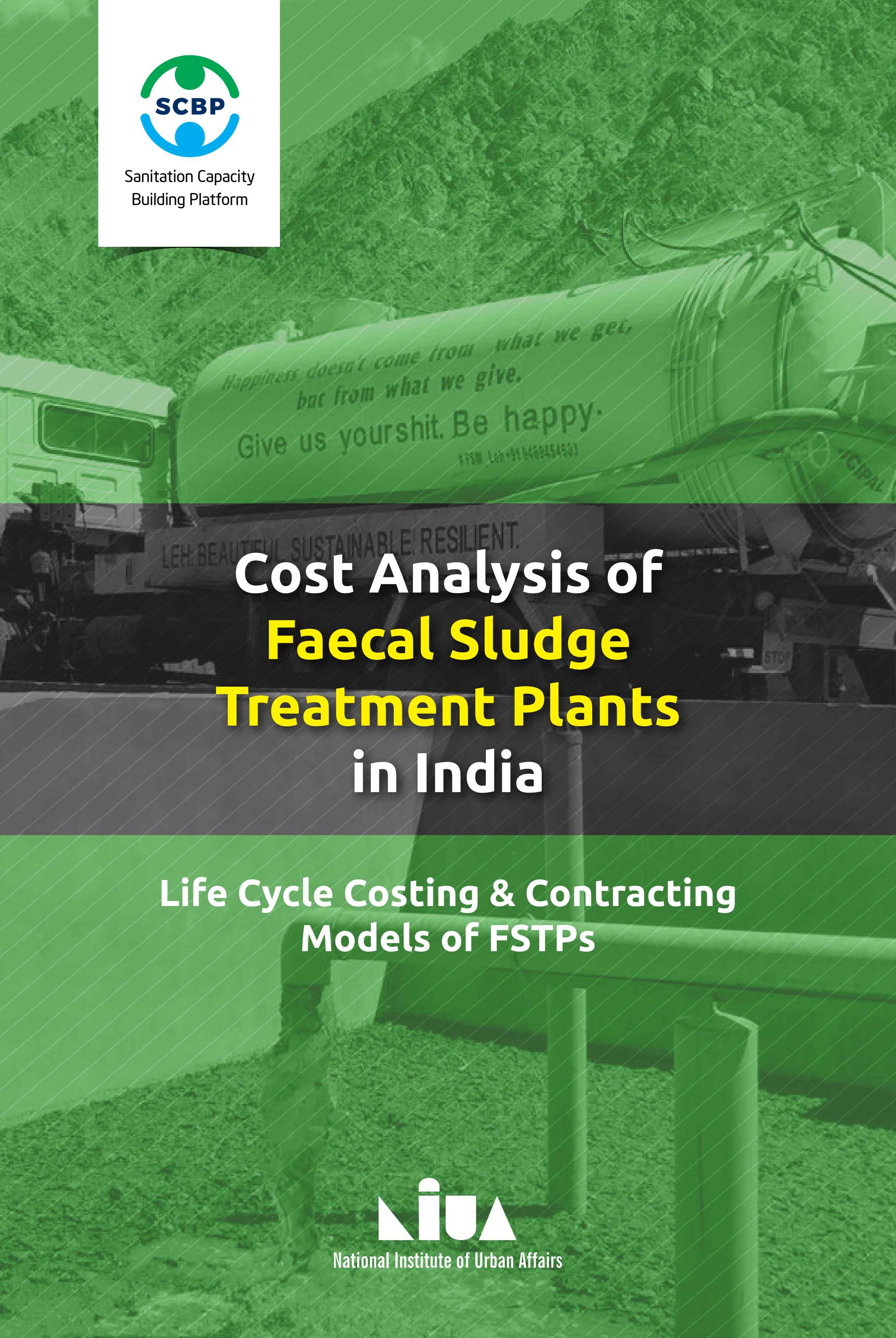
Sanitation Capacity Building Platform

Cost Analysis of Faecal Sludge Treatment Plants in India

Life Cycle Costing & Contracting Models of FSTPs



National Institute of Urban Affairs

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Foreword

Sanitation Capacity Building Platform is a platform of credible national organizations forged by NIUA. The platform advocates for a paradigm shift in favor of non sewered systems based urban sanitation solutions. Non sewered sanitation systems are relevant for India, given the predominantly septic tank based sanitation systems of urban India and the emerging priorities of water conservation, managing water demand and reducing the waste water footprint of urban India. The program core is Capacity Building for non sewered sanitation and integrated waste water management.

The program supports technical assistance, developing and delivering training content and modules, research studies and policy advise to urban local bodies, nodal national training institutes, academia and private sector. The program is supported by a grant from Gates Foundation and has in the last 4 years produced a portfolio of training modules, research reports and academia and institutional partnerships to deliver capacity building for faecal sludge management at scale. This will be sustained for the second phase of the program starting 2020.

The program has provided the state of Uttar Pradesh, Bihar and Uttarakhand, with technical assistance for a DPR preparation for their first Faecal Sludge Treatment Plants. SCBP provides on demand support to cities and has supported the city of Port Blair to review its centralized Sewage Treatment Plant DPR and suggest alternative decentralized solutions.

The program has partnered with 10 national nodal training institutes, 30 Alliance partners of the NFSSM (a coalition of agencies) and 10 Universities/ Colleges: to train more than 2000 government officials through 30 trainings across more than 500 cities of India, more than 250 students and 30 Academia Faculty, developed a set of 13 training modules, brought out 24 research and publications.

The program has created a Knowledge Hub/Portal: scbp.niua.org. Where all the SCBP work is available for dissemination. The portal received more than 140,000 individual visitors, has more than 650 users and over 9500 downloads over the past 2 years. It has the most comprehensive repository of knowledge resources on decentralized and non sewered sanitation in India.

SCBP has contributed to the MoHUA Urban Learning portal with 3 sets of capacity building documents on Urban Water and Waste Water Management: 1. Policy Framework, Policy Workbook, 3. Evaluation Metrices. Three sets of standardized and update Training Modules on Non Sewered Sanitation systems, were recently released by Secretary MoHUA.

SCBP has also contributed to the draft of the National Urban Sanitation Policy 2.0 that was submitted to MoHUA in 2018. The program has contributed to the recognition of NIUA as a lead national knowledge/CB organization. MoUs have been forged with Uttarakhand state, as a partner of choice in Rajasthan and UP. Also recognised internationally in South Asia and Africa.

About the Study

About the Study

Background

There is push for setting faecal sludge treatment plants (FSTPs) across India to ensure safe sanitation. There is an increased demand for treatment technologies and therefore a need to establish a costing benchmark across technologies for FSS. The benchmarking will enable the Governments to make informed choices, and thus help faster roll-out of FSTPs.

There are two perspectives observed in the sector:

A. **The promoters of FSTP concepts are pushing for setting up units at prices determined by the technology provider;**
B. **The Government agencies which are seeking to scale up the effort of setting FSTPs but are comparing the cost of FSTPs with the conventional sewage treatment plant.**

There is a discord as the present capital cost of FSTP is over 10X times the conventional sewage treatment plant (STP) cost on a treatment volume basis. The argument for the higher cost of FSTP are:

a. Septage has a higher organic load (10-100X).
b. FSTPs are small-scale of capacities ranging from 15-60 KLD in contrast to MLD Scale STPs.

Selection of FSTPs for rapid roll-out is possible with a costing benchmark across all the available technologies over time. This cost assessment includes CapEx, OpEx and life cycle costs. Further, assessment of successful contracting models of STPs would strengthen in defining the suitable contracting model for FSTPs, with the cost implications of different technologies over time.

Scope of Work

The detailed scope of the study includes the following activities:

- Conducting landscape analysis on the existing financial models for establishing and operations and maintenance of the STPs in India
- Analyzing the STPs for its CapEx cost and OpEx cost
- Conducting research on the existing FSTPs in the country for its design details, Capex cost, Opex cost - estimate and actuals, and life cycle cost.
- Identify the critical operation and maintenance factors of these operating FSTPs to be considered in the design and planning phases
- Application of the successful financial models of STPs to FSTPs

- Develop costing basis for FSTPs, across different models to establish economic viability sizes of FSTPs

The study focuses with the following steps:

i. Analysis of the existing contracting models of STPs and their applicability to the FSTP sector
ii. Develop contracting framework for FSTP sector
iii. Develop costing basis for FSTPs, considering the life cycle cost of the existing technologies

Methodology

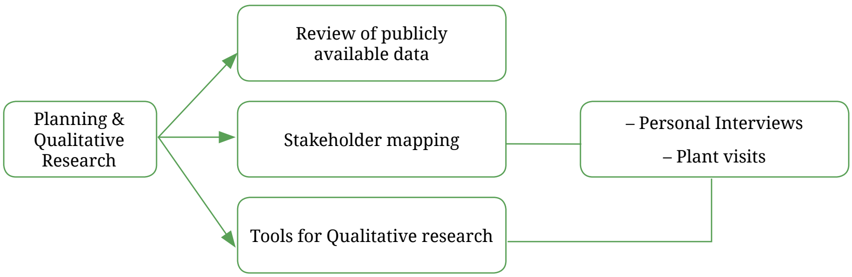
Assessment of the implemented and to be implemented FSTPs in India is being carried out. The selection of the FSTPs is primarily based on different technologies, and the cost analysis of these plants involves the assessment of capital and operation costs. The costing approach, designed to meet the objectives, is a two-stage process

a. Secondary research methods covering secondary information collection, site visits, interviews and data analysis
b. Primary and qualitative research is to investigate FSTP technologies, understand the variations in costs (CapEx and OpEx) and life cycle costing to determine reference costing

The study is designed in three phases:

Stage 1: Planning
Stage 2: Qualitative Research
Stage 3: Data Integration & Analysis

Figure 1.1: Phases of Methodology



Further, the methodology also includes primary research and interviews with the key stakeholders which is integrated and analysed for:

- Defining reference cost for FSTPs considering type of technology, CapEx, OpEx and life cycle cost
- The financial range of applicability for each of the technologies to the different contracting models
- Applicability of existing / revised contracting models to FSTP sector
- Explore options for developing a costing tool of different technologies

Further, last one year's tender calls for STPs under different national schemes were reviewed to assess the different contracting mechanisms. The different mechanisms include the following types:

- Operation & Maintenance Contracts
- Build Operate Transfer Contracts
- Private Ownership Contracts
- Full Privatization

Primary data collection

Structured Site Visits

Structured site visits were undertaken to collect primary data directly from the technology providers and O&M teams in order to garner their design data, costing – estimated and actual, and operational challenges. Life cycle costing data is also primarily got during the site visits, and with interactions with the staff. Further, since most of the technologies are less than a year, the understanding is limited.

Structured Questionnaire

A structured questionnaire was designed, tested and applied in the field to collect quantitative data on the status of the current situation of the FSTPs and the operation staff's views on the issues with the FSTPs. The team identified a set of criteria relevant to the study scope of work and can reflect the overall view on the FSTP.

Semi-Structured Interviews (SSI) and Informal / Unstructured Interviews

The SSIs were designed for interviewing 2 - 3 field staff together. The tool was flexible to accommodate diverse type of questions including closed as well as open-ended questions. SSIs were adapted for different technologies to capture the requisite information.

Primary Data Verification

During the visits to most of the FSTPs, it was observed that the site team is primarily the operations team and have limited/no knowledge of the cost of the various components involved in the treatment process. Also, the replacement frequency as well and the replacement component cost was usually not known.

In order to ascertain that the costing data is correct, a 3-step process was adopted for the same.

1. Data collection based on telephonic discussion with the technology developer
2. Data tabulation based on the information provided through the telephonic conversation, field observations and in-house knowledge
3. Sharing the data tabulated with the technology developer for confirmation

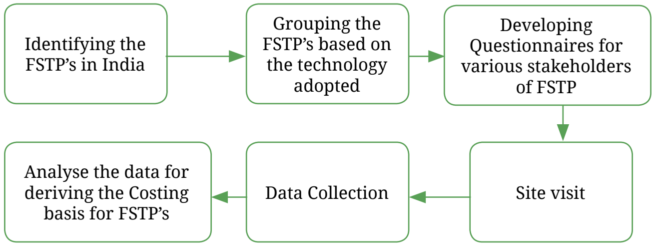
This approach therefore reduced / eliminated the mis-representation of costing data.

Visits to Faecal Sludge Treatment Plants (FSTPs)

Visits to Faecal Sludge Treatment Plants (FSTPs)

The team visited 6 FSTPs and developed the CapEx and OpEx sheets for each of the technologies. Understanding of the life cycle cost of the technology is being carried out, taking into consideration the replacement cost of different components, the Annual Maintenance Cost and risk management costs. 20 years is assumed as the lifetime of a FSTP, even though few technologies can exceed this time.

Figure 2.1: Methodology followed



A report is prepared after each visit to the site and this report is a collation of information on the FSTP which includes location of the site, date of visit, technology adopted, technology providers, its working principle, features, applicability, performance, strengths and challenges. It also focuses on the details of the area requirement, costs incurred, Operational failures, Sustainability of the technology, Capability of technology in faster roll out.

The FSTPs visited are listed below (based on type of technology used):

1. Warangal, Telangana - Pyrolyser based
2. Devanahalli, Karnataka - DEWATS based
3. Phulera, Rajasthan - DEWATS based
4. Jabalpur, Madhya Pradesh - MBBR based
5. Bhubaneswar, Odisha - DEWATS based
6. Puri, Odisha - Co-treatment
7. Leh, Jammu & Kashmir - Planted Drying Beds
8. Tenali, Andhra Pradesh - MBBR based

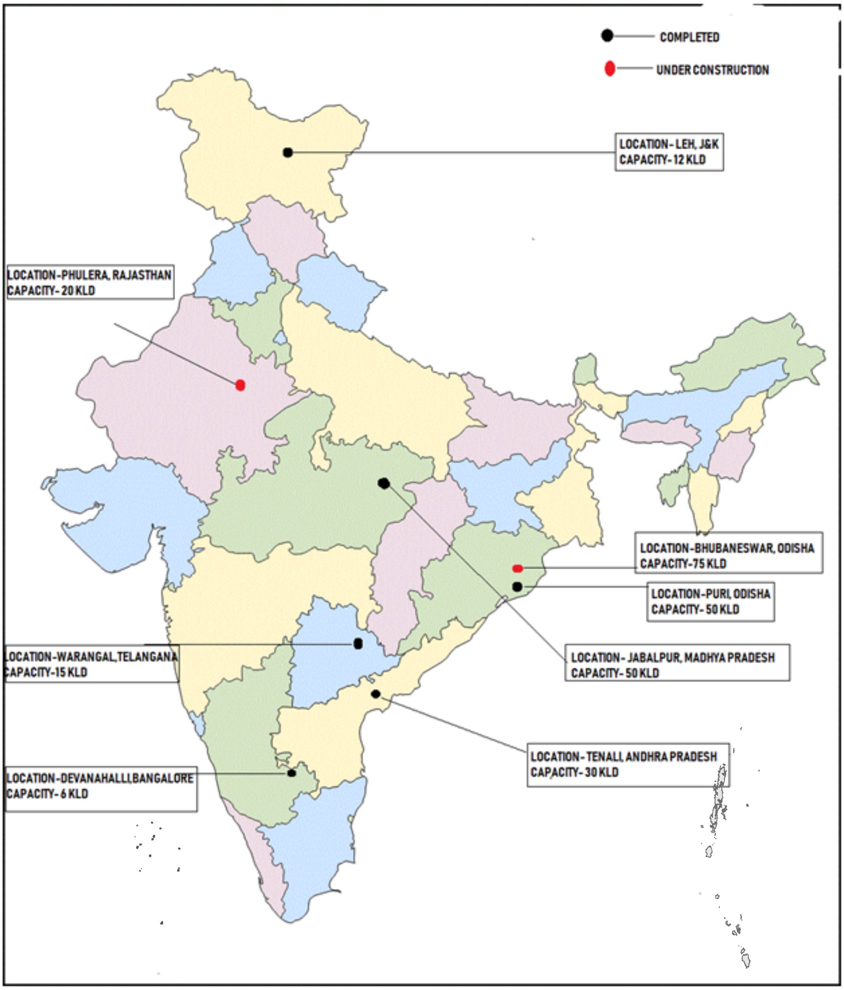
The FSTPs are of different capacities, ranging from 6 KLD to upto 75 KLD. The details of the FSTPs is discussed further.

The following table provides the details of discussions held with the key personnel for each of the technologies – with technology developers and also with the operations team. Some of the interactions with the technology developers has been on phone due to non-availability of the team during the site visits, though adequate prior intimation was often provided.

Table 2-1: List of FSTPs visited and discussions held

Sl. No	Plant Visited	Date	Persons Visited	Persons Met	Telephonic Discussions With
1	Devanahalli	16th March 2018	R S Arun Kumar Pavithra LJ Devika Muralidharan	Mr. Anantha Moorthy at Site Mr. Sasanka Velinda and Mr. Praveen At CDD	Mr. Praveen
2	Phulera			Mr. Sasanka Velinda and Mr. Praveen At CDD	Mr. Praveen
3	Jabalpur	27th March 2018	R S Arun Kumar Devika Ankita Gupta	Mr. Prince	Alok Surya, Meco Technologies, Bilaspur
4	Bhubaneshwar	16th April 2018	R S Arun Kumar Devika Jyoti Dash	Mr. Mohapatra, OWSSB	
5	Puri	17th April 2018	R S Arun Kumar Devika Jyoti Dash	Mr. Mohapatra, OWSSB	
6	Leh	6th June 2018	R S Arun Kumar Amaresh Doab Singh	Mr. Aarif and Gurmeet Singh	Mr. Praveen
7	Tenali	29th August 2018	R S Arun Kumar Akshay L V	Mr. Sambaiah	
8	Warangal	12th March 2018	R S Arun Kumar Pavithra LJ Devika Muralidharan	Mr. Ajay Chandran	Mr. Sampath At Office

Figure 2.2: FSTPs across India



Warangal

WARANGAL

Technology Description

Pyrolysis based approach is the treatment mechanism adopted in Warangal FSTP. It is the thermochemical decomposition of organic material at elevated temperatures in the presence of controlled oxygen (pyrolysis) to efficiently convert sludge to biochar without external power. It involves heating the waste at elevated temperature which kills the pathogens as well as helminths and make the end products biosafe.

FSTP at Warangal was commissioned in the year 2017 having the capacity of 15 KLD, different subsystems are integrated together to treat the faecal sludge which includes both civil and electromechanical components.

The system comprises of components such as septage receiving station with screenings and grit chambers, pasteurization unit, solid-liquid separation, dryer, pyrolizer, heat exchanger and dewatered effluent treatment system. These different subsystems integrated together form a complete plant that can process faecal sludge to biochar.

Salient features

1. Automated system with no direct contact with faecal sludge
2. Energy consumption monitoring
3. Suitable for all weather conditions
4. Modular System which can be scalable
5. Fast deployment, with low footprint
6. End to end solution

Costing details

The details of the CapEx, OpEx and replacement costs is provided in the table below. The details of the costing are taken from the technology provider. The replacement costs are taken in discussion with the operations team.

Table 2-2 CapEx of Warangal

Sl. No	Components	Total Capital cost (Rs. In lakhs)
1	Civil components (Platform, weigh bridge, compound wall & gate, Soil biofiltration unit)	25
2	Electromechanical components (Septage receiving station, holding tank, Pasteurization unit, dewatering unit, Dryer, Containers, Pyrolyser)	85
	Total Capital cost	110

Table 2-3: OpEx of Warangal

Sl.No	Cost	Total Operation cost (Rs. In lakhs/ month)	Total Operation cost (Rs. In lakhs/ year)
1	Consumable cost	0.48	5.25
2	Human resource cost	0.60	7.20
3	Admin & overheads @10%		0.72
4	Annual Maintenance Contract @ 5%		0.62
	Total OpEx		13.80

Table 2-4: Replacement Cost of Warangal

Sl. No	Components	Estimated replacement cost (Rs. In lakhs/ year)
1	Civil components (Platform, weigh bridge, compound wall & gate, Soil biofiltration unit)	0
2	Electromechanical components (Septage receiving station, holding tank, Pasteurization unit, dewatering unit, Dryer, Containers, Pyrolyser)	2.59
3	Ancillary units (Ancillary units may include one or many among the below listed items. Internal Roads, Drains, Compound walls, Guard room, OHT, Administrative units, Yard lighting, Site development, Plantation, plumbing, etc.)	0
	Total Replacement cost	2.59

Devanahalli

DEVANAHALLI

Technology Description

DEWATS is the technology adopted in Devanahalli to treat FSS, with a capacity of 6 KLD. This is the country's first FSTP, based on biological treatment methodologies – mostly passive systems. The entire system handles the solids and liquid separately. Screen chamber, biogas chamber, stabilization reactor, SDB, Integrated settler with AF, and PGF are some of the modules in Devanahalli. Liquid coming out of PGF is further treated in a collection tank through sand and carbon filters, and UV treatment.

The sludge from the drying beds are further treated with organic fraction of market waste. The intent is to use the higher temperature generated during the composting process to kill pathogens. The 60 – 65oC is good to kill the pathogens, which is evident from the composting process and compost quality.

Salient features

1. Simple, Flexible, Decentralized
2. Only physical and biological system
3. Treatment 6,000 lts per day
4. Space Required: 15-20 sq. mt per 1000 litre
5. Low operation and maintenance cost
6. Operates without skilled human resource

Possible use of water after treatment: agriculture, building construction, ground water recharge

Figure 2.2: Visit to Devanahalli FSTP

Costing details

The details of the CapEx, OpEx and replacement costs is provided in the table below. The details of the costing are taken from the technology provider. The replacement costs are taken in discussion with the technology provider too.

Table 2-5 CapEx of Devanahalli FSTP

Sl. No	Components	Total Capital cost (Rs.in lakhs)
1	Civil components (Screen Chamber, biogas, Stabilization Reactor, Sludge drying bed, Collection tank, ABR, PGF	70.90
2	Ancillary units – Co-composting plant	40.00
	Total Capital cost	110.90

Table 2-6 OpEx of Devanahalli FSTP

Sl. No	Cost	Total Operation cost (Rs. In lakhs/ month)	Total Operation cost (Rs. In lakhs/ year)
1	Consumable cost	0.48	0.48
2	Human resource cost	0.24	4.20
3	Admin & overheads @10%		0.42
4	Annual Maintenance Contract @ 5%		0.25
	Total OpEx		5.33

Table 2-7 Replacement Cost of Devanahalli FSTP

Sl. No	Components	Estimated replacement cost (Rs. in lakhs/ year)
1	Screens	0.08
2	Other components (Co-composting – shredder)	0.60
	Total Replacement cost	0.68

Phulera

PHULERA

Technology Description

DEWATS is the technology adopted in Phulera to treat FSS, with a capacity of 20KLD. It is a natural anaerobic stabilization of the waste with increased contact time with the active biomass followed by aerobic treatment of both sludge and effluent. The entire system is biological based treatment which handles the solids and liquid separately. Screen chamber, Grit chamber, stabilization reactor, SDB, Integrated settler with AF, and PGF are some of the modules in Phulera. Liquid coming out of PGF is further treated in a collection tank through sand and carbon filters, and UV treatment.

The plant in Phulera is under construction, designed to handle septage of 20 KLD.

Salient features

1. Simple, Flexible, Decentralized
2. Only physical and biological system. Works without technical energy
3. Treatment from 1,000 - 500,000 litres
4. Space Required: 15-20 sq. mt per 1000 litre
5. Low operation and maintenance cost
6. Operates without skilled human resource

Possible use of water after treatment: agriculture, building construction, ground water recharge.

Costing details

The details of the CapEx, OpEx and replacement costs is provided in the table below. The details of the costing are taken from the technology provider. The replacement costs are taken in discussion with the technology provider too.

Table 2-5 CapEx of Phulera FSTP

Sl. No	Components	Total Capital cost (Rs.in lakhs)
1	Civil components (Screen Chamber, Grit chamber, Stabilization Reactor, Sludge drying bed, Collection tank 1, Integrated settler, ABR, PGF Collection tank	202.52
2	Other components (Aggregates, Coarse Sand, UPVC Pipes and Pump)	34.43
3	Ancillary units (Generator, Street lighting, Gate on compound wall, Borewell, Plants and Landscaping, Utility access manholes and manholes and Other ancillary units)	25.00
	Total Capital cost	239.50

Table 2-6 OpEx of Phulera FSTP

Sl. No	Cost	Total Operation cost (Rs. In lakhs/ month)	Total Operation cost (Rs. In lakhs/ year)
1	Consumable cost	0.32	3.85
2	Human resource cost	0.22	2.64
3	Admin & overheads @10%		0.26
4	Annual Maintenance Contract @ 5%		0.32
	Total OpEx		7.08

Table 2-7 Replacement Cost of Phulera FSTP

Sl. No	Components	Estimated replacement cost (Rs. in lakhs/ year)
1	Civil components (Screen Chamber, Grit chamber, Stabilization Reactor, Sludge drying bed, Collection tank 1, Integrated settler, ABR, PGF and Collection tank 2)	0.40
2	Other components (Aggregates, Coarse Sand, UPVC Pipes and Pump)	2.90
3	Ancillary units	0
	Total Replacement cost	3.30

Jabalpur

सेप्टेज ट्रीटमेंट प्लान्ट
क्षमता- 50,000 लीटर
लागत - 68.99 लाख
(5 वर्षों के मेनटेनेंस सहित)
संचालन संधारण एजेंसी
मेको टेक्नोलॉजी प्रा. लि.
निर्माण वर्ष - 2017

JABALPUR

Technology Description

Jabalpur FSTP was installed in the year 2017, with the capacity of 50KLD. There are three FSTPs located in Jabalpur at three different location with the same technology and capacity.

MBBR is the simple technology adopted to treat the faecal sludge. Sludge is made to settle by adding flocculants which aids gravity settling and the supernatant is pumped to MBBR where it undergoes secondary treatment and then made to pass through the vertical rapid carbon and sand filter for tertiary treatment.

Treatment technology adopted is simple but there is no end to end solution achieved as only the liquid part is getting treated and the solids are not given any attention.

Figure 2.3 Pictures of Jabalpur FSTP

Salient features

1. Partially a gravity-based system
2. Tertiary treatment of liquid through sand carbon filters
3. Low capital cost
4. No treatment for the solids settled at the bottom
5. Skilled labour not required

Costing details

The details of the CapEx, OpEx and replacement costs is provided in the table below. The details of the costing are taken from the technology provider. The replacement costs are taken in discussion with the operating staff.

Table 2-8 CapEx of Jabalpur

Sl. No	Components	Total Capital cost (Rs. in lakhs)
1	Civil components (Holding tank)	10.25
2	Mild steel (MBBR, Settling tank and Collection tank)	5.66
	Others (Chlorine dosing tank, Centrifugal sludge pump and CPVC Pipes)	4.32
3	Ancillary units	30
	Total Capital cost	50.23

Table 2-9 OpEx of Jabalpur FSTP

Sl. No	Cost	Total Operation cost (Rs. In lakhs/ month)	Total Operation cost (Rs. In lakhs/ year)
1	Consumable cost	0.46	5.52
2	Human resource cost	0.20	2.40
3	Admin & overheads @10%		0.24
4	Annual Maintenance Contract @ 5%		0.40
	Total OpEx		8.56

Table 2-10 Replacement cost of Jabalpur FSTP

Sl. No	Components	Estimated Replacement Cost (Rs. In lakhs/ year)
1	Civil components	0.02
2	MBBR, Settling tank, Chlorine dosing tank, Centrifugal sludge pump, CPVC Pipes and Collection tank	0.61
3	Ancillary units	0
	Total Replacement cost	0.63

Bhubaneshwar

BHUBANESHWAR

Technology Description

FSTP at Bhubaneswar was getting ready to be commissioned this year and is designed to handle 75 KLD of septage per day. Construction of components are built using local building material. Digestion of the sludge occurs in the thickening zone of settler, Solids from the settler is pumped to sludge drying beds and the liquid is further treated in ABR, PGF and Maturation ponds. The Odisha Water Supply and Sewerage Board (OWSSB) has developed the design of the system in-house, inspired by their visit to DEWATS plant at Devanahalli.

Figure 2.4 Pictures of Bhubaneswar FSTP

Salient features

1. Simple, Flexible, Decentralized
2. Only physical and biological system. Works without technical energy.
3. Treatment from 1,000 - 500,000 litres.
4. Space Required: 15-20 sq. mt per 1000 litre
5. Low operation and maintenance cost
6. Operates without skilled human resource

Costing details

The details of the CapEx, OpEx and replacement costs is provided in the table below. The details of the costing are taken from the technology provider. The replacement costs are taken in discussion with the operating staff.

Table 2-11 CapEx of Bhubaneswar

Sl. No	Components	Total Capital cost (Rs. In lakhs)
1	Civil components (Inlet chamber, Settling cum thickening tank, Sludge drying bed, ABR, Horizontal PGF, Polishing pond, Leachate sump, Platform for co composting and Pumps)	154.90
2	Ancillary units	13.00
	Total Capital cost	167.90

Table 2-12 OpEx of Bhubaneshwar

Sl. No	Cost	Total Operation cost (Rs. In lakhs/ month)	Total Operation cost (Rs. In lakhs/ year)
1	Consumable cost	0.30	3.60
2	Human resource cost	0.60	7.20
3	Admin & overheads @10%		0.72
4	Annual Maintenance Contract @ 5%		0.54
	Total OpEx		12.06

Table 2-13 : Replacement cost of Bhubaneshwar

Sl. No	Components	Estimated Replacement Cost (Rs. In lakhs/ year)
1	Civil components (Inlet chamber, settling cum thickening tank, Sludge drying bed, ABR, Horizontal PGF, Polishing pond, Leachate sump, Platform for co composting and Pumps)	1.53
2	Ancillary units	0
	Total Replacement cost	1.53

Puri

PURI

Technology Description

The FSTP at Puri is the co-treatment facility along with Waste Stabilization Pond based Sewage treatment plant. The design capacity of this plant is 50 KLD. However, the present septage loads range to about 10 – 12 KLD per week. Screening unit followed by settling-thickening tanks to achieve separation of the liquid and solid fractions of faecal sludge is provided. The settled sludge is compressed due to the weight of other particles pressing down on them, and water is squeezed out, effectively increasing the concentration of the total solids. Solids are pumped into sludge drying bed for drying and the liquid is further treated in the waste stabilization ponds. A 15 MLD capacity WSP is provided for sewage treatment for an inflow of 12 MLD.

Figure 2.5 Pictures of Puri FSTP

Salient features

1. Simple, Flexible, Decentralized
2. Only primary treatment provided, along with sludge settler
3. Low operation and maintenance cost
4. Operates without skilled human resource
5. Use of components designed for STP – Drying beds, WSP

Costing details

The details of the CapEx, OpEx and replacement costs is provided in the table below. The details of the costing are taken from the technology provider. The replacement costs are taken in discussion with the operating staff.

Table 2-14 CapEx of Puri

Sl. No	Components	Total Capital cost in (Rs.in lakhs)
1	Civil components (Inlet Channel, Settling-Thickening tank, Unplanted drying beds and Platform for sludge storage)	63.20
2	Ancillary units	10.70
	Total Capital cost	73.90

Table 2-15 OpEx of Puri

Sl. No	Cost	Total Operation cost (Rs. In lakhs/ month)	Total Operation cost (Rs. In lakhs/ year)
1	Consumable cost	0.11	12.96
2	Human resource cost	0.85	10.20
3	Admin & overheads @10%		1.02
4	Annual Maintenance Contract @ 5%		0.57
	Total OpEx		13.09

Table 2-16 : Replacement cost of Puri

Sl. No	Components	Estimated replacement cost (Rs.in lakhs/year)
1	Civil components (Inlet Channel, Settling-Thickening tank, Unplanted drying beds and Platform for sludge storage)	0.35
2	Ancillary units	0
	Total Replacement cost	0.35

Leh

LEH

Technology Description

Planted drying bed is the approach used in Leh to treat faecal sludge in a high-altitude area, capacity of 12KLD. The sludge is allowed to dry in the PDB and excess water percolates and is treated as it flows through horizontal Planted Gravel filter (HPGF) and will be collected in the polishing pond where sunlight helps as solar disinfectant. The sludge which is accumulated in PDB will be removed and used as organic manure.

Figure 2.6 Pictures of Leh FSTP

Salient features

1. The technology is Robust and flexible for extreme conditions
2. No direct human contact with Faecal Sludge
3. Minimal odour during the process and aesthetically designed to locate near habitation
4. Gravity based system, Based on natural and Biological treatment with no use of chemicals or electricity
5. Simple operations that can be handled with unskilled operators and labour
6. Less O&M Cost

Costing details

The details of the CapEx, OpEx and replacement costs is provided in the table below. The details of the costing are taken from the technology provider. The replacement costs are taken in discussion with the operating staff.

Table 2-17 CapEx of Leh

Sl. No	Components	Total Capital cost (Rs.in lakhs)
1	Civil components (Planted drying beds, Horizontal PGF, Polishing pond and Green house)	42.20
2	Ancillary units	10.00
	Total Capital cost	52.20

Table 2-18 OpEx of Leh

Sl. No	Cost	Total Operation cost (Rs. In lakhs/ month)	Total Operation cost (Rs. In lakhs/ year)
1	Consumable cost	0.28	3.36
2	Human resource cost	0.30	3.60
3	Admin & overheads @10%		0.36
4	Annual Maintenance Contract @ 5%		0.35
	Total OpEx		7.66

Table 2-19 Replacement cost of Leh

Sl. No	Components	Estimated replacement cost (Rs.in lakhs)
1	Civil components (Planted drying beds, Horizontal PGF, Polishing pond and Green house)	0.83
2	Ancillary units	0
	Total Replacement cost	0.83

Tenali

TENALI

Technology Description

Similar to Jabalpur FSTP, the FSTP at Tenali is based on MBBR technology with a capacity of 20 KLD. MBBR is the simple technology adopted to treat the faecal sludge. Sludge is made to settle by adding flocculants which aids gravity settling and the supernatant is pumped to MBBR unit, consisting of MBBR unit, tube settler and clarifier, where it undergoes secondary treatment and then made to pass through the vertical rapid carbon and sand filter for tertiary treatment.

Figure 2.7: FSTP at Tenali

Treatment technology adopted is simple but there is no end to end solution achieved as only the liquid fraction is getting treated and the solids are not given any attention. Sludge Drying Beds are proposed to be established at the site, as per the operator.

Costing Details

The details of the CapEx, OpEx and replacement costs is provided in the table below. The details of the costing are taken from the technology provider. The replacement costs are taken in discussion with the operations team.

Table 2-20: CapEx Of Tenali

Sl. No	Components	Total Capital cost (Rs.in lakhs)
1	Civil (Tank)	10.00
2	Electro-mechanical (MBBR unit + PSF + ACF)	8.00
3	Ancillary units	2.00
	Total Capital cost	20.00

Table 2-21: OpEx of Tenali

Sl. No	Cost	Total Operation cost (Rs. In lakhs/ month)	Total Operation cost (Rs. In lakhs/ year)
1	Consumable cost	0.22	5.52
2	Human resource cost	0.20	2.40
3	Admin & overheads @10%		0.24
4	Annual Maintenance Contract @ 5%		0.25
	Total OpEx		5.53

Table 2-22: Replacement Cost of Tenali

Sl. No	Components	Estimated replacement cost (Rs.in lakhs)
1	Civil components	0.00
2	Electro-mechanical units	0.45
3	Ancillary units	0.00
	Total Replacement cost	0.45

Cost Analysis of FSTPs

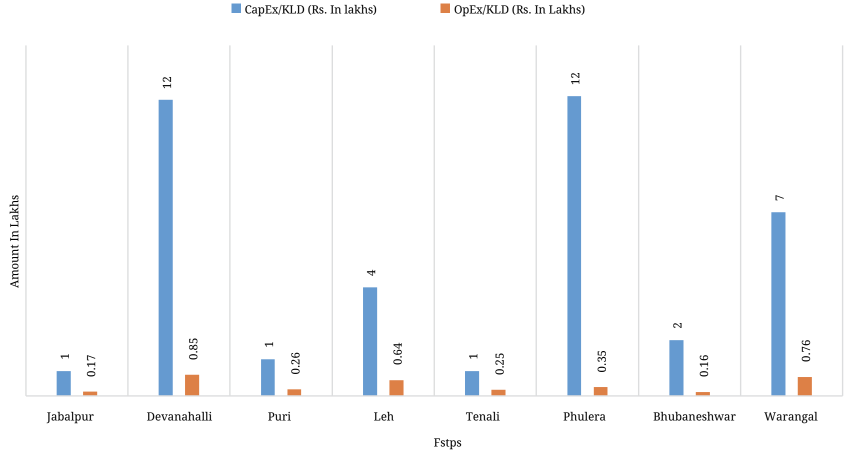
Capital and Operating Costs - Analysis

Comparative analysis of CapEx and OpEx of FSTPs

Based on the CapEx and OpEx costs of the FSTPs, a fundamental analysis of the costing per KLD is carried out to understand the variation of the costing between technologies. Noticeably, costs of the FSTPs vary significantly, from as low as Rs. 1,00,000 per KLD to as high as Rs. 17,00,000. The variations are also since the extent of treatment significantly varies between technologies. At Jabalpur, the plant handles only the supernatant liquid in MBBR, and the settled solids are disposed off without any form of treatment. Both the pyrolyser as well as DEWATS have extended treatment components for handling solids, recognizing that solids management is a critical aspect of septage treatment.

Further, the co-treatment of septage in Waste Stabilization Ponds at Puri is at a cost of Rs. 3,00,000 per KLD, establishing the fact that many of the low-cost solutions aren't necessarily meeting the required discharge standards of the PCBs.

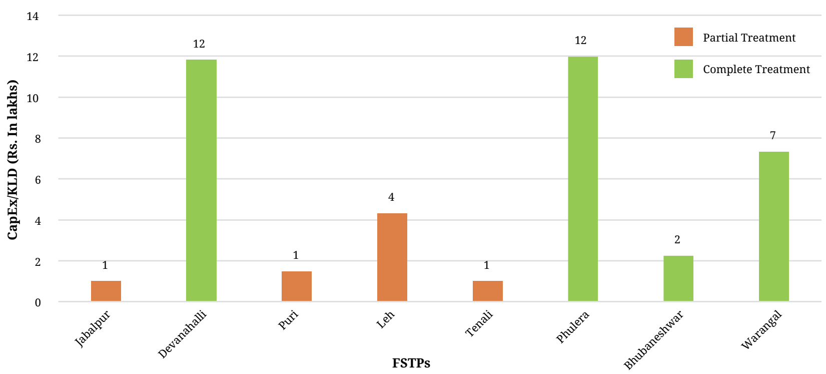
Table 3-1: Comparative Chart of CapEx and OpEx per KLD of FSS



Costing analysis for completeness of treatment

Extent of treatment has a significant influence of the cost of FSTPs. Technologies like pyrolysis ensures biosafety to the extent of eliminating helminth eggs in all its discharges – liquid as well as solid and DEWATS ensures pathogen destruction. MBBR technology in Jabalpur ensures safe liquid disposal, however falls behind completely in the faecal solids management with unsafe disposal of faecal solids.

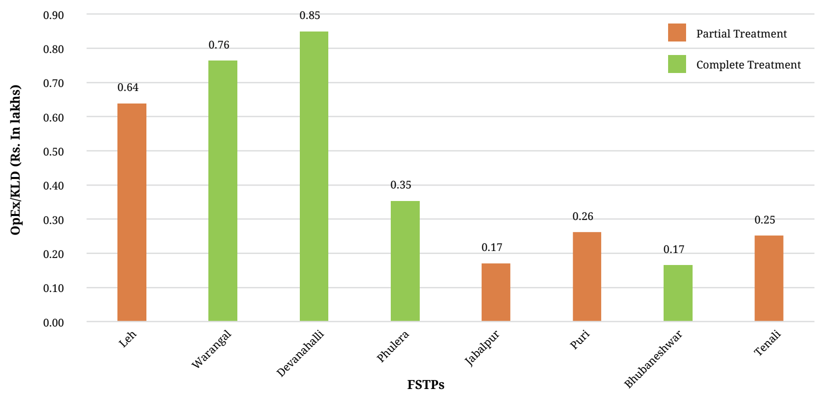
Table 3.2: Comparative Chart of Degree of Treatment and CapEx per KLD of FSS



Experiences in Devanahalli has shown that additional efforts to ensure safe management of faecal solids is significant and can cost as high as 30 – 40% of the initial CapEx. The OpEx also significantly increases, increasing from Rs. 6,00,000 per annum to Rs. 14,00,000 after incorporating co-composting of solids with MSW.

It is also noteworthy that pyrolysis system has the highest OpEx costs, making it the most expensive since its completely mechanized system.

Table 3.3 Comparison of Degree of Treatment and OpEx per KLD of FSS

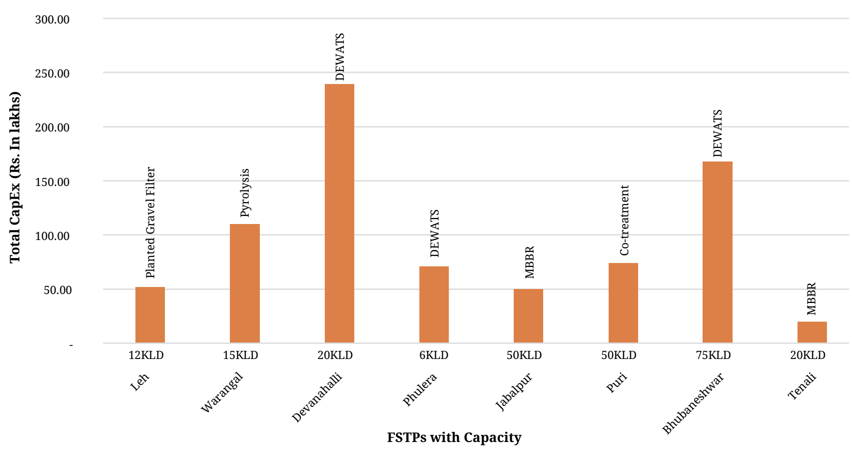


Cost Analysis for Varied Capacities and Technologies

Significant variation across the technologies and their relative capacities are observed. The cost of a technology with lower capacity generally costs higher compared to the higher capacity plants as evident from the below chart. The cost of the technology with same capacity having complete treatment solution is lower in comparison to the partial solution. The rationality among the technologies and its capacities is required to be brought in.

Comparing the CapEx of FSTPs at Phulera & Bhubaneshwar, which are based on DEWATS approach, the costs are significantly different. This difference is primarily due to the difference in choice of components under the DEWATS approach.

Table 3.4 Comparison of CapEx Vs Capacity



Life Cycle Costing

Life Cycle Costing is widely accepted that the total economic cost of a given system is best determined by assessing both the capital and operational costs together over the entire life cycle of the system. The term life cycle cost (LCC) was first introduced in 1965 in a report entitled 'Life Cycle Costing in Equipment Procurement'. The report was prepared for the U.S. Department of Defence who determined that the cost of system acquisition may be small in relation to the cost of ownership.

The concept of LCC introduced a new level of transparency to costing, and exposed hidden costs that were not immediately apparent with traditional costing methods. This approach makes it possible to determine the most cost-effective solution amongst a range of alternatives by considering all cash flows over the lifetime of the system and allows practitioners to identify potential trade-offs between initial capital investment costs and long-term cost savings.

LCC Methodology

Present Value

Costs that occur at different times in the future cannot be compared directly because of changes in the time value of money, and, therefore, must be calculated to represent their value at a common base date. This approach provides a platform for a fair evaluation of alternatives. The adjusted value is commonly referred to as the present value (PV).

Discounting

It is important to understand the difference between the discount rate and the rate of inflation. The discount rate represents the time value of money, whereas the rate of inflation describes the decrease in purchasing power and increase in operating costs. There are two types of discount rate used in NPV calculations: the real discount rate and the nominal discount rate. The main difference between the two is that the nominal discount rate accounts for inflation and deflation, whereas the real discount rate does not. The choice of discount rate to be used will depend on the purpose of the costing exercise. If the purpose of the LCC is to estimate the actual cash flow it is important to include interest rates, and thus, adopt a nominal discount rate. However, if the purpose of the LCC is to compare alternative systems then the real discount rate is usually sufficient.

System lifetime

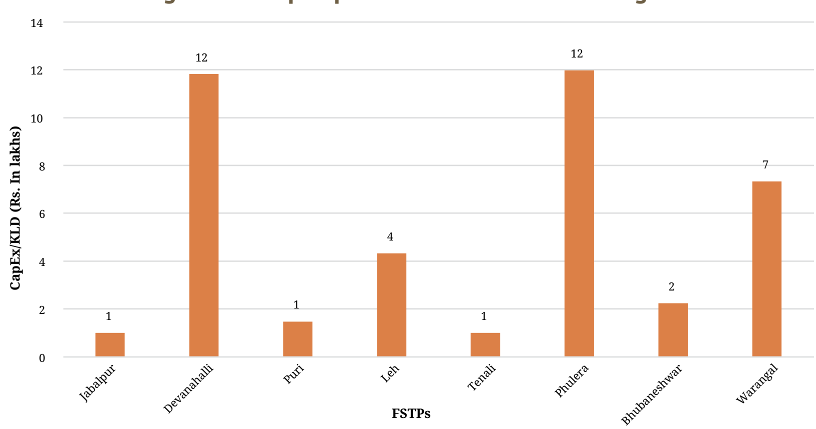
The projected lifetime of FSTPs will vary between different system types. This is an area that is often overlooked, and values used in LCC varies widely in the literature provided by the technology developers from 20 to 40 years. It could be argued that for the purpose of system comparison a single lifetime value will suffice; however, it should also be noted that systems with large OpEx will be more sensitive to variations in the nominal lifetime value.

Capital expenditure

Wastewater treatment project CapEx refers to the cost of the initial investment in materials, planning, construction, engineering, electrical and mechanical equipment. Some literature may include the cost of land acquisition, and there is generally a 15 – 20% contingency included to account for uncertainty. The type of treatment system being considered will, to a large extent, determine the CapEx distribution profile. Systems that require large structures such as DEWATS will incur higher construction costs. Complex hybrid systems such as MBBRs will have higher specialized material and labour costs. Natural systems such as CWs and Planted Drying Beds will have a much greater civil works cost than conventional electro-mechanical systems due to the large surface areas involved.

The location of the potential site can have a large influence over several areas of cost. For example, the distance to suppliers, availability of labour, access to utilities (water, electricity, gas) will vary by location, and will inevitably affect cost. The cost of civil works can rise depending on the site topography and soil geology.

Figure 4.1: CapEx per KLD of various technologies



The CapEx across the various technologies is provided in the graph below. The costing is carried out on a per KLD basis. All the FSTPs are built in the last one year, and hence the systems cost across time is not factored in.

Operation and maintenance expenditure

Although the type of technology chosen will generally dictate OpEx distribution, it is the location of the treatment plant that will ultimately determine the type of treatment technology that should be used. This is based on the predication that the most appropriate system will be chosen for a given location.

Typical OpEx profiles are dominated by three main cost components:

1. Energy,
2. Chemicals, and
3. Labour

Note: Maintenance is often accounted for under labour and replacement materials.

Depending on the system type, these three cost elements can account for up to 90% of the total OpEx in electro-mechanical systems.

Energy

Reports on the percentage of OpEx attributed to energy consumption vary widely in the literature and can range from 0 – 60% depending on system type. Because of the minimal energy used by natural systems, the remainder of the discussion here will be limited to electro-mechanical systems. The total energy cost and distribution across processes within a FSTP will vary with system type, scale, location, hydraulic, organic and inorganic load, discharge limits, and operational efficiency.

The other factors which influences the energy consumption are:

1. The scale of a FSTP
2. Final effluent discharge limits
3. Operational efficiency
4. Preventative maintenance

Chemicals

The specific cost of chemicals will vary with plant location and supplier. Chemical quantities are heavily influenced by the plants' discharge limits.

Labour

Properly trained and skilled personnel are essential for FSTP operational efficiency. The top two factors limiting performance are:

1. Operator application of concepts and testing to process control
2. Fecal sludge treatment understanding

The level of automation also influences the labour use. For small plants that are manned infrequently, the ratio of hours spent travelling to and from the plant, to hours spent operating a plant increase.

The magnitude of estimated labour cost is influenced by

- System type;
- Level of expertise required;
- Location;
- Scale; and
- Specific salary scales (also location dependant)

The labour demand of the different FSTPs is represented in the graph below:

Replacement Expenditure

The frequency and cost of parts replacement is system specific. A simplification has been made here that assumes similar replacement frequencies and associated costs based on the system classification. A detailed inventory of the components of each system is produced to make a more accurate estimation.

Life Cycle Costing and FSTPs

The application of LCCA to FSTPs is particularly appropriate because of the significant cost variability that exists between different locations. Individual systems may have different CapEx and OpEx profiles depending on location, and therefore, should be assessed on a case by case basis.

There are three types of temporal LCC variations that have to be considered in the analysis of FSTPs:

- Initial capital expenditure (CapEx),
- Recurring costs i.e. Operation and maintenance expenditure (OpEx), and
- One-off replacement costs.

The CapEx is assumed to be the total cost of the project from the start the of the procurement process, through pre-engineering, design, and construction, to the first day of operation. Depending on the scale, and anticipated duration of a project, a contractor may choose to include an inflation rate in a tender application.

Considering the plant scale range involved in this study it is assumed that a plant can be constructed in less than a year, usually in about 6-8 months, and that the project cost estimation provided by the contractor does not include an inflationary cost factor. Therefore, a discount rate needs to be applied to the CapEx to account for depreciation that occurs between the time of initial project cost estimation to the time of operations; assumed here to be one year. This value is calculated using the single present value (SPV) method. The SPV method applies to a one-off payment that occurs sometime in the future. This method is also used to account for large unit replacement parts that occur within the lifetime of the system.

Discount rate

The test discount rate (real discount rate) for OpEx is 9.75%.

System lifetime

FSTP lifetimes in the study vary from 20 to 40 years. It's assumed at 20 years for this study

Calculation

Assumptions for calculations

Inflation Rate	5%
Discount Rate	9.75%
LCC timeline	20 years

Net present value method was selected for LCC analysis. Base year for analysis was 2018, and all value was converted to base year.

Total life cycle cost was calculated using following formula
LCC = C + R + A

Where; C = the initial cost;
R = the present value of replacement cost;
A = the present value of annually recurring operating, maintenance and repair cost (excluding energy costs);

Present value was calculated by using following formula
PV = Ct / (1+r)t

Where; PV = present value
Ct = cost in the year t
r = discount rate

Discount rate was calculated by using following formula
1 + r = (1+ interest rate) / (1+ inflation rate)

To calculate the discount rate interest rate and inflation rate has been considered.

Results of LCC Analysis

The results of the LCC analysis across the 8 FSTPs are presented in the table below:

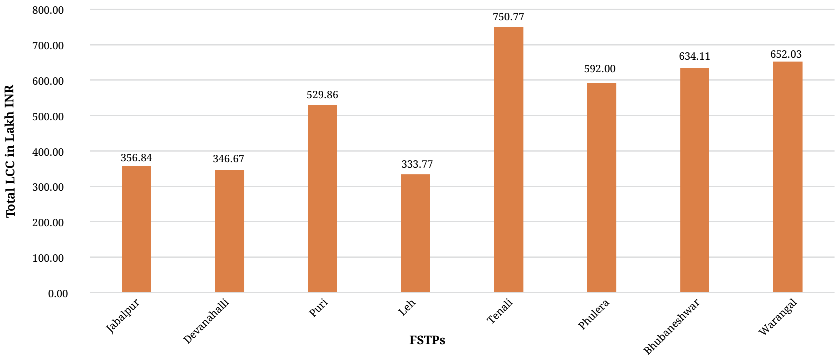
Table 4-1: LCC Analysis Across FSTPs

FSTPs	Capacity, KLD	CapEx, in Lakh INR	NPV - O&M in Lakh INR	NPV -LCC in Lakh INR	Total LCC in Lakh INR	LCC / year in Lakh INR	LCC / KLD in Lakh INR
Jabalpur	50	50.23	129.70	179.93	359.86	29.99	7.20
Devanahalli	6	70.90	118.69	189.59	346.67	28.89	57.78
Puri	50	73.90	193.01	266.91	533.83	44.49	10.68
Leh	12	52.20	119.63	171.83	343.66	28.64	28.64
Tenali	20	20.00	98.69	118.69	237.37	19.78	11.87
Phulera	20	239.45	163.39	402.84	805.68	67.14	40.28
Bhubaneshwar	75	167.90	209.52	377.42	754.84	62.90	10.06
Warangal	15	110.00	229.17	339.17	678.34	56.53	45.22

From the LCC analysis of the different technologies, it is evident that the technologies focusing primarily on liquid management are far lesser in the total LCC, when compared to technologies which focuses on both liquid as well as solids management. Phulera, Bhubaneshwar and Warangal show total LCC, at about 3-4 times that of Jabalpur, Leh and Tenali.

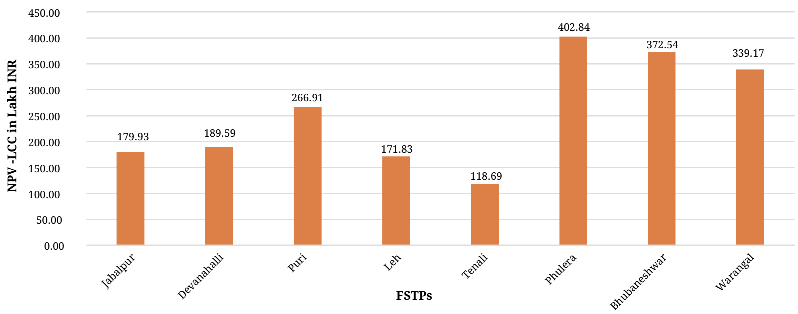
The total LCC cost across the technologies are represented in the graph below:

Figure 4.4: Total LCC Across FSTPs



The NPV of LCC for each of the FSTPs is almost 50% of what the total LCC is, which is represented in the graph below. This clearly denotes that the decision makers should consider the NPV of LCC for selecting the FSTPs for their towns and cities.

Figure 4.5: NPV of LCC Across FSTPs



Also, from the LCC analysis, O&M costs across 20-years' time frame, is relatively similar across technologies, except for Warangal, the only non-biological treatment process. Evidently, it's the only completely mechanized treatment solution, and therefore reflects in the costs.

Further analysis of the LCC value of the technology over per year cost, the following graph represents the variation across the technologies.

Figure 4.6: LCC Cost Per Year Across FSTPs

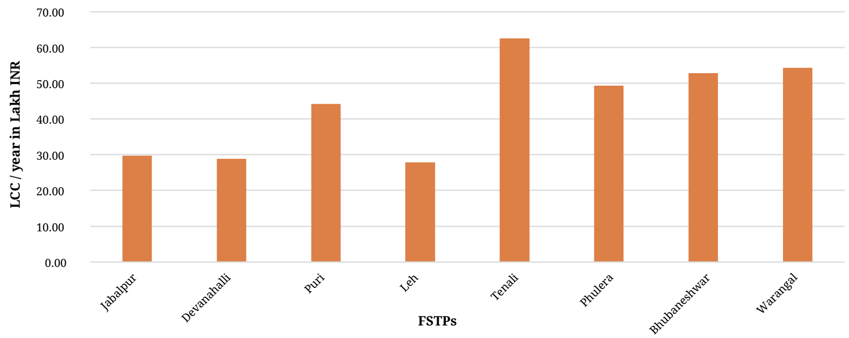
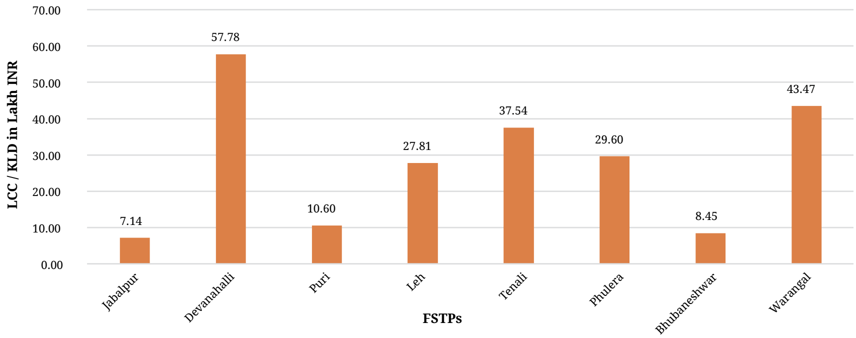


Figure 4.7: LCC Cost Per KLD Across FSTPs



FSTP Contracting Model: Analysis

FSTP Contracting Model: Analysis

The local governments or Municipalities in a city/ town simultaneously act as: service providers, owners, and customers, project sponsors, regulators in charge of price setting and monitoring as well. Local governments/Municipalities, regardless of their size, are constitutionally required to provide public services such as water, sewerage, solid waste management and sanitation. Fecal Sludge management had not been as a priority service till now for the Municipalities but is gaining relevance.

The local government has preferred to work with private sector partners in delivery of such services typically through conventional procurement contracts. Recent years have seen the development of new partnership models such as public private partnership (PPP). The PPP model has emerged as sought-after option by the local government since the accountability is high and also due to lack of funds, time constraints, skill and human resource. The PPP models have also been varied depending on the needs viz., end user, performance based, annuity based, etc. These varied contracting options for service delivery enable local government in better performance monitor, resulting in saving money, time and improving efficiency of delivery. The choice of the contract model is a risk management exercise, involving a balancing of various factors including:

- The requirements of finance sharing
- Investment ability
- Type of technology opted
- The experience and capability of the Contractors/ private players to be engaged to deliver the project
- The size of the project (in terms of the value and physical complexity)
- Time constraints on project delivery – to be executed over a normal, sequential schedule, or a fast-track schedule
- Sustainability

Sewage Treatment Plant contracts

The Sewage management services is the sector comparable to Fecal Sludge management (FSM) due to the type and form of waste being dealt with. The sewage sector has been considered as a reference to the FSTP sector due to the reasons as below

- both streams contain human waste
- both streams are liquid waste
- service delivery by the same authority and

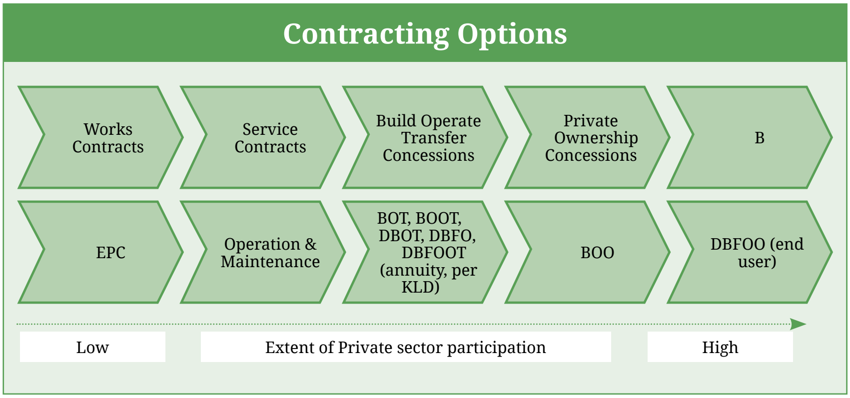
- various service delivery options available for analysis
- similar consequence on public health

The services of sewage management include collection, conveyance, treatment and disposal. In the past the laying of sewer network for collection and conveyance of sewage was only through conventional method of procurement contracting, however the recent trend has been including the conveyance and treatment under single model of contracting to a private partner. The contracting models observed in the sector are:

- Works Contracts
- Operation & Maintenance Contracts
- Build Operate Transfer Contracts
- Private Ownership Contracts
- Full Privatization

The entire spectrum of contracting models is grouped as shown in the Exhibit below:

Figure 5.1: Contracting Options in PPP



Comparing with the Central Govt.'s different programs for Sewage Treatment Plants, the tendering trends under their different programs were reviewed for analyzing the type of contracting being done for STPs. The trends observed in contracting the STP projects under these programs is shown below.

Table 5-1: Trends of Contracting under Central Schemes

Financing Schemes	SMART Cities	AMRUT	Namami Gange
Types of Contracting Models	EPC	EPC (Lumpsum)	HAM (PPP)
	Turnkey (Lumpsum)	Turnkey (Single Percentage rate contract)	
	Lumpsum price rate		
	DBO (PPP)		

Both works & services contracts and public private partnership financing mode of the sewage treatment plant projects has been observed. Turnkey, Lumpsum price, etc. contracts are different variants of works & service contracts with different forms of financial quote.

Hybrid Annuity Model is another upcoming model for contracting STPs. The GoI has approved Hybrid Annuity Model (HAM) for implementation of STP projects under Namami Gange on a PPP basis. Under this model, private investor will design, build, finance, operate and transfer the plant (STP) to the public sector at the end of the Concession Period .40% of the Capital cost will be paid to the private sector during construction of the STP. Balance 60% along with Operation & Maintenance (O&M) cost will be paid over the Concession Period on achievement of key performance indicators as per the contract. Entire cost of development and operation of the STPs will be 100% funded by the public sector. The tenders published after the approval of this model by GOI has been exclusively based on HAM model.

FSTP Contracts

With introduction of Amrut Mission, Swachh Bharat Mission and NFSSM policy, significant focus of 11 States has occurred with initiating necessary steps for effective management and safe disposal of fecal sludge and septage from on-site sanitation systems in some of their cities. The detailed analysis indicated that technological variation was almost negligible with biological treatment systems being the major preference, while, financial parameters were highly variable. However, considering the current scenario of septage management and challenges posed by biological systems, ULBs need to shift focus on alternate technologies to ensure a long-term sustainable impact. Therefore, during 2017-18, several Urban Local Bodies in India from various States including Karnataka, Andhra Pradesh, Telangana, MP, Rajasthan, Jharkhand, West Bengal, Tamil Nadu, Orissa, UP and Nagaland invited tenders in the form of EOI / RFPs for engaging a private partner, either individually or as a Joint Venture, for setting up and operating a centralized septage treatment facility.

The various methods through which these tenders were notified are through online, offline and through newspaper advertisements. These tenders involve various aspects like eligibility criteria, technical criteria and financial criteria.

Technical criteria

On comparing the eligibility criteria of various tenders except Andhra Pradesh and Telengana that were called up to know it is observed that the tenders are called keeping construction experience as a bench mark. Majority of the FSTP technology providers might not have construction experience though.

On comparing the technological aspects of these tenders, it was observed that while the States like Andhra Pradesh and Telangana provided liberty to propose any kind of proven technology for septage treatment, but the remaining states preferred to rely only on the proven biological treatment technologies including DEWATS, Sludge Drying Beds with Co-composting, Planted Drying Beds, UASB and Co-treatment with Sewage. However, some of States like Rajasthan and Jharkhand who preferred biological treatment, also included the provision for an alternate proposal in the tender, wherein the applicant can propose any alternate treatment technology but, the complete capital cost for setting up of a pilot shall be borne by the applicant only. Moreover, the responsibilities of Septage collection and transportation along with further management of sludge and other by-products were also accorded to the applicant by all the states.

Financial criteria

Further, if we consider the financial aspects of these tenders, a significant amount of variation was observed in per KLD capital and operational cost being allocated by different states. Some of the factors that might be responsible for this shall include difference in population, funds availability, proposed years of operation, extent of civil work required at the identified site and many other geography and technology specific factors. As such, no nationally standardized / recognized financial parameters have being followed by the States while tendering even in the cases wherein similar technologies have proposed for Septage treatment.

Moreover, if we look at the progress of these tenders, not even 5% of these facilities are functional as on date, the reasons being, some of them have been recently tendered, some have been retendered 2-3 times, some are in awarding stage while for others no update is available since long time.

Case Study – AP Tender for state-wide FSTPs

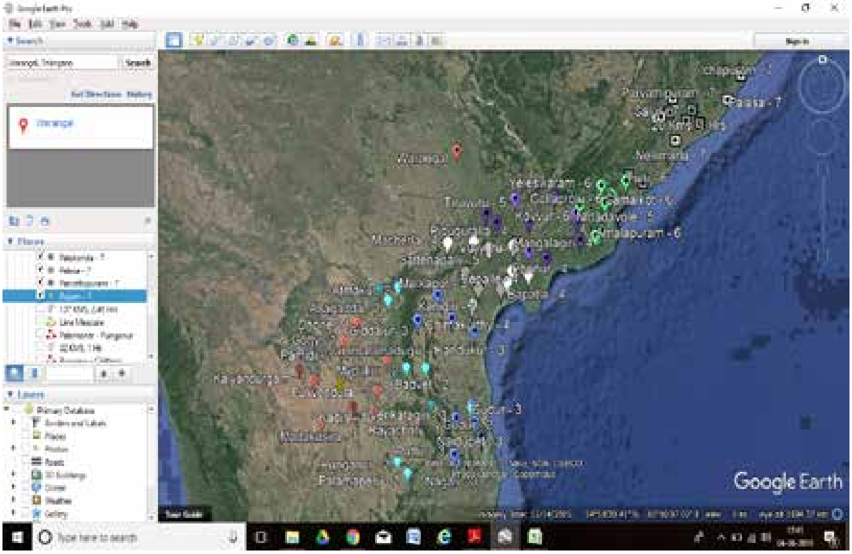
To comprehensively establish improved sanitation practices and systems, the Government of Andhra Pradesh decided to set up Faecal Sludge and Septage Treatment Plants in 76 Urban Local Bodies (ULBs) to tackle the health and environmental hazard caused when human excreta is disposed in open areas and water bodies due to lack of treatment facilities.

To achieve the vision of making urban areas of Andhra Pradesh ODF+, the Swachha Andhra Corporation (SAC) proposed to establish FSTPs in 76 ULBs. SAC has accordingly invited competitive bids to select Concessionaires to whom the setting up of FSTPs in 76 ULBs of Andhra Pradesh on Design, Build, Operate & Transfer (DBOT Hybrid Annuity) basis would be awarded.

Salient features of the Project

- The Project has been divided into 7 (seven) Packages with 11 ULBs in 6 packages, and 10 ULBs in 1 package
- 6-month setup time in 2018-19 and 9.5-years O&M thereafter
- Project value: INR 91.2 Cr
- Total treatment capacity: 1,140 KLD

Figure 5.2: 76 ULBs Considered in the Tender



Hybrid Annuity DBOT Tender
BOT typically relates to greenfield asset developments where the risk allocation to the private sector may be significant, including volume risk, finance risk, and potentially price risk. A number of BOT variants are possible depending on the allocation of roles and risk. These include DBO, DBOT, DBFOT, BOOT, DBOOT, BOO, etc.

Annuity Based BOT models are seen in sectors/projects not amenable to sizeable cost recovery through user charges, owing to socio-political-affordability considerations. Typically, rural, urban, health and education sectors are the ones where these factors are an issue. In this model, the Government harnesses private sector efficiencies through contracts based on availability/performance payments. Implementing the Annuity Based BOT model will require the necessary framework conditions, such as a payment guarantee mechanism made available through multi-year budgetary support, a dedicated fund, or a letter of credit, etc. The Government may consider setting up a separate window of assistance for encouraging annuity-based PPP projects.

A variant of this approach could be for the Government to make a larger upfront payment (say 40 per cent of the project cost) during the construction period, which is what is seen in Andhra Pradesh's tender for 76 FSTPs - Hybrid Annuity Design Build Operate Transfer model.

Key positives of the Tender

Some of the key positives from the tender document, as analysed is enumerated below.

- PPP project in Sanitation sector
- Bringing attention to sanitation in non-sewered towns and cities
- Addressing the needs of all Non-Amrut ULBs in the state in one go
- Geographic clustering approach
- Escrow account
- Technology neutral tender
- Focus on solids treatment too

Key challenges

The key challenges, in a Hybrid Annuity DBOT type PPP project, are relatively higher on the private sector, and therefore the key challenges from the private sector perspective is enlisted below:

- Long process in terms of tendering and
- Tender called reasonably close to elections
- Higher EMD per package (2% instead of 1%)
- Suitable Land identification before tendering has not been carried out in many ULBs

- ULBs are not informed / aware of the project
- Interest rate for payments based on base rate rather than lending rate
- Since there are established standards for FSTP, the payment linked to size and not actual delivery is a good approach till such standards are established

Scope for improvement

The tender should primarily take note of the fact that this is an emerging sector and need to provide far more support and confidence to the private sector, so as to encourage more and more players of enter the project. There is a need to establish that FSTPs, though are in KLD size unlike STPs which are MLD sized.

Few of the areas where the tender could have been better are listed below.

- SPV stake-holding in a consortium must be based on money raised by partners instead of net worth
- Online tendering option can be explored
- Clustering could have been done as per districts
- 5 years not ten years PPP
- Risk on PPP partners could have been limited to a % of the contract
- In cluster-type contracts individual project size-based pricing must be taken in bid submission. In case, if any ULB is not ready at all, and does not go through contract, the value thereby must be reduced based on size-based pricing and not capacity
- The contract does not allow hypothecation of project assets. Post construction about 50% of the project cost is with the tenderer, which is significantly high
- A letter of guarantee in addition to the agreement would enable better financing and encourage more private players to participate, which is good for the sector in the long run
- Force majeure and other penalties are built so as to benefit high debt project. This is not a great strategy and leads to odd options

Way Forward and Recommendations

Way Forward and Recommendations

Cost Analysis of FSTPs

Some of the major learnings from the study can be enlisted below, which forms the fundamental basis for way-forward suggestions

General

1. Underground drainage network with sewage treatment plants is not something which will come in a hurry to the tier-2 and tier-3 cities and towns. An immediate need to understand the purpose of an FSTP for these cities and town is necessary. FSM in general, and FSTP in particular is not a critical pain-point for the ULB
2. FSTP sector is upcoming and is in innovative phase, both in terms of the technologies as well as demand for performance, situational understanding and analysis. There is need to capture learnings from the developments happening scientifically and systematically
3. Majorly, the technology developers and promotors are the driving force in the country, supported by few organizations, for the installation of FSTPs so far. Except in Andhra Pradesh and Telangana, state-wide FSM approach is yet to kick-off. Having said that, states like Rajasthan and Odisha are in the forefront, particularly in exploring different technologies and assessing their requirement and applicability
4. There is also an immediate need to build credibility around the FSTP technologies. More FSTPs in different parts of the country has to come up and soon, so as to relate to the local context well for scale-up to happen. Both the Andhra Pradesh and Telangana's approach to state-wide scale up is primarily because of the FSTPs set-up in their state, and also the political will, and organizational set-up

Cost Centric

1. Too often, decision-makers focus on the initial cost of new technology and ignore the long-term, life-cycle impact of its purchase and implementation. This trend is troubling. Most decision-makers focus so much on short-term objectives and constraints that they do not have the time, energy, or knowledge to truly assess the total cost of ownership
2. The assessed technologies show a varied degree of CapEx and OpEx, variation primarily because of the extent of management of septage. All technologies exhibited complete treatment of the water fraction of septage to meet the PCB norms. The treatment of solids fraction of septage faces

technological challenges

3. Life Cycle Costing of the technologies show that the fully mechanized FSTPs are the most expensive of the lot, quite expectedly. However, it is also noticed that the cost of the mechanized systems exponentially decreases with increase in treatment capacity. On the contrary, the reduction in cost for a FSTP with major civil components is not significant because of retention time demands
4. The biological treatment approaches costs are in a cluster, comparable to each other, and in the near range to mechanized solutions
5. The co-treatment approach, as seen in Puri FSTP, shows such opportunities exists wherever the STPs are functional and have spare capacity to handle the additional septage loads
6. The technologies of STP, especially MBBR, is relatively cost sensitive, and with a sound solids management system, this can be potentially a trend to watch out for
7. All FSTPs have re-usable by-products after the treatment process. However, since they are not significantly large, this is not considered in the cost analysis

PPP and FSTP Contracts

1. The FSTP contracts observed so far are complex, with the public entity requires greater consideration and specification of contingencies in advance. Clearly, public entities need transaction advisors and consultants to help them to face the challenges of project structuring and procurement processes
2. Further, the public entity finds it less complex to carry out conventional procurement because it is accustomed to this arrangement where a well-established procedure has been in place for a long time. The shift to PPP with long term plans is something being carefully made mainstream in the FSTP sector
3. The success of the PPP from the public perspective will depend on the ability of the public entity to monitor performance of the private partner against standards and to enforce the terms of the contract

Annexures

Annexures

ANNEXURE 1: DETAILED COSTING OF WARANGAL

Sl. No.	Components	Sub Components	Capital cost in Rs
A	Civil		
1	Platform		25,00,000
2	Weigh bridge		
3	Compound wall and gate		
4	Liquid Treatment Plant -Soil Bio Filtration		
B	Electromechanical		
1	Septage receiving station	Screening unit	1,50,000
		Grit chamber	1,50,000
		Hose pipe	1000
2	Holding tank	Tank	40,000
		Sludge pump	18,000
3	Pasteurization unit	Pasteurizer	3,00,000
4	Dewatering unit	Polymer mixing chamber	20,000
		Polymer dosing chamber	20,000
		Pump	15,000
		Solid Liquid separator	2,50,000
5	Dryer	Wet end & Biomass hopper	3,00,000
		Screw conveyor	1,50,000
		Dryer with fans, radiator, motors, etc	15,00,000
6	Treated water storage tank	Pump	15,000
		Tank	5,00,000
7	Containers	Container 1 - 20 ft	6,00,000.00
		Container 2 - 40 ft	4,00,000.00
8	Pyrolyser	Dry end hopper	25,00,000
		Screw conveyors	
		Pyrolysis unit	
		Hot water generator	
9		Control panel	50,000.00
		Data logger	50,000.00

Sl. No.	Components	Sub Components	Capital cost in Rs
10	Ancillary Units		21,72,000
	Total		1,10,00,000

Consumables	Quantity/ day	Quantity/ month	Unit Rate	Cost/ month in Rs	Cost/ Year in Rs
Power, units	56	1680	10	16,800	2,01,600
Water, litres	2000	60000		2000	24,000
Polymer in kg	1	30	150	4500	54,000
Cleaning agents				10000	1,20,000
Internet cost				500	6,000
Miscellaneous				10000	1,20,000
Sub Total				43,800	5,34,600

Human resource cost					
Sl. No.	Description	Number	Rate	Cost/Month in Rs	Cost/Year in Rs
1	Site security	1	15,000	15,000	1,80,000
2	Helper	1	10,000	10,000	1,20,000
3	Operators	1	15,000	15,000	1,80,000
4	Site Manager	1	20,000	20,000	2,40,000
	Sub Total			60,000	7,20,000
	Total			1,03,800	12,45,600

Sl. No.	Components	Sub Components	Capital cost in Rs	Service life years	Annual re-placement cost in Rs
A	Civil				
1	Platform		2500000	20	0
2	Weigh bridge				
3	Compound wall and gate				
4	Liquid Treatment Plant -Soil Bio Filtration				
B	Electromechanical				
1	Septage receiving station	Screening unit	1,50,000	20	0

Sl. No.	Components	Sub Components	Capital cost in Rs	Service life years	Annual re-placement cost in Rs
		Grit chamber	1,50,000	20	0
		Hose pipe	1000	2	550
2	Holding tank	Tank	40,000	20	0
		Sludge pump	18,000	5	4500
3	Pasteurization unit	Pasteurizer	3,00,000	10	60,000
4	Dewatering unit	Polymer mixing chamber	20,000	10	3000
		Polymer dosing chamber	20,000	10	3000
		Pump	15,000	3	5,750
		Solid Liquid separator	2,50,000	10	37,500
5	Dryer	Wet end & Biomass hopper	3,00,000	10	45,000
		Screw conveyor	1,50,000	10	22,500
		Dryer with fans, radiator, motors, etc	15,00,000	10	2,25,000
6	Treated water storage tank	Pump	15,000	5	3,750
		Tank	5,00,000	10	75,000
7	Containers	Container 1 - 20 ft	6,00,000.00	20	0
		Container 2 - 40 ft	4,00,000.00	20	0
8	Pyrolyser	Dry end hopper	25,00,000	10	7,50,000
		Screw conveyors			
		Pyrolysis unit			
		Hot water generator			
9		Control panel	50,000.00	5	62,500
		Data logger	50,000.00	5	62,500
10	Ancillary Units		20,00,000	20	0

ANNEXURE 2: DETAILED COSTING OF DEVANAHALLI

Sl. No.	Components	Sub Components	Installed cost in Rs. (2017)	Present cost in Rs. (2018)
A	Civil			
1	Feeding tank	Tank	300,000	300,000
		Screens	40,000	40,000
2	Biogas digestor		1,800,000	1,800,000
3	Stabilization Reactor		1,500,000	1,500,000
4	Sludge drying bed	Drying beds	783,000	783,000
		Sand		
5	Collection tank 1		50,000	50,000
		0		
6	Integrated settler and ABR	Tank	450,000	450,000
		Anaerobic filters	12,000	12,000
7	PGF		155000	155,000
8	Co-composting unit	Shed	1,400,000	1,400,000
		Shredder	300,000	300,000
		Sieve	300000	300,000
	Total		7,090,000	7,090,000

Operations and Maintenance cost			
Consumables	**Quantity**	**Rate/Month**	**Rate/Year**
Electricity and Water supply charges		1,000.00	12,000.00
Providing uniforms & safety gears to labours, supervisors etc	For 2 Persons	2,000.00	24,000.00
Replacement of wiremesh, valves, tools and equipment		1,000.00	12,000.00
Fuel Cost			0.00
Incidental maintenance activities (contingency fund)		0.00	0.00
Sub-Total		4,000.00	48,000.00
Human resource		24,000	4,20,000
Others at 10%			42,000
Total			5,10,000

ANNEXURE 3: DETAILED COSTING OF PHULERA

Sl. No.	Components	Sub Components	Capital Cost in Rs
A	Civil		
1	Screen Chamber		20,000
2	Grit chamber		40,000
3	Stabilization Reactor		50,28,000
4	Sludge drying bed	Drying beds	94,80,000
		Sand	
5	Collection tank 1		8,56,800
6	Integrated settler and ABR	Tank	12,60,000
		Anaerobic filters	12,000
7	PGF		14,70,000
8	Collection tank 2	Sand carbon filter	20,00,000
		UV treatment unit	85,000
B	OTHERS		
1	Aggregates		23,43,728
2	Coarse Sand		1,42,800
3	UPVC Pipes		4,36,895
4	Pump	Sludge pump	4,50,000
		Submersible pump	50,000
		Pump	20,000
5	Other ancillary units		2,50,000
	Total		2,39,45,223

Consumables	Quantity	Cost in Rs / Month	Cost in Rs / Year
Electricity and Water supply charges		2,275.00	27,300.00
Providing uniforms & safety gears to labours, supervisors etc	For 2 Persons	2,600.00	31,200.00
Replacement of Tools and equipment		12,500	1,50,000.00
Fuel Cost		10,000.00	1,20,000.00
Incidental maintenance activities (contingency fund)		4,740.00	56,880.00
Sub-Total		32,115.00	3,85,380.00

Human resource cost			
Human resource	**Number**	**Cost in Rs / month**	**Cost in Rs / Year**
Plant Operator	1	10,000	1,20,000.00
Technician	1	12,000	1,44,000.00
Sub Total		22,000	2,64,000.00
Total O&M cost		54,115	6,49,380.00

Sl. No.	Components	Sub Components	Installed Cost in Rs	Service life years	Annual replacement cost in Rs
A	Civil				
1	Screen Chamber		20,000	2	11,000
2	Grit chamber		40,000	20	0
3	Stabilization Reactor		5028000	20	0
4	Sludge drying bed	Drying beds	9480000	20	0
		Sand			
5	Collection tank 1		8,56,800	20	0
6	Integrated settler and ABR	Tank	12,60,000	20	0
		Anaerobic filters	12,000	5	3,000
7	PGF		1470000	20	0
8	Collection tank 2	Sand carbon filter	20,00,000	20	0
		UV treatment unit	85,000	5	21,250
B	OTHERS				
1	Aggregates		23,43,728	5	5,85,932
2	Coarse Sand		1,42,800	5	35,700
3	UPVC Pipes		4,36,895	5	1,09,223
4	Pump	Sludge pump	4,50,000	5	1,12,500
		Submersible pump	50,000	5	12,500
		Pump	20,000	5	5000
C	Ancillary Units		93,04,777		0

ANNEXURE 4: DETAILED COSTING OF JABALPUR FSTP

Sl. No.	Components	Sub Components	Installed Cost in Rs
A	Civil		
1	Holding tank	Tank	10,00,000
		Screens	10,000
		Pump	15,000
B	Mild steel		
1	MBBR	Tank	1,20,000
		Media	96,000
		Blowers	1,30,000
2	Settling tank	Tank	65,000
		Hopper	40,000
3	Collection tank	Tank	65,000
		Sand and carbon filters	50,000
C	Others		
1	Chlorine dosing tank	Plastic drum	20,000
		Pump	
2	Centrifugal sludge pump		4,00,000
3	CPVC Pipes		12,000
D	Ancillary units		30,00,000
	Total		50,23,000

Consumables	Quantity	Cost in Rs/Month	Cost in Rs /Year
Chlorine		46,000	5,52,000
Power			
Sub-Total		46,000	5,52,000

Human resource cost			
Human resource	**Number**	**Cost in Rs /month**	**Cost in Rs /Year**
Operators	1	13,000	1,56,000
Security	1	7000	84,000
Sub Total		20,000	2,40,000
Total O&M cost		66,000	7,92,000

Sl. No.	Components	Sub Components	Installed Cost in Rs	Service life years	Annual replacement cost in Rs
A	Civil				
1	Holding tank	Tank	10,00,000	20	0
		Screens	10,000	2	5,500
		Pump	15,000	5	3,750
B	Mild steel				
1	MBBR	Tank	1,20,000	5	30,000
		Media	96,000	10	14,400
		Blowers	1,30,000	5	32,500
2	Settling tank	Tank	65,000	20	0
		Hopper	40,000	20	0
3	Collection tank	Tank	65,000	20	0
		Sand and carbon filters	50,000	0.5	10,25,000
C	Others				
1	Chlorine dosing tank	Plastic drum	20,000	2	11,000
		Pump			
2	Centrifugal sludge pump		4,00,000	10	60,000
3	CPVC Pipes		12,000	10	1800
4	Ancillary units		30,00,000		0

ANNEXURE 5: DETAILED COSTING OF BHUBANESWAR

Sl. No.	Components	Sub Components	Installed Cost in Rs
A	Civil		
1	Inlet chamber	Chamber	1,00,000
		Screens	1,20,000
2	Settling cum thickening tank	Tank	14,00,000
3	Sludge drying bed	Beds	33,00,000
		Covers	10,00,000
4	ABR	AF	21,00,000
5	Horizontal PGF	PGF	60,00,000
6	Polishing pond	Pond	3,60,000
7	Leachate sump	Sump	3,00,000
8	Platform for co composting		5,60,000
9	Pumps		2,50,000
B	Ancillary units		1,30,00,000
Total			1,67,90,000

O & M cost				
Consumables	**Number**	**Unit rate**	**Cost in Rs / month**	**Cost in Rs / Year**
Energy	2400	10	24,000	2,88,000
Misc.			6,000	72,000
			30,000	3,60,000
Human resource	**Number**	**Unit rate**	**Cost in Rs / month**	**Cost in Rs / Year**
Operators	3	20,000	60,000	7,20,000
Security	2	15,000	30,000	3,60,000
			90,000	10,80,000
Total O&M Cost			1,20,000	14,40,000

Sl. No.	Components	Sub Components	Installed Cost in Rs	Service life years	Annual replacement cost in Rs
A	Civil				
1	Inlet chamber	Chamber	1,00,000	20	0
		Screens	1,20,000	2	66,000

Sl. No.	Components	Sub Components	Installed Cost in Rs	Service life years	Annual replacement cost in Rs
2	Settling cum thickening tank	Tank	14,00,000	20	0
3	Sludge drying bed	Beds	33,00,000	20	0
		Covers	10,00,000	20	0
4	ABR	AF	21,00,000	20	0
5	Horizontal PGF	PGF	60,00,000	20	0
6	Polishing pond	Pond	3,60,000	20	0
7	Leachate sump	Sump	3,00,000	20	0
8	Platform for co composting		5,60,000	20	0
9	Pumps		2,50,000	5	62,500
B	Ancillary units		1,30,00,000		0

ANNEXURE 6: DETAILED COSTING OF PURI

Sl. No.	Components	Sub Components	Installed Cost in Rs
A	Civil		
1	Inlet Channel	Channel	1,00,000
		Screens	1,20,000
2	Settling-Thickening tank	Tank	19,00,000
		Sludge pumps	1,00,000
3	Unplanted drying beds	Drying beds	
		Covers	35,00,000
4	Platform for sludge storage		6,00,000
B	Ancillary units		1,07,00,000
	Total		73,90,000

O & M cost				
Consumables	**Number**	**Unit rate**	**Rate/month**	**Rate/Year**
Energy	480	10	4,800	57,600
Misc			6,000	72,000
			10,800	1,29,600
Human resource	**Number**	**Unit rate**	**Rate/month**	**Rate/Year**
Operators	2	20,000	40,000	4,80,000
Security	3	15,000	45,000	5,40,000
Total O&M cost			95,800	11,49,600

Sl. No.	Components	Sub Components	Installed Cost in Rs	Service life years	Annual replacement cost in Rs
A	Civil				
1	Inlet Channel	Channel	1,00,000	20	0
		Screens	1,20,000	2	66,000
2	Settling-Thickening tank	Tank	19,00,000	20	
		Sludge pumps	1,00,000	5	25,000
3	Unplanted drying beds	Drying beds			
		Covers	35,00,000	20	0
4	Platform for sludge storage		6,00,000	20	0

ANNEXURE 7: DETAILED COSTING OF LEH

Sl. No.	Components	Sub Components	Installed Cost in Rs
A	Civil		
1	Planted drying beds	Drying bed	29,00,000
		Screening unit	1,00,000
		PVC pipes	
2	Horizontal PGF		7,00,000
3	Polishing pond	Pond	4,00,000
		Pump	20,000
4	Green house		1,00,000
5	Ancillary units (road, compound wall)		10,00,000
	Total		52,20,000

Consumables	Quantity	Cost in Rs / Month	Cost in Rs/Year
Plants		5,000.00	60,000.00
Inhouse expenses		23,000.00	2,76,000.00
Sub-Total		28,000.00	3,36,000.00

Human resource cost			
Human resource	**Number**	**Cost in Rs / Month**	**Cost in Rs /Year**
Plant Manager	1	18,000	2,16,000.00
Operator	1	12,000	1,44,000.00
Sub-Total		30,000	3,60,000.00
Total O&M Cost		58,000.00	6,96,000.00

Sl. No.	Components	Sub Components	Installed Cost in Rs.	Service life years	Annual replacement cost in Rs
A	Civil				
1	Planted drying beds	Drying bed	29,00,000	20	0
		Screening unit	1,00,000	20	0
		PVC pipes			
2	Horizontal PGF		7,00,000	20	0
3	Polishing pond	Pond	4,00,000	20	0

Sl. No.	Components	Sub Components	Installed Cost in Rs.	Service life years	Annual replacement cost in Rs
		Pump	20,000	3	7667
4	Green house		1,00,000	5	25000
5	Ancillary units (road, compound wall)		10,00,000		0

ANNEXURE 8: DETAILED COSTING OF TENALI

Sl. No.	Components	Installed cost in Rs.
A	Civil	
1	Screen Chamber	20,000
		20,000
2	Holding Tank	450,000
		20,000
		15,000
3	MBBR	70,000
4	Tube settlers	30,000
		5,000
5	Clarification unit	70,000
		5,000
6	Treated water tank	200,000
		5,000
B	Others	
1	PSF	60,000
2	ACF	60,000
3	Chlorine dosing tank	30,000
4	Ancillary units	940,000
	Total	2,000,000.00

O & M cost				
Consumables	**Quantity**	**Rate in Rs.**	**Total (Rs. / Month)**	**Total/Year in Rs.**
Electricity	2000	10	20000	240000
Innoculum				24000
Sub total				264,000
Human resource	**Number**	**Rate in Rs.**	**Total (Rs. / Month)**	**Total/Year in Rs.**
Operator	1	20000	20000	240000
Sub total			20,000	240,000
Total O&M cost			20,000	504,000

DESCRIPTION OF THE COMPONENTS			ASSUMED REPLACEMENT COST			
Sl. No.	Components	Sub Components	Service life Years	1 time replace-ment cost in Rs. (Lakhs)	Replace-ment cost for a span of 20 years in Rs. (Lakhs)	Replace-ment cost/Year in Rs. (Lakhs)
A	Civil					
1	Screen Chamber	Chamber	20	0.00	0.00	0.00
		Screens	2	0.22	2.20	0.11
2	Holding Tank	Tank	20	0.00	0.00	0.00
		Air Blowers	5	0.25	1.00	0.05
		Submersible pump	5	0.19	0.75	0.04
3	MBBR	Tank	20	0.00	0.00	0.00
4	Tube settlers	Tube settlers	20	0.00	0.00	0.00
		Pump	5	0.06	0.25	0.01
5	Clarification unit	Clarification unit	20	0.00	0.00	0.00
		Pump	5	0.06	0.25	0.01
6	Treated water tank	Tank	20	0.00	0.00	0.00
		Pump	5	0.06	0.25	0.01
B	Others					
1	PSF	PSF	10	0.90	1.80	0.09
2	ACF	ACF	10	0.90	1.80	0.09
					0.00	0.00
3	Chlorine dosing tank	Chlorine dosing tank	5	0.38	1.50	0.08

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Cost Analysis of Faecal Sludge Treatment Plants in India

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SANITATION CAPACITY BUILDING PLATFORM