women suffer from poorly maintained public toilets.

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12 WaterAid. Post-2015 Toolkit: WASH and Gender Equality. Retrieved from https://sustainabledevelopment.un.org/getWSDoc.php?id=2428

13 http://jagoriwp.jagori.org/our-activities/fellow-research/rights-and-access-to-watsan/

The Urban Management Centre (UMC), based in Ahmedabad, conducted a technical audit of all public conveniences such as PT and CT in the jurisdiction of Ahmedabad Municipal Corporation in 2013. Survey results shows, majority of the community toilets (63%) did not have separate sections for men and women. Nearly 90% of public urinals did not have separate sections for men and women. Most of the urinals were for men only. Based on discussions with user groups, 15% women expressed that they felt unsafe using PTs while 20% women felt unsafe using a toilet that did not have separate sections for females. Considering the toilet accessibility for the physically disabled, 97% PTs were not designed to be accessible for the disabled. There was no provision of ramps, handrails for easy access. (Urban Management Centre, 2013). For better designing of public conveniences in terms of gender friendly, child friendly and disabled friendly, an e-learning course is available on the Swachh Bharat e-course portal. One can register for course number "413 – Designing of Community and Public Toilets" under course series 400.

Water, sanitation, and hygiene do play a large role in the lives of adolescent girls and women, both biologically and culturally. However, a limited understanding of gender as a biological differentiator and not a power construct, is usually applied in most WASH programmes and in Behaviour change communication.

Gender as a power construct should not be blindly applied in WASH to show that woman's preference for toilets is always negated by men or that men are never concerned about woman's safety while going for open defecation (SOPPECOM study).

Caste and urban sanitation

It is not unknown; however, there is extensive research that shows that caste has a major influence on achieving rural sanitation goals[14]. The Hindu notions of purity and pollution, inextricably linked with the caste system and the practice of untouchability, underlie the unsanitary practices in Indian society. These beliefs perpetuate the oppression of the "polluted castes," which are forced to undertake manual scavenging, unclog manholes and clean other people's filth. The availability of cheap Dalit labour to do these dehumanizing jobs can be cited as one of the reasons why development of toilet facilities and a modern garbage and sewage management system have been neglected so far[15]. (Subhash Gatade, Economic & Political Weekly, 2015).

The World Health Organization (WHO) estimates that when a normal latrine (meaning a latrine with a 50 cubic meter, honeycomb-style pit) is used daily by a family of six members, it will fill up after about five years. When the pit fills up, the owners must either empty it or build a new pit. In rural India, as in other parts of the developing world, when honeycomb-style latrine pits are emptied, it is done by hand. Biological germs turn out not to be the barrier to pit emptying. People in rural India equate manually emptying a latrine pit with the most degrading forms of Dalit (lower caste who generally engaged in cleaning pits and sewer lines) labour. Therefore, the idea of manually emptying a latrine pit is at least as reviled for its social implications as it is for the physically disgusting nature of the work. (Diane Coffey and Dean Spears, 2017)

Urban sanitation challenges are multi-dimensional when it comes to the understanding of caste, class and gender. However not much research has been done to address urban sanitation challenges from the gender, caste and class perspective in India.

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14 http://riceinstitute.org/research/culture-and-the-health-transition-understanding-sanitation-behavior-in-rural-north-india/

15 Retrieved from "Silencing Caste, Sanitizing Oppression, Understanding Swachh Bharat Abhiyan" – A perspective paper by Subhash Gatade in Economic and Political Weekly, October 31, 2015.

A recent research[16] on urban sanitation by Society for Promoting Participative Ecosystem Management (SOPPECOM) highlighted the following:

- Poor slum-dwelling women have developed habits that fit their caste, stage in the life course, marital status, etc. Nonetheless, every day is a different day, and the fears and discomfort that women confront are not necessarily the same in content, intensity, or even present on any given day, depending on the circumstances that they leave at home, their physical condition that day, and the presence/absence of certain groups/individuals at/near the defecation site.
- Discussion of the multiple inequalities that constrain women's choices surrounding sites of defecation begs the question, "What might the provision of adequate sanitation do to curtail gendered violence?" We find that individual women experience the risks of inadequate sanitation differently, but at broader scales, we reach the conclusions that provision of adequate sanitation is not sufficient to alter gendered social relations. Adequate sanitation without attention to gendered relations of power puts the burden of safety on women, and does not address the caste and gender-based patterns of violence against women.
- Provision of a toilet whether public or individual is not sufficient, its maintenance is a key issue. Maintenance of PTs has to be the ultimate responsibility of the ULBs. These toilets have to respond to needs of diverse women (for example old, pregnant, with children, disabled, belonging to different religious and caste communities) by being better lit, in safer locations and with regular provisioning of water. A need for a community mental health centre was evident given the various psycho- social stresses that women faced. (Society for Promoting Participative Eco-system Management, 2013-14)

16 https://www.soppecom.org/pdf/sanitation-vulnerability.pdf

Anecdote of Experiences of Women Harassment[17]:

- Sanitation in terms of open defecation and PT maintains the status quo of unequal gender relations. These relations intersect with relations of age, caste, and class. Seen as a struggle over resources, negotiations around the safe use of OD and PT sites were often to the disadvantage of women (e.g., inability to go at night).
- Widows faced more physical insecurity, but even married women avoided telling their husbands about harassment or being assaulted out of fear of conflict.
- Husbands set limits on wives' movement, time spent going for OD, and time of day of going out.
- However, gender relations were not necessarily antagonistic at the HH scale. A woman could ask her husband to accompany her for defecation. Husbands also responded to their wives' requests for Individual household latrines (IHLs) for themselves or daughters.
- Community played a significant role in shaping women's experiences around harassment. Belonging to a majority community had some advantages in both the cities. In Pune in Ambedkar Basti Marathi women told us that the Marathi municipal Corporator (ward level political representative) belonging to a right wing regional party had "fixed" the non-Marathi men and there was thus overall less violence against women in the Basti.
- Research shows that membership in the slum's dominant caste served as protection to married women, while women outside that caste might still be targets of harassment. In Jaipur women of dominant castes claimed they felt no fear, faced no trouble, and had little experience with harassment. In Pune one of the few upper caste women we interviewed told us how insecure she was in the midst of Dalits and how she feared for her daughter's safety. We argue that such talk may be true, but it enables these women to put distance between themselves and other women's experiences and fears in the settlement.
- 'Women' are not a single entity, so we need not be surprised that caste and community relations present a division.
- Women showed little hesitation to point out caste groups that engaged in harassment, but responses about sexual assault usually blamed an outsider. This may be because women were reluctant in small bastis to name someone, but it also suggests that those outside community sanctions with access to women at OD places (e.g., along a busy road) seized opportunities to assault when they presented themselves. Notably, in both Pune and Jaipur, women's triumphant responses to attackers were against outsiders.
- Overall, the possibilities for women joining forces across caste groups seem minimal.
- Communities in Jaipur are rigidly caste divided, as evidenced by a riot in one of the slums during our interview period. Little community solidarity was evident against sanitation-related violence or for the provision of sanitation.

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[17] Ibid

Manual Scavenging

a. Due to lack of awareness and technical understanding, HHs typically do not construct their OSS systems as per design guidelines. Also, it's a belief that keeping more depth of the pits will not allow frequent overflow of waste water from the OSS systems. These results workers to enter into pit and manually dig out dried feces from deep unlined pits, which lead to the dehumanizing practice of manually cleaning human excreta from dry/insanitary latrines which is known as manual scavenging. Many private and informal contractors are involved in providing emptying services. In many cases, informal workers are employed for cleaning the septic tanks by residential societies which may potentially lead to manual scavenging.

b. The practice of manual scavenging is linked with the caste system. A person from lower caste is expected to do this job. To eliminate manual scavenging, the "The Prohibition of Employment as Manual Scavengers and Their Rehabilitation Act, 2013" came into force. This act prohibits the construction or maintenance of insanitary toilets and engagement or employment of anyone as a manual scavenger. Violation of the Act could result imprisonment for a year or a fine of ₹ 50,000 or both. This act also offers rehabilitation of a person engaged in manual scavenging occupation. It is the responsibility of the ULBs to identify the manual scavengers in the city by conducting a primary survey and to rehabilitate them by providing alternate secured livelihood. The Act aims to help cities to identify and rehabilitate manual scavengers in the city.

c. Typically, many private agencies operate in the sector of emptying waste water from OSS systems and who take higher charges from the owners of OSS systems. There could be potential chances of manual scavenging where private agencies provide emptying services as the ULBs have no control on private sector. To comply with the Act, cities have started empaneling the private agencies which will work on the terms and condition provided by the ULB, which ensures manual scavenging will not be occurred during emptying of OSS systems and cleaning of sewer lines and manholes. This will help cities to prevent and to end the practice of manual scavenging.

d. Based on an elaborate study undertaken by Urban Management Centre in the Ahmedabad Municipal Corporation to help conform with the Act, Manual scavenging may occur due to manual
    - Cleaning of open defecation spots,
    - Emptying OSS systems,
    - Cleaning of sewer lines and manholes,
    - Cleaning of PTs, and
    - Cleaning of excreta from insanitary latrines.

But, it can be avoided by considering following things:

- Cities should have adequate suction based vacuum trucks to empty the waste water from OSS systems as Manual Scavenging Act clearly states waste water emptying should be done in a mechanical way. The ULB could either have these trucks themselves or the city should empanel private agencies for emptying OSS systems.
- Safety gears should be given to the workers engaged in waste water emptying and disposal system, and
- Capacity building of the workers and staff engaged in FSSM services. (Urban Management Centre, 2015)

2 Waste types and characteristics

2.1 Waste types

The urban water cycle is one of the key processes connecting human activity to natural systems. The health and well-being of both human population and environment is therefore dependent on the integration of urban water systems with the natural systems. The generation of liquid waste from human activities is unavoidable. However, not all humans produce the same amount of liquid waste. The type and amount of liquid waste generated in households are influenced by behavior, lifestyle and standard of living of the population as well as by the governing technical and judicial framework. (*Henze and Ledin, 2001*).

The different sanitation systems generate the following products:

Blackwater - is the mixture of urine, feces and flushing water along with anal cleansing water (if anal cleansing is practiced) or dry-cleaning material (e.g. toilet paper).

Greywater is used water generated through bathing, hand-washing, cooking or laundry. It is sometimes mixed or treated along with blackwater.

Urine is the liquid not mixed with any feces or water.

Brown water is blackwater without urine.

Domestic wastewater comprises all sources of liquid household waste: Blackwater and greywater. However, it does not include storm water.

Excreta is the mixture of urine and feces not mixed with any flushing water (although small amounts of anal cleansing water may be included).

Faecal Sludge is raw or partially digested in slurry or semisolid form, the collection, storage or treatment of combinations of excreta and black water, with or without grey water. It is the solid or settled contents of pit latrines and septic tanks. The physical, chemical and biological qualities of faecal sludge are influenced by the duration of storage, temperature, soil condition, and intrusion of groundwater or surface water in septic tanks or pits, performance of septic tanks, and tank emptying technology and pattern. *(Ministry of Housing and Urban Affairs, 2017)*

It is estimated that 1 truck of faecal sludge and septage carelessly dumped equals to 5,000 people defecating in open. 1 gram of feces may contain one hundred parasites eggs, one thousand protozoa, 10 lakh bacteria and 1 crore virus.

Septage is the liquid and solid material that is pumped from a septic tank, cesspool, or such on-site 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.

The effluent from the septic tank can be collected in a network of drains and/or sewers and treated in a treatment plant designed appropriately. The accumulating sludge at the bottom of the septic tank however, has to be also removed and treated once it has reached the designed depth or at the end of the designed desludging frequency whichever occurs earlier. Such a removal is possible only by trucks. While sucking out the sludge, the liquid in the septic tank will also be sucked out. Such a mixture is referred to as septage. (National Policy on Faecal Sludge and Septage Management, 2017)

It is required to dispose septage safely otherwise it can impact on health. Due to wrong designs of the septic tanks and twin pits, waste water ends up mixing with ground water which can lead to water borne diseases and environmental issues.

3 Sanitation systems and technologies

3.1 Sanitation System

3.1.1 What is a Sanitation system?

A Sanitation System is a context-specific series of technologies and services for the management of these wastes (or resources), i.e. for their collection, containment, transport, transformation, utilization or disposal. A sanitation system is comprised of Products (wastes) which travel through Functional Groups which contain Technologies which can be selected according to the context. By selecting a Technology for each Product from each applicable Functional Group, one can design a logical Sanitation System. A sanitation system also includes the management, operation and maintenance (O&M) required to ensure that the system functions safely and sustainably.

Table 5 – Classification of Sanitation Systems

Waterborne or Wet – Requires water for its functioning	Non-Waterborne or dry – No need water for its functioning
• Full flush or cistern flush (water comes from the cistern) • Pour flush (use of bucket to throw water for flushing purpose) • Low flush toilet (flushing mechanism release small quantity of water) • Aqua privy	• Urine diverting dry toilet (UDDT) • Dry toilet (sit or squat pan) • VIP toilet • Vault toilet

Sanitation systems can be mainly classified as waterless and water-based systems. Classification is usually defined by user interface and collection technology. Waterless systems are single pits, Waterless Alternating Double Pits and waterless urine diversion systems whereas, the water-based systems are Pour Flush with Urine Diversion, Decentralized Blackwater Treatment, (Semi-) Centralized Blackwater Treatment, Sewerage with (Semi-) Centralized Treatment.

3.1.2 What are the Functional Groups of a sanitation system?

A sanitation system should consider all the products generated and all the Functional Groups these products are subjected to before being suitably disposed of. Domestic products mainly run through five different Functional Groups, which form together a system. Note: depending on the system, not every Functional Group is required. A functional group is a grouping of technologies that have similar functions. There are five different functional groups from which technologies can be chosen to build a system. The five functional groups are:

- User Interface
- Containment and Storage/Treatment
- Conveyance
- Treatment
- Use and/or Disposal

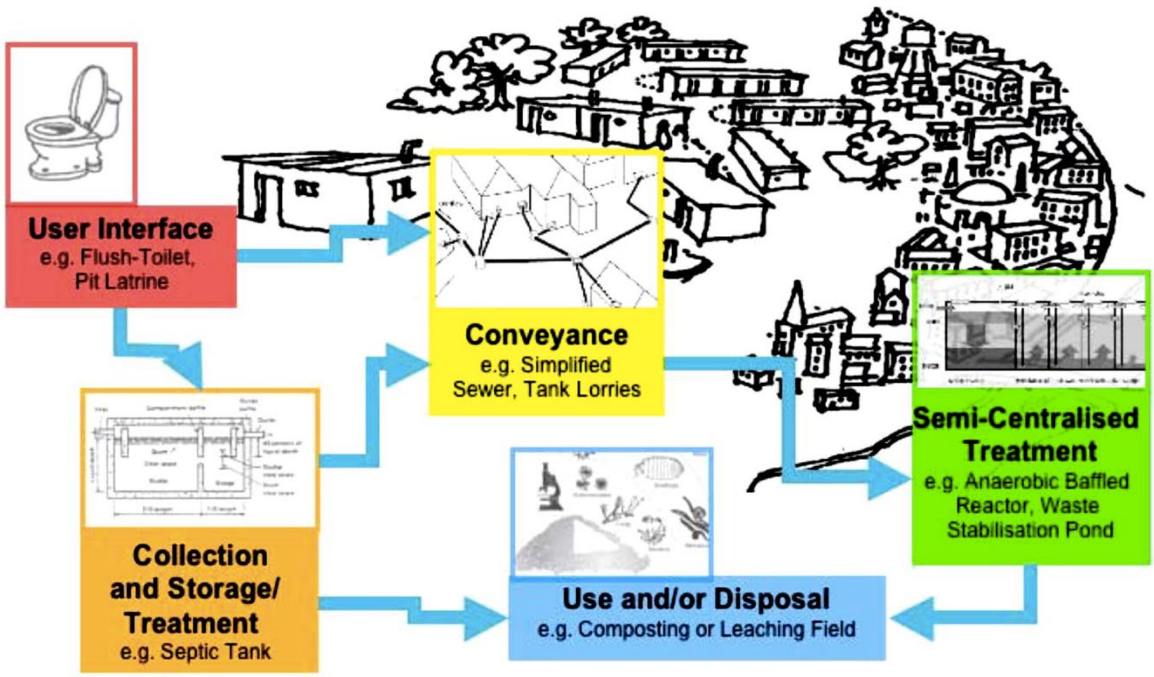

Figure 20 – Functional groups of sanitation (Source: SANDEC, 2008)

A sanitation system should consider all the products generated and all the functional groups these products are subjected to prior to being suitably disposed. Domestic products mainly run through five different functional groups, which form together a system. Addressing only the first functional group i.e. user interface, does not ensure suffice unless management of the faecal sludge generated from the toilets and management of liquid effluent flowing untreated open drains is ensured. Hence, a comprehensive approach to sanitation addressing all the functional groups starting from generation of septage to its disposal or reuse is urgently needed.

Selection of appropriate sanitation systems

Though processes and products in each functional group are pre-listed, selection of appropriate option is important. The selection should be context specific context-specific and should be made on the basis of the local situation, site context, culture and available resources. Assessment of these is essential before finalizing the desired system.

3.1.3 Functional group – User Interface

The user interface must guarantee that human excreta is hygienically separated from human contact to prevent exposure to fecal contamination. The user interface is the way in which the sanitation system is accessed. Choice of the user interface has a significant impact on the entire system design, as it defines the products or product mixtures fed into the system. Therefore, the user interface strongly influences the technological choices of subsequent processes.

Selection of user interface depends on the following six technical and physical criteria

- Availability of space
- Ground condition
- Groundwater level and contamination
- Water availability
- Climate

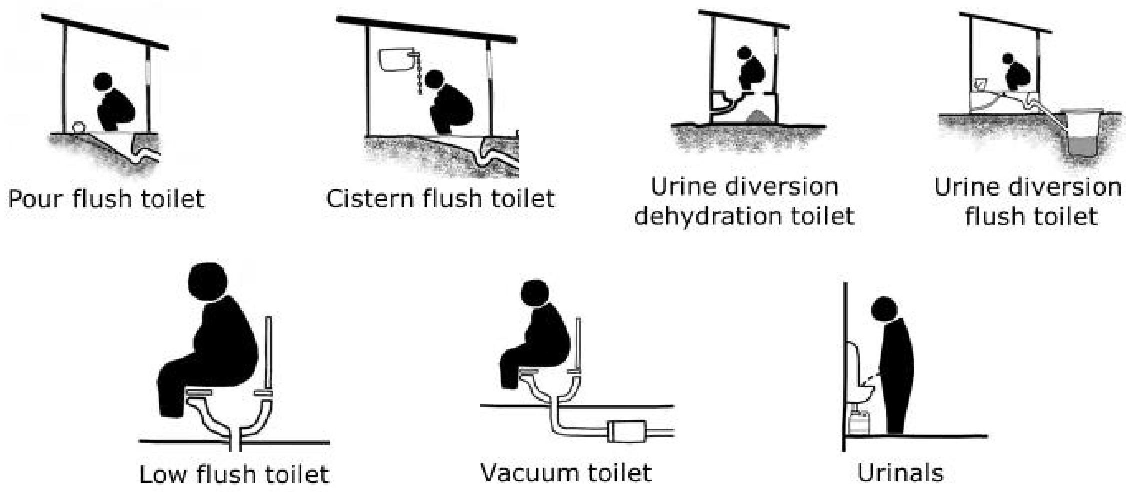

Figure 21 – User Interface Options

3.1.4 Functional group - Containment and storage treatment

<u>*Containment System*</u>

This section explains how the output products of a user interface can be collected, stored, and treated on-site. The functional group on-site containment system describes the ways of receiving, storing, and sometimes treating the products generated at the user interface. The treatment provided by these technologies is often the function of storage, and is usually passive, without requiring energy input. Products that emanate from these technologies often require subsequent treatment before use or disposal. There's quite a wide range of technologies which belong to this functional group. The technical and physical criteria for choosing appropriate collection, storage and treatment technology are as follows;

- Ground condition (Soil and strata (percolation and cost of construction)
- Groundwater level and contamination (Cross contamination (pathogens))
- Climate-Temperature (degree of treatment) and rainfall (percolation rate)

Containment systems for the management of faeces can be broadly categorized into two, offsite sanitation systems and On-site sanitation systems (OSS). Offsite sanitation systems carry the wastewater collected from the toilet to a single point of collection and treatment or outlet to water bodies. In OSS systems, faecal waste is collected in a containment system and may or may not be treated.[18] OSS systems range from a basic sanitary facility, such as single pit and twin-pit latrines, to a treatment system that connects a septic tank with a soak pit or a bio-digester toilet (aerobic and anaerobic).

<u>*Types of On-site Sanitation Systems*</u>

<u>***Single Pit***</u>

It consists of a superstructure and a pit. Faecal matter is deposited into a pit. Urine and water percolate into the soil through the bottom of the pit and wall, while microbial action degrades part of

[18] Retrieved from *Septage Management: A Practitioner's Guide*, Centre for Science and Environment, New Delhi

the organic fraction. Pathogenic germs are absorbed to the soil surface. In this way, pathogens can be removed prior to contact with groundwater.

Twin pit for pour flush toilets

It consists of a superstructure (pour flush toilet) connected to two alternating pits (two chambers). The blackwater (and in some cases greywater) is collected in the pits and allowed to slowly infiltrate into the surrounding soil. Only one pit is functional at a time while the other is allowed to rest as the liquid leaches out of the pit. Over time, the solids are sufficiently dewatered and can be manually removed with a shovel. The filled pit can be conveniently emptied after one-and-half years, when most of the pathogens die. The sludge, also called pit humus, can safely be used as manure.

The twin pits for pour flush technology can be designed in various ways; the toilet can be located directly over the pits or at a distance from them. The superstructure can be permanently constructed over both pits, or it can move from side to side depending on which one is in use. No matter how the system is designed, only one pit is used at a time. While one pit is filling, the other full pit is resting.

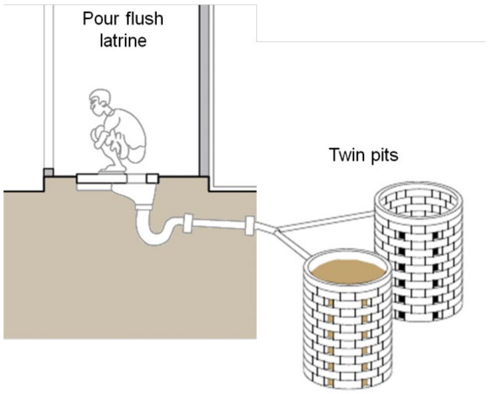

Figure 22 – Twin pits

As liquid leaches from the pit and migrates through the unsaturated soil matrix, pathogenic germs are sorbed onto the soil surface. In this way, pathogens can be removed prior to contact with groundwater. The degree of removal varies with soil type, distance travelled, moisture and other environmental factors. As this is a water-based (wet) technology, the full pits require a longer retention time (two years is recommended) to degrade the material before it can be excavated safely.

Twin pits for pour flush are a permanent technology appropriate for areas where it is not possible to continuously build new pit latrines. If water is available, this technology is appropriate for almost every type of housing density.

Pros	Cons
• Because double pits are used alternately; their life is virtually unlimited • Excavation of humus is easier than faecal sludge • Potential for the use of stored faecal material as soil conditioner • Flies and odours are significantly reduced (compared to pits without a water seal) • Can be built and repaired with locally available materials	• Manual removal of pit humus is required • Clogging is frequent when bulky cleansing materials are used • Higher risk of groundwater contamination due to more leachate than with waterless system

Pros	Cons
• Low (but variable) capital costs depending on materials; no or low operating costs if self-emptied • Small land area required	

Septic tank

A septic tank is a water-tight, single-storied tank made of concrete, fiberglass, PVC or plastic in which sewage is retained long enough to permit sedimentation and digestion. It is an underground tank that treats sewage by a combination of solids settling and anaerobic digestion. Liquid flows through the tank, and heavy particles sink to the bottom, while scum (mostly oil and grease) floats to the top. Over time, the solids that settle to the bottom are degraded anaerobically. However, the rate of accumulation is faster than the rate of decomposition, and the accumulated sludge and scum must be periodically removed. The effluent from the septic tank must be dispersed by using a Soak Pit or Leach Field or transported to another treatment technology via a Solids-Free Sewer (small bore sewers). Bureau of Indian Standards provides a Code of Practice for Installation of Septic Tanks (IS-2470 Part-1, 1985).

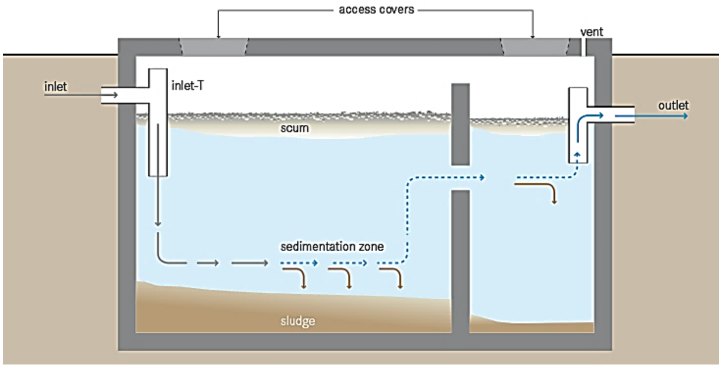

Figure 23 – Septic Tank

The design of a septic tank depends on the number of users, the amount of water used per capita, the average annual temperature, the desludging frequency and the characteristics of the wastewater. The retention time should be 48 hours to achieve moderate treatment. The retention time should be 48 hours to attain moderate treatment.

Table 6 – Recommended size of septic tank upto 20 users

No. of Users	Length (m)	Breadth (m)	Liquid depth (m) (cleaning interval of)	
			2 years	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

Table 7 – Recommended size of septic tank upto 300 users

No. of Users	Length (m)	Breadth (m)	Liquid depth (m) (cleaning interval of)	
			2 years	3 years
50	5.0	2.00	1.0	1.24
100	7.5	2.65	1.0	1.24
150	10.0	3.00	1.0	1.24
200	12.0	3.30	1.0	1.24
300	15.0	4.00	1.0	1.24

This technology is most commonly applied at the household level. Larger, multi-chamber septic tanks can be designed for groups of houses and public buildings (e.g., schools).

A septic tank is appropriate where there is a way of dispersing or transporting the effluent. If septic tanks are used in densely populated areas, onsite infiltration should not be used. Otherwise, the ground will become oversaturated and contaminated, and wastewater may rise up to the surface, posing a serious health risk. Instead, the septic tanks should be connected to some Conveyance technology, through which the effluent is transported to a subsequent Treatment or Disposal site. Even though septic tanks are watertight, it is not recommended to construct them in areas with high groundwater tables or where there is frequent flooding.

Because the septic tank must be regularly desludged, a vacuum truck should be able to access the location. Often, septic tanks are installed in the home, under the kitchen or bathroom, which makes emptying difficult. Septic tanks can be installed in every type of climate, although the efficiency will be lower in colder climates. They are not efficient at removing nutrients and pathogens.

Pros	Cons
• Simple and robust technology • No electrical energy is required • Low operating costs • Long service life • Small land area needed (can be built underground)	• Low reduction in pathogens, solids and organics • Regular desludging must be ensured • Effluent and sludge require further treatment and appropriate discharge

Urine diversion and composting toilet or ECOSAN

ECOSAN is a type of toilet in which human excreta, urine and wash water are separated through specially designed toilet seats unlike the conventional water closets where all these are collected together. Excreta is collected in the chamber constructed below the toilet seat, urine is collected in a drum/pot kept outside the toilet and wash water is diverted to a plant bed raised near the toilet.

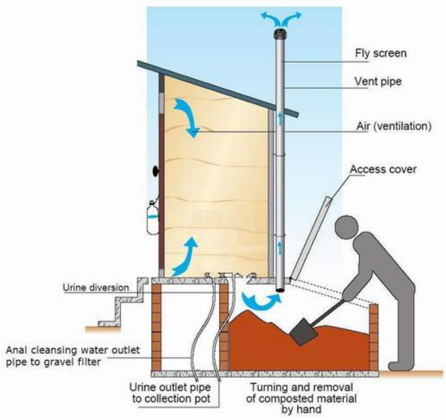

Figure 24 – Urine diversion and composting toilet (Ecosan)

Bio-digester tank system: A bio-digester toilet is an anaerobic multi-compartment tank with inoculum (anaerobic bacteria) which digests organic material biologically. This system converts faecal waste into usable water and gases in an eco-friendly manner.[19]

This technology has been developed by Defence Research and Development Organisation (DRDO) and advocated in SBM. These toilets are widely used for 80% treatment of black water from individual and cluster households or institutional buildings where there is no sewerage network.

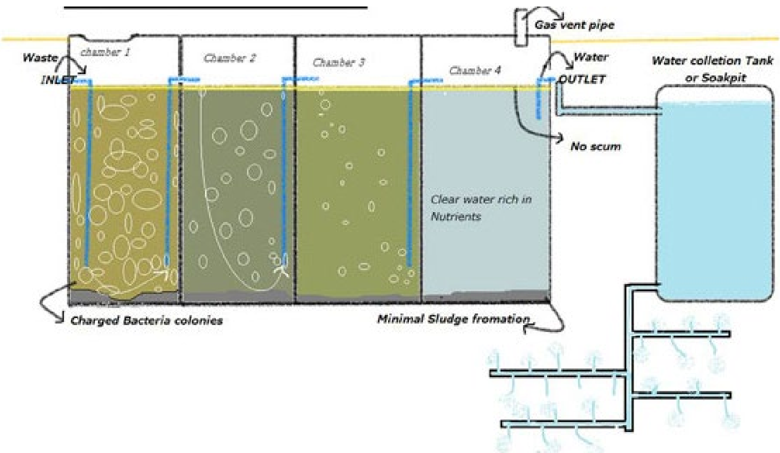

Figure 25 – Bio-digestor tank system

Anaerobic Baffle reactor

An anaerobic baffled reactor (ABR) is mainly a small septic tank (settling compartment) followed by a series of anaerobic tanks (at least three). Most of the solids are removed in the first and largest tank. Effluent from the first tank then flows through baffles and is forced to flow up through activated sludge in the subsequent tanks. Each chamber provides increased removal and digestion of organics: BOD may be reduced by up to 90%. Increasing the number of chambers also improves performance. (Tilley 2008).

[19] *Septage Management: A Practitioner's Guide*, Centre for Science and Environment, New Delhi

The majority of settleable solids are removed in a sedimentation chamber in front of the actual ABR. Small-scale stand-alone units typically have an integrated settling compartment, but primary sedimentation can also take place in a separate Settler or another preceding technology (e.g., existing Septic Tanks). Designs without a settling compartment are of particular interest for (Semi-) Centralized Treatment plants that combine the ABR with other technologies, or where prefabricated, modular units are used.

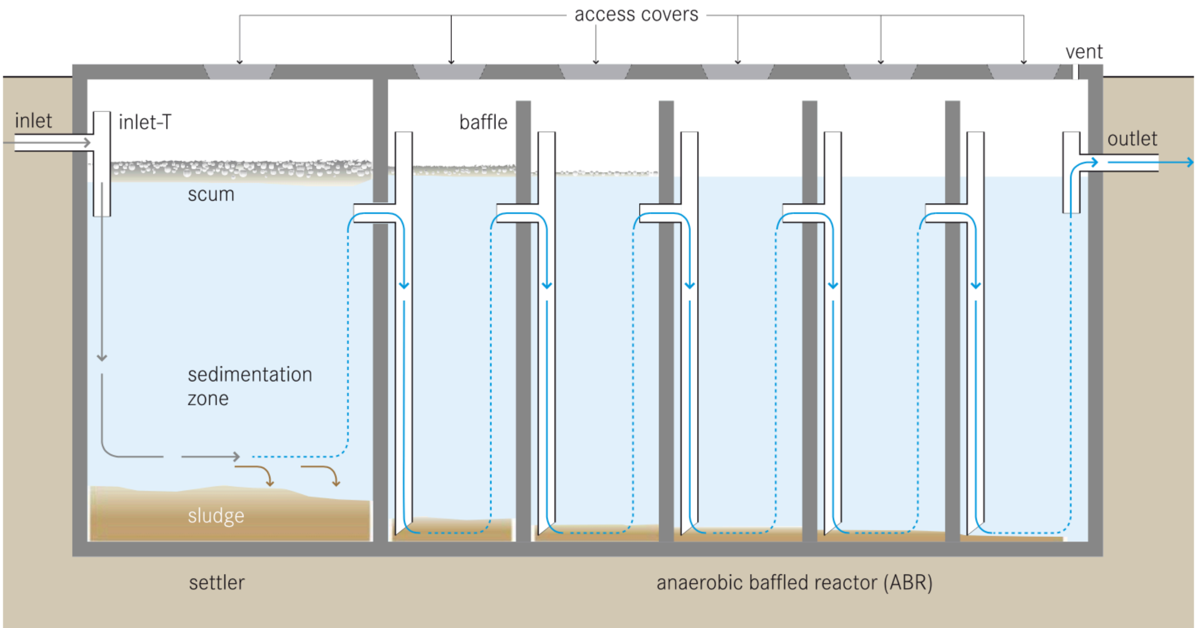

Figure 26 – Schematic diagram of ABR

This technology is easily adaptable and can be applied at the household level, in small neighbourhoods or even in bigger catchment areas. It is most appropriate where a relatively constant amount of blackwater and greywater is generated. A (semi-) centralised ABR is applicable when there is a pre-existing Conveyance technology, such as a Simplified Sewer.

This technology is suitable for areas where land may be limited since the tank is most commonly installed underground and requires a small area. However, a vacuum truck should be able to access the location because the sludge must be regularly removed (particularly from the settling compartment).

ABRs can be installed in every type of climate, although the efficiency is lower in colder climates. They are not efficient at removing nutrients and pathogens. The effluent usually requires further treatment.

Pros	**Cons**
• Low cost when divided among members of a housing cluster or small community • Minimum operation and maintenance • Resistant to organic and hydraulic shock loads • Reliable and consistent treatment	• Requires expert design and skilled construction; partial construction work by unskilled labourers • Requires secondary treatment and discharge

Anaerobic up-flow filter

An anaerobic up-flow filter is a fixed-bed biological reactor with one or more filtration chambers in series. As wastewater flows through the filter, particles are trapped, and organic matter is degraded by the active biomass that is attached to the surface of the filter material. With this technology, suspended solids and BOD removal can be as high as 90% but is typically between 50% and 80%. Nitrogen removal is limited and usually does not exceed 15% regarding total nitrogen (TN).

Pre- and primary treatment is essential to remove solids and garbage that may clog the filter. The majority of settleable solids are removed in a sedimentation chamber in front of the anaerobic filter. Small-scale stand-alone units typically have an integrated settling compartment, but primary sedimentation can also take place in a separate Settler or another preceding technology (e.g., existing Septic Tanks). Designs without a settling compartment are of particular interest for (Semi-) Centralized Treatment plants that combine the anaerobic filter with other technologies, such as the Anaerobic Baffled Reactor (ABR).

The microbial growth is retained on the stone media, making possible higher loading rates and efficient digestion. Materials commonly used include gravel, crushed rocks or bricks, cinder, pumice, or specially formed plastic pieces, depending on local availability. The connection between the chambers can be designed either with vertical pipes or baffles. Accessibility to all chambers (through access ports) is necessary for maintenance. The tank should be vented to allow for controlled release of odorous and potentially harmful gases. BOD removals of 70% can be expected. The effluent is clear and free from odour.

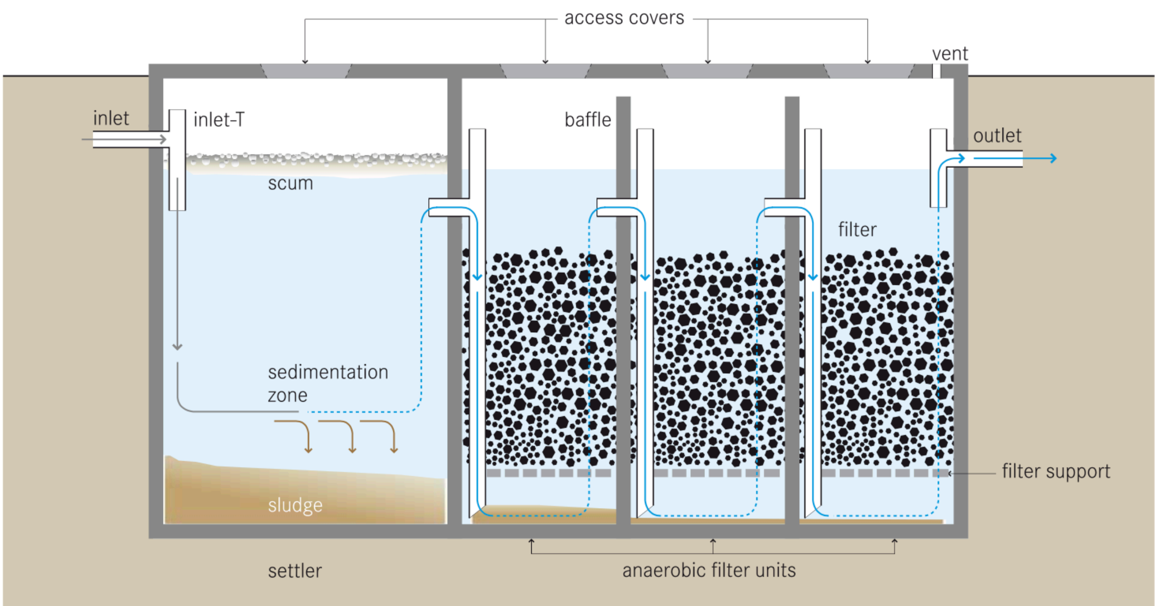

Figure 27 – Schematic diagram of Anaerobic Up-flow Filter

This technology is easily adaptable and can be applied at the household level, in small neighbourhoods or even in bigger catchment areas. It is most appropriate where a relatively constant amount of blackwater is generated. The anaerobic filter can be used for secondary treatment, to reduce the organic loading rate for a subsequent aerobic treatment step, or for polishing.

This technology is suitable for areas where land may be limited since the tank is most commonly installed underground and requires a small area. Accessibility by vacuum truck is important for desludging.

Pros	**Cons**
• No electrical energy is required • Low operating costs • Long service life • High reduction of BOD and solids • Low sludge production; the sludge is stabilized • Moderate area requirement (can be built underground)	• Requires expert design and construction • Low reduction of pathogens and nutrients • Effluent and sludge require further treatment and appropriate discharge • Risk of clogging, depending on pre- and primary treatment • Removing and cleaning the clogged filter media is cumbersome

3.1.5 Functional group - Conveyance

If waste products cannot be safely disposed of or even suitably reused on site, they have to be transported elsewhere. Conveyance describes the way in which products are moved from one process to another. Although products may need to be moved in various ways to reach the required process, the longest and most important gap lie between on-site storage and (semi-) centralised treatment.

The technical and physical criteria for choosing appropriate conveyance technology/system are as follows;

- Water availability,
- Ground condition,
- Ground water level and contamination

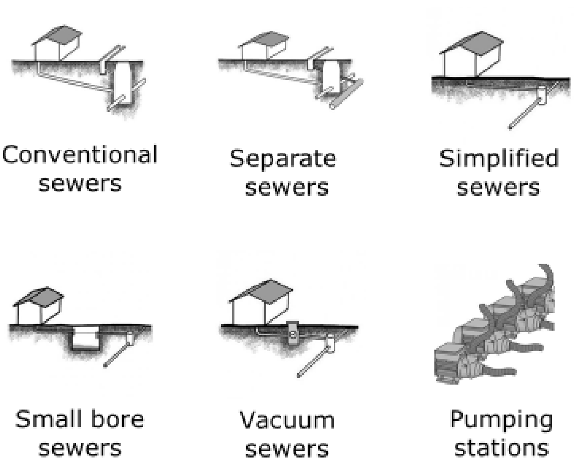

Figure 28 – Sewered conveyance options

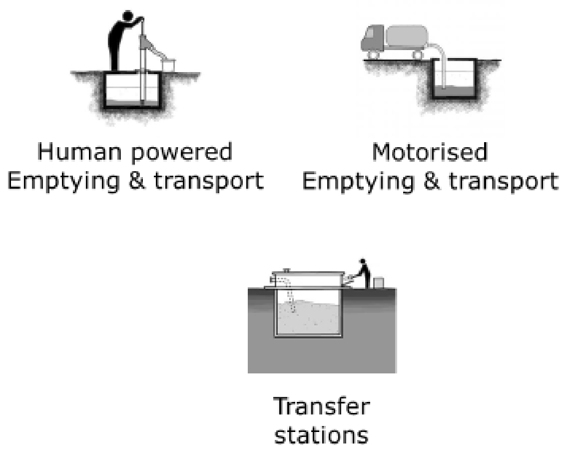

Figure 29 – Non-sewered Conveyance Options

The wastewater from households (blackwater and greywater) can be conveyed through various types of networked system (sewers) for off-site treatment whereas faecal sludge/septage from OSS needs to be emptied and transported to off-site treatment facility through motorized or manual emptying/transport options.

[*Sewered conveyance options have been discussed under section decentralised wastewater management systems*]

3.1.5.1 Non-sewered Conveyance Options for Faecal Sludge/Septage

Human-powered emptying

Human-powered emptying and transport refer to the different ways in which people can manually empty and/or transport sludge and solid products generated in on-site sanitation facilities. Human-powered emptying of pits, vaults and tanks can be done in one of two ways:

- using buckets and shovels, or
- using a portable, manually operated pump specially designed for sludge (e.g., the Gulper, the Manual Diaphragm Pump or the MAPET).

Manual sludge collection falls into two general categories, namely 'cartridge containment' and 'direct lift'. Cartridge containment and direct lift methods can be practiced safely when operators perform their tasks with the proper equipment following appropriate procedures. For instance, descending into pits as currently practiced in several areas of our country is not safe and legally banned through manual scavenging act.

Dumping of FS directly into the environment rather than discharging at a transfer or treatment site must also be avoided. In addition, local government, can help promote hygienic FS collection by highlighting best practices, imposing restrictions on unsafe practices, and providing incentives such as training, capacity building, and licensing. Formalising the informal sector through training and licensing will drive the demand for improved services, will improve hygiene, and enable business development and job creation.

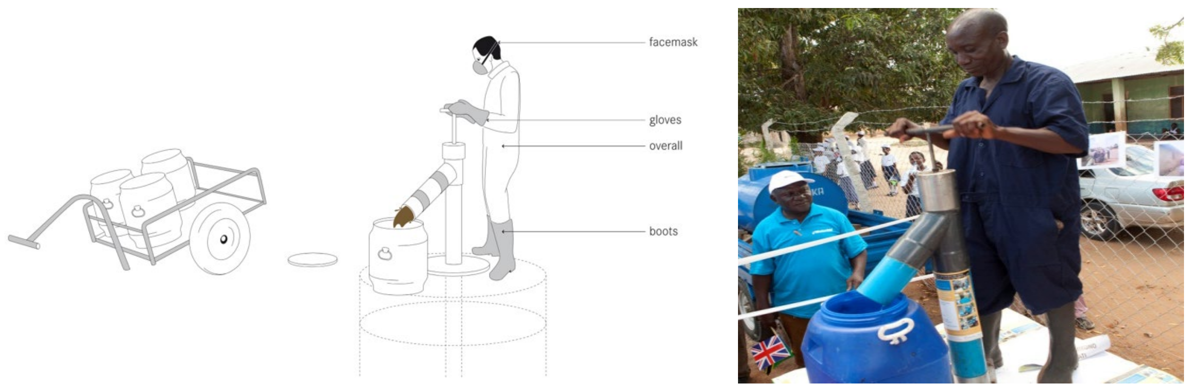

Figure 30 – Human powered emptying of OSS- Gulper

Manual sludge pumps like the Gulper are relatively new inventions and have shown promise as being low-cost, effective solutions for sludge emptying where, because of access, safety or economics, other sludge emptying techniques are not possible. Sludge hand pumps work on the same concept as water hand pumps: the bottom of the pipe is lowered into the pit/tank while the operator remains at the surface. As the operator pushes and pulls the handle, the sludge is pumped up and is then discharged through the discharge spout. The sludge can be collected in barrels, bags or carts, and removed from the site with little danger to the operator. Hand pumps can be locally made with steel rods and valves in a PVC casing.

Pros	**Cons**
• Potential for local jobs and income generation • Simple hand pumps can be built and repaired with locally available materials	• Spills can happen which could pose potential health risks and --generate offensive smells

Pros	Cons
• Low capital costs; variable operating costs depending on transport distance • Provides services to areas/communities without sewers	• Time-consuming: emptying pits out can take several hours/days depending on their size • Garbage in pits may block pipe • Some devices may require specialized repair (welding)

Manually operated diaphragm pumps, are simple low-cost pumps capable of extracting low viscosity FS that contains little non-biodegradable materials. They typically consist of a rigid, disc shaped body clamped to a flexible rubber membrane called a diaphragm. An airtight seal between the diaphragm and the disc forms a cavity. To operate the pump, the diaphragm is alternately pushed and pulled causing it to deform into concave and convex shapes in the same way a rubber plunger is used to unblock a toilet. A strainer and non-returning foot valve fitted to the end of the inlet pipe prevents non-biodegradable material from entering the pump and stops backflow of sludge during operation respectively.

Figure 31 – Manually operated Diaphragm pump

Motorised Emptying and Transport

Motorized emptying and transport refer to a vehicle equipped with a motorised pump and a storage tank for emptying and transporting faecal sludge and urine. Humans are required to operate the pump and manoeuvre the hose, but sludge is not manually lifted or transported. A truck is fitted with a pump which is connected to a hose that is lowered down into a tank (e.g., Septic Tank) or pit, and the sludge is pumped up into the holding tank on the vehicle. This type of design is often referred to as a vacuum truck.

Conventional vacuum tankers are typically fitted with either a relatively low cost, low-volume sliding vane pump or a more expensive liquid ring pump. The former is more appropriate for low-capacity vacuum tankers where high vacuum and low airflow sludge removal techniques are used. Vacuum conveyance techniques work best for removing low-viscosity sludge such as that found in septic tanks.

The type of desludging vehicle or emptier truck that would need to be procured would depend on the volume of septic tanks to be emptied and the number of trips of an emptier truck. Suction-based vacuum trucks or emptier trucks with varying capacities of tanks are available in the market. The capacity of an emptier truck typically varies from 2,000 litres to 20,000 litres. The cost of the truck varies depending upon its capacity. While making the decision regarding the procurement of emptier trucks, ULBs should consider the following factors:

- average road width of the areas from where the septic tanks need to be desludged – road widths and weight constraints
- typical volume of the tanks or vaults that will be serviced;
- characteristics of septage and size of septic tanks: to assess the amount of septage that can be desludged at a time which will consequently affect the number of trips
- distance to the treatment site, access to the site, traffic congestion: to comprehend the number of trips that can be made in a day
- availability and budget
- skill level of the operators.
- Considerations for OPEX – fuel requirements
- Financial budget for emptying services: to assess feasibility before planning for conveyance system.

Figure 32 – Transport options for emptying small volumes of FS/Septage

Figure 33 – Transport options for emptying large volumes of FS/Septage

Depending on the Collection and Storage technology, the sludge can be so dense that it cannot be easily pumped. In these situations, it is necessary to thin the solids with water so that they flow more easily, but this may be inefficient and costly. Garbage and sand make emptying much more difficult and clog the pipe or pump. Multiple truckloads may be required for large septic tanks.

Pros	Cons
• Fast, hygienic and effective sludge removal	• Cannot pump thick, dried sludge (must be thinned with water or -manually removed)

Pros	Cons
• Efficient transport possible with large vacuum trucks • Potential for local job creation and income generation • Provides an essential service to non-sewered areas	• Garbage in pits may block hose • Cannot empty deep pits due to limited suction lift • Very high capital costs; variable operating costs depending on use and maintenance • Hiring a vacuum truck may be unaffordable for poor households • Not all parts and materials may be locally available • May have difficulties with access

Transfer stations

Transfer stations or underground holding tanks act as intermediate dumping points for faecal sludge when it cannot be easily transported to a Faecal Sludge or Septage Treatment facility. A vacuum truck is required to empty transfer stations when they are full.

Operators of human-powered or small-scale motorised sludge emptying equipment discharge the sludge at a local transfer station rather than illegally dumping it or travelling to discharge it at a remote treatment or disposal site. When the transfer station is full, a vacuum truck empties the contents and takes the sludge to a suitable treatment facility.

In urban settings, transfer stations have to be carefully located. Otherwise, odours could become a nuisance, especially, if they are not well maintained. A transfer station consists of a parking place for vacuum trucks or sludge carts, a connection point for discharge hoses, and a storage tank. The dumping point should be built low enough to minimise spills when labourers manually empty their sludge carts. Additionally, the transfer station should include a vent, a trash screen to remove large debris (garbage) and a washing facility for vehicles. The holding tank must be well constructed to prevent leaching and surface water infiltration.

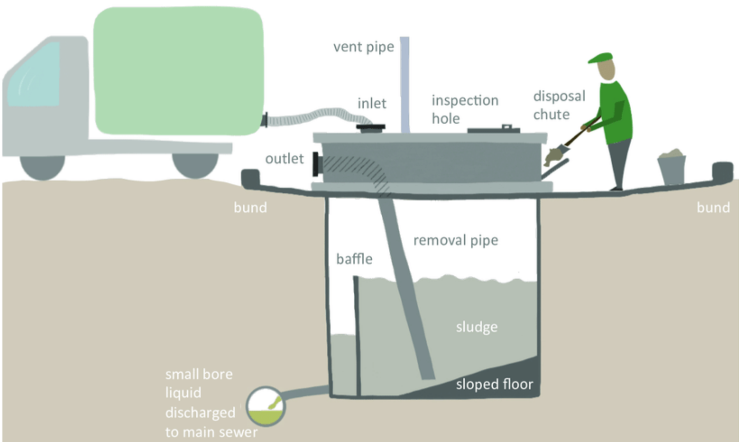

Figure 34 – Fixed type transfer station

Pros	Cons
• Makes sludge transport to the treatment plant more efficient, especially where small-scale service providers with slow vehicles are involved • May reduce the illegal dumping of faecal sludge	• Requires expert design and construction • Can lead to odours if not properly maintained

Pros	Cons
• Costs can be offset with access permits • Potential for local job creation and income generation	

3.1.6 Functional Group – Treatment

3.1.6.1 Decentralised Wastewater Treatment

Decentralised wastewater treatment is a system where the treatment of wastewater (sewage) takes place at the same location where it is generated (on-site) or is transported through a simplified conveyance system and is treated within a short distance of its generation.

Conventional centralised sewerage systems require a sophisticated infrastructure and large amounts of water to transport the wastes or excreta away. Conventional processes are expensive to operate. They require energy, skilled labour, infrastructure and maintenance. In efforts to reduce the cost and complexity of waste treatment, decentralised treatment units have been developed. Decentralisation means plugging the gap wherever centralised services are unviable or unaffordable.

Decentralised Wastewater Treatment systems are intended to complement centralised systems rather than replacing the same. Designing decentralised systems represents more a technical approach rather than a technical package. Such applications are designed to be low on maintenance and a very important feature is that system requires very minimal or no electrical energy for functioning of treatment modules/processes.

Decentralised wastewater treatment system can be designed using specific treatment modules that can be used in various combinations depending on various factors like wastewater strength and volume, space availability, intended re-use of treated by-products, required investment etc. The applications are designed and dimensioned in such a way that treated effluent or wastewater meets requirements stipulated in environmental laws and regulations.

3.1.6.2 Faecal Sludge and Septage Treatment

Faecal sludge comprises all liquid and semi-liquid contents of pits and vaults accumulating in on-site sanitations installations, namely un-sewered public and private latrines or toilets, aqua privies and septic tanks. These liquids are normally several times more concentrated in suspended and dissolved solids than wastewater. Septage comprises of liquid and solid material pumped from a septic tank, cesspool or other primary treatment source.

The purpose of treating the sludge and septage is to reduce the number of harmful pathogens, decrease the BOD, reduce organic load present in the matter and which finally after stages of biological, mechanical or similar treatment methods, can be either discharged to farmland, garden or can be re-used for other purposes such as washing floors, gardening and other similar purposes.

Table 8 – Criteria for selection of treatment options

Treatment performance	Local context	O&M requirements	Costs
• Effluent and sludge quality according to national standards	• Characteristics of sludge (dewaterability, concentration,	• Skills needed for operation, maintenance and	• Investment costs covered (land, infrastructure,

Treatment performance	Local context	O&M requirements	Costs
	degree of digestion, spreadability) • Quantity and frequency of sludge discharged at the FSTP • Climate • Land availability and cost • Interest in end-use (fertilizer, forage, biogas, compost, fuel)	monitoring available locally • Spare parts available locally	human resources, capacity building) • O&M costs covered • Affordability for households

It is important to realize that for the conversion of Faecal Sludge into a product that is safe for end-use or disposal, several processes need to take place. FS typically contains large volumes of water (more than 95%) and hence as the first step of treatment, the easily settleable solids are removed using sedimentation process (dewatering), which can be achieved on its own, or in combination with solid/liquid separation. Depending on the end-goal, further treatment needs could include converting organic matter into a stabilized form and/or pathogen reduction. One of the key elements in designing any particular series of technologies is to keep the final goal in mind. If the final goal is to make a dry product that can be reused in agriculture, then particular care has to be paid to dewatering and pathogen reduction. If the goal is to incinerate the sludge for energy production, then dryness is very important while pathogens do not play a role (outside of worker protection).

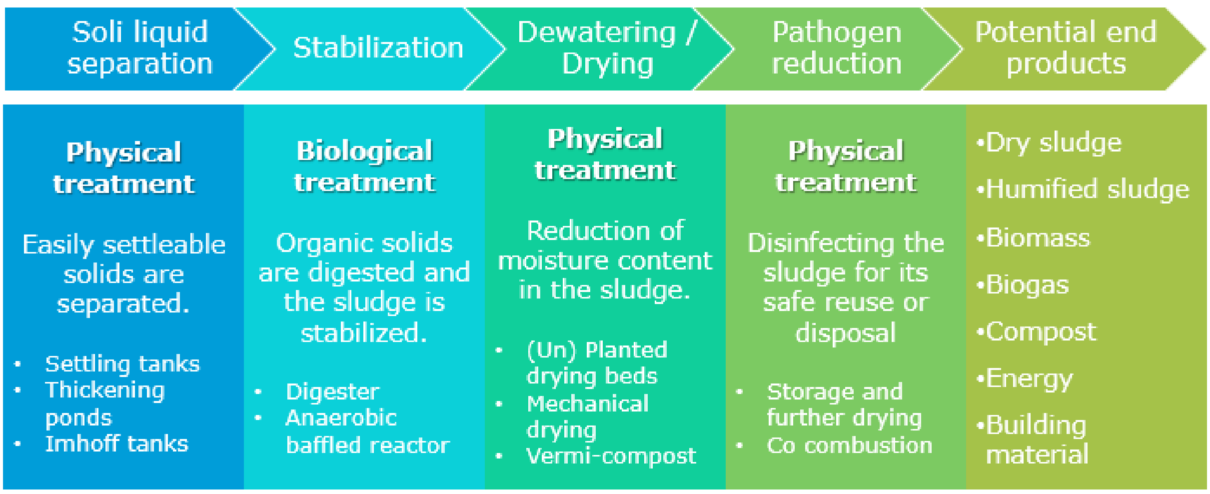

Figure 35 – Treatment Chain for Faecal Sludge/Septage Treatment

Faecal Sludge and Septage Treatment - Approaches/Technologies

A. Co-treatment in STP

One of the approaches for Faecal Sludge and Septage (FSS) treatment is co-treatment with sewer-based wastewater treatment technologies. However, appropriate treatment facilities are needed at sewage treatment plants to receive, pre-treat, and distribute the septage into the appropriate process units. Septage which may be considered a high strength wastewater, can be either dumped into an upstream sewer or added directly into various unit processes in a sewage treatment plant. The considerably higher solids content of faecal sludge may lead to severe operational problems such as solids deposition and clogging of sewer pipes. This is mostly because the diameter and slope of sewers are designed for the transport of municipal wastewater typically containing 250 to 600 mg TSS/L rather than the 12,000 to 52,500 mg TSS/L present in FS. Hence, the first step in designing a co-treatment system includes determining how the FS will be transported to the treatment facility and discharged into the influent stream.

The typical components of septage receiving facility at STP includes dumping station, screens, grit removal, equalization tank and odor control unit.

B. Deep Row Entrenchment

Deep row entrenchment consists of digging deep trenches, filling them with sludge and covering them with soil. Trees are then planted on top, which benefit from the organic matter and nutrients that are slowly released from the FS. In areas where there is adequate land available, deep row entrenchment can present a solution that is simple, low cost, has limited O&M issues and produces no visible or olfactory nuisances. Benefits are also gained from the increased production of trees. However, the availability of land is a major constraint with deep row entrenchment, as is the distance/depth to clean groundwater bodies. Deep row entrenchment is considered most feasible in areas where the water supply is not directly obtained from the groundwater source and where sufficient land is available, which means the sludge would have to be transportable to rural and peri-urban areas. In many countries' legislation is still lacking for this option.

Figure 36 – Deep row entrenchment

Advantages and Constraints

The main advantage of deep row entrenchment is that very little is needed for it: no expensive infrastructure or pumps that are very susceptible to poor maintenance. In addition, growing trees has many benefits such as extra CO_2 fixation, erosion protection, or potential economic benefits.

Constraints are that sufficient land has to be available in an area with a low enough groundwater table and, moreover, legislation still needs to catch up in many countries to allow for this technology.

C. Anaerobic Digestors

Anaerobic digestors treat organic waste in airtight chambers to ensure anaerobic conditions. Anaerobic digestion has been widely applied in centralized wastewater treatment facilities for the digestion of primary sludge and waste activated sludge, typically with plug flow (PFR) or continuously stirred reactors (CSTRs). The main design parameters for anaerobic digesters are the hydraulic retention time (HRT), the temperature and the loading pattern. Operating conditions that play an important role in the design and operation of anaerobic digesters include:

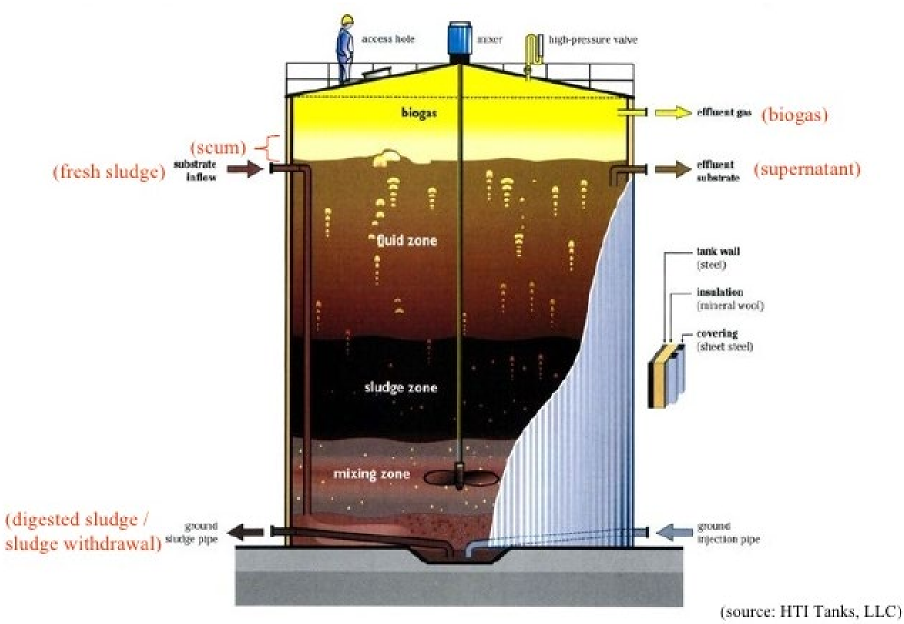

Figure 37 – Representative image of Anaerobic Digestor

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

Advantages and Constraints

Anaerobic digestion has the potential to produce biogas while stabilising FS, reducing sludge volume and odours. However, operation and maintenance (O&M) of anaerobic digesters requires a relatively high level of skilled operation. Inhibition of digestion needs to be considered due to the inconsistent nature of FS, and also detergents and heavy metals should be addressed at the household level.

D. Imhoff Tanks

An Imhoff tank is a compact sized tank that combines the effect of a settler and an anaerobic digestion system in one. It is a compact system which is well-known for wastewater treatment and has been implemented in Indonesia for FS treatment. Imhoff tanks are most often used as a primary treatment technology in wastewater treatment where it serves as a solid-liquid separation system including partial digestion for the settled sludge. The Imhoff tank is a high raised tank (up to nine meters for wastewater sludge) where sludge settles at the bottom and biogas produced by the anaerobic digestion process rises to the top. The settling compartment has inclined walls (45° or more) and a slot at the bottom, which allows the sludge to slide down to the center into the digestion compartment. The gas transports sludge particles to the water surface, creating a scum layer. T-shaped pipes or baffles are used at the inlet and the outlet to reduce velocity and prevent scum from leaving the system. The sludge accumulates in the sludge digestion chamber, and is compacted and partially stabilized through anaerobic digestion.

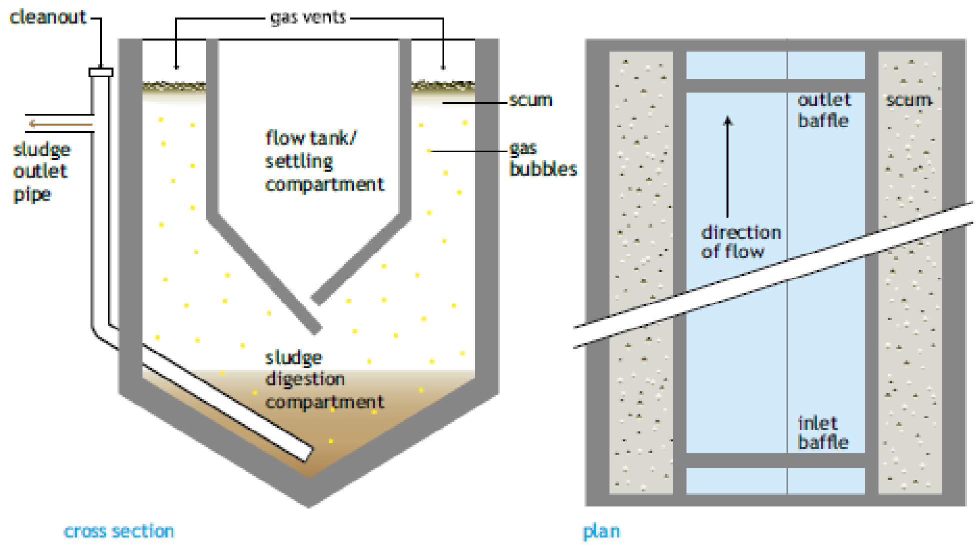

Figure 38 – Representative schematic of Imhoff Tank

Advantages and Constraints

The main advantages of Imhoff tanks compared to settling-thickening tanks are the small land requirement, the possibility of operating only one tank, and the physical separation between the settled sludge and the liquid fraction. The main constraints compared to settling thickening tanks are the increased operational complexity, slightly higher costs as the Imhoff tanks require an additional elevation to accommodate the inclined baffles, and the risk of damage to the sludge draw-off pipe in case of an inadequate draw-off frequency. Operation and maintenance of an Imhoff system is not as complex as some technologies, but it requires skilled operators. Cleaning of flow paths, the sides of the tank as well as the removal of scum is very important.

E. Settling / Thickening Tanks

Settling-thickening tanks are used to achieve separation of the liquid and solid fractions of faecal sludge (FS). Settling-thickening tanks for FS treatment are rectangular tanks, where FS is discharged into an inlet at the top of one side and the supernatant exits through an outlet situated at the opposite side, while settled solids are retained at the bottom of the tank, and scum floats on the surface. During the retention time, the heavier particles settle out and thicken at the bottom of the tank as a result of gravitational forces. Lighter particles, such as fats, oils and grease, float to the top of the tank. As solids are collected at the bottom of the tank, the liquid supernatant is discharged through the outlet. Quiescent hydraulic flows are required, as the designed rates of settling, thickening and flotation will not occur with turbulent flows. Baffles can be used to help avoid turbulence at the inflow, and to separate the scum and thickened sludge layers from the supernatant.

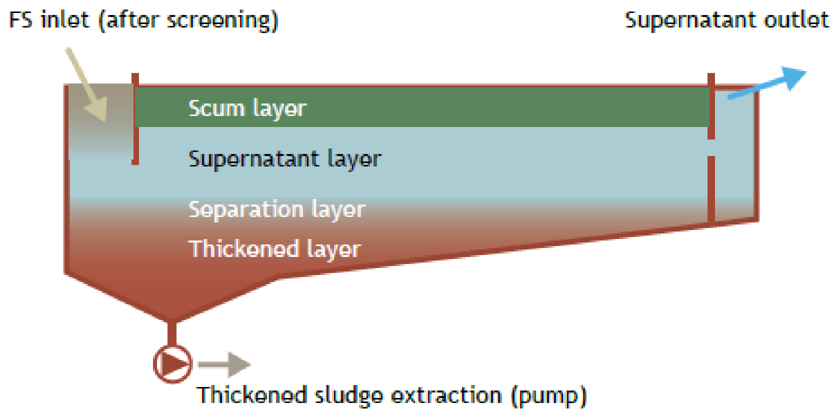

Figure 39 – Representative diagram of Settling – Thickening Tank

F. Unplanted Sludge Drying Beds

Unplanted sludge drying beds are shallow filters filled with sand and gravel with an under-drain at the bottom to collect leachate. Sludge is discharged onto the surface for dewatering. The drying process in a drying bed is based on drainage of liquid through the sand and gravel to the bottom of the bed, and evaporation of water from the surface of the sludge to the air. Depending on the faecal sludge (FS) characteristics, a variable fraction of approximately 50-80% of the sludge volume drains off as a liquid (or leachate), which needs to be collected and treated prior to discharge. After reaching the desired dryness, the sludge is removed from the bed manually or mechanically. Further processing for stabilization and pathogen reduction may be required depending on the intended end-use option. When considering the installation of a drying bed, the ease of operation and low cost needs to be considered against the relatively large footprint and odor potential.

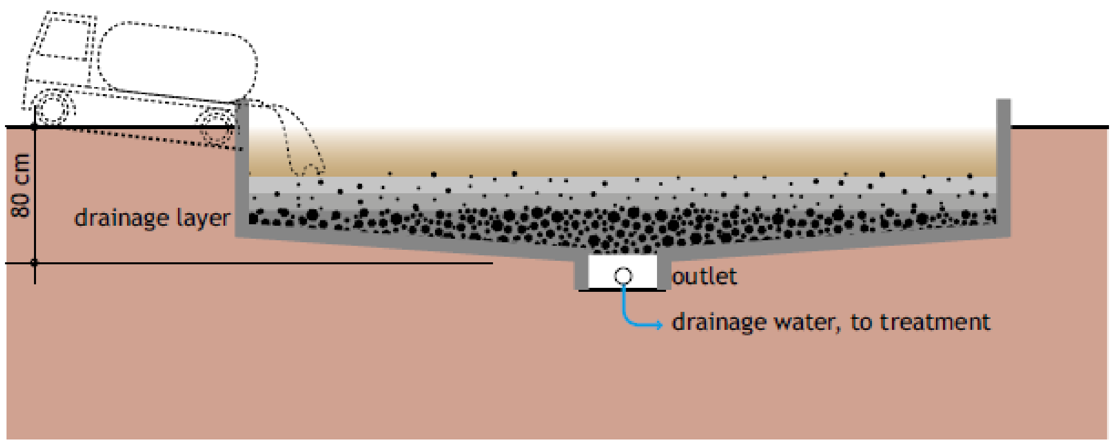

Figure 40 – Representative diagram of Unplanted Drying Beds

G. Planted Drying Beds

Planted drying beds (PDBs), also sometimes referred to as planted dewatering beds, vertical-flow constructed wetlands and sludge drying reed beds, are beds of porous media (e.g. sand and gravel) that are planted with emergent macrophytes. PDBs are loaded with layers of sludge that are subsequently dewatered and stabilized through multiple physical and biological mechanisms. The dewatering, organic stabilization and mineralization performance of the PDB depends on a variety of factors such as the media type and size, the type of plants, the maturity of the beds, climatic factors, and the sludge characteristics, as well as operational factors such as the hydraulic loading rate (HLR), the solids loading rate (SLR), and the loading frequency.

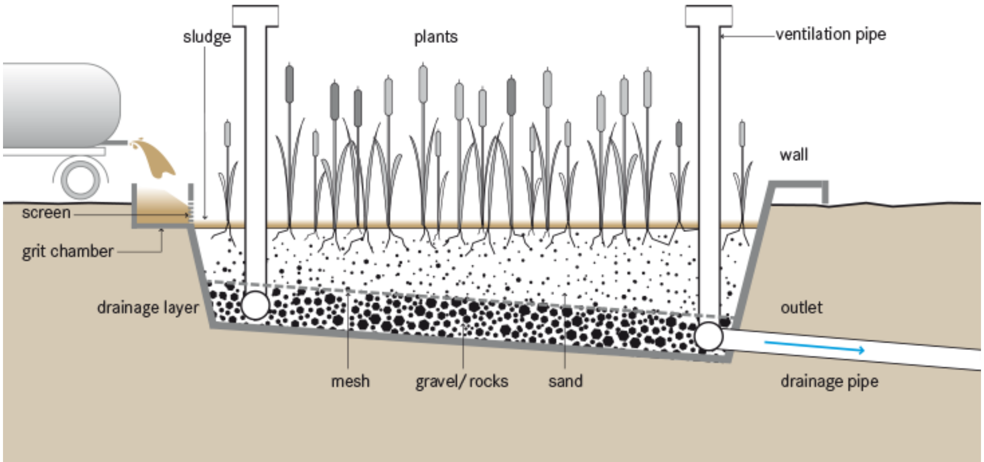

Figure 41 – Representative diagram of Planted Drying Beds

H. Mechanical Sludge Treatment

Mechanical dewatering or thickening can be carried out prior to, or following other treatment steps. Dewatering and thickening are important for reducing the volume of sludge that needs to be further treated or managed. After the sludge thickening process, additional reduction of the water content is often necessary and this can be done either naturally or by machine processes such as centrifugation or pressing. Four technologies that are widely used for dewatering WWTP sludge are the belt filter, the centrifuge, the frame filter press, and the screw press.

Centrifuge

Centrifuge technology dries the FS as it is squeezed outwards on the surface of a cylinder rotating around its horizontal axis, due to the centrifugal force. The flocculated sludge is injected into the middle of this cylinder, and the particles are pushed outward against the surface. An Archimedean screw transports the released liquid to the side where the sludge entered, while another transports the sludge to the other end. The main disadvantage of the centrifuge is the high energy requirements.

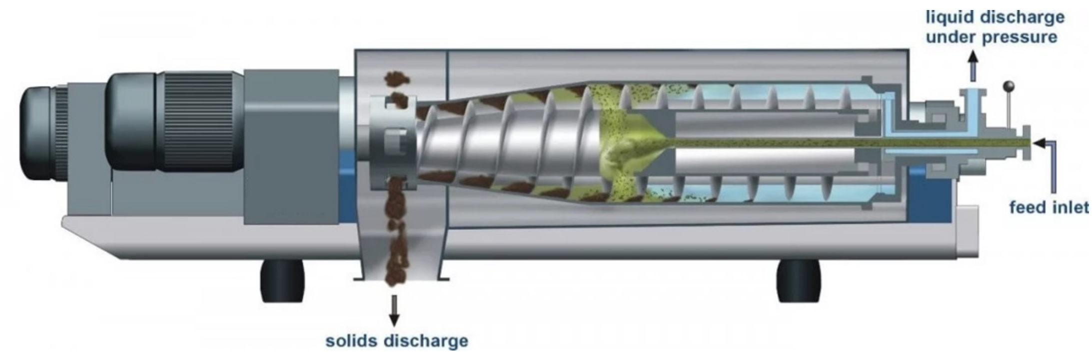

Figure 42 – Representative diagram of Centrifuge

Screw Press

A screw press consists of a rotational screw placed in a perforated cylinder. The sludge is loaded at one end, it is pressurised due to a diminishing distance between the screw and the cylinder, and the liquid that is squeezed out is removed through the pores in the cylinder. The dewatered sludge is discharged at the other end. Screw presses provide dewatering at relatively low equipment and operational costs, and minimal maintenance skills are required. However, the dewatering is comparatively lower than other mechanical dewatering technologies.

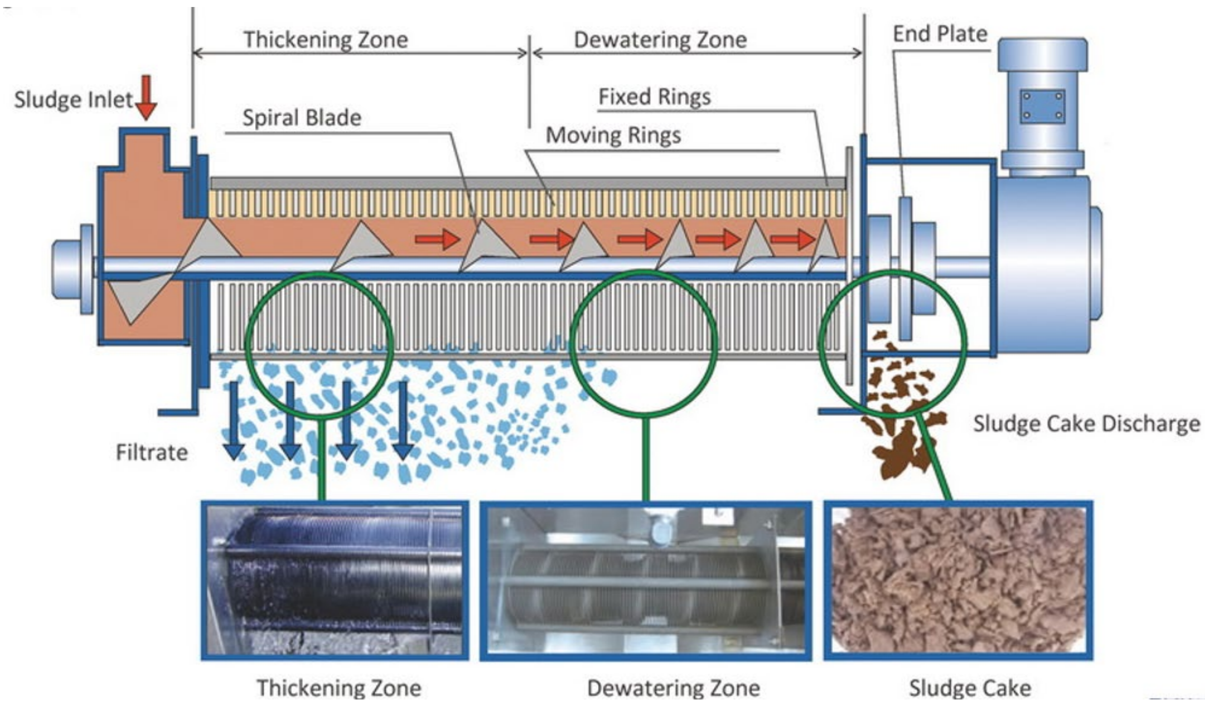

Figure 44 – Representative diagram of Screw Press

Belt Press

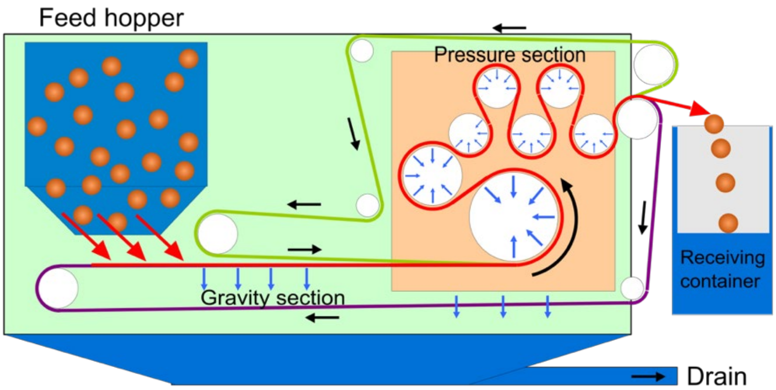

Figure 43 – Representative diagram of Belt Press

Belt filter press: This allows the water to be squeezed out of the sludge as it is compressed between two belts. The main disadvantages of a belt filter press compared to other mechanical dewatering techniques are the need for skilled maintenance and the difficulty in controlling odours. The system consists of:

- A gravity drainage zone where the flocculated sludge is deposited and conveyed on a porous and mobile belt;
- A compression zone where a second belt is applied on the upper layer of the sludge, and compresses it to a pressure that can reach 7 bars; and
- A zone where the belts are separated and the dewatered sludge is released.

Frame-Filter Press

Frame-filter press system consists of porous vertical frames fixed in two walls that are positioned in front one of the other to create a chamber. This is a batch process in which the sludge is filled into the chamber at high pressure (up to 15 bars resulting in the leachate being released through the porous frames and the dewatered sludge being released through the opening of the lower wall).

I. Co-composting of FS

Composting is a biological process that involves microorganisms that decompose organic matter under controlled predominantly aerobic conditions. The resulting end product is stabilized organic matter that can be used as a soil conditioner. It also contains nutrients which can have a benefit as a long-term organic fertilizer. Co-composting of FS with MSW is best implemented with sludge that has undergone dewatering (e.g. settling-thickening tanks or drying beds).

Advantages and Constraints

The main advantage of co-composting is formed by the thermophilic conditions and the resulting pathogen inactivation. The output of co-composting is a good soil conditioner which provides potential for income generation depending on the demand for compost. However, operating a co-composting plant and generating a safe product with value requires technical and managerial skills, which can be limiting if not available.

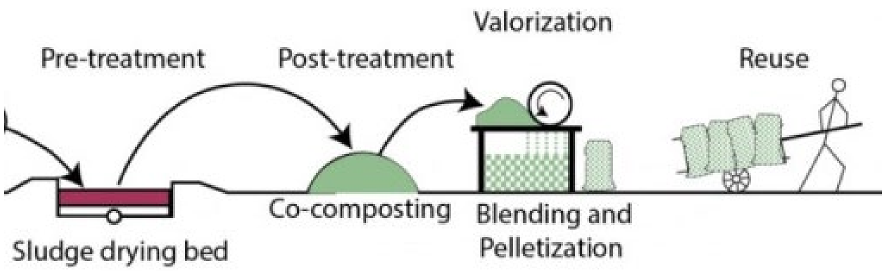

Figure 45 – Representative process of Co-composting

J. Sludge Incineration

Incineration of sludge is a form of disposal which involves the burning of 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 example in cement kilns. The ash that is produced from incineration could potentially be used, for example as a cover material for urine diversion dry toilets or in construction, or it can be disposed of in landfill sites. Sludge needs to be dewatered prior to combustion, but stabilization treatment is not necessary as it decreases the volatile content of the sludge. Commonly used incineration systems are multiple-hearth incineration, fluidized-bed incineration and co-incineration with municipal solid waste.

Advantages and Constraints

Disadvantages include: the potential emission of pollutants; the need for highly skilled operating and maintenance staff, high capital and O&M costs; and residual ashes. Advantages are that the sludge volume is substantially reduced and all pathogens are removed.

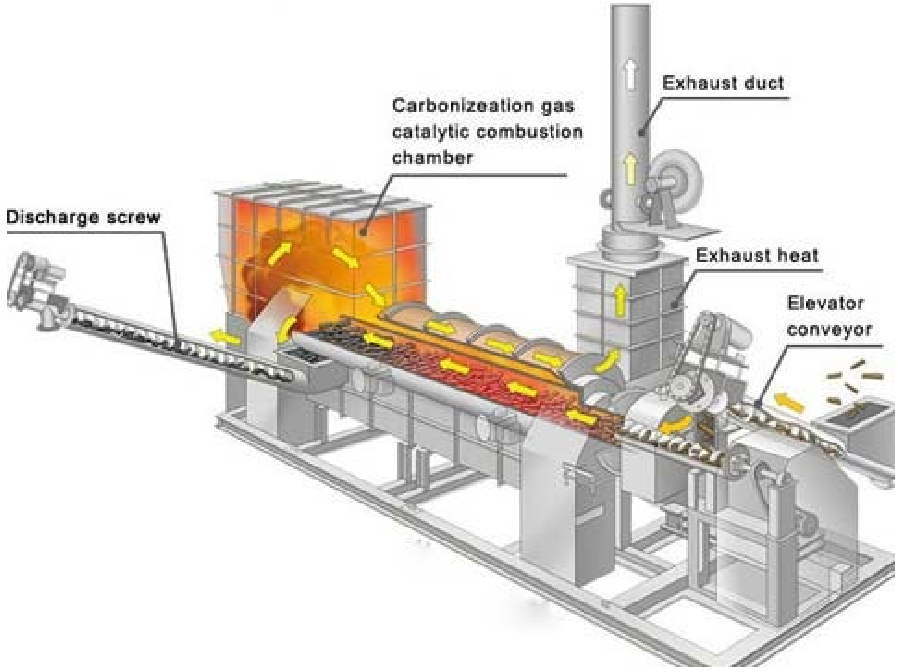

Figure 46 – Representative picture of Sludge Incineration Plant

K. Thermal Drying and Pelletising – LaDaPa System

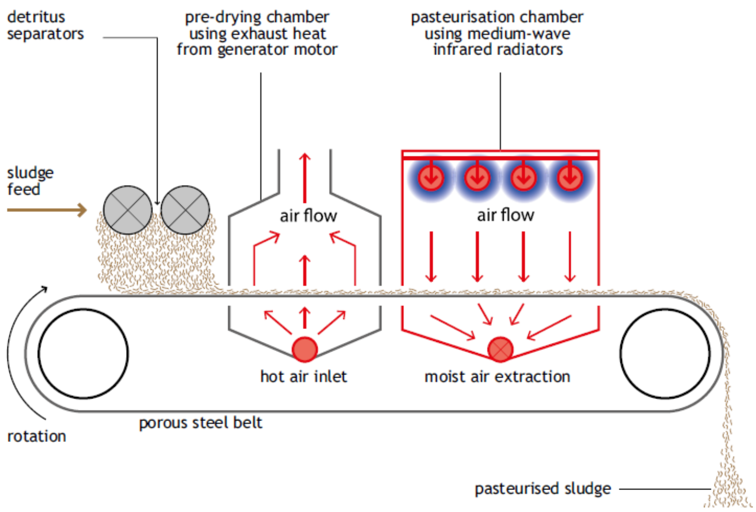

Figure 47 – Representative diagram of LaDaPa System

These 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 odours produced. Indirect thermal dryers produce less contaminated vapor.

Advantages and Constrains

Thermal drying results in a significant reduction in volume as well as pathogen content. Dried sludge is easy to handle and to market, and can be used in agriculture. The main constraints are the expense, high energy requirements, the potential risks of fire or explosion due to the gas and dust in the system, and the high maintenance requirements.

Pelletizing combines mechanical dewatering and thermal drying technologies. The dried pellets can then be used as an energy source or soil conditioner, and are relatively easy to transport and to market.

L. Geobags

Geobags are of high-strength, permeable, specially engineered textiles designed for containment and dewatering of high moisture content sludge and sediment. They are available in a variety of sizes, depending on your volume and space requirements.

Figure 48 - Geobags

Advantages and Constraints

The advantage is as high flow rate allows residual materials to dewater, whilst containing solids and Custom fabricated with seaming techniques that withstand pressure during pumping operations. The main constraint is it has to be disposed of after first use and can't be reuse it for second.

3.1.7 Disposal and Re-use of treated septage

There are numerous usages of treated septage. The discharged treated water can be disposed in lakes, river or open farm fields. However, it is important to check the parameters of the treated discharged water before disposal. The disposed water in the farm fields is actually a re-use of the treated water. This helps in improving the yield of the soil as the treated water still contains nitrogen and relevant required nutrients for crops to grow. However, this treated water should be released only in those farmlands which do not grow vegetables or edible crops. The other uses of this water could be for use in gardening or flushing.

The treated sludge is converted into cakes or pellets that are then, packaged or sold loose as manure. This manure is rich in nutrients otherwise nowadays absent in the natural land. As these manures are free from any manufactured chemicals, it is organic in nature and biochemically not harmful to the yield crop.

3.1.8 Approaches for FS/Septage Treatment

The existing approaches in the treatment of faecal sludge can be classified into the following types:

Clustering: This refers to clustering nearby towns and providing them with a common faecal sludge treatment plant. The towns should be at a distance that is economically viable for the desludging operators to serve. A stakeholder consultation with the desludging operators and the municipal authorities of the town can help arrive at the feasible location for the treatment plant.

Co-treatment: This method uses the existing sewage treatment infrastructure to treat faecal sludge. It can be done in the following ways:

- Adding the faecal sludge at the headworks of the sewage treatment plant in a controlled manner. Process the septage along with the bio-solids (i.e. sludge) produced during the wastewater treatment process.
- Separate the septage liquid from the septage solids and process each separately: liquid with the domestic wastewater and solids with the STP biosolids.

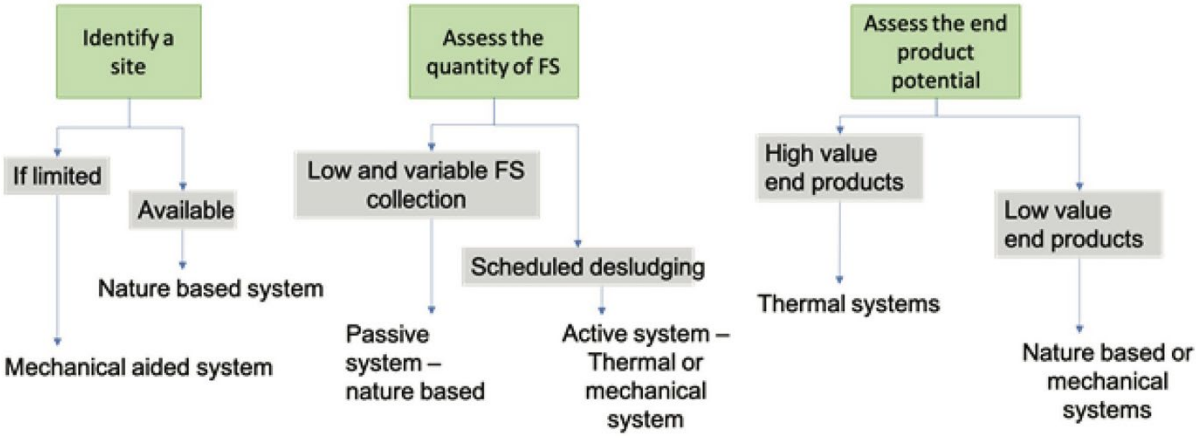

Figure 49 – Criteria for selection of FS treatment approach/technology

The present utilisation of the sewage treatment plant (STP) in terms of hydraulic load (quantity of sewage treated) and organic load (quantity of biodegradable components in the sewage) should be tested to determine the suitability of the STP for treating faecal sludge. The location of STP should be located one that can be easily serviced by desludging trucks. Co-treatment can help reduce infrastructure investment in treating faecal sludge.

<u>*Planetary model:*</u> This refers to installing transfer stations throughout the city for collecting faecal sludge. These are dedicated facilities installed strategically throughout the municipality that serves as a drop off locations for collected faecal sludge. They may include a receiving station with screens, a tank for holding the collected waste, trash storage containers, and wash down facilities. Faecal sludge from the transfer station is then transferred to the treatment facility using bigger tankers. Presence of transfer station can make safe disposal of faecal sludge economical for small desludging truck operators who would otherwise have to travel very long distances in small trucks to safely dispose of the faecal sludge.

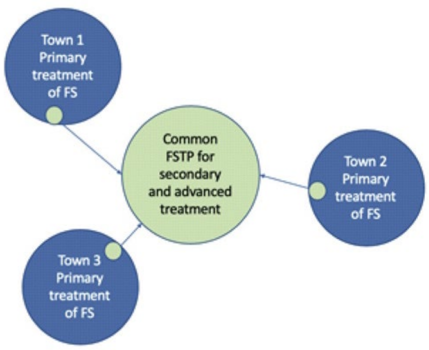

Figure 50 – Planetary Model

<u>*Co-digestion*</u>: This refers to treating faecal sludge with wet organic solid waste. This reduces the need to have separate infrastructure for the treatment of faecal sludge and wet waste. Also, this ensures optimum use of infrastructure especially when the collection of faecal sludge is intermittent.

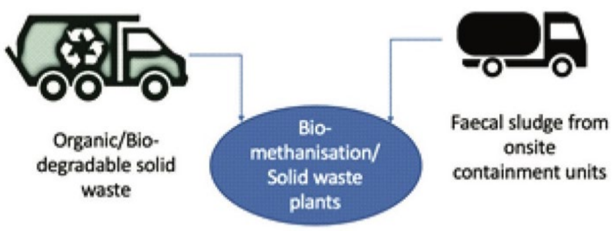

Figure 51 – Co-digestion

Co-location: This refers to locating a faecal sludge treatment facility at an existing solid waste treatment or sewage treatment facility premises. This can help in reducing the time an effort consumed in finding another piece of land exclusively for faecal sludge treatment.

Standalone FSTP: In cases where none of the above approaches is possible, the ULB must plan for a standalone FSTP.

The approach to treatment can also significantly vary based on the rural and urban divide. In India, there is significant difference between Urban and the rural areas in terms of administration, resources availability and the prioritisation of developmental issues. This can have an effect on the choice of technology options for treatment. For e.g.: a remotely located village with minimal availability of resources for maintaining the treatment systems may choose to opt for a system which is simple and easily to maintain. However a rural area located in the periphery of a urban settlement, could opt for a more mechanised system to use the land more judiciously. Similarly, based on the priority of the community towards treatment both urban areas and rural areas can choose incremental methods to adopt treatment system. For instance, they could adopt a low tech system such as trenching to solve the current issue indiscriminate disposal of faecal sludge and then plan to adopt more complex technologies based on their other objectives of treatment such as improved treatment, revenue from end products, low area foot print, etc.

The below diagrams indicate an approach for incremental treatment systems – using various parameters of treatment objectives, quantity of faecal sludge generation and the technology sophistication.

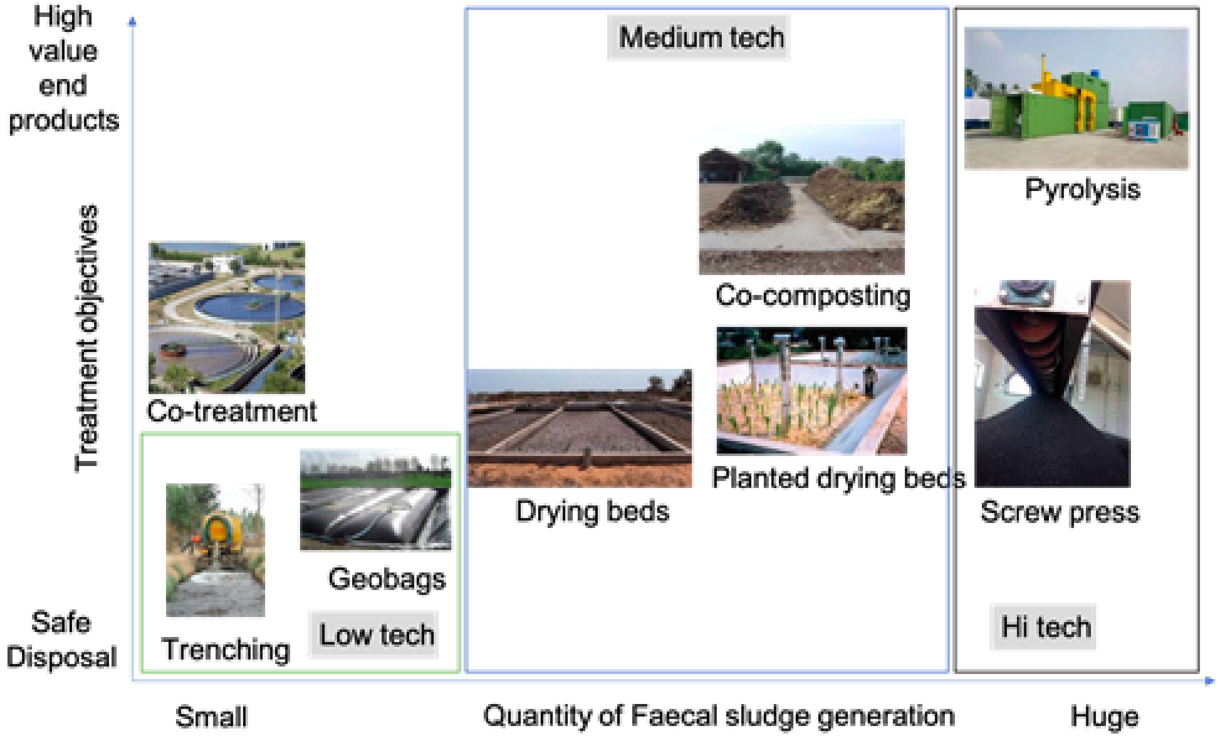

Figure 52 – Selection of treatment approach for FS/Septage

Treatment technology matrix

Selection of appropriate treatment technologies can depend on many factors such as a) End product requirement, b) Climatic conditions, c) Characteristics of faecal sludge and septage, d) availability of Capex and Land, e) Availability of Operation and maintenance ecosystem, among some of the major variables.

Table 9 – Matrix for selection of technology for FS/septage treatment

S. No.	Treatment Systems	Applicable Areas	Effective Treatment Volumes	Land Requirement	CAPEX (in INR)	OPEX (in INR)
1	Trenching	• Suitable for low (less than 5 cu.m.) and fluctuating volumes of faecal sludge that needs treatment • Ideal for rural areas in arid/semi-arid regions, where groundwater table is very low (more than 20m below ground) • Can also be used in peri-urban areas/fringe areas of a city, site should be away from human habitation by atleast 100m • The site should be away from surface water bodies by atleast 200m.	1-5 KLD	Huge, 0.2-0.25 sqm. per person equivalent	Nil	3,00,000
2	Geobag with constructed wetlands	• Suitable for rural and peri-urban areas where FS loads are fluctuating and volumes are less than 10 cu.m per day • Suitable for tourist places during peak seasons	1-10 KLD	Medium, 0.04 sqm. per person equivalent		18,00,000
3	Anaerobic digestion, DEWATS with co-composting	• Suitable for towns less than 1 lakh population and where demand-based desludging is planned	3-30 KLD	Medium, 0.03 sqm. per person equivalent	7,00,000 per KLD	12,00,000
4	Planted drying beds with DEWATS	• Suitable for towns less than 50,000 population and where demand-based desludging is in planning • Ideal for fluctuating FS treatment volumes	3-10 KLD	Medium, 0.04 sqm. per person equivalent	6,00,000 per KLD	10,00,000
5	Thickening tank, DEWATS and drying beds	• Suitable for towns and cities upto 5 lakhs population with demand-based desludging (or) 1 lakh for scheduled desludging	15-75 KLD	Medium, 0.03 sqm. per person equivalent	5,50,000 per KLD	24,00,000
6	Screw press, belt dryer and pyrolysis	• Suitable for cities with a population higher than 1 lakh • Suitable for cities with an industrial base	15-70 KLD	Low, 0.01 sqm. per person equivalent	4,50,000 per KLD	24,00,000

4 Citywide FSSM Planning

Figure 53 – Key steps in FSSM Planning

4.1 Assessment of existing situation

The assessment of the initial situation, which is the first step in the planning process is crucial, as it provides the baseline information for decision making. The main goals of the assessment of the initial situation are to set the scene, understand the context, get to know stakeholders and provide enough information to start elaborating the Faecal sludge management scenarios, including context specific design parameters and therefore this characterized mainly by data collection via different options. It is necessity to understand baseline information at the beginning stage of the Faecal sludge management planning process and to identify the data needs to be collected. It is important to identify the shortcomings and challenges of an existing Faecal sludge management system and able to describe an enabling environment.

4.1.1 Data to be collected

- Population and demography: number of inhabitants, number of people per household, population density and growth rate, type of housing
- Water and hygiene: drinking water coverage and infrastructure, drinking water sources, types of supply (e.g. networks, taps in houses, fountains, trucks), operators (public/private), prevalence of diseases related to faecal matter
- Physical characteristics: geomorphology, hydrologic basins, areas prone to flooding, types of soil, ground water table
- Climatic data
- Storm water management
- Local economy: main economic activities in the city, main sources of household revenue, average income

Table 10 – Relevant information of existing sanitation services

Latrines and onsite treatment	
Water availability	Information on existing water supply services (including daily consumption per household) can be used to estimate daily wastewater production
Sanitation facilities	Current levels of service (household and shared facilities) including approximate household coverage and number and location of communal or public toilets
Onsite treatment	Types of onsite sanitation system serving households with household connections
Waste collection and conveyance	
Existing sewerage infrastructure	Coverage of sewerage and proportion of household with household connections
Faecal sludge and septage collection services	Coverage and frequency of servicing
Offsite wastewater treatment and reuse	
Wastewater treatment	Location and types of wastewater treatment infrastructure (if any exists)
Discharge or end-use	Location where wastewater and faecal sludge is disposed or end-used

4.1.2 Tools and Methods of data collection

The collection of good quality data is not an easy process, especially in contexts where data is scarce, not collected or analysed properly, or hidden or manipulated for political or personal reasons. Governmental agencies usually have the reports, statistics and maps that can serve as a preliminary introduction.

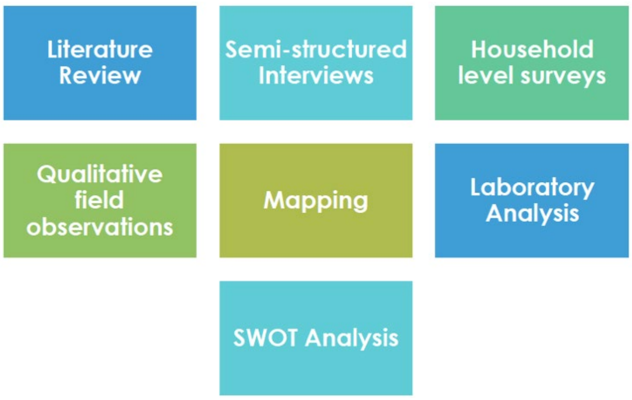

Figure 54 – Tools and method of data collection

4.2 Stakeholder analysis

Managing faecal sludge at city level in an efficient and sustainable way requires the involvement and support of all concerned key stakeholders. Stakeholders is mean that any group, organization or individual that can influence or be influenced by the project. In order to understand and engage stakeholders, stakeholder analyses should be performed. Stakeholders analysis is the process of identifying and characterizing the stakeholders, investigating the relationships between them, and planning for their participation. It is vital tool for understanding the social and institutional context of a project or a policy. Its findings can provide early and essential information about who will be affected by the project and who could influence the project, which individuals, groups or agencies need to be involved in the project and whose capacity needs to be built to enable them to participate. Identification of stakeholders is one of the important tasks when starting a new project.

Figure 55 – Key Stakeholders

Stakeholder	Examples
Municipal Authorities	• Mayor • Municipal technical services (environment, sanitation, hygiene and public health) • Muicipal police
Regional and National Authorities	• Regional director e.g. Sanitation, Health, Hydraulics, Water Company, Public Works, Statistics, Urbansm and Habitat, Local development, Agriculture
Utilities	• Public, Semi-private (parastatal) or private (commercialised)
Traditional Authorities and Influential Leaders	• Ethnic leaders • Neighborhood leaders • Religious leaders
Small Scale FS Businesses	• Mechanical service providers, FSM business owners, FSM business owners associations or interest groups
Organizations active in Sanitation	• CBOs • Local or international NGOs • Universities, research centres • Donor agencies
Potential endusers	• Farmers, Farmers associations and institutions helping farmers • Fuel consumers
Household	• Users or Owners

Table 11 - Typical characteristics of the main stakeholders and actions to be undertaken

Stakeholder categories	Main interests	Opportunities	Involvement needs and required actions
Municipal Authorities	• Public health • Cleanliness of the city • Collection and management of sanitation fees	• Power for enforcement through regulatory framework and police • Management of treatment units • Link with other stakeholders, existing contracts and authorizations • Development of social services	• Sensitization, need for capacity building, collaboration • Institutional and regulatory frameworks often need to be developed and their application enforced • Often lack financial, human resources and land • Involve them in the financing scheme
Regional and national authorities	• Respect for laws and regulations • Capacity building • Master plans	• Collaboration between agencies, development of synergies • Support for baseline data	• Sensitization information
Utilities	• Sufficient revenues • Municipal, regional or national priorities	• Collection, transport and treatment under the same umbrella • Cross-subsidy to allow social service	• Collaboration, sensitization • Ensure that they act as 'public services' reaching low-income areas and not only upper-class neighborhoods
Traditional authorities	• Public health	• Support and land property	• Consultation, information, sensitization
Small-scale FS businesses • Mechanical service providers	• Sufficient revenues • Disposal sites close to working area • Clarification of legal status, better image	• Increase in quality of service • Lower emptying price • Collaboration with manual service providers	• Organize in association (empowerment) • Organize the market • Control the respect for rules • Contracts/ licenses should be issued by

Stakeholder categories	Main interests	Opportunities	Involvement needs and required actions
			municipal authorities
Small-scale FS businesses • Manual service providers	• Sufficient revenues • Gain status, social recognition • Reduce risk at the workplace	• Improvement of working conditions	• Organize in association (empowerment) • Empowerment ('give them a voice') and capacity building • Organize a service of collection and transport or transfer of sludge
Organizations active in sanitation	• Wellbeing of citizens • Clean environment • Capacity building • Visibility	• Experience in sanitation advocacy • Existing structures, human resources and competencies • Contact with households • Capacity to obtain funding	• Some organization can be of great help (facilitation, experience, and international funding) • Their relationship with the authorities should be investigated
Potential end-users	• Affordable and safe products • Yield increase	• Increase WWTP's revenue through selling of end-products	• Create end-user groups (empowerment) • Market study, and willingness and capacity to pay
Households (users and owners)	• Affordability of collection service • Clean environment	• Pressure on municipal authorities and service providers • Pay more for a better service • Better management of onsite systems	• Information, sensitization for behavior change, especially management of onsite systems • Assessment of willingness and capacity to pay • Advice for latrine construction

Table 12 – Stakeholders participation matrix

		Participation Levels			
		Information	**Consultation**	**Collaboration**	**Empowerment/ delegation**
Planning	Launch of the planning process	All stakeholders		Municipality, utilities	
	Detailed assessment of current situation		Key stakeholders[1]	Municipality, utilities	
	Identification of service options		Key stakeholders[1]	Municipality, utilities	
	Development of an Action Plan	All stakeholders	End-users	Municipality, utilities, FS operators, NGOs	Empower weak and non-organised groups
Implementation		Households, traditional authorities and opinion leaders	End-users	Municipality, utilities, FS operators, NGOs	Empower and delegate to municipality, utilities, FS operators, NGOs
Monitoring & Evaluation		Key stakeholders	Households, FS operators, end-users	Municipality, utilities, selected NGOs	

Table 13 – Stakeholders involvement techniques and participation levels

	Information	**Consultation**	**Collaboration**	**Empowerment/ delegation**
Personal meetings	■	■	■	■
Focus groups		■	■	■
Workshops	■	■	■	■
Site visits	■	■		
Media campaigns	■			
Household surveys		■		
Advocacy/ lobbying	■		■	■
Mediation		■	■	■
Logical framework		■	■	

4.3 Planning for technology option across FSSM value chain

4.3.1 Planning for technology option for containment

It is important to understand the deciding factors for selecting a suitable and appropriate containment system. For example, areas with clay, tightly packed or rocky soils, a high groundwater table or where there is frequent flooding are not appropriate for twin pit latrines. But otherwise, if sufficient water and land is available, twin pits can be a viable option. A vacuum truck should be able to access the location as the septic tank must be emptied at regular interval. A typical diagram[20] of both the systems is shown below.

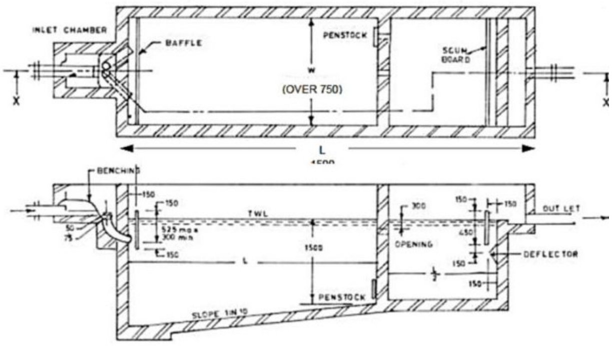

Figure 57 – Septic Tank

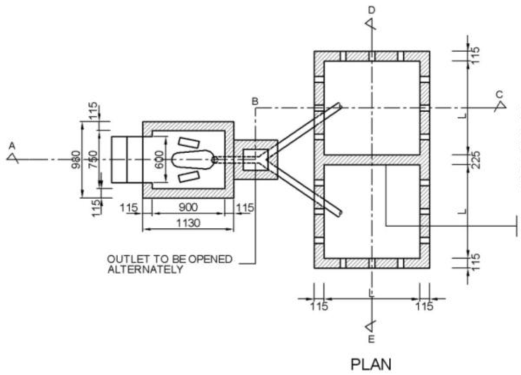

Figure 56 – Twin pit

Table 14 - Comparison of a septic tank system with a twin pit

Parameters	**Septic Tank**	**Twin Pit**
Applicability	• Non-availability of sewer network • Suitable in peri-urban settlements without centralized system	• Water use 25-50 LPCD
O&M requirement	• Desludging is required once in 2-3 years • Septage must be transported for further treatment before disposal	• Desludging is required once the pit is full • Safe to desludge manually after 2-3 years
Risk and Limitation	• Cost and space requirements are high • Retention time is insufficient if it receives too much waste water • Unregulated desludging may violate the manual scavenging act, 2013	• Manual desludging of excreta and its disposal before the cleaning cycle of 2-3 years • Bottom of the pit should be atleast 2m above the groundwater table • Not designed to cater grey water
Soil characteristic	• Must be suitable for infiltration of effluent	• Highly permeable soil

[20] Typical diagram of both septic tank and twin pit is taken from Manual on sewerage and sewage treatment systems, Part A: Engineering, CPHEEO, 2013

Criteria for selection of containment system:

- Availability of space
- Soil and groundwater characteristics
- Type and quantity of input
- Desired output
- Availability of technologies for subsequent transport
- Financial resources
- Management considerations

4.3.2 Planning for desludging and conveyance

Desludging can be done in broadly two ways – either on demand based or by a scheduled based system.

4.3.2.1 Demand Based Desludging

Demand based desludging system refers to a model wherein the households raise a service request for desludging service by the ULB or the private operator once the septic tank is full and overflowing. The cleaning services of the ULB are presently treated as part of complaint redressal system for overflowing OSS system rather than regular cleaning and maintenance service. The ULB operates the trucks on their own or engages private players for desludging services. Currently, demand-based desludging is prevalent in most of the cities in India. Since this is a market-driven model, the prices per trip for septic tank desludging is quite high.

If the city wants to adopt/continue with demand-based desludging, it should be regulated heavily. HHs should be made aware to desludge their tanks periodically and regulations should be made and followed for the same.

4.3.2.2 Scheduled Based Desludging:

Scheduled based desludging system refers to a model wherein the ULB prescribes a scheduled regime and provides services either itself or through its empanelled operators at a fixed time interval. For e.g.; the ULB will send alert and scheduled desludging of OSS systems in 3 years. Here, the charges are built into the annual property tax levied on the HH.

In a scheduled based system, the ULB will require additional vacuum trucks compared to demand-based system, as in the demand-based system, HHs generally request for emptying their OSS systems once in 8-10 years against the recommended cleaning cycle of 2-3 years by CPHEEO. This system requires regulations and penalties to be put in place to ensure periodic cleaning by households. Awareness generation activities are required to be undertaken by ULBs to educate households about the need for regular cleaning of OSS systems.

In this, a septage conveyance plan or a schedule is drafted. For any plan to be effective, robust data on volumes and locations are required. The ULBs should make efforts to collect baseline data – the type of sanitation systems connected to toilets, effluent disposal system, size and age of collection systems, when they were last cleaned and most importantly, their access, to plan for workable desludging schedules. It is advisable to divide the city into working zones for the same. Pilot desludging schedules can be implemented to learn operational issues and devise solutions, before scaling up to the whole ULB. While formulating zones, availability of septage disposal and treatment site/ existing

STPs should and their distance from the zone should be taken into consideration. It is recommended that households in demarcated septage management zone should be within 30 km. travel distance from identified disposal sites, for workability. (Advisory Note on Septage Management in Urban India, 2013)

Prior to this planning, the ULB shall first assess its role and capacity for implementation of the septage management plan. ULB should assess various aspects of septic tank emptying like how many septic tanks are required to be emptied annually as per CPHEEO norm versus how many are emptied in a year, how many vacuum emptying trucks/ capacity of trucks are required if number of septic tanks emptied as per CPHEEO norms versus how many trucks are available/working with capacities of emptier trucks, assessing the cost per emptying visit, method of maintaining the register for septic tank emptying services database etc. (Guidelines for Septage Management in Maharashtra, 2016).

Table 15 – Scheduled Vs. On-demand Desludging

Scheduled Desludging	Demand Desludging
• Services at the predefined regular schedule (generally 3-5 years) as determined by the city • City divided into zones for desludging • Works as a public service model • Service either by ULB or registered private sector • Charges can either be taken through user charges or sanitation tax (can be levied if desludging provided as a service to the citizens)	• Services upon request i.e. demand based • Works as a complaint redressal model • Service by ULB (depending on capacity) or private sector depending (may or may not be licensed) and user charges are taken from households
Pros: • Pro-active system wherein desludging is offered as a public service to the HHs • Services are offered to all HHs in the city thereby comparatively more equitable • More cost effective due to efficiency gains and optimal business structure • Comparatively more affordable to HHs since charges to be paid every year are low • Positive implications on the health of the community and environment over a period of time	**Pros:** • HHs decide when to avail to desludging services
Cons: • Participation by HHs and their willingness to desludge every 3-5 years which may need extensive IEC activities • Comparatively more infrastructure requirement	**Cons:** • Very low desludging frequency by HHs • No control over desludging charges. Can vary substantially with generally high prices per trip • Need strict monitoring so that septage is disposed at the designated site and not in any other area in and around the city

Scheduled Desludging	Demand Desludging
	• Low efficiencies of septic tanks with poor quality effluent overflow being released in rivers/ water bodies causing negative environmental impact

4.3.2.3 Desludging Operations

There are primarily two models for provision of desludging services in a city:

Model 1: ULB manages the desludging on its own

In this model, the ULB owns, operates and maintains the desludging vehicles. The ULB has to ensure adequate number of vehicles of different sizes. The ULB has to also ensure adequate number of skilled human resources to operate these vehicles for desludging. There is a dedicated number where citizens could call to avail the service. ULBs should prepare a standard operating procedure (SOP) to define standard processes of service provision.

Model 2: ULB outsources the desludging to private agencies

In this model, the ULB outsources the desludging service to private contractors. The selection of private agencies for emptying OSS should generally include the service providers' past experience, availability of mechanical emptying vehicles, trained human resources and adequate safety gears.

In this model, after receiving the desludging request from the HH, the ULB diverts the service requests to the empanelled agency. Even after outsourcing, the ULB should ensure appropriate monitoring of the service providers and compliance with the ULB's standard operating procedures.

Technology options for emptying and conveyance of septage

Currently many ULBs do not have appropriate vehicles as well as adequate numbers for desludging septic tanks. It has been seen that if ULBs have the desludging vehicles, they do not have adequate drivers or helpers to run the vehicles and provide the service. HHs thus find it easier to call private contractors to desludge their septic tanks which may not be undertaken in a safe manner.

Selection of appropriate vehicles is the first step and various selection criteria have to be considered to select the appropriate vehicle. If the city has procured certain large capacity of desludging vehicles, but does not have adequate and skilled human resources to run those vehicles or has an area of the city where the roads are narrow and cannot be accessed by the large trucks, then the desludging plan for the city is bound to fail. The criteria for selection of appropriate vehicles should include the following:

- Road widths/ condition/ terrain
- Quantity of faecal sludge and septage generated
- Financial resources available
- Availability of skilled human resources to operate and maintain the vehicles
- After sale service/ skill for repair of the vehicle
- Method of desludging – (will affect the number of vehicles)

The first and most important criterion is to assess the quantity of septage generated in the city, and from which parts of the city. Smaller sized vehicles would be more useful for a city which has narrow lanes.

Demand based desludging may require lesser number of vehicles than scheduled based desludging. This initial level assessment has to be made before procuring the vehicles. Types of vehicles generally used for desludging are:

- conventional vacuum trucks used for desludging septic tanks which can be accessed through broader roads,
- mini vacuum tankers which can be used where the septic tanks are located on narrow lanes and do not have proper access to roads, and
- Gulper which is smaller mechanized tricycle or motor cycle mounted collection tanks of 20-40 litres capacity with smaller vacuum pumps at the primary level backed by a secondary transport system and which can be used in informal and slum and slum like settlements and very narrow road lanes.

4.3.3 Planning for Technology Options of Treatment and Reuse

4.3.3.1 Estimating quantity of septage generation in the ULB

Quantity of septage generation in the city is required prior to establishing a treatment plant. Based on an 'Advisory Note on Septage Management in Urban India, MoHUA' and United States Environmental Protection Agency (USEPA) 1984, per capita septage generation can be assumed at 230 litres per year. This means, by multiplying the current year's population of the ULB with 230 litres/year, the ULB can estimate the quantity of total septage generation in the city in a year.

For more precise estimation of septage generation, the ULB could conduct a sample survey of different types of properties connected with OSS. From the survey, the ULB could then derive the total septage volume generated across the city.

4.3.3.2 Planning for Treatment and Disposal Site

The ULB has to assess the existing infrastructure available in the city before planning to establish a FSTP. If the ULB is partially covered with sewerage network and has a functional STP, then the septage can be disposed in the sewer line. Before that, the ULB needs to ensure the capacity of STP to take the additional load for treatment of septage.

If the ULB currently has no sewerage network but has plans to establish the same with functional STP in next 2-3 years (in case these have been approved as part of service level improvement plan (SLIP) under the AMRUT or any other state government supported schemes or self-financed), it is advisable to construct sludge drying beds and dispose the septage in sludge drying beds till the STP become functional. This is an interim solution to manage faecal sludge and septage safely.

If the ULB is currently not covered with sewerage network or a STP, and it has no plans to establish the same; the ULB can decide to construct a FSTP similar to Devanahalli. To establish FSTPs, let us discuss the parameters to be considered to identify a new septage treatment site.

Identification of New Faecal Sludge Treatment Site

To identify a new treatment site, the following parameters should be assessed:

Land availability**:** Availability of government land for establishing a treatment plant. Private land will cost more to acquire it for setting up a treatment plant.

Distance of treatment site: Long distance of treatment site will lead to higher fuel cost and might result in lesser trips.

Neighborhood: the treatment plant needs to be appropriately distanced from a residential area. The site's immediate environs need to be assessed.

Uninterrupted electricity: The treatment plant will require a reliable power supply for its efficient functioning, if the treatment technology has mechanical parts for its operation.

Geological parameters: Geological parameters such as depth of groundwater table at the selected location and type of soil should be considered. Also it will be an advantage if the selected site is not prone to flooding and it should not be a low-lying area.

Factors to be considered for Choosing Treatment Technology

Various treatment technologies are available and the ULB should carefully assess based on the selection criteria and then decide a suitable technology. ULBs need to know the advantages and disadvantages of the treatment technology and should assess how much mechanization is required to run the treatment plant. ULBs should also assess the geological condition of the site and requirement of capex and opex for the treatment technology. A full life cycle cost of the plant should be worked out for the technology and it should be viable for the city to comfortably operate and maintain the same.

Septage Treatment Options

Septage can be converted into compost or energy after its treatment. Various available options for septage treatment are listed below. The ULB may choose a combination of these technologies. These technologies are identified based on the national and international case studies.

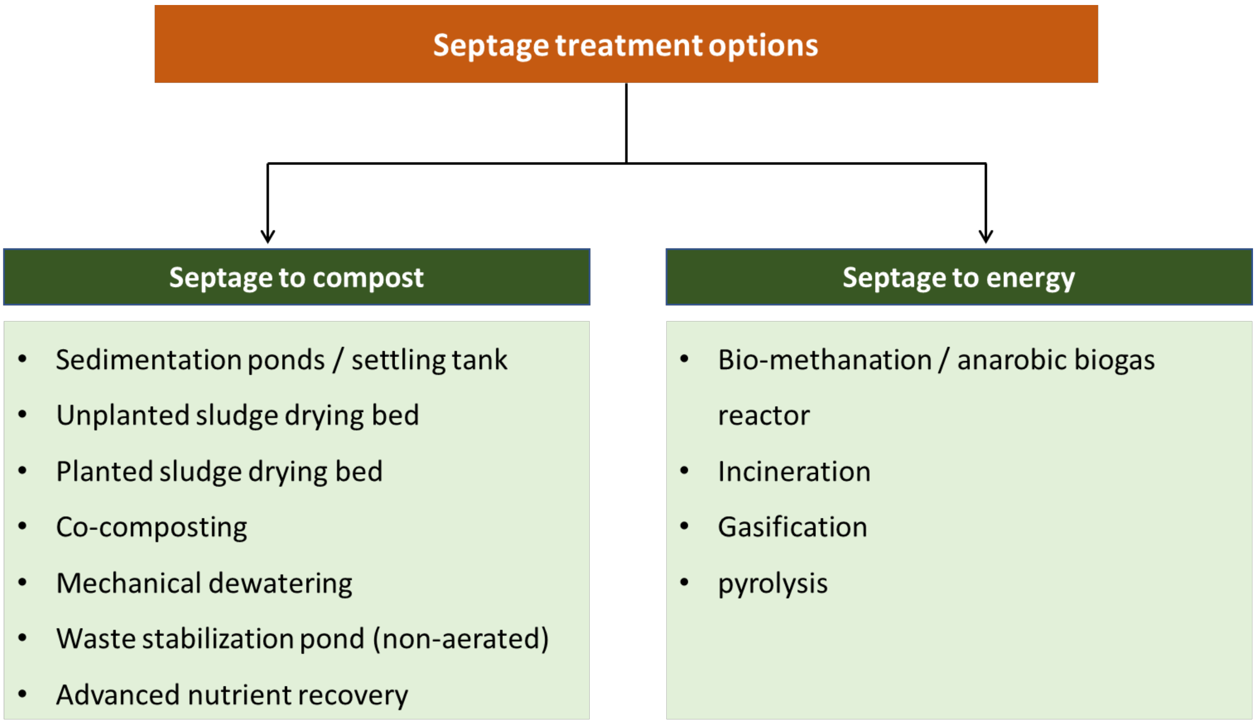

Figure 58 – Faecal Sludge/Septage Treatment Options

4.3.4 Financing of the FSSM

After understanding all the components of the FSSM value chain, it is essential to identify the possible financial sources to implement the FSSM plan in the city. Currently, SBM, Smart Cities Mission and

AMRUT are the missions which have fund allocation for implementing FSSM in the city. Funds can be availed from the SBM for construction of individual toilets, public toilets, community toilets and OSS systems. Whereas fund for procuring vehicles and equipment for conveyance of septage, establishing treatment plant and disposal site, can be availed from the Smart Cities Mission and AMRUT mission.

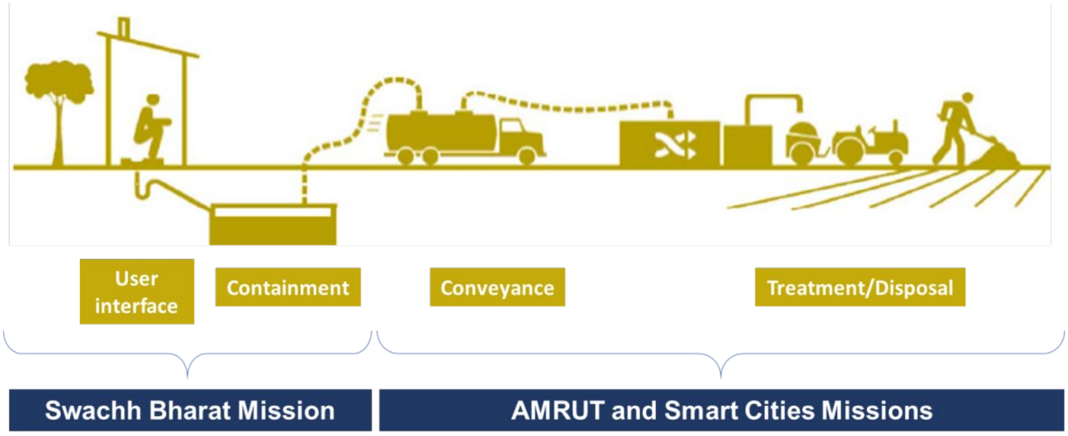

Figure 59 – Source of funding across FSSM Value Chain

Table 16 – Assessment of CAPEX and OPEX across FSSM Value Chain

	User interface	Containment	Conveyance	Treatment/Disposal
capex	Construction of new individual toilets, PTs and CTs	Construction of new septic tanks and refurbishments of septic tanks	Procurement of new suction emptier trucks	Land cost and construction cost of treatment plant
opex	Maintenance of PTs and CTs	-	Fuel cost for emptier trucks, salaries of drivers, maintenance of machines etc.	Operations of the treatment facility: Staff salaries, electricity bill etc.

4.3.4.1 Potential Sources of Financing for Capex and Opex

To ensure financial sustainability of FSSM services, it is important to assess capacity for financing of both capex and opex over the planned period. This can start with an assessment of financial requirements for both capex and opex, along with subsequent tariff restructuring, to make the system

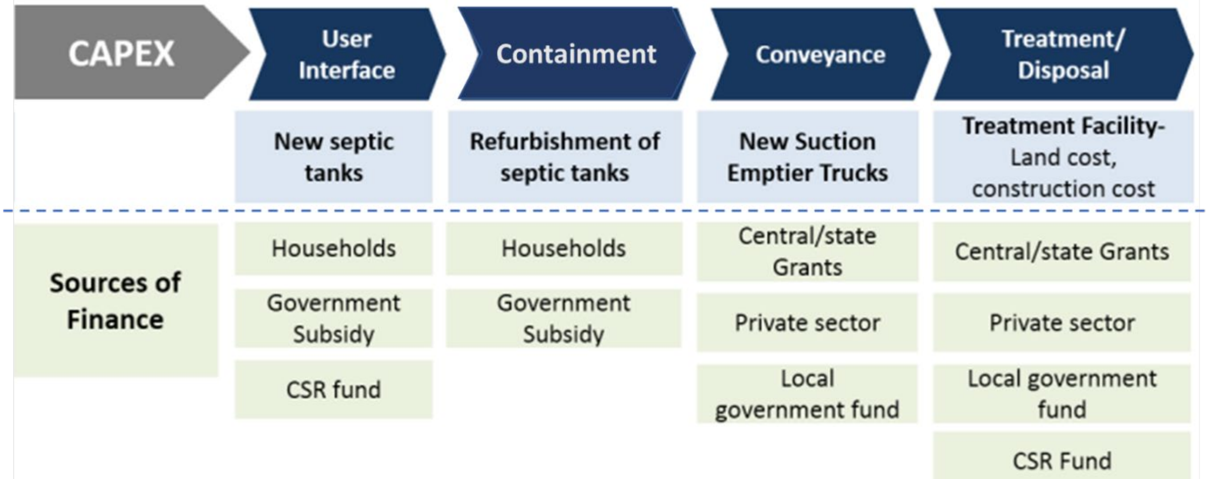

Figure 60 – Potential sources of financing for CAPEX

sustainable. The assessment also provides guidance on potential sources of finance for meeting these expenditures including funding through external grants, private sector investments, user contributions, external debt or through local government internal resources. *(Ministry of Housing and Urban Affairs, 2013)*.

The ULB needs to identify the potential financial sources available to avail fund for capex across the value chain. For construction of new septic tanks, possible sources for supporting capex include HHs, government subsidy and CSR funds. For refurbishment of septic tanks, which is a part of containment, the predominant source of capex would be government subsidy or HHs have to borne the capex. For conveyance of septage, capex can be sought from central or state grants, and under local government schemes. Private sector participation is also a potential source for capex to procure vehicles. Establishing the FSTP and the disposal site are major areas where more funds will be required if any private land needs to be procured. Possible sources from where capex can be obtained would be grants from central and state governments, funds from local government and CSR funds. Private sector participation is also a potential source of finance but willingness of the private sector is to be assessed.

The government typically will support only for the capex and not for opex; the ULBs have to explore possible sources to cover opex costs. Potential sources for opex may include housing society fees, annual sanitation tax, and desludging fees taken from the property owners on the request of desludging their OSS systems. Revenue generated by selling of product after the treatment of septage will also feed into opex revenues.

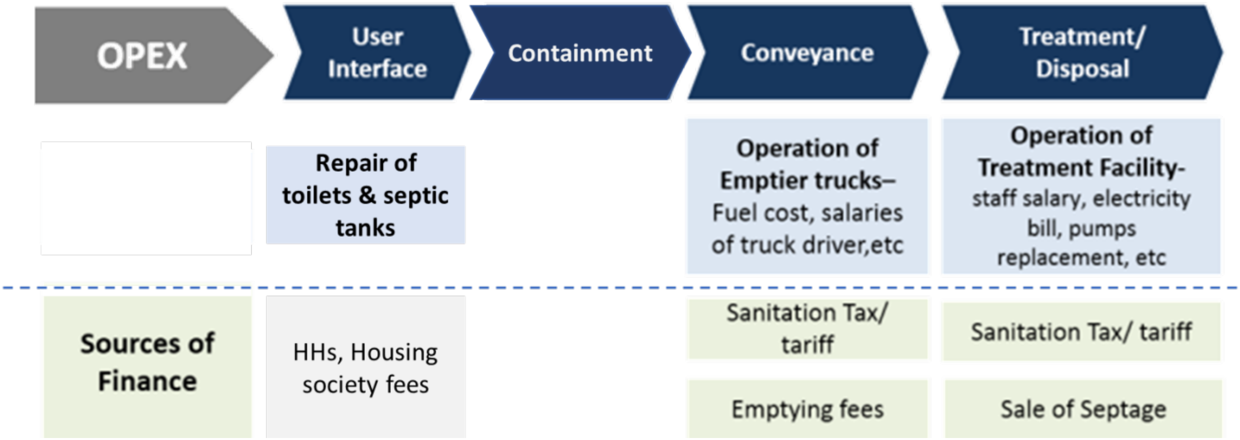

Figure 61 – Potential sources of financing for OPEX

4.3.4.2 Identification of Revenue Sources

The ULB can decide to levy taxes/user charges or both, on the HHs for FSSM services. Opex can be recovered by levying taxes and user charges from HHs. The ULBs could introduce a sanitation tax. Such a sanitation tax will be paid by the HHs to the ULB as part of annual property taxes.

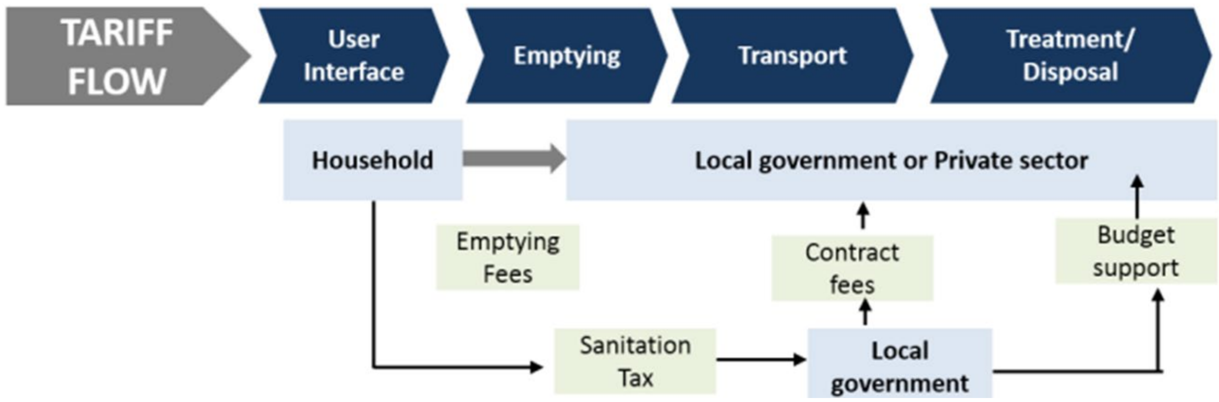

Figure 62 – Possible sources for generating revenue

4.3.5 Planning Tools

There are various tools available to guide the city managers through the process of preparation of citywide FSSM plan.

SANIPLAN tool for FSSM

SANIPLAN is a decision support tool that provides a structured approach to planning for urban sanitation. It focuses on integrated service performance with a detailed assessment of finances. It is a planning tool which can support more informed stakeholder participation. Based on local priorities, users can identify key actions for service improvement. Its dashboards also support more informed interaction with decisions makers.

SANIPLAN has three modules: 1) performance assessment, 2) planning and 3) financial planning. A key feature of SANIPLAN is to develop a feasible financing plan for both capital and operating expenditures in context of local finances. SANIPLAN can be used for various sectors – water, sanitation, solid waste, and can be customized for a specific context.

Visit https://pas.org.in to access the SANIPLAN tool

Visit https://www.youtube.com/watch?v=zWJDWwJV3xA for video on demonstration of SANIPLAN for Wai Town in Maharashtra.

SaniTab

SaniTab is an easy to use app (android based only) for conducting sanitation surveys. It can be used to generate baseline information and to create a database for properties connected with OSS systems. It can be used for planning and monitoring ODF and faecal sludge management activities in cities, or for impact assessment. It is easy to administer and allows quick analyses. Key features of SaniTab are

- Citywide digital data collection tool
- Providing enabling environment for spatial analysis
- Quick and ease in survey, minimizing human error
- Real time monitoring of survey activity

Visit https://pas.org.in to access the SANITAB tool

Activity 01 – Group Exercise

Group Exercise 1

Calculate the total septage to be collected per day from City X

FSSM Plan		
Sr. No.	**Description**	**No.**
Input Details		
A	Population	65,251
B	Total Households (HHs)	13,112
C	HHs having toilets with septic tanks	9,901
D	No. of community/public toilets having septic tanks	21
E	Average volume of household and community toilet septic tanks (cum)	5
F	Septic tank cleaning cycle for HHs (Years)	3
G	Septic tank cleaning cycle for CT/PT (Days)	7
H	No. of working days in a year	300
I	No. of trips possible per emptying vehicle per day (trips/day/vehicle)	4

1. Number of tanks to be emptied in a day = _______ daily
   - HHs toilets connected to septic tank / cleaning cycle for HHs = _______ annually
     - HHs toilets to be cleaned daily = annual cleaning / number of working days = _______ daily
   - CTs connected to septic tank / cleaning cycles for CTs = _______ daily

2. Number of trucks required = _______ nos.
   - Number of tanks to be emptied in a day / Number of trips per day = _______ nos.

3. Volume of septage to be treated = _______ cu.m. / day
   - Average volume of HHs and CTs septic tanks x Number of tanks to be emptied in a day = _______ cu.m. / day

Group Exercise 2

Calculate the tariff requirement to recover the O&M cost

2A. Requirement of opex for scheduled emptying service

Assumption

Fuel efficiency of a truck as 5 km/litre
Fuel cost is ₹ 70/litre
Avg. distance of septage disposal site is 15 km
Avg. repair and maintenance cost of an emptier truck is ₹ 2,000/month
Requirement of human resource is 2 per truck and salary is ₹ 10,000/person
Emptying service is provided 300 days a year

Calculation Guide

Fuel cost for scheduled emptying service No. of septic tanks to be emptied daily * 300 * Average distance * 2 * fuel cost / fuel efficiency	
Repair and maintenance cost of emptier trucks Number of emptier trucks required * 12 * 2000	
Establishment cost No. of emptier trucks required * 12 * No. of human resource * monthly salary	
Sub Total (1+2+3)	
Total annual O&M cost for scheduled cleaning (including 10% overhead charges such as insurance and other miscellaneous cost) Sub Total (1+2+3) * 1.10	

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NIUA National Institute of Urban Affairs

Group Exercise 2	Calculate the tariff requirement to recover the O&M cost 2B. Requirement of opex for septage treatment plant

Assumption	< 25 cu.m./day = ₹ 5,000 per month
	25-50 cu.m./day = ₹ 10,000 per month
	50-75 cu.m./day = ₹ 15,000 per month
	> 75 cu.m./day = ₹ 20,000 per month
	Avg. repair and maintenance cost is ₹ 10,000/month
	Requirement of human resource in two shifts is 4 and salary is ₹ 10,000/month per person
	Assume all the HHs as individual properties

Calculation Guide	Energy cost for septage treatment facilities Energy cost per month * 12	
	Repair and maintenance cost of the plant 12 * 10,000	
	Establishment cost No. of human resource * monthly salary * 12	
	Sub Total (1+2+3)	
	Total annual O&M cost for septage treatment plant (including 10% overhead charges such as insurance and other miscellaneous cost) Sub Total (1+2+3) * 1.10	

A. Annual O&M cost = 2A +2B = ₹________
B. Per property tariff requirement for septage management = ₹________

(Annual O&M cost (A) / total number of properties) * Tax collection efficiency

- Consider tax collection efficiency = 70%

Note: Users may calculate differential tariff structure across the properties uses; properties with toilet facility v/s properties dependent on the community toilets etc.

Answer key to Group Exercise 1

Number of tanks to be emptied in a day	14
Number of trucks required	4
Volume of septage to be treated	70 cu.m.

Answer key to Group Exercise 2

2A. Requirement of opex for scheduled emptying service

Sr. No	Particular	Cost (in ₹)
1	Fuel cost for scheduled emptying service	17,64,140
2	Repair and maintenance cost of emptier trucks	96,000
3	Establishment cost	9,60,000
4	Sub Total (1+2+3)	28,20,140
5	Total annual O&M cost for scheduled cleaning (including 10% overhead charges such as insurance and other miscellaneous cost)	31,02,154

2B. Requirement of opex for septage treatment plant

Sr. No	Particular	Cost (in ₹)
1	Energy cost for septage treatment facilities	1,80,000
2	Repair and maintenance cost of the plant	1,20,000
3	Establishment cost	4,80,000
4	Sub Total (1+2+3)	7,80,000
5	Total annual O&M cost for septage treatment plant (including 10% overhead charges such as insurance and other miscellaneous cost)	8,58,000

Total annual opex: ₹ 39,60,154

Per property tariff requirement for septage management = ₹ 211 per year

National Mission for Clean Ganga

Ministry of Jal Shakti
(Department of Water Resources,River Development & Ganga Rejuvenation)
Government of India

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