



Sanitation Capacity
Building Platform

FAECAL SLUDGE AND SEPTAGE MANAGEMENT

Training of Trainers (ToT) Module

PART-B: REFERENCE MATERIAL



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CONTENT

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SECTION I

IFSSM TOOLKIT

Introduction

Faecal Sludge and Septage Management has been a neglected area in most of the Indian cities. It has not received attention because of poor understanding of faecal sludge/ septage, lack of proper technical guidance, inadequate resources, shortage of skilled manpower and lack of finance. As per census 2011, toilets connected with onsite sanitation system are higher than the ones connected to sewer networks in India; 40 percent of households with toilets connected to sewer network as compared to 60 percent that depend on onsite sanitation systems, mainly septic tanks. An analysis of service level benchmark information suggests that majority of the cities depend fully on onsite sanitation systems.

Currently on-site pit latrines and septic tanks account for a substantial proportion of toilets in urban India. Further, as urban households without toilets obtain facilities over the next few years under SBM, it is likely that many will acquire on-site arrangements like pit latrines and septic tanks in cities at locations where sewerage systems are not available. Thus, while the containment of human waste will be largely achieved under SBM, its treatment still poses a huge challenge. While onsite sanitation is prevalent in cities, there are major gaps in its implementation across the sanitation service chain. While the gaps and consequences of lack of access to toilets are well reported, those relating to septage collection, conveyance and treatment remain largely unknown and unaddressed by most, if not all, municipal bodies and most state governments. Even in the general discourse, this major health hazard is not well understood or talked about.

Septage Management is a significant element of urban sanitation. With Swachh Bharat Mission (SBM), Government of India has set an impressive target of universal access to improved sanitation for all by 2019. The Clean India Mission has specific goals of creating open defecation free cities and integrated city-wide sanitation. The wide prevalence of on-site sanitation system in India necessitates the need to explore on-site sanitation options along with improved access to toilets and safe management of septage.

Citywide Integrated Faecal Sludge Management (IFSM) planning involves assessment and planning across the full service chain. It was observed that though many city officials aspire to adopt Integrated Faecal Sludge Management (IFSM) plan in their cities but there is lack of know-how, understanding and capacity to actually implement it. It is in this context that a web-based IFSM toolkit for Citywide Assessment and Planning was developed at the CEPT University under the Performance Assessment System (PAS) Project, an action research programme funded by the Bill and Melinda Gates Foundation.

IFSM Toolkit for Citywide Assessment and Planning

The main objective of the toolkit is to help users identify key areas of assessment for commencing IFSM planning in a city through a step-by-step approach and various tools for data collection and field assessment. It will help initiate informed discussion among stakeholders and provide for 'evidence-based' decision making by city authorities.



The tools are organized around five key areas: a) Service Performance, b) Institutions Regulations Policy, c) Technology Options, d) Private Service Providers and e) Financial Assessment. Assessing the current situation of FSM in these five areas is important to develop a FSM plan that is technically appropriate and financially feasible at local level. Assessment in each area entails review of available information at city level, identifying information gaps, and conducting field studies where necessary. The web-based toolkit can be accessed at <http://ifsmtoolkit.pas.org.in/>.

Module 1: Assessing Service Performance across the Full Service Chain

Assessing service performance across the service chain through a city level assessment is the first step in planning process. It is an important exercise, which provides an initial sense of the state of FSM in the city, help in understanding the context and identifying gaps in key services. The data collection and field assessments in the city should start with a kick-off meeting with key stakeholders.

Assessment areas		
Assessment through City level Performance Indicators	Assessment across each link in the service chain	Summary and vision
Assessment Tools		
1. SANIPLAN: Information collection and initial performance assessment	a. SaniPlan , SaniPlan-FSM b. Data for SaniPlan Input: List of sources	
2. Physical and spatial analysis of city	a. Sample maps	
3. Field assessment of toilets and onsite systems	a. SaniTab tool (Android installer.apk file) b. Manual for Surveyors c. Template for survey of small contractors and masons d. Template for technical assessment of onsite systems	
4. Field assessment of emptying services and treatment	a. Template: Onsite system emptying service b. Template: Wastewater quality assessment	

Assessment Areas

Assessment through City Level Performance Indicators

A sanitation service chain includes links for Access – Collection – Conveyance – Treatment – Reuse/Disposal. Service performance assessment is done for each of these links in the chain on the basis of key indicators. This is done using the first module of SANIPLAN for performance assessment. SANIPLAN provides a structured approach to data collection for this. Performance indicators have been developed as SAN-Benchmarks to capture different city contexts with full onsite sanitation, as well as mixed systems that have part sewerage and part onsite systems. SANIPLAN also enables traffic light analysis by comparing with benchmarks and peer performance.

Assessment across each link in the Service Chain

Detailed assessment of services will need to be done across each link in the chain through appropriate field assessments:

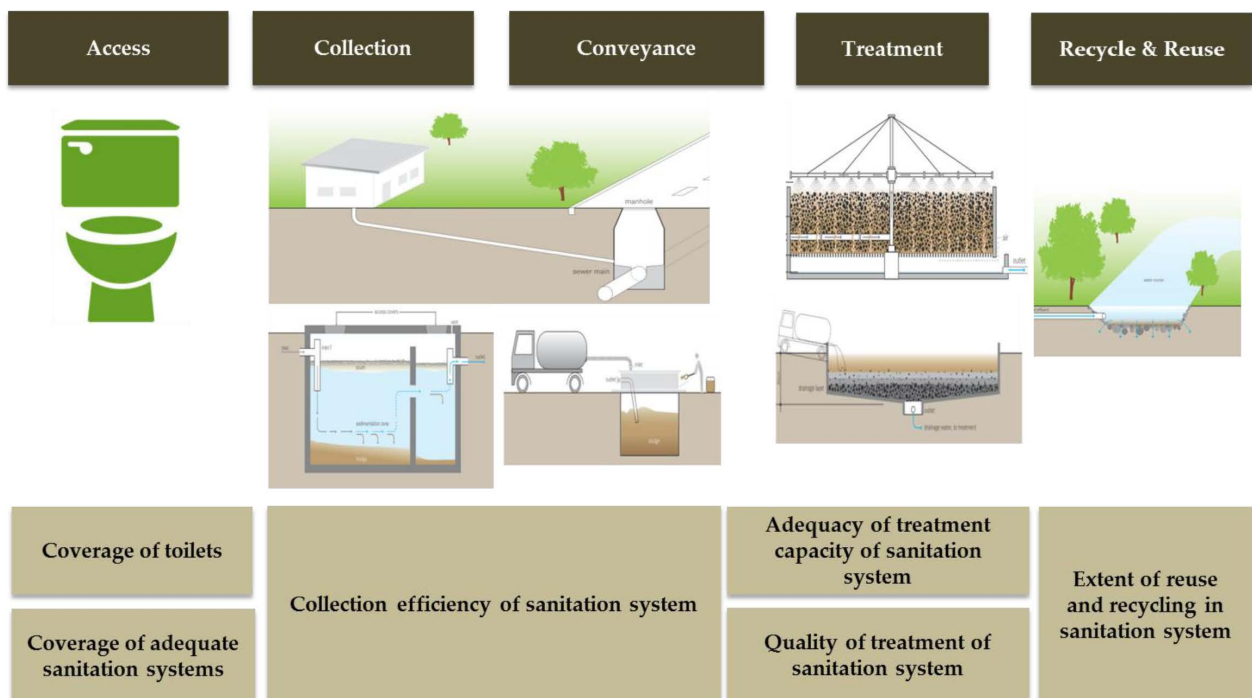
Access: Describes the type of toilet facilities available to the residents. It is useful to assess dependency of residents on of individual,community and public toilets. Ideally such information should be assessed for various zones/wards of the city.

Collection of septage: Describes the ways of collecting, storing,and sometimes treating the Faecal waste generated by the users. It is necessary to identify the type of toilets (septic tanks, double pits etc), and details related to location, size, design and access for emptying.

Conveyance: It is also important to assess how the faecal sludge is conveyed from household/community toilets to the treatment / disposal site. One needs to identify who is involved in emptying, the equipment used (e.g. septic tank emptier, jetting machine) and its details related to type and size and the fees charged for emptying by public and/or private agencies. As far as possible, details should be collected for different wards/zones of the city. The monitoring system for FSM should also be assessed.

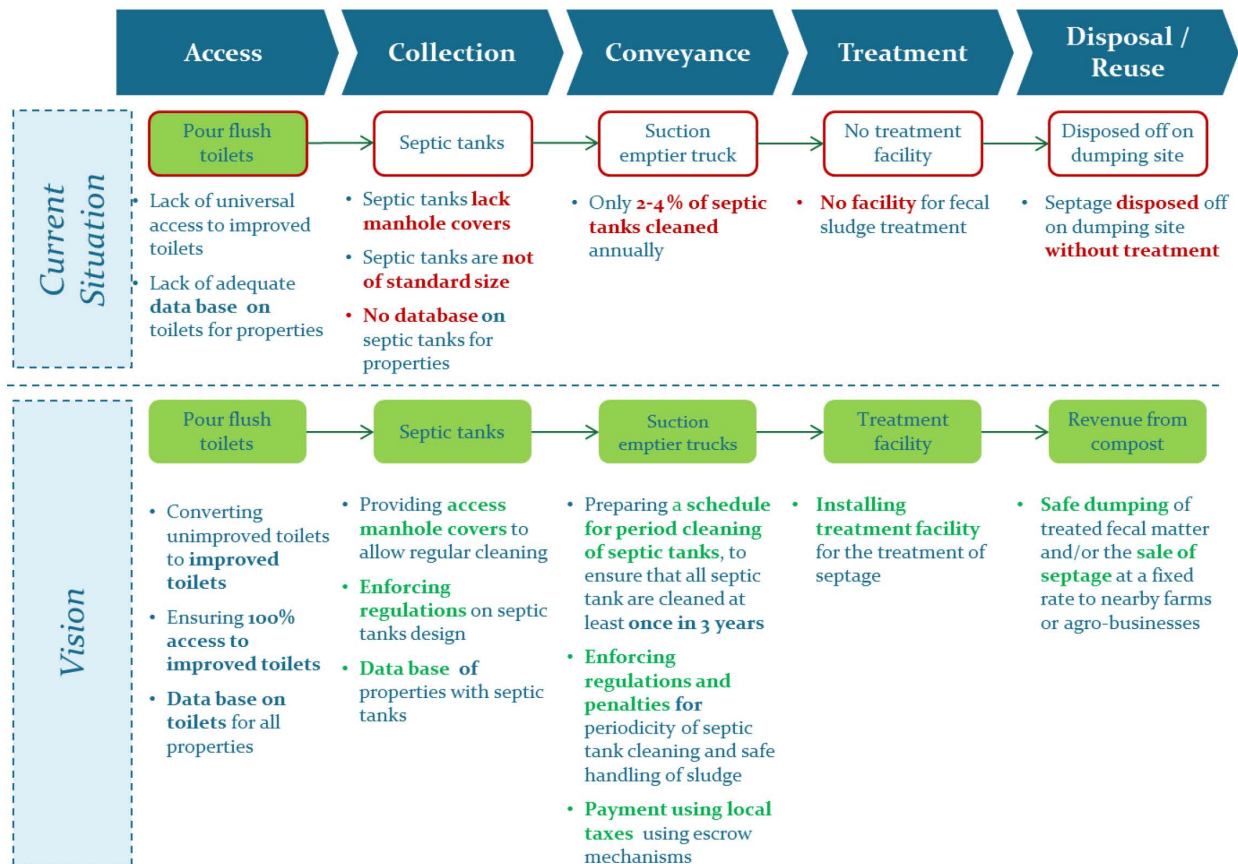
Septage treatment, disposal: Assess how the collected faecal sludge is treated. In a large number of cities, it is often discarded in water bodies or on the ground without any treatment. It is important to assess the soil and water quality at the location where the septage is being treated / dumped.

Extent and nature of reuse: The treated sludge can be used as fertilizer or used to generate energy. Assess how the sludge is used, assess the market, if any, for treated sludge.



Summary and Vision

The summary of assessment combines SANIPLAN results with field assessments to provide a citywide picture across the service chain. This can guide stakeholder consultation and deliberations on a vision to improve performance for end-to-end sanitation. This may be done using simple charts across the service chain as well as charts indicating faecal sludge flows across the service chain to show performance in relation to prevailing norms. The vision will suggest what needs to be achieved and potential actions across the full service chain.



Assessment Tools and Resources

The data collection and field assessments in the city should start with a kick-off meeting with key stakeholders. As a first step, it will be necessary to obtain background information about the city. For this, identify available plan documents, any recent surveys done by the local government as well as by any research / academic institutions in the city.

Examples of key plan documents and key data sources:

Census of India, 2001. 2011	Service Level Benchmark (SLB) report
City Master (Development) Plan	Environment Status Report (ESR)
City Sanitation Plan (CSP)	Municipal budgets and financial statements
City Development Plan (CDP)	Recent surveys carried out for any projects
Slum Free City Action Plan	DPR of any projects at state or central level
ODF City Plan	Water audit/ Energy audit

Assessment of service performance can be done with the following 4 main tools. This information and analysis will also help in establishing an overall understanding of the existing situation of the city. In cities where adequate data or information is not available from local government systems or earlier studies, SANITab may be used for property level information collection.

1. SANIPLAN: Information collection and initial performance assessment

SANIPLAN provides structured input formats for data needed to assess SAN-Benchmarks. It covers aspects related to: Demography, access to toilets and septic tanks, community/ public toilets, sewerage connections and network, septic tank emptying, treatment facilities for sewage, grey water and faecal sludge treatment. It also seeks financial information related to taxes / charges for septic tank emptying, and overall financial situation of the local government.

SANIPLAN enables assessment of service performance for SAN Benchmark indicators along with peer comparisons. It uses the set of indicators suggested by the Service level benchmarking (SLB) framework of the Government of India. The wastewater indicators have been adapted to capture the onsite sanitation systems as per SAN-Benchmarks. The model allows the user to specify ranges for peer comparisons.

- a. **SaniPlan , SaniPlan-FSM**: Excel based decision support tool. Users can input values, select different actions for service improvement and see results in the form of dashboards. SaniPlan as a whole covers all 3 sectors i.e. water, sanitation and solid waste. However, SaniPlan-FSM has been tailored to suit only IFSM needs.
- b. **Data for SaniPlan Input: List of sources**: SaniPlan requires a large number of data inputs. This checklist provides suggestions about possible sources for data points.

2. Physical and spatial analysis of city

The detailed assessment of the city sanitation should also include spatial analysis. It is important to understand the variation in physical and socio-economic characteristics over space. For this purpose, maps with ward and administrative boundaries and other features should be used to depict the analysis of sanitation situation in the city.

- a. **Sample maps:** A collection of maps that can be used as examples of maps that need to be generated for IFSM and planning.

3. Field assessment of toilets and onsite systems

It is important to get information on type of toilets used (dry, pour flush, flush) and the containment (single pit, two-pit, septic tank, sewer connection). This information may be available from the census or other local studies. In case this is not readily available, it may be necessary to carry out a house/property level survey. Based on time and resources available, one can do a sample survey or cover all households/properties. For a sample survey, one has to ensure adequate representation of all wards/zones and all socio-economic groups. Use of tools like SaniTab (see link) can help in conducting rapid surveys.

- a. **SaniTab tool** (Android installer .apk file): PAS Project has developed an android based application named 'SANITAB' as a data collection, survey and a mapping tool. This tool, consisting of an online questionnaire, can be used by any city council to conduct household level sanitation survey in the city using personal digital assistants (PDAs).
- b. **Manual for Surveyors:** Contains instructions for surveyors using SaniTab for each question as well as using the app.
- c. **Template for survey of small contractors and masons:** A guide containing points for assessing capacity of local contractors and masons that are involved in the actual construction of toilets.
- d. **Template for technical assessment of onsite systems:** This checklist provides a list of areas and parameters needed for assessing onsite faecal waste systems. It also provides 'desirable' qualities/ good practices for the same next to each assessment parameter for easy comparison.

4. Field assessment of emptying services and treatment

Field assessment of emptying services for septic tanks and septage treatment needs to be done at two levels. One is at the household level to assess services related to emptying septic tank and the other is on how the septage is treated, and if not where is it disposed. Emptying of septic tank is done by local government or private enterprises. It is important to assess the current emptying practices, by both public and private sector in terms of their response time, costs, fees, equipment used and disposal of septage. It is necessary to assess how the septage is discharged, treated and reused. Often collected septage is dumped on ground or in water bodies without any treatment. This has serious implications on soil and ground water. It is important to assess how the septage is disposed of. The environmental implication of this practice needs to be assessed in terms of ground water pollution and soil quality.

- a. **Template for Onsite system emptying service:** Onsite systems require periodical emptying which maybe provided by the local government or private providers. This template assists users in easily collecting information required to assess adequacy of existing services.
- b. **Template for Wastewater quality assessment:** The effluent and septage being discharged need to adhere to established wastewater quality norms. This template provides all related standards in one place.

Module 2: Enabling Environment: Policy, Regulation and Institutions

Sanitation is increasingly seen as a key issue in environmental protection. Improper disposal of human wastes can pollute water bodies, groundwater, and land surfaces and affect the quality of life for those living in the area. This requires moving away from a ‘complaint redressal’ mode of FSM service delivery to a service delivery mode for FSM. In this context, it is important to understand and assess the prevailing enabling and regulatory environment as well as capacity of local stakeholders to manage the citywide FSM services. This can be assessed by a review of: a) State/national policies and guidelines on FSM, b) Regulatory framework for treatment, disposal, and reuse of faecal matter, and c) assessing roles and responsibilities of local government for FSM.

Assessment areas		
National and state policy and guidelines	Regulatory regime for FSM and the institutional roles	Assessing local capacity for FSM
Assessment Tools		
5. Assessing policies and regulations affecting FSM at local levels	a. Sample policies and guidelines (NUSP , FSM guidelines GOI /GoM , GoTN , FSM in Urban Maharashtra , Other Sanitation Acts)	
6. Assessing capacity at local level: local government and other stakeholders	a. Examples of Process mapping b. Examples of citizens charter c. Interview guide for local government to assess capacity for PSP	

Assessment Areas

National and state policy and guidelines on FSM

In many developing countries, it is recognized that a large number of cities depend on on-site systems of waste water and FSM, and that they will continue to do so in the foreseeable future. New FSM policies are beginning to emerge at national and local level. Where such policies exist, it is important to identify key aspects of these policies that affect FSM at city level. Key policy areas to be assessed relate to the roles and responsibilities of various agencies at state and local level. It will also be necessary to assess areas of compliance for local government as required by the national or state policies.

While the municipal legislations/constitutions generally provide roles and responsibilities of local governments on sanitation, it is important to review the provisions in the national/state level policy on FSM and its consequent impact on role of local government.

Specifically the aspects to be reviewed include: a) National and State (Province) laws and policies that provide the overall framework for FSM; b) financial provisions related to grants for project funding or subsidies for facilities for different components of the service chain, c) Rights and responsibilities of

citizen and local governments and other service providers, and d) Equity aspects in the policies and programmes through analysis of budgetary allocations for specific groups and locations.

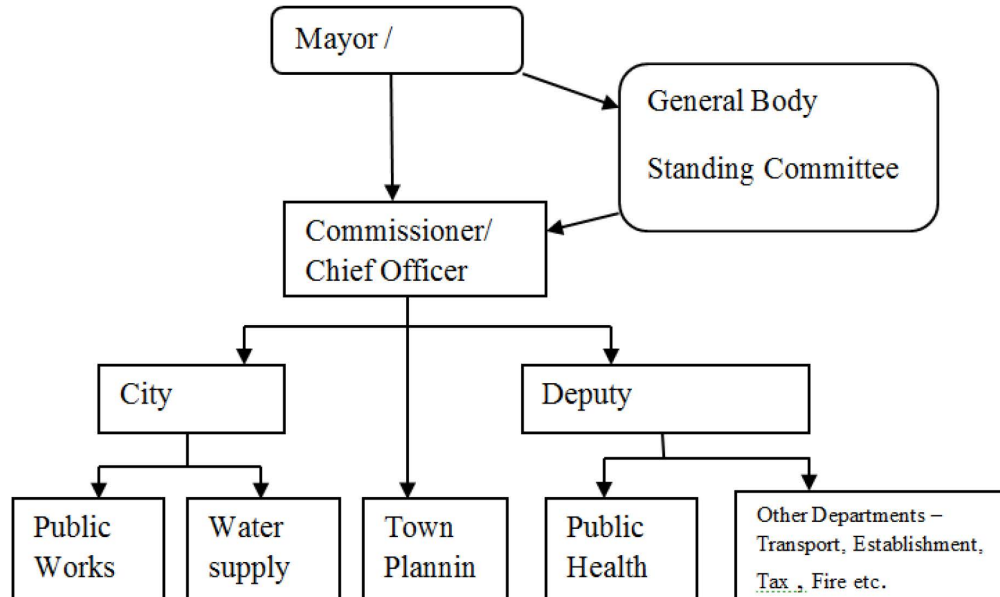
Regulatory regime for FSM and the institutional roles

Regulatory framework for each link of the FSM chain may be different, so it is necessary to explore various regulations that affect different links. For example, for toilets – it is the building regulations and/or urban planning regulation that prescribe minimum sizes and type of toilets. This is monitored at the local level through the building permission process.

There are state and local regulations related to design, discharge standards, building codes, planning and contracts. The health department of local government generally regulates waste water discharge (drains, stagnant water pools etc.). For waste treatment and disposal to natural water bodies, the state/national environmental regulations provide guidance. State bodies as well as local governments may also levy fines for offenders.

Assessing local capacity for FSM

Understanding of the institutional setup at local level is essential for understanding how the system works. Key aspects of assessment include identifying important stakeholders and key decision making authorities.



It is important to assess local government capacity to deliver FSM services and its ability and willingness to engage private sector enterprises for delivering FSM services. Local government capacity maybe assessed in terms of its organizational structure, number of staff by educational background and experience, data management, monitoring systems and robust internal processes for FSM services delivery or monitoring. The assessment will require both data on structure and staff but also more qualitative assessment of staff awareness and commitment to sanitation services. An

important consideration will also be to review processes related to different aspects of FSM service delivery through appropriate process mapping exercises.

Assessment Tools and Resources

Analysis of the institutional setup is essential for understanding how the FSM system works. It is important to identify the key decision making authorities and important stakeholders within the system. The set of tools include assessment of hierarchy within the local government and the roles and responsibilities at each level of the hierarchy in the sanitation department. A stakeholder analysis should also be done.

5. Assessing policies and regulations affecting FSM at local level

It is essential to review existing policies and regulations related to sanitation, and septage management. Often such policies are framed at national or state level. The policies and regulations have to be reviewed with a focus on their implications on each link in the service chain: a) policies toilet and septic tank/pit design and technical considerations, (b) the building plan approval process for onsite sanitation systems, c) licensing procedures for septic tank emptiers, d) appropriate selection of private sector partners through bidding and related contracting procedures, and e) regulatory provisions related to waste disposal and quality standards. Special attention needs to be paid on the equity aspects of such policies.

a. Sample policies and guidelines

- [National Urban Sanitation Policy - India](#)
- [Feacal Sludge Management guidelines by Government of India](#)
- [Feacal Sludge Management guidelines by Government of Maharashtra](#)
- [Feacal Sludge Management guidelines by Government of Tamil Nadu](#)
- [Feacal Sludge Management in Urban Maharashtra](#)
- [Other Sanitation Acts](#)

6. Assessing capacity at local level: local government and other stakeholders

Stakeholder Analysis: At the local level, a number of stakeholders are likely to influence IFSM policy, plan and implementation. It is useful to assess all stakeholders ranging from staff from local government, elected representatives, local civil society organizations, other NGOs, consultants, credit institutions, and organizations of local professionals and businesses.

A stakeholder analysis may be done to identify important stakeholders in the city that can have direct and indirect links to FSM activities. A stakeholder mapping is done on the basis of the influence of each stakeholder and their interest in the IFSM related activities. This analysis helps identify key stakeholders, who must be consulted at different stages of FSM process through appropriate stakeholder consultation processes.

- a. **Examples of process mapping:** It is also be useful to identify key activities linked to FSM for which process mapping is done to identify their efficiency and key changes needed. Process mapping can be done using a workflow diagram that provides a clearer understanding of a process or series of parallel processes.
- b. **Examples of citizen's charters:** Many local governments have developed Citizens' Charters to assess service provision. A Citizens' Charter represents the commitment of the Organisation towards standard, quality and time frame of service delivery, grievance redress mechanism, transparency and accountability. It would be good to assess whether the local government's citizens charter includes FSM services.
- c. **Interview guide for Local government to assess capacity for PSP:** This tool is a detailed interview guide that will help us understand overall experience of local government related to involvement of private sector participation for provision of urban services. This tool will help us understand the rationale behind entering into PSP, It will help to assess the capacity of the municipality in terms of whether they were able to draft the PSP on their own or did they require any external support. The tool will help to understand the procurement process of PSP and what kind of monitoring systems were established to monitor the PSP and lastly the tool will help to understand whether the local government has the institutional capacity to undertake PSP in FSM services.

Module 3: Technology Options for FSM Services

In designing a citywide IFSM service, it is important to assess technology options for each link in the service chain. This ranges from appropriate toilets and onsite systems such as septic tanks and conveyance to treatment and reuse. For toilets and septic tanks, assessment of these systems is necessary. For emptying services, options such as scheduled emptying of pits/septic tanks and assessing infrastructure requirements need to be assessed. Finally, many technologies are available for septage treatment. These will need to be assessed using a framework for choosing an appropriate option for treatment of septage at a city level. The possibility of reuse will also need to be assessed.

Assessment areas		
Assessing technical options for toilets and septic tanks	Assessing options for emptying services and conveyance	Assessing options for treatment and reuse of faecal sludge/septage
Assessment Tools		
7. Assessing options for conveyance of septage services	a. Determining infrastructure required for septic tank emptying cycle b. Template for licensing of septage transporter c. Template manifest form for emptying	
8. Assessing options for treatment and reuse of faecal sludge	a. Factors influencing selection of treatment facilities	

Assessment Areas

Assessing technical options for toilets and septic tanks

The performance assessment area provides an understanding of frameworks used in assessing current facilities, services and technology. For developing a citywide IFSM Plan, it would be necessary to identify various technical options to refurbish current facilities. For existing toilets, this would include aspects such as conversion of single pit or service latrines to an improved latrine (e.g. two-pit ventilated or a toilet with septic tanks). For toilets with septic tanks, some refurbishment may be necessary to ensure that it has accessible openings for easy emptying. For new toilet construction, there are various options to be considered – such as pre-fabricated toilets or in-situ construction. On containment of faecal sludge, there are options such as bio-toilets, eco-san toilets etc. Each of these options will have to be assessed on the basis of its capital and operating costs for the household, and its service quality.

Assessing options for emptying services and conveyance

Based on the analysis carried out for existing system, appropriate options for organizing the emptying services will need to be assessed. The two main options generally considered or used are: a) a scheduled service organized around 3 to 5 year cycle as being done in some cities in Vietnam and Philippines, or b) a demand-based or on call service as in Dakar, Senegal or Accra, Ghana.

For example, the scheduled service is preferable where: a) regulation requires this, b) capacities of septic tanks across properties are not significantly different at least within each zone, c) where there is a history /experience of providing such services (e.g. for SWM) through ULB itself or by contracts with private sector. The decision may also be affected by presence of private service providers and their capacity and preferences. Similarly, the choice would also be affected by the spatial pattern of the city and current or potential location for septage treatment or disposal. To assess this choice, at least a qualitative assessment exercise maybe developed to assess the likely efficiency gains from providing a scheduled service. Where more detailed data is available, a modelling exercise can be done to assess efficiency in terms of time savings and total costs over a 3 to 5 years period. In any case, qualitative assessment should be done for each option. The factors to be considered may include current regulatory provision, likely efficiency gains, local acceptability among decision makers and different consumers.

Once an assessment of these two options is developed, it should be discussed and agreed upon with local stakeholders and key decision makers.

Once the choice is made, further assessment should be done in terms of number, type and capacity of septic tank emptier to be used. This will depend on quantitative analysis based on load and trips required as well as on the prevailing road patterns in the city and ease of access to properties. More detailed planning may include route planning for a scheduled service, though in case of contracts with private providers, this will ideally be done by the selected private providers.

Assessing options for treatment and reuse of faecal sludge/septage

Most cities in South Asia lack septage treatment facilities. There are various options available to treat faecal sludge. These are: Waste Stabilization Ponds; Constructed Wetlands; Drying Beds (Planted/Unplanted); Settling/Thickening Ponds; Mechanical De-watering etc.

These technical options have to be assessed on the basis of (a) their technical performance; (b) capital and operating cost; (c) land requirement; (d) electricity requirement for 24x7; and (e) potential for reuse. A sanitation system matrix developed by PAS may be useful in such assessment.



Assessment Tools and Resources

Assessment of technology options can be done with the following two main assessment tools focused on assessing options for emptying services and for treatment of faecal sludge.

7. Assessing options for conveyance of septage services

To assess options for septic tank emptying and conveyance of septage, it is important to determine the requirement for septic tank emptiers – both type and quantity. This tool enables calculation of these requirements using factors such as: number of septic tanks, type of areas to be reached, cleaning cycle expected, and distance to treatment site.

- Determining infrastructure required for septic tank emptying cycle:** Onsite systems require regular emptying. This excel based tool allows the user to calculate infrastructure requirements for the same based on population, sludge generation, desired cycle length etc.
- Template for licensing of septage transporter:** In cases where the local body is not directly involved in transportation of septage and has outsourced the process, the operating agency needs to be issued licenses to be able to carry out the work. This tool contains a template for the same as well as related instructions.
- Template manifest form for emptying:** Manifest forms are an integral part of a comprehensive septage management program. It contains information on the type and quantity of the waste being transported, instructions for handling the waste, and signatures of all parties involved in the disposal process. This ensures accountability in the process. This tool contains a template for such a form.

8. Assessing options for treatment and reuse of faecal sludge

This tool provides a ready framework for assessing options for treatment and reuse of faecal sludge. The various technologies are listed along with their characteristics. Assessment can be done on suitability of these technologies in a particular context on the basis of various factors viz: land requirement, capital and operating costs, level of mechanization etc.

- a. **Factors influencing selection of treatment facilities:** A comparison of the available technologies for septage treatment on the basis of various parameters such as capital and operating costs, land requirements, ecological effect etc.

Module 4: Potential of Private Sector Role across the Service Chain

While the city governments generally have the mandate to ensure service provision, often there is an active private sector that provides FSM services in the city. It is necessary to assess the current role of private sector providers as well as their potential role in a citywide service provision.

The assessment will thus need to start with a quick landscape analysis, and can be followed by a detailed assessment after the FSM strategy is developed. Interviews with the city government officials will be needed to assess their views and perceptions of various options for private sector engagement.

Assessment areas		
Assessing local government capacity for PSP	Landscape study of private sector	Develop and review potential structure of PSP option
Assessment Tools		
9. Guide to a landscape study of private sector	a. Interview guide for Private sector players	
10. Review of potential structure of PSP option	a. Interview guide for Local government about FSM-PSP structure and contracts b. Interview guide for Private sector about FSM-PSP structure contracts c. Model contract/bid documents (O&M / construction)	

Assessment Areas

Assessing local government capacity for PSP

The main objective of this assessment is to understand the past experience of local government with planning and implementing engagements with the private sector in provision of urban services. This would be based on an understanding of the processes and key stakeholders required for implementing a private sector engagement right from the evaluation of need for the project to contracting, implementation and monitoring. This assessment would help to assess the key challenges that are encountered before, during and after awarding the contract as well as the positive practices that have enabled success from local government point of view.

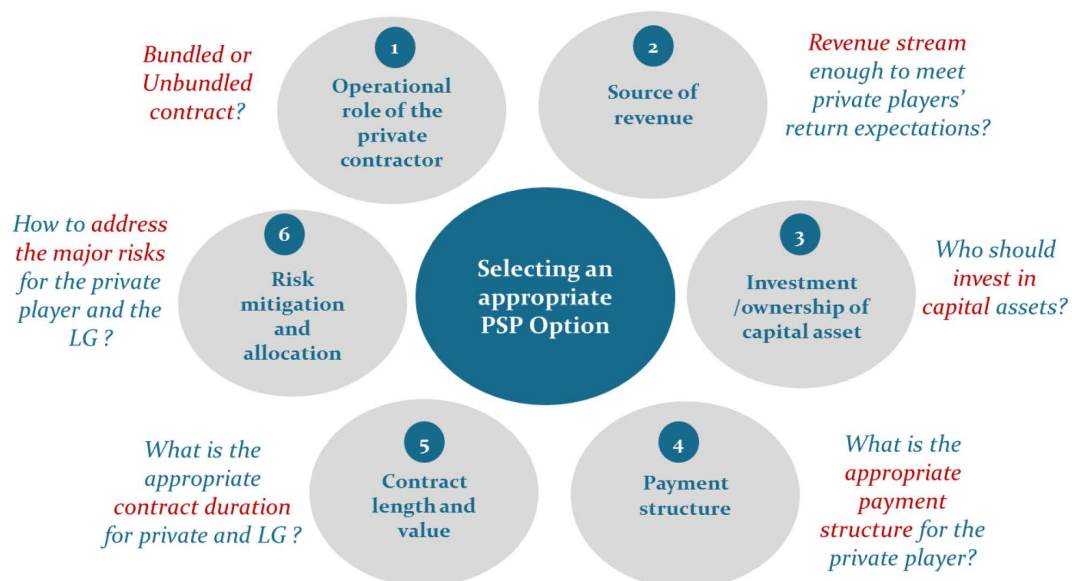
Landscape study of private sector

In order to assess the potential and scope for private sector involvement, it is necessary to assess the types of private players operating within city area or in the region to assess their interest in citywide IFSM services. This landscape study would help provide an Assessment would include work profile, interest, expertise and capacity and willingness to undertake various activities of septage management services.

Develop and review potential structure of PSP option

There are six decision areas processes involved in structuring and assessing a PSP option for septage management.

1. **Operational role of Private Sector – appropriate bundling of contracts:** Should the local government put out an integrated FSM contract for the entire service chain, or unbundle the contract for specific activities
2. **Return expectations and source of revenue:** What are the likely revenue requirements to meet private players' return expectations? What could be the potential sources for these revenues – taxes or user charges?
3. **Investment and ownership of capital assets:** Should the capital investments in the vacuum truck and sludge treatment facility be borne by the private players or by the local government?
4. **Payment structure:** What is the appropriate payment structure? E.g. should it be a fee per unit, or a lump sum contract or a monthly fee?
5. **Contract length and value:** What is the appropriate contact duration and value which compensates private players for the risks they undertake, while providing the local government with the flexibility to switch providers?
6. **Risk mitigation and allocation:** What are the major identified risks for the private sector and the city government that need to be mitigated? If it is difficult to mitigate some risks how should these be allocated?



Once these key questions are addressed, it will be possible to develop an appropriate structure of engagement with the private sector as well as develop the necessary contracts and bid documents. Based on these, a further round of detailed consultations should be done with both the local government as well as a few key private players to get their feedback.

Assessment Tools and Resources

9. Guide to a landscape study of private sector

This tool is a detailed interview guide that will help the municipality identify the work profile, interests, capacity, willingness and interests of private sector in undertaking various activities of septage management. It will help to assess/understand four key areas: a) number of private players in the market, b) technical capacity of private players, c) barriers and enabling factors for undertaking PSP, d) potential interest of the private sector in various activities of septage management, and e) their perceptions of risks and expected returns.

- a. **Interview guide for Private sector players:** A guide cum sample questionnaire for assessing the capacity of private players being considered for outsourcing operations.

10. Review of potential structure of PSP option

The potential PSP structure as developed along the six key decision areas will need to be backed by draft contract and bid documents. This set of decisions and materials should be reviewed by further round of interviews with both the local government officials as well as a few of the potential private sector contractors. The attached interview guides can be used for this purpose. Based on the feedback, these documents can be finalized in order to proceed to procurement.

- a. **Interview guide for Local government about FSM-PSP structure and FSM contracts:**
The potential PSP structure as developed along the six key decision areas will need to be backed by draft contract and bid documents. This set of decisions and materials should be reviewed by further round of interviews with both the local government officials as well as a few of the potential private sector contractors. The attached interview guides can be used for this purpose. Based on the feedback, these documents can be finalized in order to proceed to procurement. Interview guide for Local government about FSM-PSP structure and FSM contracts: A guide to assessing the local government's preferences on the various options in contract bundling for outsourcing and the standard terms and clauses of such contracts.
- b. **Interview guide for Private sector about FSM-PSP structure contracts:** A guide to assessing the private sectors' interest in the various options in contract bundling and their preferences and understanding about the standard terms and clauses of such contracts.
- c. **Model contract/bid documents (O&M / construction):** Comprehensive model formats for contract/ bid documents.

Module: 5 Financial Assessment

To ensure financial sustainability of FSM services, it is important to assess capacity for financing of both capital and O&M expenditure over the plan period. This can start with an assessment of financial requirements for both capital and O&M expenditures. The assessment also provides guidance on potential sources of finance for meeting these expenditures including through external grants, private sector investments, user contributions, external debt or through local government internal resources.

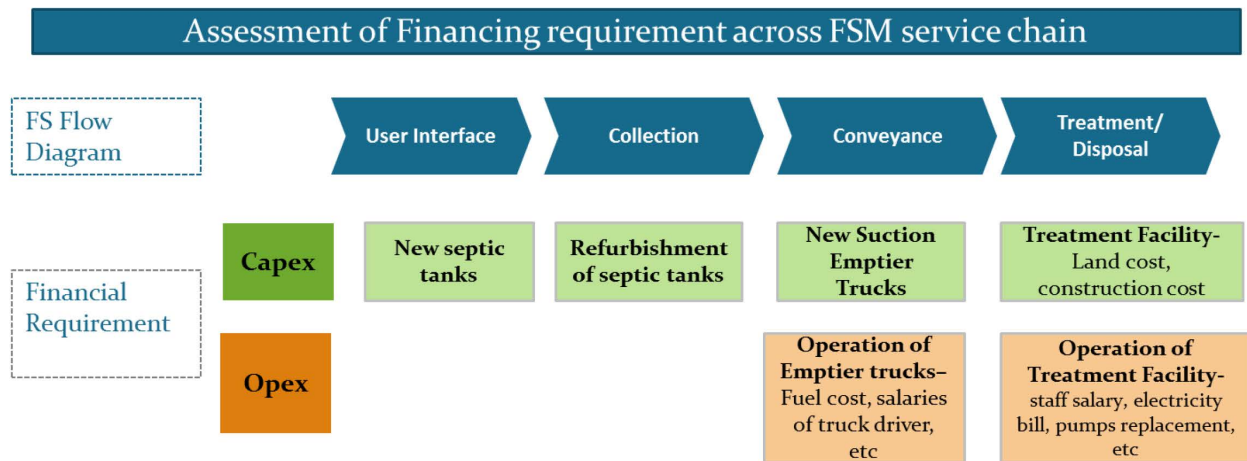
Assessment areas		
Assessment of finance requirements and potential sources	Potential sources of finances for capital/ O&M expenditures	Review of required tariffs
Assessment Tools		
11. SANIPLAN: Financing plan and tariff review	a. SaniPlan , SaniPlan-FSM b. Financial planning using SaniPlan	
12. Assessing willingness to pay and to charge	a. Questionnaire: Assessing willingness to pay b. Sample resolution by local government	

Assessment Areas

Assessment of finance requirements and potential sources

The first step in Financial Assessment is to determine the financing requirements for proposals for the full service chain – starting with toilets in the user interface, to collection, conveyance and treatment or disposal. The finance requirements are essentially based on costs of achieving the various improvement activities suggested. It is also important to ensure that both capital costs and O&M costs are assessed. SANIPLAN can be used to assess these costs.

In addition to these costs, there may also be additional activities such as awareness generation, improving data and monitoring systems and improving efficiency in collection of taxes and user charges by the local government. SANIPLAN enables the users to identify all actions. Actions are categorized as: a) data improvement measures, b) process/ policy improvement measures, c) existing system improvement measures, and d) creation of new infrastructure. All selected actions are calibrated to generate a profile of phasing, as well as capital and O&M expenditure requirements.



Potential sources of finances for capital/O&M expenditures

For developing a financing plan for FSM, potential sources of funds for capital expenditures will be required and terms and conditions for each will need to be identified. The potential sources for capital expenditures may include grants from national/provincial government; own resources of local government, CSR funds from corporate sector or loan from financial institutions. In case of private sector participation, the willingness of private players to meet capital expenditure will also need to be assessed. Similarly, background assessment of various ongoing programmes at the state and national levels will provide an idea of the possibility of accessing such funds to meet the capital expenditure requirements as well as for other needs such as awareness generation or data improvement measures.

SANIPLAN enables users to suggest possible sources for each selected action.

Review of required tariffs

An overall assessment of city finances will help to assess ability and willingness of city government to meet its own obligations for meeting its share of capital expenditure and to ensure sustainable sources for O&M expenditure through local taxes, user charges or surplus from its revenue account. If the local government plans to take debt, its sustainability through adequate debt service coverage will need to be assessed. This assessment can be carried out in SANIPLAN. This will require information for at least 3 to 5 years on local government revenue and expenditure to be able to project municipal finances over the plan period for overall municipal budget as well as separately for wastewater and sanitation sector.

This assessment in SANIPLAN makes it possible to assess the extent of tariff increases necessary for sanitation related taxes or charges as well as for the general tax such as property tax, which is the main source of own income for most local governments. It may also be possible for the local government to levy a sanitation tax. Assessment of taxation involves an assessment of ability to levy tax/user charge and affordability and willingness to pay. Consultation with administrators and elected representatives on their willingness to levy such a tax/user charge is very important. This can also be backed by focus group discussions among key user groups in the city.

Assessment Tools and Resources

Financial assessment can be done mainly through SANIPLAN. It provides features for assessing financing requirements as well as exploring the implications of different sources of finance for both capital and O&M expenditures. Its detailed assessment of municipal finances also helps to carry out an analysis of required tariff levels.

11. SANIPLAN – Financing plan and tariff review

SANIPLAN provides a structured approach to assessing financial requirements as well as to assess required tariff levels. Tariffs are determined on the basis of both sources of capital expenditure as well as a detailed analysis of municipal finances.

In order to assess the levels of acceptable tariffs, discussions with various stakeholders will be needed including local government both staff and elected representatives as well as the households and property owners who use these services. For the latter, focus group discussions with different groups including the poor will be needed.

- a. **SaniPlan , SaniPlan-FSM:** Excel based decision support tool. Users can input values, select their choices and see results in the form of dashboards. SaniPlan as a whole covers all 3 sectors i.e. water, sanitation and solid waste. However, SaniPlan-FSM has been limited and tailored to suit IFSM needs.
- b. **Financial planning using SaniPlan:** A guide to using Saniplan for financial planning.

12. Assessing Willingness to pay and to charge

In designing a FSM plan, it is important to assess how much the people are willing to pay for a regular or a demand based emptying service. Associated with the willingness to pay is the criterion of ability to pay (or affordability). Such assessments are usually undertaken through a survey or Focus Group Discussion (FGD), where the potential consumers are asked their willingness to pay for different level of service. The assessment of affordability requires greater understanding of the socio-economic status of the community. Since private sector provision of FSM is new in many cities, it is important to assess if there is a real demand and willingness to pay for FSM services by private sector. In case, the service is expected to be based on taxes or annual charges to be paid to the local government, it is also equally important to assess the willingness of the local government to levy these charges. SANIPLAN provides options and can be used for discussion with decision makers.

- a. **Questionnaire: Assessing willingness to pay:** Sample questionnaire for conducting survey to assess citizens' willingness and ability to pay for FSM services.
- b. **Sample resolution by local government:** An example of a formal expression of opinion or intention of the local body to a) Undertake FSM activities, b) Levy a sanitation tax and open an escrow account for the same.

SECTION II
FAECAL SLUDGE TREATMENT
TECHNOLOGIES

1.1 BACKGROUND

Most cities in India do not have a networked sewerage system, and those which have a sewerage system do not have full coverage or adequate wastewater treatment facilities. On-ground reality points towards wide prevalence of on-site sanitation systems. However, poor regulation and absence of monitoring of on-site systems at local level has resulted in unsafe disposal of grey and black water.

According to the National Urban Sanitation Policy of Government of India (GoI), one of the policy goals is integrated city wide sanitation which includes safe and sanitary disposal of 100% human excreta either through conventional or non-conventional means. Also advisory on septage management by MoUD recommends periodic desludging of septic tanks, adequate and safe transportation of septage and its proper treatment before reusing the septage.

Assessment by PAS project in Gujarat and Maharashtra has revealed that out of 167 cities in Gujarat 62 cities (37.12%) have partial sewerage network and partial onsite system, whereas 105 cities (62.87%) are fully dependent on onsite sanitation system. Septage collection facilities are present in 131 cities (78.4%) and septage treatment facility is available in only 5 cities (3.0%).

In Maharashtra out of 252 cities, 220 cities (87.30%) are fully dependent on onsite sanitation system and 32 cities (12.69%) have partial sewerage and partial onsite sanitation system. Septage collection facility is available in 189 cities (75.0%) whereas only 6 cities (2.38%) have septage treatment facilities.

Figure 1: Requirement for Septage Management- Gujarat

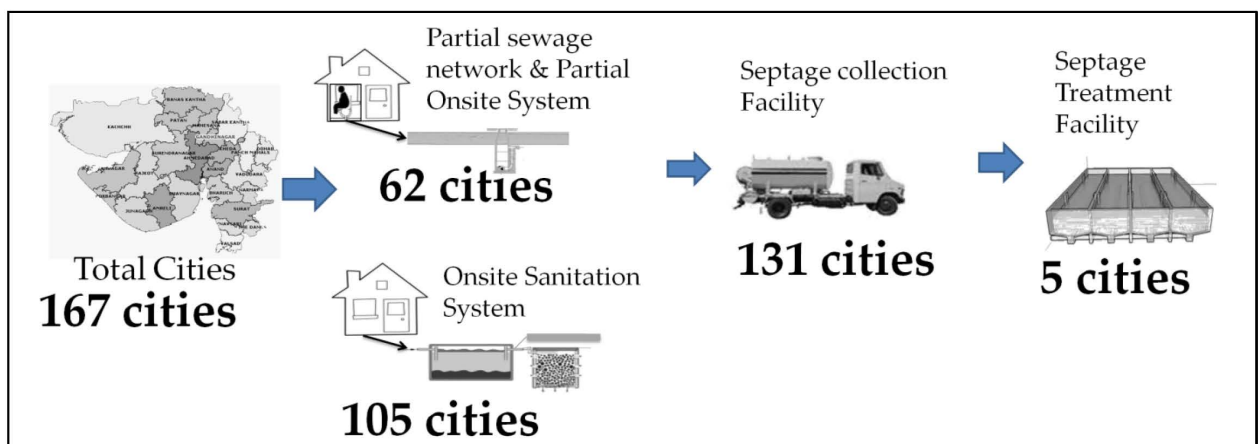
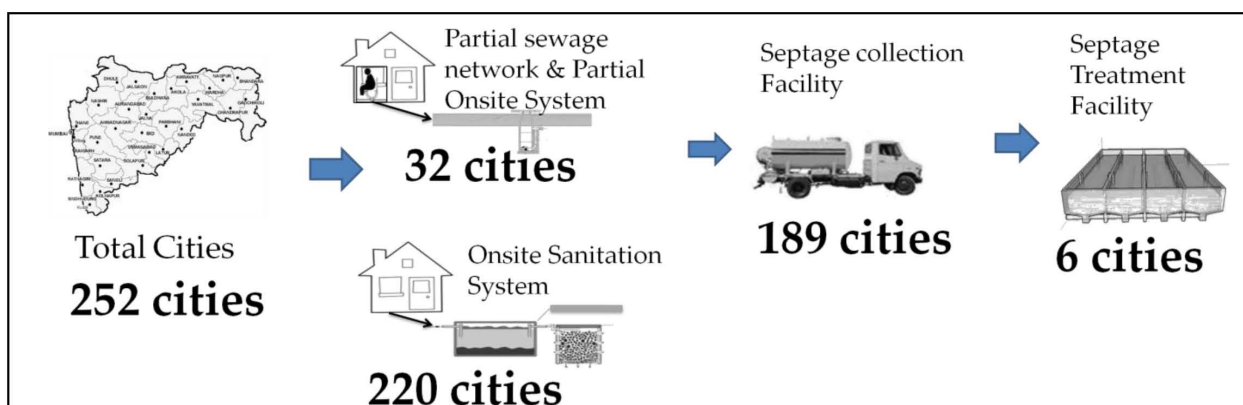


Figure 2: Requirement for Septage Management- Maharashtra



Treatment of septage is essential part of the sanitation value chain. However, there is no clear guidance which would compare different technologies available and which would suit specific site conditions. Hence we have tried to capture it in our study of septage treatment options.

1.2 OUR STUDY

Various types of options are available for the treatment of Septage. Each option have their own advantages and disadvantages. Hence care should be taken while selecting an appropriate option for the treatment of Septage based on local site conditions, level of treatment required, cost factor, expertise for construction and operation, etc. Comparing various options will provide better idea for selection of suitable treatment technology.

While reviewing various options for the Septage treatment, it was observed that treatment options could broadly be divided into two types . One is from Septage to Compost and another is from Septage to Energy.

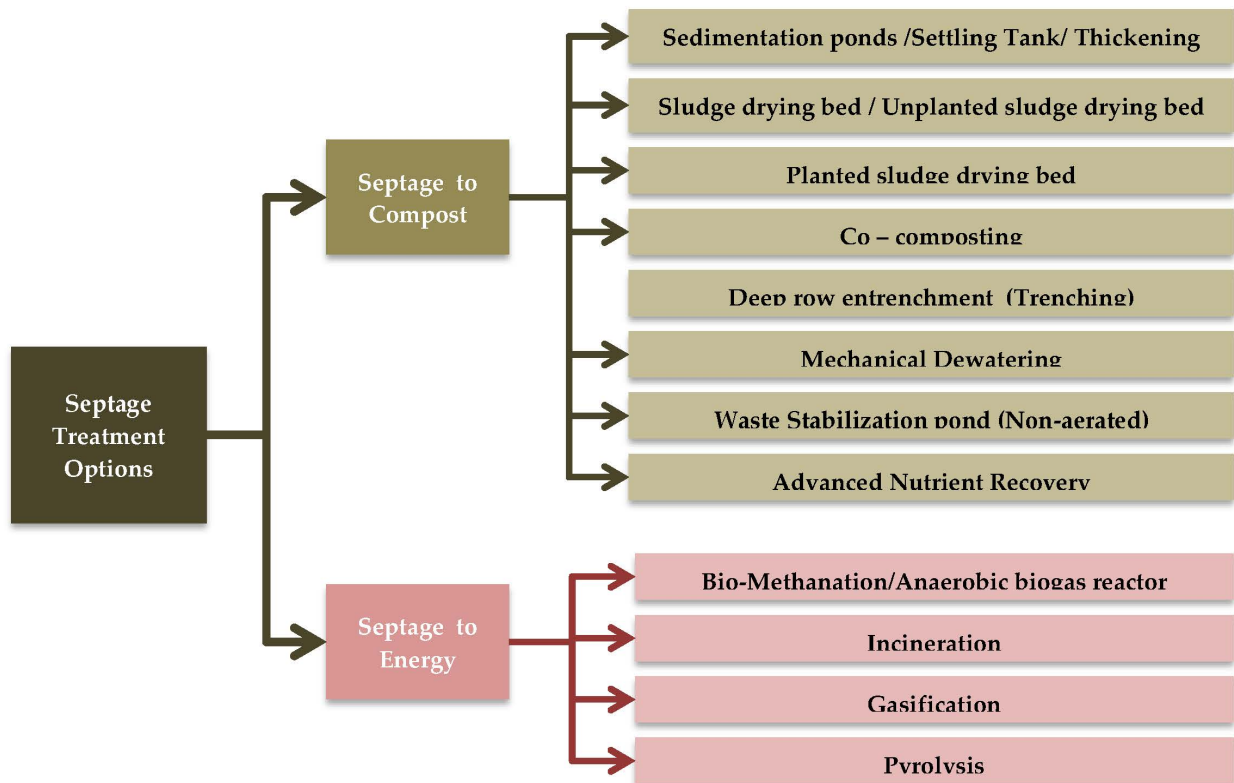
1.2.1 Septage to Compost

This option details out various technologies for conversion of Septage to dried sludge. Dried sludge can be used as Compost for agriculture purposes. Compost from Septage can be used as a soil amendment to reclaim land or can be used in landscaping or horticulture. Treatment options vary from simple technology to advanced hi-end technology.

1.2.2 Septage to Energy

This option describes technologies available for conversion of Septage to Energy. Septage is a source of energy because of presence of high organic matter. Various technologies are developed across the world for conversion of Septage to different forms of Energy like bio-gas, heat, bio-char, bio-oil, etc. Such energy can be used in production of Electricity, heat and as transportation fuel. Thus waste is converted to valuable asset through these technologies.

Figure 3: Different types of Septage treatment options



1.3 COMPARISON OF TREATMENT OPTIONS

1.3.1 Septage to Compost

Different considerations are taken into account while comparing treatment options from Septage to compost which are detailed out below.

1.3.1.1 Technical Description

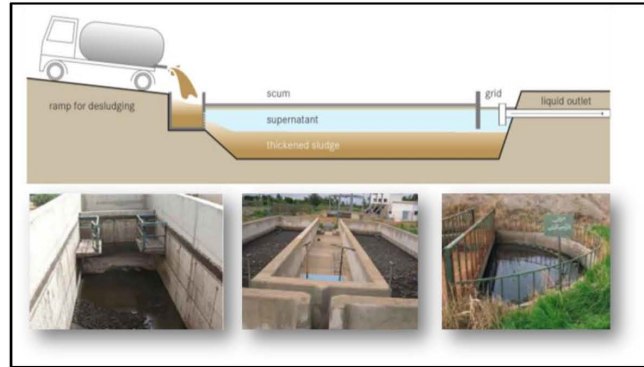
1. Sedimentation ponds /Settling Tank/ Thickening ponds

Sedimentation or Thickening Ponds are simple settling ponds that allow the sludge to thicken and dewater. The effluent is removed and treated, while the thickened sludge can be treated in a subsequent technology. Settling tanks provide a liquid retention time of a few hours (enough to ensure quiescent settling of settleable solids).

Here Input is faecal sludge and output is dried Septage and effluent, which can be used in agriculture, arboriculture and pastures. This treatment option can be coupled with sludge drying bed or co-composting for treatment of thickened sludge. It can be implemented at neighbourhood level or city level. This technology is affected by seasonal changes and can be efficiently used in hot and temperate climate.

The discharging area must be maintained and kept clean. The thickened sludge must be removed mechanically when the sludge has thickened sufficiently. Septage and effluent may require further treatment.

Figure 4: Sedimentation ponds /Settling Tank/ Thickening ponds



2. Sludge drying bed / Unplanted sludge drying bed

An Unplanted sludge Drying Bed is a simple, permeable bed that, when loaded with sludge, collects percolated leachate and allows the sludge to dry by evaporation. Approximately 50% to 80% of the sludge volume drains off as liquid. The bottom of the drying bed is lined with perforated pipes that drain away the leachate. On top of the pipes are layers of sand and gravel that support the sludge and allow the liquid to infiltrate and collect in the pipe.

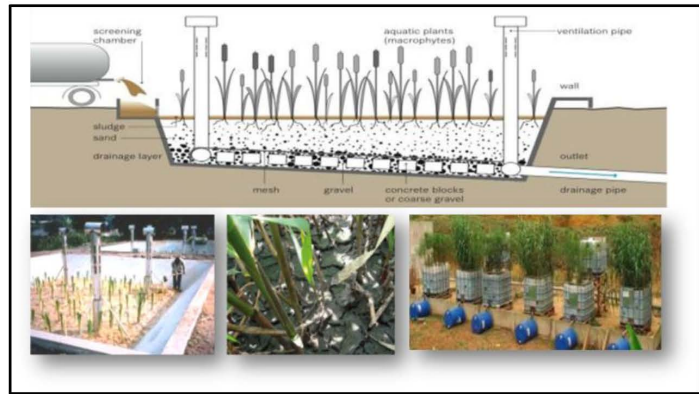


In this technique input is faecal sludge and output is treated sludge and effluent, which can be used in agriculture, arboriculture and pastures. It can be implemented at neighbourhood level or city level. This technology is affected by seasonal changes and can be used in hot and temperate climate. Excessive rain may prevent the sludge from proper settling and thickening.

Dried sludge must be removed every 10 to 15 days. Sand must be replaced when the layer gets thin. Treated Septage and leachate may require further treatment based on output quality.

3. Planted sludge drying bed

Planted sludge Drying Bed is similar to an Unplanted sludge Drying Bed with the benefit of increased transpiration. The key feature is that the filters do not need to be desludged after each feeding /drying cycle. Fresh sludge can be applied directly onto the previous layer; it is the plants and their root systems that maintain the porosity of the filter. The roots of the plants create pathways through the thickening sludge to allow water to escape more easily.



In this technique input is faecal sludge and output is treated sludge and effluent, which can be used in agriculture, arboriculture, pastures(to grow cattle fodder). It can be implemented at neighbourhood level or city level. It is affected by seasonal changes.

The drains must be maintained and the effluent must be properly collected and disposed off. The plants should be periodically thinned and/or harvested. Treated Septage and Leachate may require further treatment based on output quality.

4. Co-composting

Co-Composting is the controlled aerobic degradation of organics using more than one feedstock. Faecal sludge has a high moisture and nitrogen content while biodegradable solid waste is high in organic carbon and has good bulking properties. There are two types of Co-Composting designs: open and in-vessel. A Co-Composting facility is only appropriate where there is an available source of well-sorted biodegradable solid waste. Mixed solid waste with plastics and garbage must first be sorted.



In this technique input is faecal sludge and biodegradable organic solid waste and output is compost which can be use in agriculture, arboriculture and pastures. It can be implemented at neighbourhood level or city level. It is affected by seasonal changes and depending on the climate (rainfall, temperature and wind) the Co-Composting facility can be built to accommodate the conditions. At places where there is heavy rainfall covered facilities are especially recommended.

Careful monitoring of the quality of the input materials & keeping track of the inflows, outflows, turning schedules, and maturing times is required to ensure a high quality product. Turning must be done periodically.

5. Deep row Entrenchment (Trenching)

It 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. Availability of land & distance to groundwater and surface water bodies are the main constraints. This technology is feasible in areas where the water supply is not directly obtained from the groundwater.



6. Mechanical Dewatering

Mechanical dewatering is normally associated with large wastewater treatment plants and is used to separate sludge (residual sludge from wastewater treatment plants or faecal sludge from on-site sanitation) into a liquid and solid parts. These techniques are usually sophisticated and costly for smaller systems to be implemented at community level. The process does not treat the sludge, it only separates solid from liquid parts. Both solid and liquid parts still contain pathogens and pollutants and further treatment is necessary. Mechanical parts need periodical inspection and replacement.

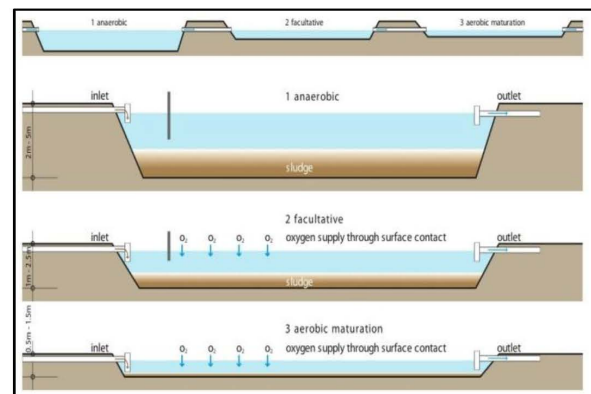


In this technique input is faecal sludge and output is black water, organic solid waste, compost/biosolids which can be used in agriculture, arboriculture and pastures. It requires to be coupled with co-composting or incineration treatment technique. This technology is not affected by seasonal changes as it entirely depends on mechanical process.

7. Waste Stabilization Pond (Non - aerated)

WSP comprises pre-treatment units (tanks or ponds) for solid-liquid separation followed by a series of one or more anaerobic ponds and one facultative pond.

A number of problems may arise where waste stabilisation ponds are used to treat municipal wastewater and co-treat FS. In many instances, the problems are linked to the fact that the wastewater ponds were not originally designed and equipped to treat any additional FS load.



In this technique input is faecal sludge and output is sludge & effluent, which can be used in agriculture, arboriculture, pastures, ground water recharge in deep aquifer and in desert areas. It requires to be coupled with co-composting or sludge drying bed. It can be implemented at neighbourhood level or city level. This technique is affected by seasonal changes.

As per sanitation experts and review of various technical documents, it was analysed that waste stabilisation pond is a good option for treatment of wastewater but not a good option for treatment of Septage.

8. Advanced nutrient recovery

Wastewater, municipal sludge or the ash after drying, which is incinerated or disposed of, can be a very rich source for nutrients, in particular phosphorus and nitrogen. There is a wide range of promising technologies emerging which can convert septage to phosphorus and nitrogen. Some of these techniques are still not fully developed. These technologies are expensive and require engineering knowledge to guarantee a sustainable and long-term operation of the facility.

In this technique blackwater, faecal sludge and grey water is converted to fertilizer and treated waste which can be use in agriculture, arboriculture, pastures, ground water recharge in deep aquifer and desert areas. This technique cannot be implemented on neighbourhood or small level. It has to be implemented on city level as it is highly expensive technique.



1.3.1.2 Simplicity in Construction & Operation

Sr No	Technologies / Parameters	Sedimentation ponds /Settling Tank/Thickening ponds	Sludge drying bed / Unplanted sludge drying bed	Planted sludge drying bed	Co - Composting	Deep row entrenchment	Mechanical Dewatering	Waste stabilization pond (Non - aerated)	Advanced nutrient recovery
1	Expertise for design	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
2	Built with Local materials	Yes	Yes	Yes	Yes	Yes	No	Yes	No
3	Expertise for construction	No	No	No	No	No	Yes	Yes	Yes
4	Expertise for operations	No	No	Yes	No	No	Yes	Yes	Yes

Inferences:

- Expertise is required while designing various options based on site conditions, volume of Septage to be treated, etc.
- Mechanical dewatering & advanced nutrient recovery are hi-tech technologies which require advanced machineries for its construction. Hence these two treatment options cannot be built with local materials. Rest all other options can be built with locally available materials.
- Sedimentation ponds/thickening ponds, unplanted sludge drying bed and Co-Composting technologies do not required expertise for their operations.
- Thus while comparing various options from the considerations of simplicity in construction and operation, Sedimentation tank/settling tank/thickening pond, Unplanted sludge drying bed, Co-Composting & Deep row entrenchment options seems to be more preferable.

1.3.1.3 Financial Parameters

Sr. No	Technologies / Parameters	Sedimentation ponds (SP) /Settling Tank (ST)/Thickening ponds	Sludge drying bed / Unplanted sludge drying bed	Planted sludge drying bed	Co - composting	Deep row entrenchment	Mechanical Dewatering	Waste stabilization pond (Non - aerated)	Advanced nutrient recovery
1	Capital cost	Low	Moderate	Moderate	Low	Low	High	Variable	Very High
2	Land required	High	Moderate to High	High	High: cold climates, average : warmer climates	High	Low	High	Low
3	O & M cost	Low	Low to Medium	Low	Low	Low	High	Low	Very High
4	Resting period (i.e No. of days / months / years)	SP : 8-12 Months; ST: 2-4 months	10-15 days	2-3 years / 5-6 Years	6-8 weeks	-	-	Anaerobic ponds - 1 to 7 days Facultative ponds - 5 to 30 days	-

Inferences:

- While comparing various financial parameters of all the treatment options, unplanted sludge drying bed and co-composting treatment seems to be most viable options. These options are followed by sedimentation ponds & planted sludge drying bed with moderate land requirement because of high

resting period. For the areas where land is not easily available, mechanical dewatering or advanced nutrient recovery treatment options can be adopted but with higher capital and O&M cost.

1.3.1.4 Advantages, Disadvantages & Prevalence

Sr. No.	Description	Advantages	Disadvantages	Prevalence in India/Abroad
1	Sedimentation ponds /Settling Tank/ thickening ponds	<ul style="list-style-type: none"> • Can be built with local available materials • Low capital and operating cost • No energy requirement • Great plus is after sedimentation, sludge is used for agriculture / tree plantation. 	<ul style="list-style-type: none"> • A major minus is the smell, especially if fresh undigested Septage is coming from public toilets. • Large land requirement • Post treatment required for both solid and liquid effluent through SDB or Co-composting 	Accra/Ghana & Bangkok, Alcorta (Argentina)
2	Sludge drying bed / Unplanted sludge drying bed	<ul style="list-style-type: none"> • No energy requirement • Can be built with local available materials • Moderate capital cost and low capital cost 	<ul style="list-style-type: none"> • Requires large area • Odour problem • Only applicable during dry seasons or needs a roof during rainy season 	Punjab (100 villages) World Bank Project; Accra, Ghana, USA , Dakar, Senegal, Malaysia
3	Planted sludge drying bed	<ul style="list-style-type: none"> • Can handle high loading • Low capital cost; low operating cost • No energy requirement • Widely used by DEWATS for sewage treatment; could as well be used to treat Septage after diluting by mixing with sewage. 	<ul style="list-style-type: none"> • Requires large land area • Long storage time • Requires expert design and operation • Leachate requires secondary treatment • Large de-sludging cycle hence larger area required • More capital and O&M cost as compared to unplanted SDB 	Europe, USA, Thailand, Dakar Senegal, Africa
4	Co - Composting	<ul style="list-style-type: none"> • Best combination of cheap bio-technology and agriculture • Good choice for most Indian hot weather cities. • Low capital & operating cost • Easy to set up and maintain and can be built with local materials • No energy requirement 	<ul style="list-style-type: none"> • Requires large land area • Requires segregated organic waste • Long storage times • Operational issues in terms of constant mixing required 	Massachusetts, U.S.A; Kalpabriksha Compost Plant in Kathmandu, Bangladesh. Till recently in Dhrangadhra, Gujarat and Barshi, Maharashtra.
5	Deep row entrenchment (Trenching)	<ul style="list-style-type: none"> • No expensive infrastructure or energy required • Odours are eliminated. • Risk of exposure to pathogens is reduced 	<ul style="list-style-type: none"> • Large land requirement • Not feasible where GW is high 	China, south-East Asia, Africa
6	Mechanical Dewatering	<ul style="list-style-type: none"> • Reduces volume of sludge • Process can be fully automated 	<ul style="list-style-type: none"> • Constant power supply required • Need expert design • Both dewatered sludge and effluent requires post treatment 	
7	Waste stabilization pond (Non - aerated)	<ul style="list-style-type: none"> • No energy requirement • Low O&M cost 	<ul style="list-style-type: none"> • Not a good option for treatment of Septage alone 	

Sr. No.	Description	Advantages	Disadvantages	Prevalence in India/Abroad
			<ul style="list-style-type: none"> • Requires wastewater for process to work • Requires large area • Requires expertise for design and operation 	
8	Advanced nutrient recovery	<ul style="list-style-type: none"> • Recovery of nutrients • Effluent requires no further treatment • Production of fertiliser 	<ul style="list-style-type: none"> • Highly expensive technology • Requires expert knowledge • Some processes are still in development stage • Not proven technology • Sludge requires further treatment 	In Bangalore (under operation) in 2 extended aeration STPs of BWSSB, septage is received at inlet chamber. DEWATS in their Bangalore campus are running a septage treatment plant of 3 cum capacity In Kerala in 4 cities new STPs being built are designed to receive septage at their inlet chamber.

1.3.2 Septage to Energy

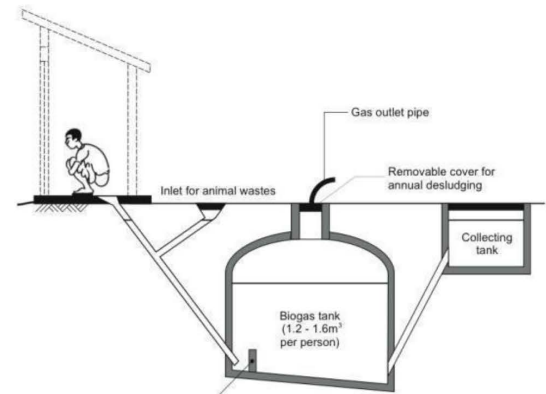
Various considerations taken into account while comparing treatment options for conversion of Septage to Energy are detailed out below.

1.3.2.1 Technical Description

1. Bio-Methanation/Anaerobic biogas reactor

In this treatment technology there is microbes driven anaerobic decomposition of organic components from faecal sludge to biogas. Faecal sludge & organic solid waste is converted to Treated sludge, effluent and Biogas. Pre-treatment of sludge is required but not compulsory. To start the reactor, active sludge (e.g. from a septic tank) should be used as a seed. The tank is essentially self-mixing, but it should be manually stirred once a week to prevent uneven reactions. However once stable state reached, stirring not essential. Gas equipment should be cleaned carefully and regularly so that corrosion and leaks are prevented. Grit and sand that has settled to the bottom should be removed once every year. Bio-Methanation/Anaerobic biogas reactor option is popularised by Sulabh organization in India.

Figure 5: Bio-Methanation/Anaerobic biogas reactor



Advantages:

- Established and mature technology.
- Best suitable for wastes with high moisture content.
- Technology could be optimized for any scale.
- Considerable reduction in the emission of greenhouse gases like methane is possible.

Disadvantages:

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

2. Incineration

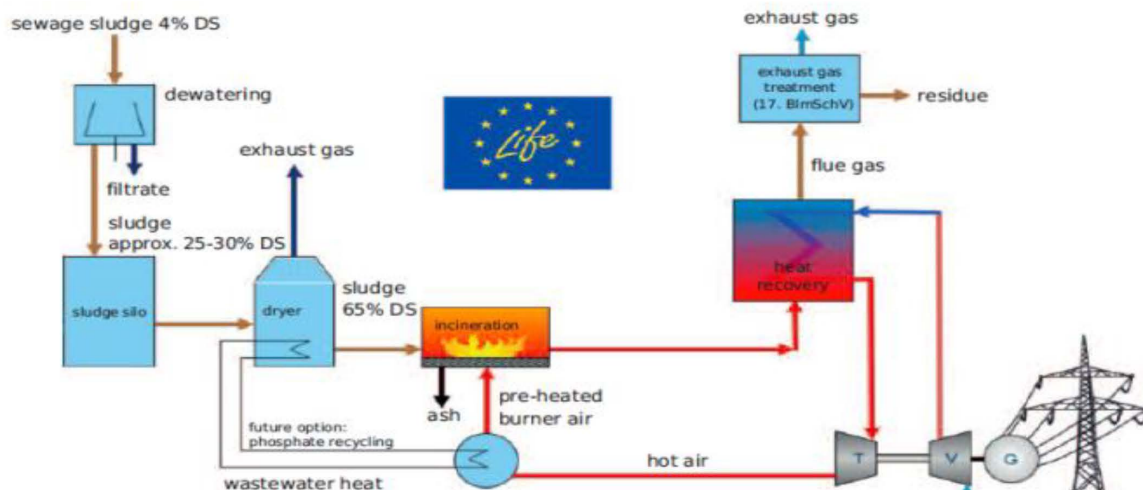
In Incineration treatment option there is oxidation of organics in the sludge under the conditions of complete aeration or oxygenation and requires high temperature. Incinerators are a useful technology to combust household waste, medical waste, slaughter waste, etc. instead of discharging it in a landfill. Furthermore, heat and energy may be recovered and it helps to avoid open burning of municipal waste which creates much more harmful emissions and endanger human health and environment. In this treatment sludge is converted to heat. Drying of sludge is required prior to treatment in incinerators. This technology requires trained operators. There is risk of malfunction if not properly maintained and operated. Requires high quantum of electrical energy.

Advantages: Incineration is relatively effective technology for treating all kinds of wastes.

Disadvantages:

- Liberates considerable amounts of emission
- Sludge incineration costs are not attractive to be used in India
- Sludge incineration is not proven in India

Figure 6: Incineration



3. Gasification

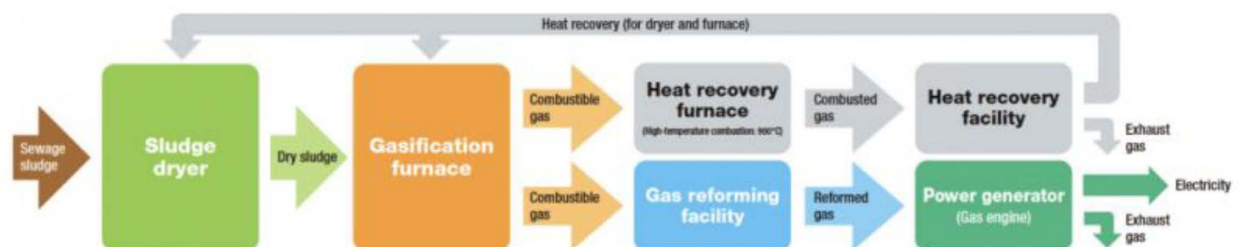
In Gasification treatment technology there is thermal transformation of organic mass under limited supply of air/oxygen to Syngas. In this technology sludge is converted to Syngas & Biochar. Drying of sludge is required prior to treatment in incinerators. This technology also requires trained operators and there is risk of malfunction if not properly maintained and operated.

Advantages: Technology best suitable for dry feedstocks. The produced gas can be converted into any type of fuel by FT synthesis.

Disadvantages:

- Gasification of faecal sludge is a relatively new concept in India.
- Process is very energy intensive, as wet feedstock cannot be used directly in a gasifier.
- The process is economically less viable.

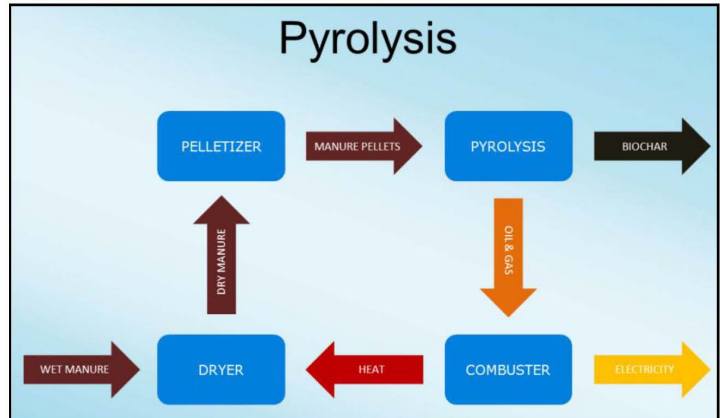
Figure 7: Gasification



4. Pyrolysis

In pyrolysis treatment technology there is thermal conversion of carbonaceous materials in sludge to produce complex oil in the absence of air/oxygen. In this technology sludge is converted to Bio-oil, Pyrolytic Gas and Bio-char. Here also drying of sludge is required prior for treatment in incinerators. This technology requires trained operators and there is risk of malfunction if not properly maintained and operated.

Figure 8: Pyrolysis



Advantages: Energy recovery efficiency is high.

Disadvantages:

- Pyrolysis has been attempted only for the treatment of plastic and related feedstocks so far.
- This process is also energy intensive like gasification, as more energy is needed to dry feedstock.
- High capital and operational costs make the process economically less viable.

1.3.2.2 Energy Requirement and Recovery

Sr. No	Technologies	Bio-Methanation/ Anaerobic biogas reactor	Incineration	Gasification	Pyrolysis
1	Operational Energy Demand	Limited (Except for advanced sludge pre-processing methods)	High	Very High	High
2	Energy Recovery Efficiency	50-70%	50-60%	70-80%	70-80%
3	Energy Product and its applications	Methane as a fuel for heat, electricity and transport Compost-Soil fertilizer	Electricity or heat from hot steam/air	Syngas - As fuel for heat and electricity	Pyrolytic oil as industrial fuel in boilers. Char as solid fuel for heat production in furnaces and medium for soil amendment

Inferences:

- From the above table, it can be observed that energy requirement for operation is least in Bio-Methanation process and maximum in gasification process.
- Efficiency of energy recovery is comparatively low in incineration and bio-Methanation process and high in Gasification and pyrolysis process.
- However, in India only proven technology for sludge to energy is bio-Methanation. Incineration technique is mostly used for treatment of bio-medical wastes and not for sludge treatment.
- Gasification and pyrolysis are new techniques and still not proven for treatment of sludge & energy recovery in India.

1.3.2.3 Financial Parameters

Sr.No	Technologies	Bio-Methanation/ Anaerobic biogas reactor	Incineration	Gasification	Pyrolysis
1	Capital cost	Medium-High	Medium-High	High	High
2	O&M Cost	Medium-High	Medium-High	High	High
3	Land Requirement	Low (Underground Construction)	Less	Less	Less

Inferences:

- From the financial analysis of all the treatment options, it can be analysed that Gasification and pyrolysis are most expensive technologies because of high capital and O&M cost.
- Bio-Methanation and Incineration options are less costly compared to other options.
- In terms of land requirement, all the treatment options require less area.
- From the point of economic/commercial viability, Bio-Methanation is most viable option in India whereas viability of Gasification and pyrolysis is still not proven in India.

1.3.2.4 Environmental Parameters


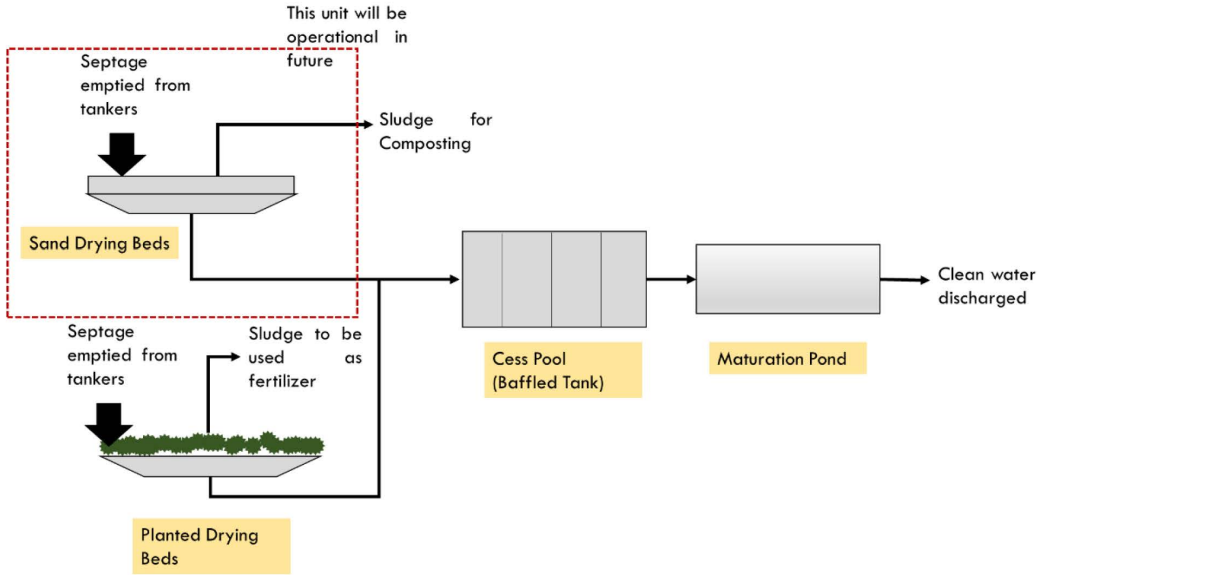
Waste disposal from Bio-Methanation/ Anaerobic biogas reactor is complete but environmental concerns like odour and pathogens dissemination from stabilized sludge are present. Treatment options through incineration have critical issues like ash disposal and regulated emissions of toxic organics and flue gases. Gasification faces limitations because of ash discharge and emission of toxics, heavy metals etc. In pyrolysis there is a minor constraint with handling of char and ash.

1.4 WAY FORWARD

Thus looking at various options and comparing them from various perspectives, one can select proper treatment technologies according to the prevailing local site conditions. However, looking at various parameters considered above and considering ideal site conditions, treatment technologies such as Unplanted sludge drying bed, Co-composting and Bio-Methanation seem to be most viable options.


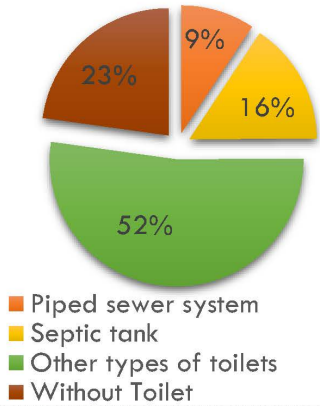
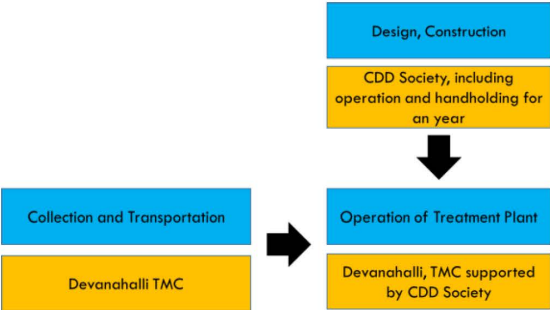
1.5 CASE STUDIES

Septage Treatment Plant, Faridpur, Bangladesh

Location				
Faridpur town is located in Faridpur Sadar subdivision of Faridpur District in the Division of Dhaka, Bangladesh. The town is located near the banks of the Padma River at 23.6°N latitude and 89.8°E longitude.				
Demography		Plant details		
Population	0.15 Million	Treatment Capacity	24 m ³ /day	
Population Dependent on onsite sanitation systems	100%	Year of Commissioning	October 2016	
		Operating capacity	10 m ³ /day	
		Area	6070 sqm	
		Influent/ Effluent Characteristics		
Climate		Parameter	Inflow	Outflow
Average Temperature	25 C	pH	7.31	not tested
Average Annual Rainfall	1,127 mm	TSS (As percentage)	not tested	not tested
Average ground water level	3 m bgl	BOD (mg/L)	1860	not tested
		COD (mg/L)	9061	not tested
Treatment process description				
				

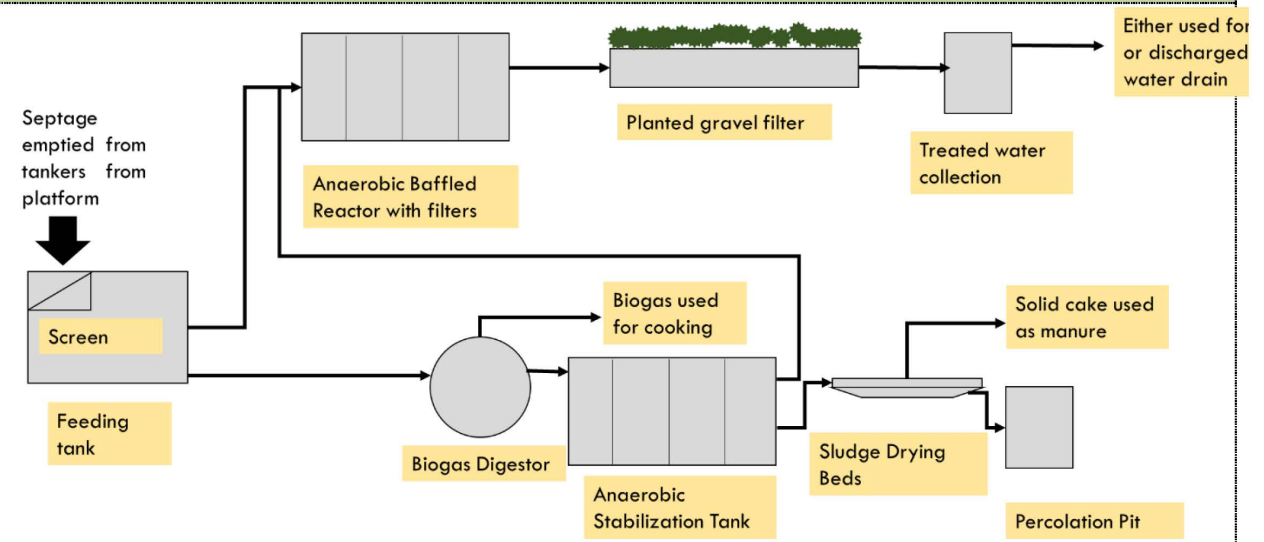
Dimensions of Units			
Name of unit	Number of unit	Size of unit	
Planted drying bed	12	8m X 8m	
Unplanted drying bed	16	10.75m X 3.75m	
Cesspool	6	7m X 6m	
Maturation pond	1	12.20m X 10.28m	
Process Description			
<p>In the present process, septage is emptied through tankers in planted drying beds. The collected sludge in the planted drying bed would be used as fertilizer. The permeate from the planted filter goes to the cesspool. Cesspool is a baffled tank which provides sufficient time to the wastewater for further treatment. The discharge from the cesspool is sent to the maturation pond for further polishing treatment. The water from the maturation pond is discharged in the nearby water body.</p>			
Finance, Operation and Maintenance			
Name of the Agency operating the faecal sludge treatment plant	Society development committee	Operations and Maintenance expenditure	7500 USD for Stuff salary and shed changing of unplanted drying bed/ annum
Cost of Construction (Year of construction)	USD 3,75,000 (2016)	Source of O & M expenditure	By public private partnership model (Faridpur municipality and society development committee)
The source of funds for capital costs	UK Aid	Persons required or employed	One (Agriculturist) permanent and four stuff day basis
Sources			
<ol style="list-style-type: none"> 1. Google maps 2. Faridpur Sadar website 3. Practical Action, Bangladesh 			

FSTP Devanahalli, Karnataka

Location	Demography (Census 2011)		 <p>Devanahalli, Karnataka</p>
<p>The Town Municipal Council (TMC) Devanahalli was constituted in 1938. It is situated along Bangalore - Hyderabad National Highway No.7 at a distance of 34 Kms from Bangalore. The town is located at 13 15' 0.6" N and 77 42' 25.7" E.</p>	Parameter	Value	
	Population	28,051	
	Households	6,400	
	Area	15.94 sq km	
	Density (persons/ sq km)	1,760	
	Sex Ratio	961	
	Literacy Rate	71.3 %	
Sanitation Infrastructure in Devanahalli			
<p>As per the Census of India 2011, only 9 % of the households have access to piped sewer network. 68% of the Households depend on onsite sanitation systems. 16% of them have toilets connected to septic tanks while 47% have VIP type toilets. Hence management of fecal sludge becomes a critical issue for the Town Municipal Council.</p>			 <ul style="list-style-type: none"> ■ Piped sewer system ■ Septic tank ■ Other types of toilets ■ Without Toilet
Project Background	Stakeholder and Responsibilities		
<p>Devanahalli is part of the greater Bangalore urban agglomeration. Bangalore and the vicinity has a large dependence on onsite sanitation. Devanahalli in particular has a large proportion of onsite treatment systems. With the support of active municipal council and the Bill and Melinda Gates foundation, it was decided to develop and demonstrate India's first faecal sludge management plant. The CDD society and the municipal council conceptualized the project. The municipal council provided the land for the faecal sludge treatment plant (FSTP), the CDD society designed and commissioned the plant while the Bill and Melinda Gates foundation funded the project.</p>	<p>At present the FSTP is being maintained by the CDD society. They have a contract to design, construct and train the operator for an year. The fecal sludge is transported through trucks owned by the TMC Devanahalli.</p>		
	 <pre> graph TD A[Design, Construction] --> B[CDD Society, including operation and handholding for an year] B --> C[Operation of Treatment Plant] D[Collection and Transportation] --> C E[Devanahalli TMC] --- D F[Devanahalli, TMC supported by CDD Society] --- C </pre>		

		Description of Technology
Plant Capacity	6 m ³ /day	The FSTP at Devanahalli incorporates the unit processes of DEWATS. The treatment technology mainly focuses on anaerobic digestion of the organic components in the faecal sludge. For the treatment of the supernatant liquid, after settling, a combination of anaerobic baffled reactor and anaerobic filter is used followed by the planted gravel filter. For the treatment of solids, biogas digester is primarily used followed by stabilization tank. The liquid portion from the stabilization tank flows into the anaerobic baffled reactor and the solids are sent to the sludge drying bed.
Current volume handled	3-4 m ³ /day	
Year of Commissioning	November 2015	

Process flow Diagram



Fecal sludge being discharged



Screen inside feed tank



Feed Tank



Sludge drying beds



Stabilization tank



Overview of plant

Process Description

The honey sucker trucks discharge the solids, collected from pits and septic tanks, through a screen into the feed tank. The operator of the FSTP ensures the screen is clean. The screenings are stored in a plastic container and disposed with municipal solid waste once the container is full. The faecal sludge is stored in the feeding tank for 3-4 hours which causes separation of liquid and solid layers.

The liquid part of the faecal sludge is discharged first into the anaerobic baffled reactor. The anaerobic baffled reactor in FSTP is combination of settler, anaerobic baffled reactor and anaerobic filter with two compartments for settler, four compartments of baffled reactor and two compartments of anaerobic filter. The treated liquid from the anaerobic baffled reactor is then polished through the planted gravel filter and stored in collection tank. The water from the collection tank is used for gardening, or discharged in storm water drains.

The solids from the feed tank are discharged in biogas digester. The gas generated by the digester is used for cooking by the operator of the plant. The digested solids are sent to the stabilization tank. The purpose of the tank is to hold and stabilize the effluent. The stabilized solids are then sent to the sludge drying beds. The dried sludge is sold to the farmers at Rs.1/ Kg.


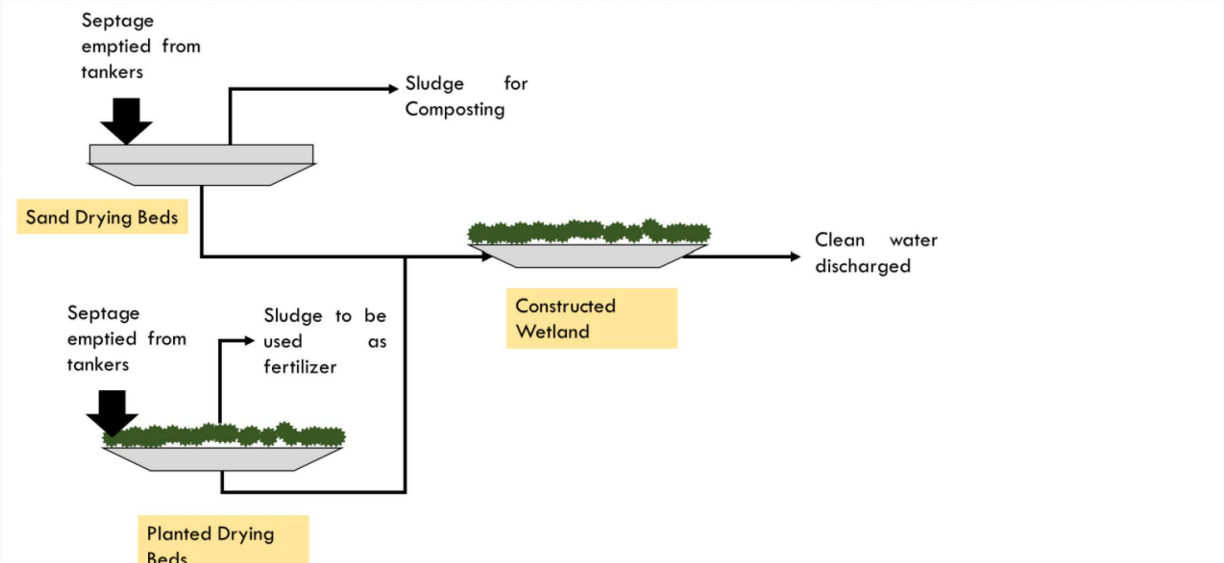
Waste water Characteristics				Specific Requirements	
#	Parameter	Influent	Discharge	Operating Conditions	
1	Chemical Oxygen Demand (COD) (mg/L)	60,000	<100	Operational and Maintenance	Daily parameters of input and output are checked. The level of stabilization tank is also checked to ensure proper functioning of the plant. The plant requires regular testing of the influent and effluent. Also for proper functioning it is essential to desludge the ABR and Biogas Digester.
2	Biological Oxygen Demand (BOD) (mg/L)	28,941	<30	Area	625 sq m
3	pH	7.44	7.7	Operation Cost (Rs.)	3-4 lakh per year. The cost consists of labour charges for temporary jobs. This excludes the salary of the permanent operator.
				Capital Cost (Rs.)	70 lakhs er tank as per 2015 prices

Advantages

- The plant runs on gravity and hence does not use any electrical/ moving equipment like pumps.
- Reuse of biogas and reuse of sludge 1Rs./Kg


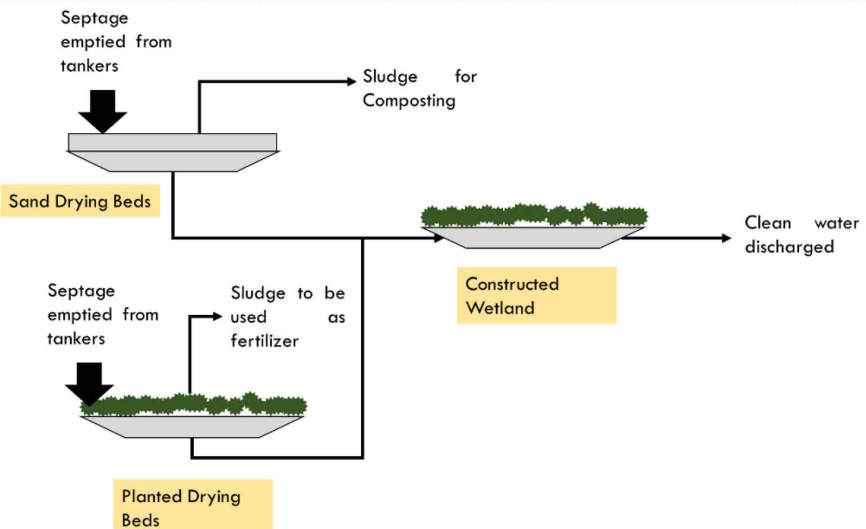
Limitations	Risks
<ul style="list-style-type: none"> It is essential to ensure the continuous daily feed for the plant since it is a biological operation. 	<ul style="list-style-type: none"> Technical staff for operation of the plant.
References	
<ul style="list-style-type: none"> CDD Society. (2016, July 7). <i>Articles: CDD India</i>. Retrieved from CDD India website: http://www.cddindia.org/O&Mproject/articles.html S, A. (2016, July 7). FSTP Plant. (T. Bose, Interviewer) 	

Septage Treatment Plant, Jhenaidah, Bangladesh

Location				
<p>Jhenaidah town is located in Jhenaidah District in Khulna division. It is located at 23.5 N and 89.1 E. The area of the town is 39.63 sq km.</p>				
Demography		Plant details		
Population	0.15 Million	Treatment Capacity	45 m3/day	
Population Dependent on onsite sanitation systems	100%	Year of Commissioning	Not started	
		Area	500 sqm	
Influent/ Effluent Characteristics				
		Parameter	Inflow	Outflow
Climate		pH	NA	NA
Average Temperature	30 C	TSS (As percentage)	NA	NA
Average Annual Rainfall	2000 mm	BOD (mg/L)	NA	NA
Average ground water level	1.5 m bgl	COD (mg/L)	NA	NA
Treatment process description				
				

Process Description			
<p>There are two parallel systems employed at Khulna. In the first process the waste is emptied from tankers in sand drying beds. The permeate of the sand drying beds is then sent to the constructed wetland. The sludge from the sand drying beds is sent for composting. From the constructed wetland the clean permeate is discharged. The sludge collected in the constructed wetlands takes considerably long time for accumulation. After the constructed wetland is filled with sludge, the sludge would be removed and sent for composting/further treatment or direct application.</p> <p>In the second process, the tankers are emptied into planted drying beds. The process is similar to the first process wherein the permeate is sent to the same constructed wetlands as the first process. The sludge from the planted drying beds here is used directly as fertilizer.</p>			
Finance, Operation and Maintenance			
Name of the Agency operating the faecal sludge treatment plant	Jhenaidah Municipality	Operations and Maintenance expenditure	USD 150/month
Cost of Construction (Year of construction)	USD 1,00,000 (2016)	Source of O & M expenditure	Under discussion with municipality
The source of funds for capital costs	Bill & Melinda Gates Foundation	Persons required or employed	01 semi-skilled and 01 non skilled staff required.
Sources			
<ol style="list-style-type: none"> 1. Google maps 2. Wikipedia, Jhenaidah-District-Town 3. SNV Netherlands Development Organisation 			

Septage Treatment Plant, Khulna, Bangladesh

Location				
<p>Khulna is the 3rd largest city in Bangladesh. It is located on the banks of the river Rupsha and Bhairab & at the Southwest of the country. It is situated between 21.38' north latitude and 88.58 east longitude and is 12 ft above mean sea level</p>				
Demography		Plant details		
Population	1.5 Million	Treatment Capacity	180 m ³ /day	
Population Dependent on onsite sanitation systems	100%	Year of Commissioning	Not started	
		Area	6000 sqm	
Influent/ Effluent Characteristics				
		Parameter	Inflow	Outflow
Climate		pH	NA	NA
Average Temperature	30 C	TSS (As percentage)	NA	NA
Average Annual Rainfall	2000 mm	BOD (mg/L)	NA	NA
Average ground water level	1.5 m bgl	COD (mg/L)	NA	NA
Treatment process description				
				

Process Description			
<p>There are two parallel systems employed at Khulna. In the first process the waste is emptied from tankers in sand drying beds. The permeate of the sand drying beds is then sent to the constructed wetland. The sludge from the sand drying beds is sent for composting. From the constructed wetland the clean permeate is discharged. The sludge collected in the constructed wetlands takes considerably long time for accumulation. After the constructed wetland is filled with sludge, the sludge would be removed and sent for composting/further treatment or direct application.</p> <p>In the second process, the tankers are emptied into planted drying beds. The process is similar to the first process wherein the permeate is sent to the same constructed wetlands as the first process. The sludge from the planted drying beds here is used directly as fertilizer.</p>			
Finance, Operation and Maintenance			
Name of the Agency operating the faecal sludge treatment plant	Khulna City Corporation	Operations and Maintenance expenditure	USD250/month
Cost of Construction (Year of construction)	USD 2,00,000 (2016)	Source of O & M expenditure	Under discussion with municipality
The source of funds for capital costs	Bill & Melinda Gates Foundation	Persons required or employed	01 semi-skilled and 02 non skilled staff required.
Sources			
<ol style="list-style-type: none"> 1. Google maps 2. Kulna City website 3. SNV Netherlands Development Organisation 			

