Insights from Faecal Sludge Management in Devanahalli

- Five years of operations

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Front Cover - Devanahalli FSTP
Back Cover - Agricultural trial site inside the Devanahalli FSTP

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Preface

The central questions that this **thematic note** seeks to address include: **What can municipalities learn about creating a conducive enabling environment for faecal sludge management (FSM)? How can engineers create Faecal sludge treatment plant (FSTP) designs that work well on the ground both technically and financially?**

The *Swachh Bharat Mission* (SBM) has made significant strides in addressing the need for toilet infrastructure in India. To realize public health and environmental quality goals related to this development, there is an increasing need for effective solid and liquid waste management. Currently, about one-third of India is connected to piped sewers. While infrastructure is being built to cover unserved cities and towns, sanitation goals are not being achieved as the pace of these developments often falls behind rapid population growth and urbanization rates. FSM is emerging as a viable alternative to costly and slow-to-implement centralized systems. This is particularly true for those municipalities that face constraints of capital availability and skilled human resources, limitations of existing onsite sanitation systems and challenges like steep topography. **As a result, a flourishing FSM sector is evolving in India, with 109 FSTPs completed in 14 states and another 193 FSTPs under construction (as per information available on 16th July 2020 from Centre for Policy Research).** New FSTPs face hurdles, due to inadequate planning and implementation arising from limited operational, technical and financial experience of FSTP operations.

This publication presents CDD Society's critical learnings from the continued engagement, for implementation and operations, of Devanahalli's FSTP from 2015 – 2020. The Devanahalli FSTP draws upon CDD Society's longstanding design concepts of nature-based, anaerobic digestion, gravity-based flow, minimal operation and maintenance, low energy use, no chemical use and superior aesthetics. Built at a capital and operational cost of INR 90 lakh and INR 24 lakh per year respectively, coupled with a revenue generation model based on co-composting, makes it a compelling proposition for sustainable FSM operations.

The Devanahalli FSTP was originally conceived under the auspices of the Bill and Melinda Gates Foundation (BMGF) project '*Strengthening the Operation & Maintenance Sector for Servicing Decentralized Urban Sanitation Infrastructure in Karnataka, India*' granted to Bremen Overseas Research and Development Association (BORDA) in 2013. It builds upon CDD Society's long experience with decentralized wastewater systems and safe sludge disposal. As the implementing partner on this project, CDD Society delved into the government, technical and market landscapes for decentralized sanitation infrastructure in Karnataka. With an in-depth investigation of onsite sanitation and desludging service providers across several towns, including some without centralized sanitation systems, CDD Society gained many practical insights on FSM that are shared here.

The Devanahalli FSTP was inaugurated on World Toilet Day, November 19th in the year 2015. At the time, it was the first planned town-scale FSTP in the country. The term "Faecal Sludge Management" was almost unheard of, apart from a few sector experts. Against this backdrop, there was a conscious effort from CDD Society to


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ensure that the Devanahalli FSTP design should stand the test of time and that it will be operational with minimal expert supervision even in a small town like Devanahalli. The FSTP was handed over to the TMC in April 2019 and they have been able to operate it with minimal expert supervision. More importantly, **the last six months of 2020 have seen full utilisation of FSTP capacity.**

After 5 years of successful operations, we pause, look back and bring out some of the key insights that we think are relevant for dissemination to the broader set of sanitation stakeholders within the country. The **insights cover the spectrum of Sustainability - Financial as well as Operational, Policy and Technology.** There are some major insights that have implications on all the three aspects above and they have been captured in greater detail. However, we believe that all the insights presented in the document have not only contributed to the sustainability of FSM operations in Devanahalli but have also influenced how other cities plan, implement and sustain FSM.

We would like to acknowledge the contribution of The Bill and Melinda Gates Foundation, BORDA South Asia and Town Municipal Council of Devanahalli for having supported CDD in this pursuit. We would also like to acknowldge key contributions of Ms. Susmita Sinha, Ms. Sujaya Rathi, Ms. Vrishali Subramanian, Ms. Prerna Prasad, Ms. Tarika Vaswani, Ms. Rohini Pradeep, Mr. Krishna Swaroop and Mr. Ganapathy P.G. who were instrumental in producing this document.

We hope that this publication goes a long way in helping the people working in the FSM sector to learn from this rich experience.

Happy Reading!

Devanahalli Faecal Sludge Treatment Plant

To address the issues highlighted in **Box 1**, the Town Municipal Council (TMC) of Devanahalli undertook the **Sanitation Safety Planning (SSP)** exercise in the year 2012-13. This was jointly conducted by The World Health Organisation (WHO), Biome Environmental Solutions (a Bangalore based architectural firm which also specialises in wastewater management) and the Karnataka Water Supply and Sewerage Board (KWSSB). The SSP exercise provides a structured approach to bring together various stakeholders to identify health risks in the sanitation system and supplement it with the requisite improvement and monitoring plan. **The SSP undertaken for Devanahalli highlighted how water stress in the town was forcing farmers to use faecal sludge (FS) (with rudimentary treatment methods) as a source of water for irrigation amongst other issues; and exposed the numerous pathways of contamination that existed, as a result of raw faecal sludge being indiscriminately dumped into the environment**. With regards to FSM the SSP exercise suggested minimising contamination exposure pathways.

In 2015, we at Consortium for DEWATS Dissemination (CDD) Society were looking for a demonstration site for showcasing approaches to FSM. This was in alignment with the Devanahalli TMC's need (as a result of the SSP) to identify ways of minimising exposure pathways from harmful contaminants and pathogens in faecal sludge. Discussions between CDD and TMC led to the idea of implementing a FSTP that would help **achieve** the following:

- A **cleaner town** (dedicated space for treatment of FS)
- **Production of a safe by-product** from FS (safe water and nutrients available for farmers)
- An **aesthetically beautiful** treatment plant (contrary to the belief that treatment plants are dirty places)
- **No direct human contact** with FS (minimising health concerns)
- A **self-sustainable facility**
- Implementation of a sanitation service that **stays abreast with the urban and commercial developments** of the area

Box 1 - Devanahalli sanitation practices prior to 2015

- Faecal sludge contained in leach pits
- Desludging at irregular intervals
- Indiscriminate disposal of faecal sludge into surface water bodies/storm water drains
- Reuse of faecal sludge without treatment on farms
- Unsegregated collection and dumping of solid waste

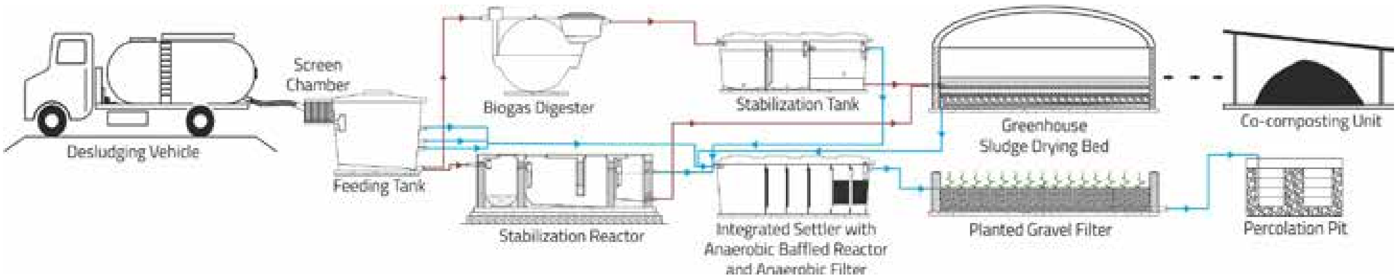

Figure 1 - Devanahalli Faecal Sludge Treatment Plant Schema

Modules that would address the above-mentioned concerns were thus selected for the treatment process. **The implemented modules ensure that there is no visible untreated sludge, minimal odour, no direct contact with people or the environment**. The selected modules are:

- Screen chambers (2)
- Feeding tank (1)
- Biogas digester & stablisation tank (1)
- Anaerobic stabilisation reactor (2)
- Unplanted sludge drying beds (10)
- Integrated anaerobic modules comprising of settler (1), Anaerobic baffle reactor (2) and Anaerobic filter (2)
- Planted gravel filter (1)
- Co-composting unit (1)

Three by-products: compost, treated wastewater and biogas are being obtained from the Devanahalli FSTP. The compost is being sold to farmers – it serves as a safer alternative to the untreated faecal sludge that they were previously using. Additionally, it costs them a fraction of what they were paying for chemical fertilisers. Biogas generated from the treatment process, is being used on-site as fuel for cooking by the plant's operator. And lastly, the treated wastewater is being used for irrigation at the plant itself, helping keeping it green! In fact, farmers have expressed interest in procuring the treated wastewater too.

Box 2 - FSTP Key Specifications

- **Design capacity:** 6 cubic metre/day
- **Influent quality:** BOD 30,000 mg/L, COD 60,000 mg/L
- **Effluent quality:** BOD <30 mg/l, COD <150 mg/l
- **Energy requirement:** 830 KWh/month (for running the GHSD)
- **Design period of the FSTP:** 15 years
- **Human resources for operation:** 1 Plant Manager, 1 Operator, 3 Support Staff

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- **Conveyance mechanism:** Vacuum truck: 1 government truck (regular disposal at FSTP) 3 private trucks (irregular disposal at FSTP) (all trucks of 3 - 3.5 cubic metre capacity)
- **Weekly minimum truck loads:** 3

01

Simple Operation and Maintenance tasks

– go a long way in ensuring sustainability

Conventional wastewater treatment plants are largely based on aerobic treatment technologies, which need human resources who are knowledgeable and skilled in maintaining the same – as these systems comprise of complex processes as well as electro-mechanical components. **Operation of these systems is resource-heavy and hence cost-intensive; this setup tends to give problems overtime**.

One of CDD's core design principles has always been to keep O&M requirements simple and affordable. **What cannot be maintained must not be built.** O&M, after all, is a critical sustainability factor for any implemented infrastructure.

This understanding coupled with our intention to have the FSTP at Devanahalli serve as a demonstration unit for others to learn from, led us to include the factors listed in **Box 3**, in the design of FSTP to ensure simple O&M.

As a result, we have faced very few O&M challenges overall. We believe that the steps we took to keep the O&M simple have gone a long way in ensuring the sustainability of the plant, till date.

In fact, the same operator has been operating and maintaining the plant from the time the plant was commissioned in 2015. He shows much interest and motivation when it comes to operating the system. Even Visitors have appreciated how well he has integrated himself with his work!

Though O&M is simple, having consistent staff helps in ensuring that the system is in continuous operation and that treatment efficiency is sustained.

Box 3 - Features of Devanahalli's O&M Plan

1. Few and simple activities for regular and periodic operations as well as maintenance

2. O&M tasks require basic skills and technical knowledge (An unskilled operator and not an engineer can be trained to undertake O&M of the treatment plant)

3. No moving parts installed in the FSTP (Faecal sludge moves from one module to another either through gravity or through the pressure exerted by generated biogas)

4. No chemicals or electricity* required through the treatment process

*As part of efficiency improvements certain technical modules were introduced. For example, green house solar drier roof. This unit requires electricity for basic activities like running exhaust fans, for which the operator has been trained.

Figure 2 - Devanahalli FSTP operator, Mr. Raju performing regular cleaning operations of the feeding tank.

02

Financial sustainability of FSM services

– Use of multiple revenue streams

The success of any sanitation intervention is assessed primarily from a sustainability perspective; financial sustainability forms a key component of this perspective. From November 19th, 2016 i.e. a year after it was commissioned, till date, the FSTP at Devanahalli is being managed entirely by the TMC with technical support from CDD Society. It is essential to understand the components that are crucial in keeping the plant operational on a long-term basis.

A breakup of the **Operational costs include (Table 1):**

- desludging operations (45%)
- co-composting operations (30%)
- FSTP operations (25%)

Currently, the FSTP **operational costs are being met through multiple revenue streams (Table 2)** - the predominant ones being user fees collected from pit emptying services and sale of co-composted sludge. There have been other smaller revenue streams like revenue from advertisements on the billboard at the site, and the sale of vegetables (grown at site using the compost prepared by co-composting faecal sludge and municipal wet waste/vegetable market waste). These streams collectively help offset part of the overall costs. This clearly indicates that multiple revenue streams may be needed, and can be put in place, to meet operational costs. However, in Devanahalli's case, inspite of the multiple revenue streams a funding gap of 38% of the operational costs exists. It can be argued that if the plant was operating at full capacity instead of 50% on an average, there would be more revenues from co-composting. However, more co-composting would mean additional human resources as well. Thus even in a complete capacity utilization scenario, a funding gap is likely to exist. Considering towns where reuse of treated FS does not have ready takers as in Devanahalli, the funding gap might be even more due to limited income from reuse.

In the pursuit of a constant source of funding, CDD Society and TMC Devanahalli had jointly **proposed** that a **sanitation tax** be included in the property tax. However, willingness (on the part of residents) to pay this tax was low. This is potentially because residents already pay a significant amount as property tax. Plus, there were additional **challenges in getting this proposition implemented at the state level** with the Directorate of Municipal Administration of Karnataka (DMA).

Currently, a portion of **Municipal funds and funds disbursed through the finance commissions have been allotted for FSTP operations**. These funds cover staff salaries (FSTP operator, desludging vehicle driver and helper) and desludging vehicle maintenance costs.

It is **recommended that towns invest in IEC activities** (though this turns out to be an additional cost) and try **integrating contracts for collection and O&M for treatment services**; as this can help in improving the efficiency of the system by ensuring regular collection and treatment. It allows the TMC to link the performance of the FSTP with desludging services. Parallel efforts through IEC help improve user practices and keeps people sensitised to the importance of FSM and its role in providing improved sanitation i.e. building a scientifically designed onsite sanitation system (OSS), desludging it regularly and not disposing solid waste in toilets.

Both the recommended methods when sustained over a good period of time - over 2-3 years - have the potential to ensure more frequent desludging leading to more regular disposal of FS to the FSTP and thus more production of reusable treated FS that can be sold. This can improve cost recovery*.

Table 1 - Operational costs for FSTP, truck operations and co-composting unit**

S.No.	Cost heads	Cost (INR Lakhs)	Percentage of total cost
1.	O&M of desludging vehicles	9.71	45%
2.	O&M of the FSTP	5.3	25%
3.	O&M of Co-composting unit	6.4	30%
	Total cost of FSM per year (A)	**21.41**	**100%**

Table 2 - Revenue generated to cover operational costs in Devanahalli

S.No.	Revenue generated per year	Cost (INR Lakhs)	Percentage of total cost
1.	User fee from desludging service provision	5.01	38%
2.	Sale of co-compost	4.40	33%
3.	Advertisement and lease of land	1.97	15%
4.	Sale of vegetables	1.06	8%
5.	Tipping fee and registration of truck from private operators	0.76	6%
	Total Revenue Generated from FSM operations (B)	**13.20**	**100%**

Financial gap in meeting operational costs - (A - B) - **INR 8.21 Lakh**

*As on date standards for FS reuse are not notified in India - and thus the co-compost ideally needs to meet FCO standards.

** These figures are for the year 2018-2019

03

Faecal Sludge characteristics are highly variable

– necessitating designs that can handle variations in influent faecal sludge

Unlike sewage, faecal sludge (FS) characteristics vary widely. They vary locally at the level of households and commercial establishments as well as across cities and countries. Additionally, characteristics are influenced by user practices, containment design, soil type, climatic zone, method of collection and transport etc.

Since we were closely associated with the Devanahalli FSTP in terms of understanding and improving its operational efficacy, comprehensive quality analysis of FS was undertaken that was delivered at the FSTP for treatment over a course of two years. The objective was to assess the parameters of pH, COD, TS, VS, NH_3-N and PO_4(all measured in mg/L except pH) .

It was found that, in Devanahalli in 2015, approximately 81% of the containment systems in use were single pits and the remaining were either septic tanks or toilets directly discharging into an open drain. Roughly 65% of the total containment systems did not have a bottom lining. Approximately 90% of all the FS delivered to the FSTP was from households and 73% of what arrived at the FSTP was about 5 years old.

To achieve best results, a methodology was devised where all the samples were collected at the feeding tank during the discharging process by the truck. The samples were collected at three intervals. A composite sample was prepared that was then analysed at the CDD

Table 3 - FS characteristics from FSTP Devanahalli (Number of samples = 250)

Parameters	Mean	Maximum	Minimum	Standard Deviation	Median
pH	7.4	9.4	6.4		
COD, mg/l	59,745	1,90,300	7,450	42,839	50,825
TS, mg/l	42,395	1,24,375	868	30,568	31,605
VS, mg/l	15,223	86,390	265	17,565	21,005
NH_3-N, mg/l	1,323	10,800	100	1,422	1,000
PO_4, mg/l	1,001	8,240	100	1,525	640

TS – Total Solids, VS – Volatile Solids, NH_3-N – Ammonia Nitrogen, PO_4- Phosphate

Laboratory. Table 3 summarizes the analysis from 250 FS samples arriving at the Devanahalli FSTP.

The sample analysis shows a high concentration of COD, TS, VS, NH_3-N and PO_4. As per Strauss, 1997, the faecal sludge samples analyzed fall under the category of Type "A" high strength wastewater (highly concentrated). High solid content values, were indicators of long desludging intervals, use of single pit latrines, low water supply, low water table. BOD and COD measurements were gradually phased out as they were not providing very clear insights on the nature of FS. VS and TS gave clear insights on biodegradability and solids content whereas NH -N and PO indicated the nutrient load in FS. Variations in characteristics were observed in relation to age of sludge (**positive correlation between COD and age**), and type of sources like commercial, household and institutes. It was also observed that the **FS delivery to theFSTP increased during the rainy season**. Also, since there was a good percentage of unlined pits, the incoming FS had high grit concentration requiring robust grit removal mechanisms.

While it was observed that there was a lot of variation in the FS characteristics (evident from the maximum, minimum and standard deviation values), they were used to benchmark reasonable ranges to consider during the design of new FSTPs (Table 4).

Table 4 - FSTP influent parameters considered for different types of towns

Parameters	Towns predominantly having single pit latrines (>70%)	Towns predominantly having septic tanks (>50%)
COD (mg/l)	Approx. 40,000	Approx. 30,000
TS (%)	Approx. 5%	Approx. 2-3%

For more information - https://www.susana.org/_resources/documents/default/3-2741-7-1488813934.%20et%20alpdf

04
Choosing FSTP Design Capacity
- An incremental approach

Devanahalli, has in the last few years **transitioned** from being a mostly small, **rural/semi-urban town to an urban** town. This is largely due to its proximity to the Bengaluru Airport. A transition like this usually results in change of **user practices** with regards to water and sanitation – from conservative to profuse practices i.e. from pour flush toilets with pits to western toilets with septic tanks (that need frequent desludging).

Additionally, experience in Devanahalli shows that FS loads have been irregular; records indicate that the FSTP accepted an average of about three loads weekly. At any given time, a maximum of only one-third of the **FSTP capacity** has been utilised i.e. it has **rarely reached or exceeded its design capacity**. This is because desludging is being carried out only when the pit is full or in cases of emergency like backflow of toilets during the rainy season. All such factors impact the functioning of a plant and should be kept in mind when designing the FSTP.

Currently, there are three broad ways to calculate the design capacity of a FSTP (Box 4):

Box 4 - Methods to calculate FSTP design capacity

1 - FS collection by desludging operators
2 - FS accumulation in the containment systems
3 - FS generation using population projection figures

The Devanahalli FSTP was designed using the FS collection method. Additionally, other factors like potential increase in water supply or the likelihood of scheduled desludging coming into practice were taken into consideration during the design phase. The groundwater table along with soil conditions were other factors that were looked into. In conclusion, though the approach to FSTP capacity picked was the most conservative in terms of sizing, using the other methods would have led to an over-estimation of design capacity. For example, using method 3 gives a design capacity of 24 cum instead of the current 6 cum (which is currently sufficient to accommodate the FS loads coming from private as well as TMCs desludging vehicles).

Treatment efficiency may suffers if a plant is over-designed. The Devanahalli experience shows that one should begin with a small plant that can offer efficient treatment and is simultaneously easy-to-operate. However, more land should be made available in the initial phase itself for potential scale up in design and operations.

Figure 3 - Methods to calculate FSTP design capacity

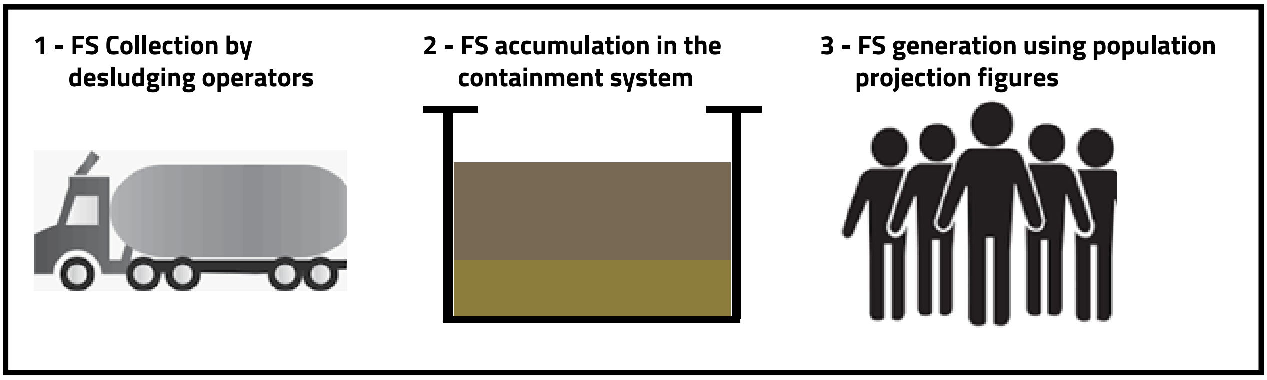


Figure 4 - Co-composting unit set up in the extra land that was allocated during the design phase

05 Private Desludging Operations

- Incentives required to bring sludge to a government-owned FSTP

For an FSTP to work efficiently and achieve its treatment goals, it is essential that it receives FS according to its design. At any given time, a maximum of only one-third of the Devanahalli FSTP capacity has been utilised. This happens because private desludging operators do not empty the collected loads at the FSTP. They tend to discharge FS loads at the closest available location, mostly a farm, a covert dumping site or even a water-body or culvert.

Experience from Devanahalli clearly indicates that this unchecked practice can be attributed to the absence of a legal enforcement structure and lack of incentives for behaviour change.

There are a few ways incentives could be built into the entire process:

1. Select a **site for the FSTP, which is close to several peri-urban areas** needing FS collection and treatment

2. Introduce **licenses for private operators to regulate FS collection services** (instances of harassment from police and citizens will also reduce once this system is in place)

3. Provide for **transfer stations** closer to points of FS generation

4. **Integrate collection and treatment** as a single service

5. **Education and awareness** on the health risks of raw faecal sludge among desludging operators and the public can also help promote desired behaviour.

A combination of these for towns which have FSTPs coming up, could potentially help private desludging operations become more efficient, which in turn means that the treatment efficiency of the FSTP is maintained.

Figure 5 (Top) & 6 (Bottom) - Desludging of a pit in Devanahalli

06
Producing pathogen free, nutrient-rich compost
– *Efficacy demonstrated through field trials*

The FSTP was intended to produce a safe, dry and nutritive by-product. Devanahalli, being located in an agricultural area, has a ready market for a nutritive soil conditioner. Moreover, farmers were accustomed to using untreated FS in their fields, after taking a few safety precautions. Combining these two requirements defined the demand and supply for a safe, natural and nutrient-rich version of soil conditioner.

In order to meet these requirements, technology interventions that would reduce moisture content, remove pathogens and improve carbon content, were essential.

This was done through co-composting. Dried faecal sludge was co-composted with segregated municipal wet waste using the Windrow method, which helped in the inactivation of pathogens by maintaining a high stable temperature (approximately 65 - 70°C for a period of 3-5 days). Additionally, it provided carbon content to the by-product. This technology intervention helped to produce a by-product that had moisture content in the range of 25-30% making it easier for packaging and field application. In addition, the by-product has a C:N ratio of <20 as per the Fertiliser Control Order (FCO) recommendations. The compost samples tested were found to be negative for Helminth eggs, which makes it safe for handling and field application.

Another assessment was conducted to compare the efficacy of co-compost against other soil conditioners by comparing plant growth characteristics. Two plants, namely field beans and sweet potato, were grown on soil nourished with different types of soil conditioners like faecal sludge, co-compost, farmyard manure. The soil conditioners were balanced with P (Phosphorus) & K (Potassium) through the addition of inorganic fertilisers wherever required. A randomised block trial was designed to conduct the experiment in a scientific manner.

It was found that field beans grown under co-composted faecal sludge had a comparatively higher yield and showed improved growth in other physical parameters (plant height, number of leaves, number of beans, weight of beans and bean seeds) as compared to other soil conditioners. Most importantly, the harvested beans were free from pathogens and E. coli. Sweet potato, the second plant that was harvested, also showed better root yield when provided with FS based compost as compared to other soil conditioners. Other parameters like vine length and number of branches were better for co-compost applied plots.

The efficacy of the soil conditioner was endorsed by loyal clientele – a group of farmers who were the first to use it on their farmlands. This initial group of farmers experienced a twofold increase in their yield of crops; and went on to encourage other farmers to use the soil conditioner. Similar results were found in field trials. This helped keep the demand for treated FS going and compost sales thus played an important role in the financial sustainability of the FSTP, contributing to 29% of its revenue.

Experience from the Devanahalli FSTP suggests that technical interventions can greatly enhance the quality of the end product. Further, if towns have a readily available market for the same, it can help in ensuring financial sustainability. In places where there is no demand, safe disposal of the end product should be incorporated as part of the design.

Note: A deterrent to the nutritional value of the soil conditioner can be the presence of heavy metals, which sometimes do occur in the final product. This could happen because of the use of unsegregated waste as feeding material for co-composting. Research to use alternate sources of feed may help overcome this problem. As of now, vegetable market waste and dry leaf litter could be used as a substitute to avoid this problem.

Table 5 - Characteristics of mature co-compost

Parameters	FCO Standards	Final compost from windrow
pH	6.5 - 7.5	6.51
Conductivity (dsm -1)	8.2	0.9
Particle size	Minimum 90% material shoule pass through 4.0 mm sieve	Passes
Moisture, % by weight, minimum	25	30.2
Bulk density	<1.0	0.77
Total organic carbon, % by weight, minimum	12	16.5
Total N, % by weight, minimum	0.8	0.7
Totap P (as P2O5), % by weight, minimum	0.4	0.24
Total K (as K20) % by weight, minimum	0.4	0.98
C:N	<20	12.1

Table 6 - Presence of pathogens in co-compost

Parameters	Compost Standards	Co-composted FS from the windrow
Helminth eggs	<= 3 - 8 eggs/gram of dry solids (Source: Strauss, 1991)	Negative
Faecal coliform (MPN - most probable number)	<1000 MPN/g (Source : CCME when compost contains only yard waste)	>1,600 MPN/g

For more information - https://www.witpress.com/elibrary/wit-transactions-on-ecology-and-the-environment/238/37456

07
Technological Upgradations
– To drive treatment efficiency

Faecal sludge cannot be treated in the same way as wastewater due to the extremely high organic and solids load in it. In order to improve the understanding of treating faecal sludge, the performance of the FSTP is constantly monitored. Since this was a first-of-its-kind system, and a demonstration unit for future FSTPs, it was essential to **periodically assess the technology choices**. In the course of this assessment, gaps were identified and a few modifications were implemented through consultations with sector experts across the globe to enhance treatment efficiency. This insight details out the three technological modifications that were introduced at the FSTP.

Technical Upgradation 1

Anaerobic Stabilisation Reactor
- An effective primary treatment module

When the Devanahalli FSTP was designed, a combination of (two) biogas digesters (BGD) and a stabilisation tank (Figure 7) were selected as treatment modules for efficient mixing and stabilisation of incoming faecal sludge. The design of these systems was developed keeping in mind the fact that the incoming sludge would get mixed adequately and get adequate retention time for stabilisation. However it was already known that there would be minimal gas production (hence the BGD's gas storage capacity was also kept small). The stored gas would push the sludge into the next module thus decreasing the pressure inside the BGD. This would in turn enable the liquid to rise in the BGD thereby allowing mixing.

As the quality and quantity of FS was evaluated over the first few years of operations, the purpose of the combination of biogas and stabilization tank modules did not seem to be providing any specific benefit.

The FSTP was receiving diluted faecal sludge and in smaller quantities. Therefore, the stabilisation tank could perform the same function without the need for a BGD. From a replicability perspective, construction of biogas digesters requires special skills, thus Stabilisation Reactor* was a better option.

Factsheet - Stabilization reactor - https://cddindia.org/wp-content/uploads/2019/04/anaerobic-stabilization.pdf

Figure 7 (Top) - Highlighted portion shows the original biogas disgester and stabilisation tank that was replaced with a Stabilisation Reactor

Figure 8 (Bottom) - Stabilisation Reactor

Technical Upgradation 2

Novel filter media combinations for Sludge Drying Bed
- for reduction of sand loss

Sludge drying beds (SDB) were initially used as the final module for sludge treatment at the Devanahalli FSTP. The performance of a SDB depends on climatic conditions (temperature and relative humidity), operational factors (sludge height and solid loading rate) and moisture content of the dried sludge. Operations of the Devanahalli FSTP for the first year indicate that the **drying time of sludge** (approximately 23 days) in the sludge drying beds was not consistent with the design drying time of 15 days. **Percolation** in the filter media i.e. through sand (1.5 mm particle size) was **slow** and it r**etained moisture for a longer time**. Additionally, filter media, **sand** in particular, **attached itself to the dried faecal sludge** in the process of removal. This led to a **significant amount of sand being lost** in the process.

Based on these observations, in 2017, CDD made some modifications to improve the performance of the SDB. This was done by providing stability to the filter media in order to prevent sand loss. Sand (of particle size 1.5 mm) in the **SDB was replaced with a combination of perforated bricks and a coarse filter media** (sand of particle size 2.5 mm). The non-perforated portion of the brick gives a firm support to the sludge and aids its easy removal while the perforated portion hold the filter media (coarse sand) in position. Sand helps in filtering the free water.

The above combination facilitates better handling of dried sludge, which can be removed easily even at a higher moisture content (around 50 - 60%). Additionally, it was also found that over a period of 6–7 months, there was only 0.1–0.2 mm of sand loss (against 3–5 cm of sand loss with the earlier arrangement), which means that in 2 years' time there would be **roughly 1 cm of sand loss**. This leads to saving 5 – 6 tonnes of sand thereby reducing the cost incurred in purchasing sand for replenishment. The **drying time** has now r**educed to approximately 18 days** from the earlier 23 days.

Figure 9 - Perforated bricks placed in the unplanted sludge drying beds to aid easy removal of dried sludge and prevent sand loss

Technical Upgradation 3

Green House Solar Drier Roofs
- for improvement in drying time

As mentioned in the previous technological upgradation insight, the actual drying time of sludge was approximately 23 days in the unplanted sludge drying beds. This needed to be reduced to a value closer to the design value of 15 days to optimise the operations of the plant. To enhance/optimise the drying time of the SDB, another measure adopted was the usage of greenhouse solar drier roofs (GHSDs).

A GHSD roof, with an air-circulation arrangement, was installed over the existing unplanted sludge drying bed. This helped in maintaining a high temperature inside the unit (reaching a maximum temperature of 60°C for approximately five to six hours a day) thus leading to the inactivation of pathogens and simultaneously drying the sludge (Approximate moisture content – 50-60%). Approximately between the 15th - 18th day of loading, the sludge cakes become dry enough to be taken out and co-composted.

Figure 10 - Green house solar drier roof arrangement over the unplanted sludge drying beds for enhanced moisture removal

Technical Upgradation 4

Handling solid waste in faecal sludge at the FSTP

- A key consideration during design

Onsite containment systems in Devanahalli contain a significant amount and variety of solid waste. This hinders FSTP operations. **Solid waste** ranging from **2 – 25 kg per load of incoming FS** has been retrieved at the Devanahalli FSTP. It includes items like **sanitary napkins, cigarette butts, medical waste (sharps objects and disposed medicines), plastic bags, pens, sticks and blades**. Further, as the pits in Devanahalli and neighbouring areas are unlined, FS contains a **significant amount of grit and silt.** The solid waste and grit led to excess sludge accumulation, and backflow in the modules in the initial months of FSTP operations.

A modification to the design was thus undertaken and during the installation of a larger feeding tank, **screen and grit chambers were also re-designed**. The screen chamber trapped larger solid wastes. In addition, a grit chamber was provided at the entrance of the feeding tank. Due to the escaping solid waste (smaller than 20mm) from the screen, a wire mesh was placed to prevent waste like cigarette butts and napkins from entering into the inlet chamber. The O&M procedures and their frequency had to be changed for all treatment modules to avoid such problems.

Experience from the Devanahalli FSTP tells us that **solid waste will inevitably be present in faecal sludge.** This is highly unlikely to change until there is a **foundational change in user behaviour** that will potentially come through IEC campaigns aimed to affect user practices. Until then, all **FSTP designs should accommodate solid waste as an influent parameter**.

Figure 11 - Efficient removal of solid waste from the feeding tank of the FSTP after design modification of the screens

08

Continued Political Commitment

- A critical component for implementation and sustenance

A town, the size of Devanahalli is driven primarily by its **leadership and management/administration team** (Raman et al, 2015) . Thanks to its proximity to the Bengaluru Airport, the town got the opportunity to leap forward and become a part of fast-paced development. In order to sustain the fast pace of development, officials realised the importance of working towards holistic town development; of which, sanitation formed an important component. This motivated them to **actively seek advice and foster partnerships for improved sanitation in the town**.

TMC Devanahalli's commitment towards improving sanitation in the town - before implementing the FSTP and during the last five years of operations is evident from the following initiatives:

1. **Provision of land for construction of the FSTP*** – The TMC granted potential sites to situate the FSTP and finally approved a prime location close to the highway (NH7)

2. **Passage of key resolutions by the elected representatives* (Box 5)** – In 2015, four resolutions were passed that covered crucial components for FSM sustainability. These were: regulation of FS disposal, outsourcing of FSTP and truck operations, monitoring the construction of pits and septic tanks and addition of desludging fee to the property tax.

3. **Appointment of full-time personnel for FSTP and truck operations**** - The TMC provided personnel to assist with regular operation and maintenance of the FSTP and trucks.

4. **Tendering out operation and maintenance activities**** – The TMC outsourced FS collection and treatment through an open bid tender in 2017. This was done with the intention of bringing in private organisations to ensure that there was regular disposal of FS at the treatment plant to keep the plant operations steady

5. **Conducting IEC campaigns in the town***** – In partnership with organisations, the TMC conducted IEC campaigns to help achieve ODF status. Additional campaigns were conducted at schools and selected communities on solid waste management and menstrual hygiene and wellbeing. All of these were aimed at ensuring that investments being made in the town, last.

6. **Acquisition of alternate sources of funds for further improvement**** – The TMC pursued alternate sources of funds as there was an element of uncertainty in regular disbursal of government funds. They did not want efforts to come to a halt or suffer any kind of setback due to a lack of funds. Hence, CDD helped TMC to secure Corporate Social Responsibility (CSR) funding (from Oracle) and used it towards bridging the toilet gap in the town, helping the town achieve Open Defecation Free (ODF) status. Further CSR funding (from Oracle itself) has also helped fund small-scale greywater management and solid waste management units - all pilot

Bhuvaneswari Raman, Mythri Prasad-Aleyamma, R´emi De Bercegol, Eric Denis, Marie-H´el`ene Zerah. Selected Readings on Small Town Dynamics in India. USR 3330 "Savoirs et Mondes Indiens" Working papers series no. 7; SUBURBIN Working papers series no. 2. 114 pages. 2015.

demonstrations, aimed at understanding requirements to take the same to scale, at town level.

**Enabled FSM to take off in Devanahalli by creating a conducive legal and institutional environment to make interventions for the improvement of public life/health*
*** Helped sustain the operating environment as well as make new interventions*
**** Complemented the new FSTP with behaviour change campaigns*

However, not all of the above taken measures persisted through. Points 2 and 4 mentioned above have been kept on standby. These initiatives were started with the intention of seeing how different approaches work. Now that the TMC has a reasonable understanding of them, they may or may not revert to the earlier method. Additionally, with respect to the inclusion of a separate sanitation tax – the proposal did not go through as it wasn't accepted by citizens as well as by the state administration. Currently the TMC is able to manage all their operating expenditure through their municipal budget. However, in the future, if needed, they may reconsider the sanitation tax proposal or explore new funding sources.

As Devanahalli was the first-of-its-kind FSTP in India as well as the first project of its nature for CDD Society, the initial decisions by the TMC were largely taken following a top-down approach. The site selection and implementation process were initiated without any stakeholder consultation, which led to project delays and increased the overall costs. Objections were raised by landowners adjacent to the FSTP site having concerns of bad smell and vector nuisance. Later the National Highway Authority raised concerns regarding potential blockage of traffic in case desludging vehicles were allowed to park at the service road to offload faecal sludge.

Experience from Devanahalli shows us that taking additional efforts to identify potential stakeholders and consulting them to reach a middle ground in case of any conflicts is essential. It helps facilitate greater community buy-in for the project, in turn leading to timely completion of the project, in turn. This was an important learning for the TMC; prompting them to organise an exposure visit for their councillors, which resulted in them better understanding DEWATS™(the core technology of the FSTP), being completely convinced about it amongst themselves, then extending their support towards the same.

All this was well worth the effort – given the FSTP is running smoothly till date and the TMC Devanahalli has received many awards for their work on FSM in the town.

Box 5 - Resolutions and their intentions

Resolution 1 – Regulation of FS Disposal – To prevent private desludging operators from indiscriminately dumping collected faecal sludge into drains, water bodies and farms.

Resolution 2 – Outsourcing of FSTP and Truck operations – To aid regular collection and disposal of FS to the FSTP in order to maintain treatment efficiency and financial sustainability

Resolution 3 – Monitoring of construction of pits and septic tanks – To ensure that all new containment systems are constructed as per standard designs

Resolution 4 – Adding a sanitation tax to the property tax – To have a fixed source of revenue for continued FSTP operations

Our innovations story is not over yet ....

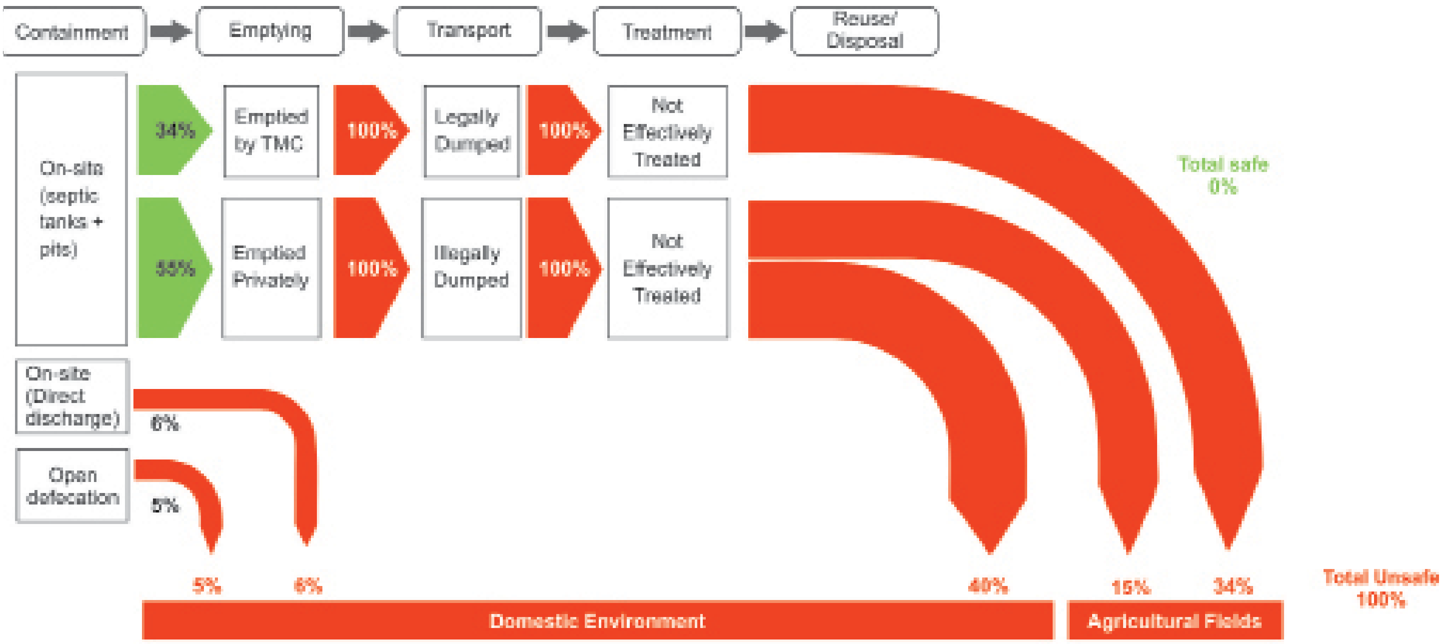
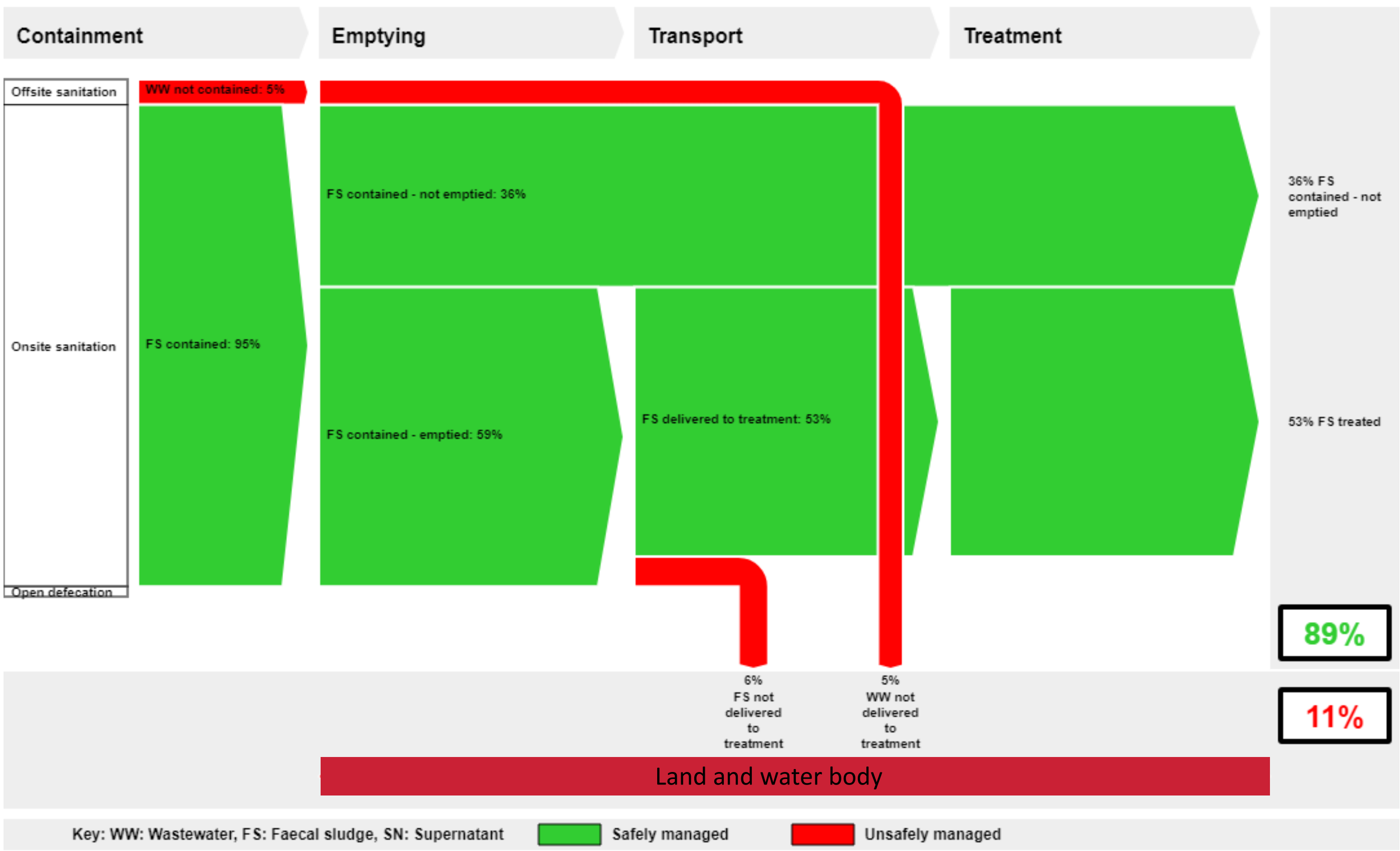


Figure 12 (Top) - Devanahalli Shit Flow Diagram (2014)

Figure 13 (Bottom) - Devanahalli Shit Flow Diagram (2020)



Conclusion

Being the first planned town scale FSTP in the country, Devanahalli had many challenges to overcome. We worked with the objectives of

- Creating an asset that will be easy-to-operate and maintain
- Keeping the operation and maintenance costs low.
- Coming up with a design that is easy to replicate and quick to build
- Building a reuse model
- Enacting policies that will sustain the momentum

At the heart of this were extensive stakeholder engagements with Government officials, public representatives, vacuum truck operators, farmers, citizens, masons and sanitation workers. There were targeted Capacity Building and IEC programmes for different sets of stakeholders. Grants from BORDA and BMGF were extremely critical.

A lot of thought and effort thus went into getting it right the first time. All of this was intended so that Devanahalli becomes a model to emulate and not another waste management facility. After five years of FSM operations at Devanahalli, we can confidently say that the Devanahalli FSM story has not been confined to the town's borders.

FSM in Devanahalli has been a process of continuous improvement. Devanahalli provided a fertile ground for continuous testing of technologies which has helped fine tune, iterate and improve our designs. **The designs that are deployed today, across contexts, are more optimized and efficient when compared to the Devanahalli FSTP.**

However, we believe that the **Innovation story is not yet over**. FSM in the country is still in its early stages and the **ecosystem needs technologies that are robust and sustainable.** Technical upgradations through the use of **hybrid technologies and optimization** of existing technologies is the need of the hour. This will not only help deploy better technologies for upcoming FSTPs but can also provide ways to augment capacities of existing FSTPs – both from capacity utilization and performance improvement aspects.

The enhanced FSTP designs, based on the initial Devanahalli FSTP design, have been **widely adopted** by different states in the country. More importantly, while FSTPs were operational in other parts of the world, it was important to see a properly designed operational FSTP in India – that too in a small town - to convey a message to the policy makers and decision makers that we have the capabilities to design and implement FS treatment systems that can be sustainable.

- **Different cities have come up with their own FSM policies** and guidelines–adopting context-specific measures
- **Landscaping, operator and office rooms** becoming a key feature of almost every FSTP
- **CSR investment has flowed into Devanahalli** to help continue its journey towards a model Sanitation Town

While Devanahalli is a small town, we believe its FSM story to be a significant chapter in India's FSM Journey.

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