Report

Assessment of the FSM value-chain in Sri Lanka

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Contents

Abbreviations (1)

ABF	Aerated Baffled Filter Reactor
ABR	Anaerobic Baffled Reactor
ADB	Asian Development Bank
AF	Anaerobic Filter
BoQ	Bill of Quantities
BORDA	Bremen Overseas Research and Development Association
BOT	Build-Operate-Transfer
CAD	Covered Anaerobic Ditch
CAPEX	Capital Expenditure
CEA	Central Environmental Authority
DEWATS	Decentralized Wastewater Treatment Systems
DIY	Do-it-yourself
DSU	District Support Unit
EA	Environmental Authority
eqv.	Equivalent
FRP	Fiber Reinforced Plastic
FS	Fecal Sludge
FSM	Fecal Sludge Management
FSTP	Fecal Sludge Treatment Plant
GoSL	Government of Sri Lanka
GPOBA	Global Partnership on Output-Based Aid
HSF	Horizontal Sand Filter
IP	Intellectual Property

Abbreviations (2)

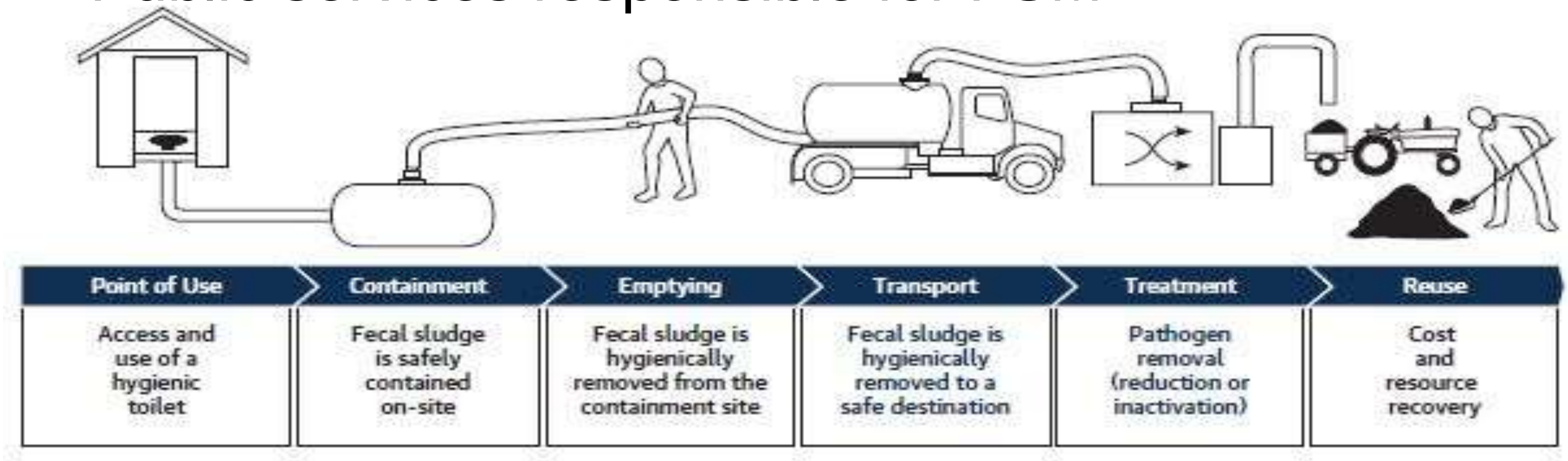
JICA	Japan International Cooperation Agency
JV	Joint Venture
LA	Local Authority
LDPE	Low-density Polyethylene
LKR	Sri Lankan Rupee
LLDPE	Linear Low-density Polyethylene
MBBR	Moving Bed Biofilm Reactor
MBR	Membrane Bioreactor
MC	Municipal Council
MEP	Mechanical, Electrical And Plumbing
Mio	Millions
MOH	Medical Officer of Health
MoU	Memorandum of Understanding
MSTP	Municipal Sewage Treatment Plant
MSW	Municipal Solid Waste
MWSUD&HF	Ministry of Water Supply, Urban Development and Housing Facilities
NA	Not Available
NPD	Department of National Planning
NSWMSC	National Solid Waste Management Support Centre
NWSDB	National Water Supply and Drainage Board
O & M	Operation and Maintenance
OPEX	Operational Expenditure
PC	Provincial Council
PE	Polyethylene
PGF	Planted Gravel Filter

Abbreviations (3)

PHI	Public Health Inspector
PLC	Programmable Logic Controller
PPP	Public Private Partnership
PS	Pradeshiya Sabha
RBC	Rotating Biological Contactor
RRR	Resource Recovery and Reuse
SA	South Asia
SBR	Sequencing Batch Reactor
SDB	Sludge Drying Bed
SEA	South East Asia
SL	Sri Lanka
SME	Small and Medium Enterprises
SOP	Standard Operating Procedure
ST	Septic Tank
STP	Sewage Treatment Plant
TA	Technical Assistance
TSU	Technical Support Unit
UC	Urban Council
UDA	Urban Development Authority
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNICEF	United Nations Children's Fund
UNOPS	United Nations Office for Project Services
WASSIP	Water Supply and Sanitation Improvement Project
WW	Wastewater
WWT	Wastewater Treatment
WWTP	Wastewater Treatment Plant

FSM value-chain components assessed

- Containment infrastructure
- De-sludging services
- Wastewater Treatment Plants
- Fecal Sludge Treatment Plants
- Resource Recovery and Reuse options
- FSM / WWTP consultants and contractors
- Public services responsible for FSM

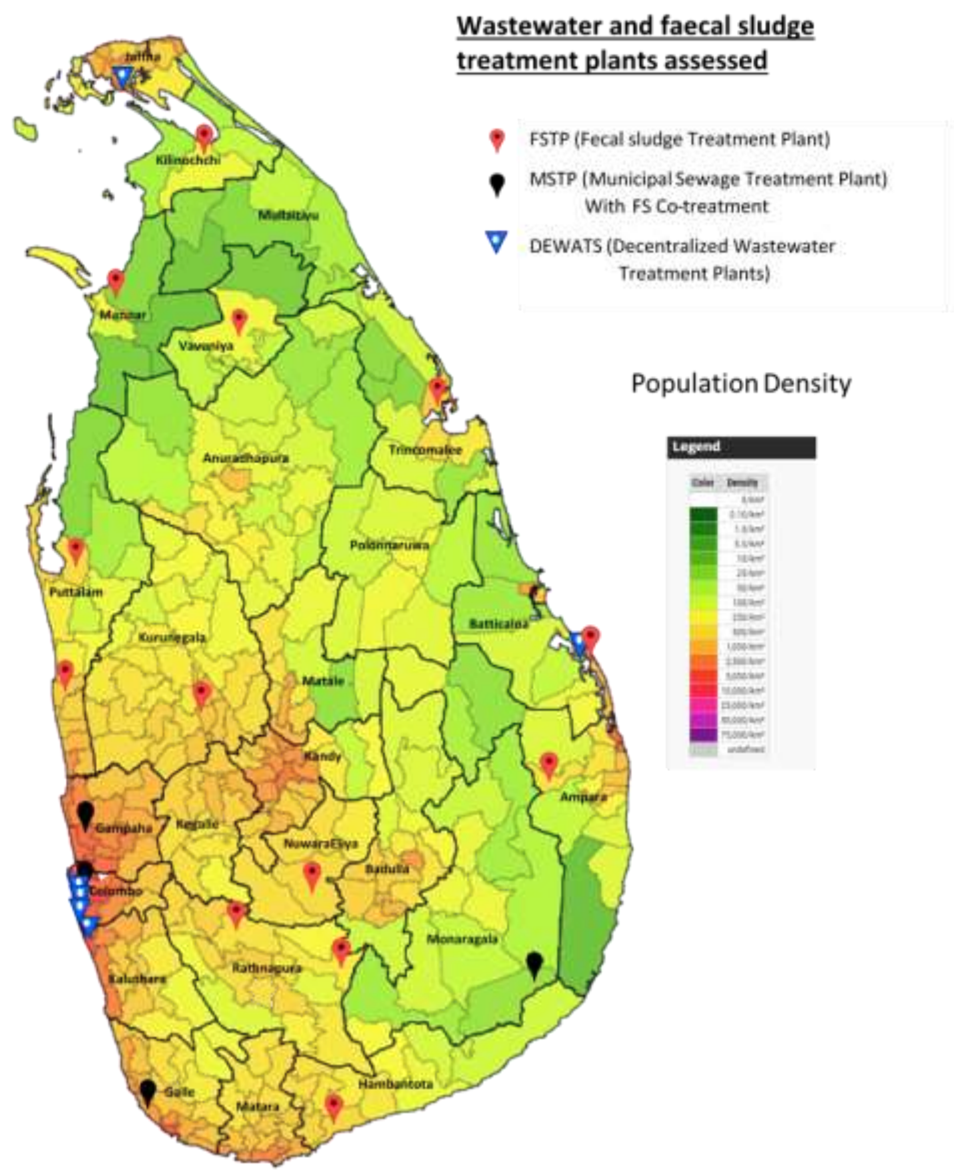


Locations of FSM assessments in Sri Lanka

FSTP (Fecal Sludge Treatment Plant)			
	Province	**District**	**Location**
1	Central	Nuwara Eliya	Nuwara Eliya
2	Eastern	Trincomalee	Trincomalee
3	Eastern	Batticaloa	Batticaloa
4	Eastern	Ampara	Ampara
5	Northern	Kilinochchi	Kilinochchi
6	Northern	Mannar	Mannar
7	Northern	Vavuniya	Vavuniya
8	North-Western	Puttalam	Puttalam
9	North-Western	Puttalam	Chilaw
10	North-Western	Kurunegala	Kurunegala
11	Sabaragamuwa	Rathnapura	Rathnapura
12	Sabaragamuwa	Rathnapura	Balangoda
13	Southern	Hambantota	Tangalle

MSTP (Municipal Sewage Treatment Plant) with FS co-treatment			
	Province	**District**	**Location**
1	Southern	Galle	Hikkaduwa
2	Uva	Monaragala	Kataragama
3	Western	Gampaha	Ja-Ela - Ekala
4	Western	Colombo	Zoysapura

DEWATS (Decentralized Wastewater Treatment Plant)			
	Province	**District**	**Location**
1	Eastern	Batticaloa	Batticaloa Hospital
2	Northern	Jaffna	Gurunagar
3	Western	Colombo	Rathmalana
4	Western	Colombo	Lunawa
5	Western	Colombo	Moratuwa
6	Western	Kaluthara	Modarawila(Panadura)



Methodology of the study

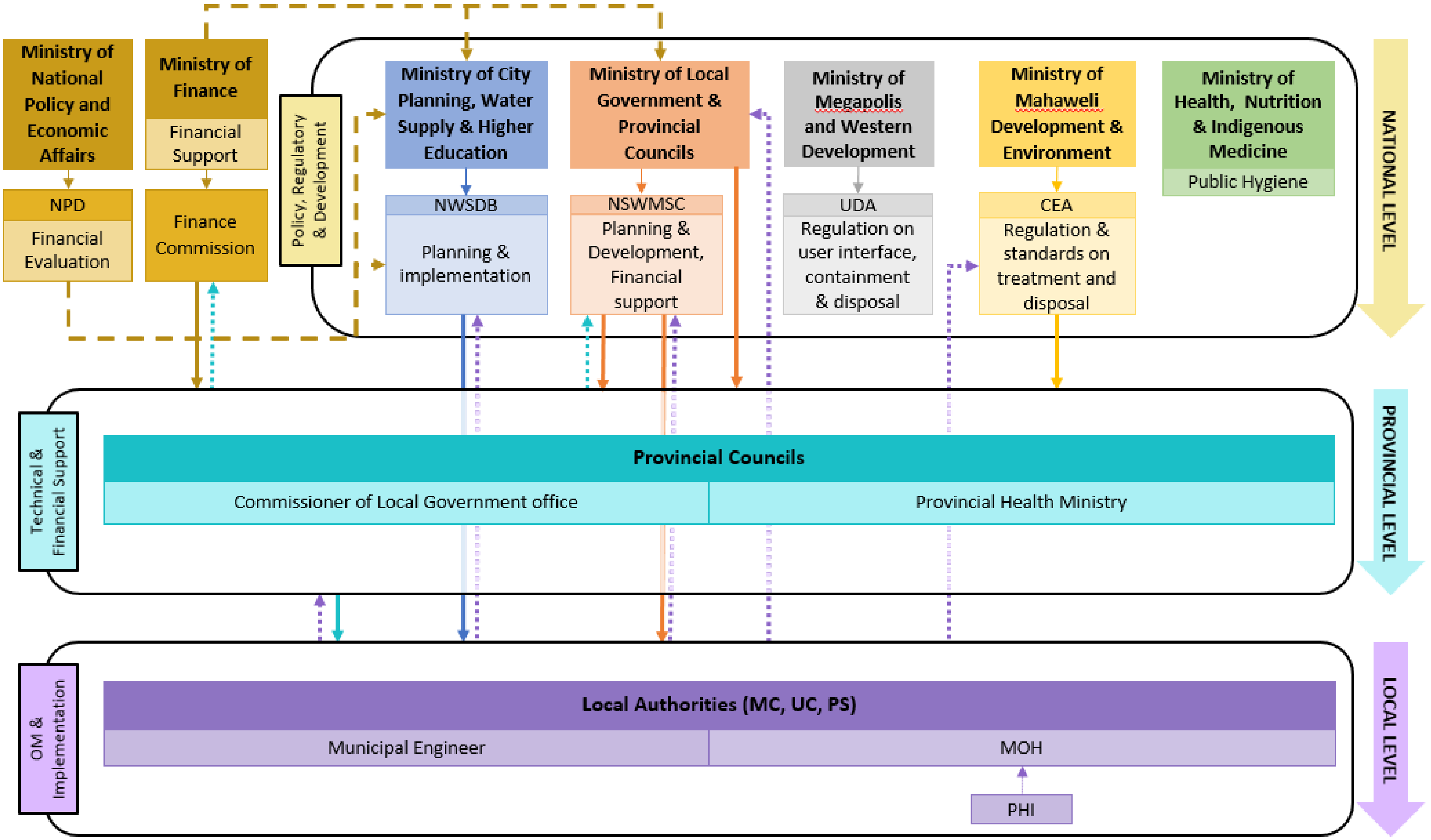
To assess FSM value-chain components both quantitative and qualitative data were collected through -

- ❖ Review of existing documents
- ❖ On-site assessments
- ❖ Data collection using semi-structured questionnaires
- ❖ Key Informant Interviews -
    - ➢ Personnel from WASSIP, NWSDB, Local Authorities
    - ➢ Private business – pre-fabricated containment, consultants, gully bowsers

For each of the FSM value-chain components following parameters were assessed based on the component -

- ❖ Management of the system, production, marketing
- ❖ Finance – capital expenditure, O&M costs, revenue sources
- ❖ Physical – area and structural requirements
- ❖ Technical – type of design and operational efficiency
- ❖ Overall operation of the plant
- ❖ Labor involvement and skill required for operation, occupational hygiene
- ❖ RRR options if any

Responsibilities for FSM on local, provincial and national levels



NPD: National Planning Department, **NWSDB:** National Water Supply & Drainage Board, **NSWMSC:** National Solid Waste Management Support Center, **UDA:** Urban Development Authority, **CEA:** Central Environment Authority, **MC:** Municipal Council, **UC:** Urban Council, **PS:** Pradeshiya Sabha, **PHI:** Public Health Inspector, **MOH:** Medical Office of Health

Ministries and their key responsibilities related to FSM (1)

Institution	Key Responsibilities (relevant to sanitation sector)
Ministry of Urban Development, Water Supply & Housing Facilities	Formulating sector Policies, project and programme coordination, budget allocation, review progress and monitor
	National Water Supply Drainage Board (NWSDB) Implementing agency responsible for planning and development of infrastructure and operation of services. Receives national annual budget allocation to implement planned projects and programs.
Ministry of Local Government and Provincial Councils	• Implementation of policies, plans and programs with respect to provincial council and local government jurisdictions • Granting of loans to local authorities for public utility projects
	Local Authorities (LAs) Set up and ensure operation of safe and sustainable collection, transport, treatment and disposal of sanitation systems
	Provincial Councils (PCs) •Develop provincial level strategies and implementation plans •Funding through specific schemes and plans •Monitoring and evaluation
	National Solid Waste Management Support Centre (NSWMSC) Providing technical and financial assistance on waste management and sanitation to LAs

Ministries and their key responsibilities related to FSM (2)

Institution	Key Responsibilities (relevant to sanitation sector)
Ministry of Mahaweli Development & Environment	Implementation of policies, acts, plans and programs pertaining to the environment and natural resources.
	Central Environment Authority (CEA) Regulation, maintenance and control of the quality of the environment. Develops and updates the standards for effluent discharge and enforces compliance.
Ministry of Health	Regulator for water & food quality, hygiene education, sanitation and public health services.
Ministry of Megapolis and Western Development	Formulation of policies, programs and projects, monitoring and evaluation in regard to the urban development
	Urban Development Authority (UDA) Approval of building plans and establish necessary standards and criteria related to disposal of wastewater and sewage emanating from buildings/ new constructions in urban development areas
Ministry of Finance	Budget allocation and Macroeconomic Policy
Ministry of National Policy and Economic Affairs	**National Planning Department (NPD)** Financial Evaluation of sanitation projects (for both internal and external funded projects)

General information about FSM in Sri Lanka (1)

The assessment has shown that the collectable quantity of septage and its quality is difficult to determine.

- According to the Water Ministry of Sri Lanka, 85 - 90% of wastewater is disposed on-site in septic tanks, about 4 % are treated in MSTP and we estimate that about 5 - 6 % of the remaining sewage is treated by DEWATS, e. g. treatment systems with a capacity below 750 m^3 / day in institutions, private businesses and real estate.

- Based on the actual treatment capacity of FSTPs, it is estimated that only about 5 % of septic tanks are regularly emptied by de-sludging services. Many of these are “black water” holding tanks in areas with high groundwater levels;

- There is no documented evidence about how many of the septage tanks in operation are inaccessible or leaking and therefore do not allow for a collection of septage;

- The organic pollution load of septage in Sri Lanka has not been determined;

General information about FSM in Sri Lanka (2)

There is extensive experience in Sri Lanka on different approaches to septage treatment.

- Only part of collected septage is treated in FSTPs, e.g. co-treatment of septage in MSTP, treatment in facultative pond systems and in simple fecal sludge treatment plants on PILISARU sites operated by the LA;
- The NWSDB operates septage co-treatment stations at their MSTPs, and technically supports Local Authorities in implementing lagoon-type FSTP;
- Through the ongoing WASSIP and other sanitation improvement programs, the number of FSTP is continuously increasing;
- Over 100 local authorities in Sri Lanka have initiated PILISARU waste recycling centers and thus have solid waste disposal sites that can accommodate FSTP;
- Income through FSM related activities (collection, treatment, sale of dried sludge) reduces payment of subsidies for waste management by local authorities;

General findings and recommendations – Septic tanks

The number of septic tanks in operation is unknown by local authorities. Depending on the height of local groundwater-tables and the feasibility to soak away, it is assumed that only 1 – 5 % of households in Sri Lanka regularly empty their septic tanks. Many septic tanks are also inaccessible (e. g. no manhole, remotely located and or covered by buildings)

Conventional septic tanks

- Built by local craftsmen with bricks / mortar and / or concrete
- Often leaking and corroded due missing additives in mortar plaster
- Standardized dimensions of septic tanks provided by the Sri Lankan Standards Institute (SLSI)

Pre-fabricated concrete septic tanks

- Manufactured by SMEs specialised in pre-cast fabrication of concrete products
- Molds for septic tanks, lining of soakage pits, screens, control boxes are low-cost and locally made
- Existing designs of small STs do not match relevant standards (e. g. minimum depth)
- Heavy (over 1 ton for smallest unit), therefore costly and difficult to transport (only by trucks with crane)

Pre-fabricated septic tanks made of thermo-plastics (LDPE)

- Light-weight (appx. 20-30 kg for 1,000 l tank), easy to transport
- Professional design that combines mechanical and biological treatment components (e.g. AF)
- Manufactured by Sri Lankan roto-molding industries (e.g. Arpico, Anton) that also produce water tanks
- High price compared to other SA and SEA countries due to 80% import tax on LLDPE

Recommendations

1. To improve quality of septic tanks, develop technical standards for product certification of pre-fabricated ST
2. In order to reduce prices, allow for a duty-free import of production materials for septic tanks

General findings and recommendations – Wastewater Treatment Consultants and Contractors

- Only WWT consultants and contractors registered and listed by the Central Environmental Authority (CEA) are eligible to carry out technical planning and implementation work for WW and FS treatment;
- Out of +50 registered companies, only +/- 10 companies provide professional consulting and construction services for WWTP of up to 750 m^3 for private clients;
- Private consultants and contractors are clustered only in the Colombo metropolitan area;
- Most private consultants and contractors interviewed are reluctant to work for WW and FS treatment projects of the public sector;
- Design and construction of large scale state-of-the-art MSTPs are not part of the product and service portfolios of Sri Lankan consultants and contractors;
- There is a need for more diversity and better quality control of technological WWT options, especially for compact, low-cost / low-maintenance FSTP and DEWATS;

Recommendations

1. Train staff during the start-up phase and provide work instructions for O & M activities;
2. Improve technical expertise of private and public sanitation consultants/contractors to dimension, design and construct low-maintenance WWT/FSTP

General findings and recommendations – De-sludging service providers

- Licensing of desluding service providers is required to expand services - these would be both public and private service providers. However, current licensing procedures limits the engagement of private service providers because licenses are difficult to obtain;
- Septage collection fees (LKR 4,000 - 8,000) allow for profitable businesses;
- It was found that only within GPOBA projects, septage collection fees for low-income households are subsidized;
- Existing leasing/credit arrangements provided for purchase of septage collection trucks is compatible with companies‘ cashflow requirements;
- Gully bowser services cannot meet high demand of customers during peak rainy season;
- Disposal of septage into public FSTP is restricted for private septage collection services due to limited treatment capacities;

Recommendations:

- As it is difficult to determine scope for local FS collection service that meets demand, counting of septic tanks and analysis of septage (= septic tank census) is needed to determine the business potential.
- Densely populated areas in central and south Sri Lanka require an expansion of the FSM business through provision of more FS collection and treatment capacities.
- Training of public gully-bowsers to operate FSTP could make up for the lack of operational staff for FSTPs managed by Local Authorities.

General findings and recommendations – Decentralized Wastewater Treatment Solutions (DEWATS)

- Various types of decentralized wastewater treatment plants (DEWATS) with a designed treatment capacity from 10 to 750 m^3 / day are in operation in Sri Lanka, ranging from low-maintenance type of plants (e.g. with ABR, AF, PGF, ponds) to complex systems (e.g. MBR, MBBR);
- DEWATS in operation in Sri Lanka are either custom built, pre-fabricated type (import tax of pre-fabricated plants is sometimes lower than tax of imported parts and equipment);
- DEWATS employed by the private sector (e.g. hotels, apartment houses) reflect key selection criteria such as investment/operation cost, space requirement, discharge standards imposed by council departments (often stricter than the general discharge standards by the MWSCP&HE !);
- DEWATS employed by the private sector are operated either by staff of the client or on a contractual basis by the consulting company responsible for technical implementation;
- DEWATS imported under bilateral development cooperation agreements are difficult to maintain according to limited O & M budgets of clients and non-availability of spare-parts in Sri Lanka (e.g. hospital plant in Nuwara Eliya;
- Maintenance work is carried out by Sri Lankan consulting companies responsible for project implementation as they store most of the replacement parts frequently needed;
- We observed that a number of low-maintenance type of DEWATS plants were not dimensioned according to acknowledged professional design principals and quality standards of construction;

Recommendations

- In order to increase infrastructure lifetime, to reduce costs and to improve convenience for users and operators, it is recommended to comprehensivley train responsible technicians and engineers to design, dimension and supervise construction of low-maintenance DEWATS / FSTP

General findings and recommendations – Faecal Sludge Treatment Plants (FSTP)

- 3 types of FSTP to be found in Sri Lanka: “Facultative pond-lagoon systems”, “Inter-connected sedimentation tanks” (both managed by local authorities); “Co-treatment of FS in MSTP” (managed by NWSDB);
- Most of these FSTP facilities are either over- or under dimensioned;
- Some FSTP do not have operational staff (e.g. in Puttalam; Vavuniya)
- Some FSTP have been abandoned after start-up (e.g. in Trincomalee, Ampara)

Recommendations:

- Determine demand for FS collection, treatment services and ST improvements (“ST census”) at LA levels as part of FSM feasibility studies;
- Co-treatment facilities for faecal sludge should become a mandatory feature of all new MSTPs;
- Adapt regular analysis of septage discharged by public and private service operators as practiced by NWSDB;
- Insist of employment of a minimum staff of 2 workers for basic protection, operation and maintenance work to minimize an early destruction of infrastructure.
- Provide assistance for start up of FSTP after commissioning and train O & M staff.
- Develop simplified standardized operational procedures and work instructions for un-skilled staff to improve operation and maintenance of FSTPs.
- Develop realistic business plans with LAs and TSUs of NWSDB for FSM.
- Develop cost-efficient standardized designs for low-cost FSTP including pre-fabrication;

General findings and recommendations – Resource Recovery & Re-use

- Infrastructure for drying of treated septage sludge is part of all FSTP categories in Sri Lanka;
- In „open-tank treatment systems“ located at PILISARU waste recycling stations stations run by local authorities, sludge is recovered and sold as dried or co-composted biofertiliser;
- In lagoon systems in the north, sludge is disposd after emptying of anaerobic sedimentation tanks. Despite recovery, dried FS is not further refined, sold or reused. Infrastructure provided for sludge drying and storage is not utilized;
- Due to the technical process design of FSTPs, sludge drying / composting is currently labor-intensive and requires pumping of sludge;

Recommendations

- Practical resource recovery of sludge depends on a user-friendly but simple technical FSTP design according to low-maintenance principles (e.g. gravitation);
- However, actual resource recovery and reuse is only practiced if it is identified as a business opportunity by the private/public sector to create additional revenues;
- Improve convenience of re-finement of treated fecal sludge according to sanitation safety standards;

Feasibility and sustainability of the business models

Business models	Financial & Institutional Feasibility	Scalability conditions	Types and possible extensions
Private businesses on Containment – prefabricated septic tanks	Financial feasibility is low as a stand alone product. However, in combination with other products the feasibility increases	Policies directed towards safe containment supported with soft loans to households for increasing affordability	Business model becomes feasible if sanitation policy is directed improvement/exchange of non-functional containment
Businesses on Emptying & Transport	Financial feasibility for private operators depend on the fleet size and size of gully bowser High Financial feasibility for public gully bowser	Proper licensing conditions for the private player; For public operations increase in fleet size by 1-2 gully bowsers would increase the financial feasibility	Both private and public entity can own and operate gully bowsers
Business models on treatment	Financial feasibility depends on the number of sewered connections	Availability / opportunity of sewer coverage and land for FSTP	Private entities operating FSTPs are a possibility

Feasibility and sustainability of the business models

Business models	Financial & Institutional Feasibility	Scalability conditions	Types and possible extensions
Business models combining Emptying, Transport and Treatment	High financial feasibility mainly from the revenue of gully browsing services	Efficient and standardised design for the FSTP; operational guidelines, manual and capacity building of the staff	Possibility of private gully browsing services with municipality operating the treatment plant. However, since the revenue from gully services are higher, the chance of municipalities outsourcing the activity is lower.
Business models combining Emptying, Transport, Treatment and Reuse/Disposal	Additional source of revenue and proper disposal of the dried FS	Efficient and standardised design for the FSTP; operational guidelines, manual and capacity building of the staff. Bank loans towards retrofitting the defunct treatment plant	Possibility of private gully browsing services with LA operating the treatment plant. However, since the revenue from gully services are higher, the chance of municipalities outsourcing the activity is lower.
Integrated waste management system	Financially feasible only if part of the property tax is used to cover costs of SW collection and segregation. Certification of the organic fertilizer.	Land requirement for operations. Certification of the organic fertilizer.	Recycling of plastic being added to the MSW management as a source of revenue. Sometimes this is outsourced to private entities

Findings and recommendations-
National Water Supply and Drainage Board (NWSDB)

- Implementing agency responsible for planning and development of infrastructure and operation of services. Receives national annual budget allocation to implement planned projects and programs.
- Professional expert staff, both for planning, management and operation of water supply and wastewater treatment installations
- Co-operation partner on the operational level for bilateral and international development cooperation entities, incl. development banks active in Sri Lanka
- Engagement in sanitation / wastewater treatment programs only observed in regions where NWSDB is also responsible agency for the water supply
- ST: Preparation of guidelines for construction of conventional septic tanks
- DEWATS: Dimensioning and design of treatment plants
- FS collection: Operates gully bowser trucks at Ja-Ela and Soyzapura MSTP
- FS treatment: Co-treatment of FS within MSTP except in Kurunegala and Kataragama;

Recommendations:

- Improve and standardize design parameters for low-cost modular FSTP
- Improve and standardize modular DEWATS designs
- Train technical staff in order to supervise quality construction of FSTP and DEWATS
- Develop technical guidelines and implementation standards for the FSM value chain.

Findings and recommendations – Municipal Councils, Urban Councils, Pradeshiya Sabhas

- Public Health Inspectors, PHIs, and municipal engineers in charge of FSM related activities lack technical knowledge related to domestic wastewater and fecal sludge treatment;
- Lack of technical knowledge in urban / municipal councils makes it difficult to prepare proposals/tenders for new or rehabilitation of broken FSM infrastructure
- Size and treatment capacities of existing FSTPs do not match demand;
- Technical design parameters of existing FSTP do not match basic sanitation safety standards;
- Some FSTP ceased operation due to techncial malfunction / lack of operational skills after start-up;
- Capital investments for WWTP and FSTPs as well as major repairs can only be undertaken with financial support from National entities;

Recommendations:

- Operational expenses of simplified FSTPs could be covered by municpalities through income from public gully-bowser services, disposal fees and sale of dried septage sludge / compost.
- Revison and standardization of low-maintenance technical treatment designs will lead to improved performance of future FSTPs even if operated by unskilled staff;
- Most of the currently dysfunctional FSTPs could be repaired / rehabilitated with limited investments.

Structure of assessments (1)

Individual assessments are presented on two different slides:

Within the “description” section general observations are summarized and visualized.

Within the “assessment” section qualitative and quantitative information is provided according to selected performance parameters of FSM components according to findings made during on-site visits and information given by stakeholders. Information is structured in as below:

Management

Informs about management structure and qualification.

Finances

Shows investment, operation and maintenance costs and revenues created by FSM services.

Infrastructure

Informs about the construction/ building/ material quality of FSM infrastructure assessed.

Technical design and treatment efficiency

Describes the functionality of the technical design and documents evidence of FS treatment

Operation & Maintenance (O&M)

Reports on the quality of O&M efforts to ensure performance of treatment infrastructure

Resource recovery and reuse (RRR)

Informs about technical features and actual activities related to RRR

Structure of assessments (2)

The assessments reflect the experience of experts as well as the comparative nature of the study in Sri Lanka. Assessments are presented under the categories: "strengths," "weaknesses," "lessons learned" and "recommendations" for individual FSM components investigated and for a specific cluster of components within the FSM value chain.

<u>Strengths</u>

Highlights aspects that run well; comments on comparative qualities, i.e. internal resources and tangible assets.

<u>Weaknesses</u>

Emphasizes things that are lacking and aspects that competitors do better, i.e. resource limitations and unclear selling propositions.

<u>Recomendations</u>

Recommendations on how to improve weaknesses with existing strengths and limited resources.

Septic tank manufacturers

Prefabricated concrete Septic Tanks Description (1)

The pipe-shaped concrete septic tank is popular througout Sri Lanka (especially in coastal areas with high water tables). It is pre-fabricated by SMEs with a simple concrete casting technolgy in many districts of Sri Lanka. Molds are produced in Sri Lanka. The ST is often connected to a soak-pit that is lined with a short, perforated concrete pipe that is filled with broken stones or gravel. Delivery of STs is carried out by trucks with integrated lifting cranes with a capacity of 3 tons. In addition to its weight of 1.5 tons, the main disadvantage of this system is the very limited depth of the water table for sedimentation of only 40 – 60 cm (according to MWSCP&HE and NWSDB the depth of the water table in an ST should be 100 cm!) which results in reduced treatment efficiency and frequent emptying intervals that will increase O & M costs significantly (ref. DEWATS in Jaffna and Ratmalana).

Prefabricated conrete Septic Tanks Description (2)

The design of concrete-made septic tanks could be easily improved if STs were made out of shorter but wider pipes with divider walls which would be placed vertically into the ground (with bottom and cover plates) instead of horizontally. Tanks are available in differents sizes from 1 to 3 cbm.





Prefab Concrete ST Assessment

Production and marketing: Pre-cast concrete product made by SME. Marketing is done ex-workshop or by distributors;

Costs: Price of septic tanks range between LKR 35,000 and 70,000; matching soakaway pit lining 7,000; transport on-site LKR 8,000;

Physical Infrastructure: Heavy weight 1.5 to 2 tons; covers break easily; truck mounted cranes needed for lifting and placement of ST;

Technical design and treatment efficiency: Current design not compatible with SL construction standards (1 m liquid depth) of ST. Low depth for sedimentation and anaerobic digestion. Keeping up of minimal treatment efficiency depends on frequent desludging.

Installation, hygiene, desludging: STs are preferred by NWSDB due to their shallow depth of installation. Tanks are only partially buried in the ground. Frequent de-sludging required by de-sludging services or DIY on-site.

Resource Recovery and Re-use: Lack of anaerobic digestion and stabilisation of sludge prohibits its direct and safe application as organic fertilizer in gardening or agriculture without further post-treatment/refinement (drying, composting).

Strengths

- Low-cost septic tank solution
- Produced with locally available materials and distributed in almost all districts of Sri Lanka

Weaknesses

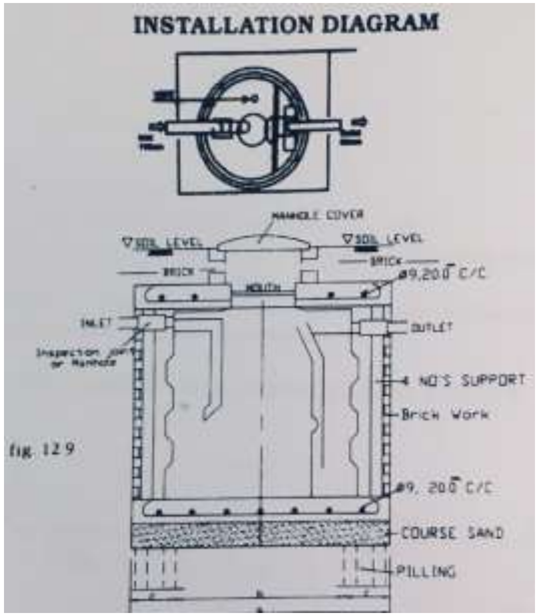
- High weight requires special lifting and transport equipment
- No delivery to locations that are difficult to access
- Short de-sludging intervals increase (bi-annually) increases operational costs
- Low treatment efficiency due to low depth

Recommendations

- Increase depth of ST to improve sedimentation and anaerobic digestion, to lengthen desludging intervals and retention time

Prefabricated PE Septic Tanks Description

Pre-fabricated septic tanks out of polyethylene (PE) plastic compounds are manufactured by a thermophilic industrial process called “roto-molding” that is also used for the production of water tanks. Any manufacturer of PE water tanks could also produce STs that are robust, light-weight, easy to transport and to install. Design and production of PE-septic tanks are very similar throughout SA and SEA. Designs are determined by a pressure resiststant shape and wall-thickness. In areas with high water tables, concrete foundations and concrete anchors are required to avoid up-flow of ST. Required size as well as mechanical and biological treatment processes selected are determined by national discharge standards, which eventully determine the costs of a septic tank treatment based WW treatment system. The price for one kg of roto-grade LDPE is about $1.5. Recycled LDPE-granules can also be used at 50% of the cost. Production of a PE tank with a volume of 1,000 l cbm and a wall-thicknesss of 5-6 mm requires approximately 25-30 kg of low-density polyethylene. Unfortunately, Sri Lanka currently levies an import tax on LDPE powder and pellets.



Prefab PE ST Assessment

Production and marketing: The 2 largest manufacturers in Sri Lanka (Anton and Arpico) have roto-molding facilities in the Metro-Colombo area and sales outlets throughout Sri Lanka.

Costs: 1 m^3 tank LKR 70,000, 6 m tank 250,000; transport and installation by client; brick-wall lined foundation-shell LKR 30,000.

Physical Infrastructure: with standard LDPE single-shell, manhole, in- and outlet and wall thickness of 6 mm; recycled LDPE can be utilized.

Technical design and treatment efficiency: Different designs and various sizes from 1 m^3 to 6 m^3; integrated anaerobic filter device available; treatment efficiency according to national standards -

Installation, hygiene, desludging: Installation manuals are provided. Discharge of effluent into soakaway or public drains; de-sludging recommended in 5 year intervals.

Resource Recovery and Re-use: A direct resource recovery on-site is not possible, only after treatment of septage at an FSTP.

Strengths

- State-of-the art septic tank that meets international product and treatment efficiency standards
- Long lifetime
- Long desludging intervals
- Production process allows for recycling of LDPE plastic

Weaknesses

- Relatively high price due to 50% import tax on LDPE pellets and powder

Recommendations

- Reduction of import duties on PE for STs
- Develop a professional ST-design that allows for resource recovery of biogas

Wastewater Treatment Consultants and Contractors

Wastewater Treatment Consultants Description

Wastewater treatment consultants in Sri Lanka have to be registered and approved by Sri Lankan authorities annually to carry out their work as consultant or sub-contractor. Out of +50 consultants registered by the CEA, only about 15 were found to have functioning websites and a business history in domestic wastewater treatment. All consulting companies assessed are located in the Colombo Metropolitan area. They have the ability to design and implement DEWATS plants with a treatment capacity of up to 750 m^3 /day. Consultants assessed had both licence agreements with international partners to import and market assembled DEWATS but also the technical expertise, and equipment to built customized DEWATS for their clients (hotels, apartment houses, office buildings, hospitals) that belong almost exclusively to the private sector. Consulting companies hold import licences for special equipment and spare-parts. Operation and maintenance of WWTP (also plants by other companies) are carried out by the consulting companies on request.

Wastewater Treatment Consultants Assessment

Management and staff: In general, business owners are managers of the SME and have professional technical education and business experiences. Permanent staff of companies range from 10-25 persons.

Products, marketing, clients: Sale of imported compact treatment plants from licenced international partners or customized plants up to 1,000 m^3 /day; marketing done through exhibitions, internet and client contacts (preferred). Almost 90% are private clients.

Costs / terms of payment/ turnover: Individual project volume ranges between LKR 1 to 50 million; annual turnover up to 100; 5 to 20 projects are implemented per year. Advance payment of up to 50% by private clients. FS prepared only if advance payment is made.

Technical designs and equipment: According to requirements of clients, different types of treatment plants are provided such (SBR, RBC, MBR and Jokasso). Consultants keep major spare-parts in stock.

Installation, hygiene, desludging: Installation is usually done by the companies. Technical design only is done on request. Operation and maintenance work done according to request of clients.

Strengths

- Professional designs and configurations for small to medium sized domestic wastewater treatment systems
- Client-specific and demand-based approach
- Operation and maintenance carried out on as after sales service on request

Weaknesses

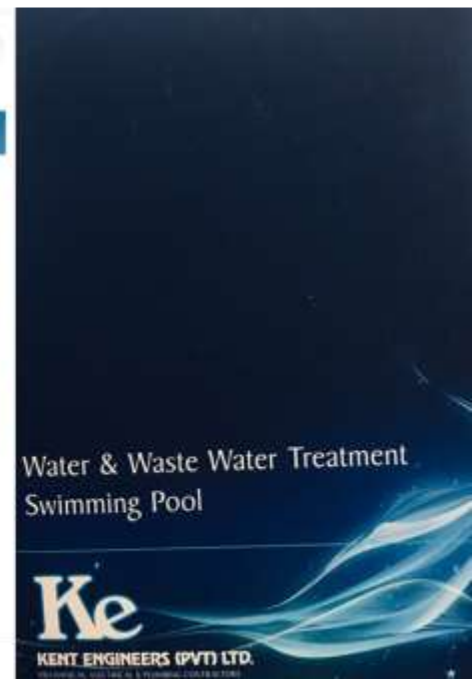
- High import duties on technical equipment. It is sometimes cheaper to import an assembled WWTP than its parts
- Designs of energy efficient, low-cost treatment WWTP systems are unknown
- FSTP are not yet part of the business portfolio

Recommendations

- Increase involvement of private consultants in public sector projects (also supervision);

Wastewater Treatment Contractors Description

The wastewater treatment contractors assessed operate comparatively larger businesses than consultants and do not belong to the small business category anymore. Kent Engineers Ltd. is a so called „MEP contractor“ and responsible all types of mechanical, electrical and plumbing work in large construction projects. It has a specialized wastewater department. Out of its 2,000 professional staff, only 35 work for its WWT department. PURITAS is a subsidiary of the Sri Lankan Hayleys conglomerate and specialisted in drinking water and wastewater treatment (also industrial). Its subsidiary, PURITAS also manages BOT projects in cooperation with the Government of Sri Lanka and has cooperation agreements with VEOLIA and GE-Water. Both companies built and manage sewage treatment plants with a treatment capacity of up to 1,000 cbm. Larger WWTP projects are carried out by specialized international contractor companies in cooperation with NWSDB.



Wastewater Treatment Contractor KENT Ltd. Assessment

Management and staff: Professionally run company with management, departments and staff performing according to SOP and work instructions.

Finances: MEP part of construction work amounts to 20-30% of project costs for a large building. Large building projects are official duty-free projects were WWT equipment is exempted from import taxes.

Products, marketing clients: WWTP installation is offered only as part of a larger MEP installation project. No individual WWTP projects are facilitated. Company is not concerned about marketing. Participates only in real-estate exhibitions.

Technical design and treatment efficiency: Mostly aerobic activated sludge SBR design is followed. Tanks are made mostly our of concrete, but mild-steel and FRP also used. Treatment efficiency depends on requirements in building permits.

Installation, operation & maintenance: All services are offered within the BoQ of KENT as MEP sub-contractor. Clients mostly opt to operate WWT by their housekeeping firms at low-cost.

Resource Recovery and Re-use: Extent of RRR depends on the collection and treatment of sludge from the WWTP.

Strengths

- Integration of WWT within BoQ of building contractors for new buildings.
- Technical skills as MEP contractor enables KENT to install new WWTP at new urban real estate developments.
- One stop service provision – design, installation, construction, O & M

Weaknesses

- Expertise not utilised as specialized, stand-alone WWTP contractor.
- Expertise limited to aerobic activated sludge treatment.

Recommendations

- Integrate low-maintenance WWT technologies (ABF, AF) into portfolio and extend company’s outreach to public housing projects

Wastewater Treatment Contractor PURITAS Assessment

Management and staff: Probably the largest WWT consulting and contractor in Sri Lanka. Professional management incl. SOPs. Employs 55 permanent expert staff and 250 staff on construction sites on contract basis, other MEP staff employed by the holding company.

Finances: 30-40 projects implemented annually; annual revenue target $1.5 – 2 million.

Products, marketing, clients: All types of aerobic and anaerobic biological treatment plants. MoU with VEOLIA for MBBR. Serves both the private and public sectors. No WWTPs above 1.000 m^3 /day treatment capacity. Interested in future collaboration with large “donor agencies”.

Technical design and treatment efficiency: Capable to design and implement various technical options (incl. lagoon-based FSTP). Holder of intellectual property (IP) in WWT.

Installation, operation and maintenance: Out of a total of 400 projects implemented since 1995, the company operates and maintains 50 plants on a contractual basis.

Resource Recovery and Re-use: Does not play a major role within its promoted range of technical options.

Strengths

- Highly skilled and professional provider of technical WWT treatment solutions with capacities below 1,000 m^3 /day.
- Partner in first BOT based WWTP in Sri Lanka.
- Service provider for operation and maintenance.
- Wide range of experience with different technical treatment options.

Weaknesses

- Lack of experience to design and construct large scale STPs.
- RRR is not yet regarded as integrated part of WWT.

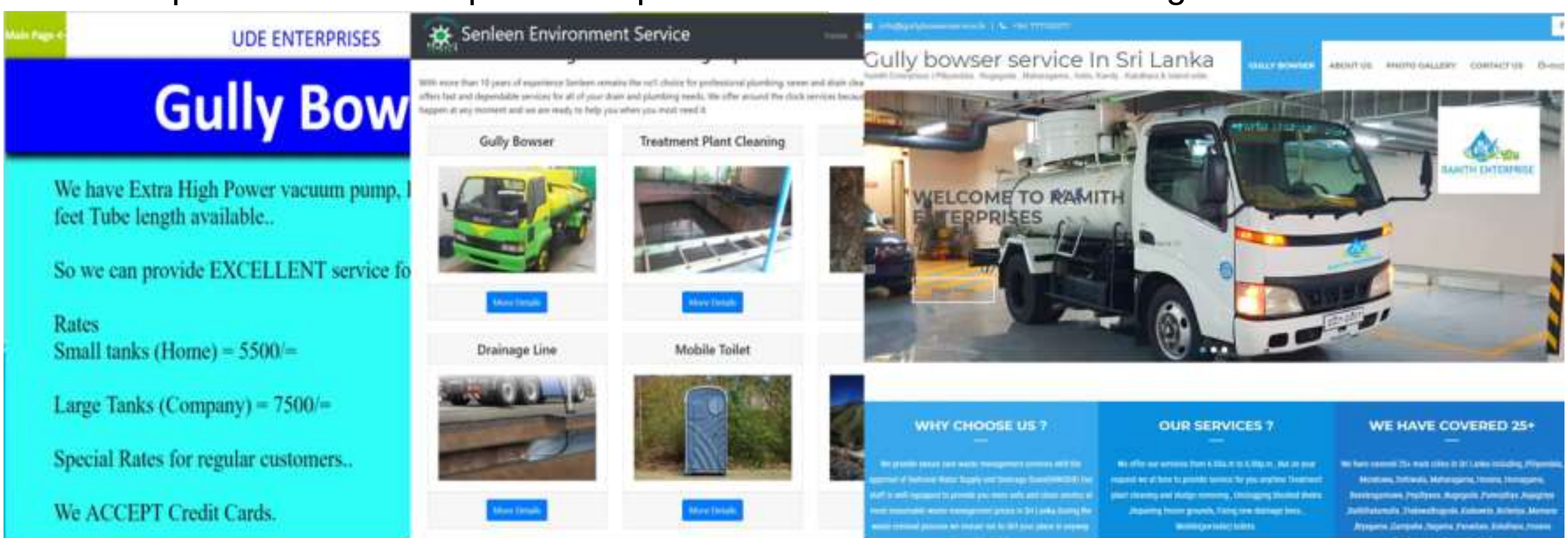
Recommendations

- Partnering with international development cooperation requires know-how to disseminate low-maintenance DEWATS technologies country-wide in Sri Lanka.

De-sludging service providers

Desludging services Description

Desludging services for septic tanks can be found in all regions of Sri Lanka, especially where high groundwater table and/or soils limited infiltration rates donot allow a soakaway of septage. Highest demand for gully-bowser services is documented during the rainy season when septic tanks tend to to overflow. Whereas a majority of so called “gully-bowser trucks” are operated by private businesses in the Colombo Metropolitan area, public gully-bowsers run by the local authorities are the dominant service providers in the more rural areas of Sri Lanka. Private enterpreneurs own and operate up to 10 trucks in Metro Colombo, the fleets of local authorities is generall limited in numbers to 1 – 3 trucks due to public funding constraints for investments. Some public treatment and disposal sites in rural areas also do prohibit disposal of septage by private operators, hence establishing a monopoly for public gully-bowsers as unregulated disposal of septage is prohibited in Sri Lanka. Fees for septage collection vary according to location and volume between $ 20 to $ 60, depending on the size of competition. A general assement sheet for public service providers is based on responses from multiple municipal and urban council staff during the assessments.



Desludging service provider UDE — Assessment

Management and staff: Based in Gampaha District, north of Colombo; start-up of business 6 month ago. Owner is a medical doctor who runs a number of other small businesses.

Costs, Income, Outlook: About 75 trips per month; Costs amount to $1,500 per month (incl. leasing, staff, maintenance costs). Current monthly profit reported to be $200. Good business opportunities due to high groundwater table (1 m) in the area

Marketing and clients: Website; ikman.lk; Provides sms services for clients as emptying intervals are short (3-6 months) in the region. Short response time to requests. Payment by credit card possible; No tipping of staff by clients required. Client base consists of 70% households and 30% businesses with black-water holding tanks.

Vehicle fleet: 1 truck with a volume of 7,000 l. It is parked overnight at a fuel-station near the owner's house.

Disposal: At Madampitiya pump house (operated Colombo Municipal Council)

Challenges: Faces difficulty to empty old septic tanks with crusted sludge and scum;

Strengths

- Dynamic start-up
- Demand and client oriented business attitude
- Fast and friendly service provider that knows limitations of public services

Weaknesses

- Experience related to emptying black-water holding tanks only – not septic tanks
- Dependence on public provider of sludge disposal services

Recommendations

- Addition of another business unit for septic tank installation would bring additional benefits for desludging services.

Desludging service provider RAMITH Assessment

Management and staff: Father of the business owner was a gully-bowser driver of the Council. Business in operation for 12 years. 2 persons, driver and assistant, are employed on one truck.

Costs, Income and Outlook: Trucks are leased. Monthly running costs amount to $230;

Marketing and clients: Ramith offers 24/7 services on short notice. Marketing via Internet, Facebook.

Vehicle fleet: The fleet comprises of 5 trucks which range from a size of 3 to 12 tons.

Disposal: Discharge of septage at the wastewater treatment plant of NWSDB in Dehiwala.

Challenges reported: Lack of support and cooperation of FS treatment plant operated by the NWSDB: Limitation of disposal permits, disposal site operated only between 10am – 4 pm. Long queue, sometimes closed

Strengths

- Motivated owner-managed SME
- Operational radius up to 50 km
- Different truck sizes allow for efficient service provision and also storage of septage if needed

Weaknesses

- Lack of regulatory framework for disposal creates business risk
- Limited capacity for septage disposal hampers growth of business

Recommendations

- In future, gully-bowser service providers ought to be eligible to build and operate an FSTPs according to standards provided by NWSDB.

Desludging service provider LA Assessment

Management and staff: Public health department is responsible for the waste management in a town. No professional management. A crew of 2 (driver and assistant) operate the truck and are trained on-the-job.

Costs, income, outlook: Trucks are operated only during office hours. Clients have to book desludging weeks in advance when no private services available. Gully-bowser services provide a regular stream of income for local authorities. Highest collection fees reported in Jaffna ($ 50 – by low-income housing project)

Marketing and clients: No marketing. No regulated de-sludging intervals. Clients must call-in weeks in advance.

Fleet: Fleets comprise of 1-3 trucks of 3 to 10 m^3 volume.

Disposal: Septage collected is disposed at a solid waste disposal site or at an FSTP operated by local authorities.

Challenges reported: Limited business planning and growth potential. Performance of business depends on the number of gully-bowsers in operation. Extremely limited budget for operation & maintenance.

Strengths

- Income from sludge collection contributes to reduction of government subsidies for waste management
- Sludge collection, treatment and refinement (drying, composting) are combined within one service provider.

Weaknesses

- Emptying and collection fees cover only the costs of operation and maintenance – not depreciation of capital (trucks)
- Business hours are limited and not demand/ customer oriented
- Reliant on international aid industry for procurement of gully-bowser trucks

Recommendations

- Gully-bowser crews could contribute to operation of FSTP during the time of septage disposal.

Decentralized Wastewater Treatment Systems (DEWATS)

Types of DEWATS found in Sri Lanka

Many different types of “Decentralised Wastewater Treatment Systems” (DEWATS) with a daily treatment capacity of up to 1,000 m^3 of wastewater per day can be found in Sri Lanka. They can be classified as follows:

a) Low-cost, low-maintenance systems based on septic tanks and anaerobic baffled reactors (ABR) for low-income, multi-storey housing projects (Jaffna, Ratmalana, Lunawa)

b) Pond / lagoon systems connected to small sewerage systems (Hikkaduwa)

c) Oxidation ditch type plants (Panadura, Batticaloa hospital)

d) Compact aerobic sequential batch reactors (SBR), both prefabricated and customized (hotels, apartment houses, institutions)

e) Rotating biological contactors (hotels)

f) Moving-Bed-Bio-Reactor (MBBR) for hotel area in Pasikuda Beach (near Batticaloa)

g) Pre-fabricated compact treatment plants (e.g. Jokasso)

h) Simplified extension of sewerage systems in combination with a pumping station allows for treatment of wastewater from low-income areas in municipal sewage treatment plants (i.e. GPOBA program)

- Assessments in this chapter focus on DEWATS types a), b), c), f) and h)

a) DEWATS – Ratmalana Description

The current system was commissioned by NWSDB in 2016 under the “Global Partnership on Output Based Aid Project” (GPOBA). The treatment plant serves 328 apartments of 8 apartment blocks. The plant is divided into inter-connected treatment modules. Septic tanks provide primary mechanical treatment and are located in between the apartment blocks. Other treatment modules are located on a nearby 5,000 m^2 plot where a small pumping station lifts the pre-treated WW from the septic tanks into a splitter box from where the WW is directed into 2 anaerobic baffled reactors (ABR) that are connected to planted gravel filters from where the treated effluent is discharged. The Ratmalana DEWATS is located only about 750 m away from the NWSDB Head Office and Galle Road.








a) DEWATS - Ratmalana Assessment

Management:
Overall management is with the NWSDB which was also responsible for project implementation under GPOBA.

Costs: 48 Mio LKR (eqv. $ 330,000; 35 Mio LKR for construction and 13 Mio LKR for rehabilitation)

Physical Infrastructure:
Construction quality is poor. The ABR is leaking, the upper half of the ABR superstructure is not underground, connection pipes to HSFs hang in the air.

Technical design and treatment efficiency:
The ABR is over-dimensioned. Wetland/ gravel filter design is faulty (neither horizontal nor vertical!). Manholes in are ABR missing.

Operation & maintenance:
Wetland is poorly maintained and subsurface flow is blocked. Desludging done free of charge by NWSDB (subsidized coupon-based payment system)

Resource Recovery and Re-use:
NA._Faecal sludge transported for treatment to MSTP in Soysapura, Moratuwa.

Strengths

- Piloting and demonstration of low-maintenance DEWATS in low-cost housing project
- Innovative, subsidized payment system (pre-paid coupons) for desludging of septic tanks

Weaknesses

- Oversized treatment plant
- Unprofessional design
- Low construction quality (corrosion resistant cement not used)
- No O&M manual or SOP available

Recommendations

- Follow standardized guidelines for design and construction of low-cost DEWATS
- Improve skills of NWSDB construction supervisors

DEWATS – Lunawa Description

The Lunawa Samudra Shakthi low-income housing scheme is situated in Moratuwa close to the sea. 160 apartments with 800 people are located in a total of eight 4-storey housing units. A stand-alone DEWATS system was implemented as the housing complex is located over 1.5 kilometers away from the existing sewerage network.

Existing septic tanks between the houses were rehabilitated and connected to newly built anaerobic baffled reactors (ABR) and anaerobic filter reactors (AF). A gravity collection network along the road is connected to a pumping station from where the effluent is pumped across the Puranappu Raja Mawatha railway line into the sea.




a) DEWATS - Lunawa Assessment

Management:
Overall management is with the NWSDB which was also responsible for project implementation under GPOBA.

Implementation Costs: 29 Mio LKR (eqv. $ 200,000)

Physical Infrastructure:
Construction quality is poor. The ABR is leaking, the upper half of the ABR superstructure is not underground, connection pipes to HSFs hang in the air.

Technical design and treatment efficiency:
The ABR is over-dimensioned. Wetland/ gravel filter design is faulty (neither horizontal nor vertical!). Manholes in ABR are missing.

Operation & maintenance:
Wetland is poorly maintained and subsurface flow is blocked. Desludging done free of charge by NWSDB (subsidized coupon-based payment system).

Resource Recovery and Re-use:
NA._Faecal sludge transported for treatment to MSTP in Soysapura, Moratuwa.

Strengths

- Piloting and demonstration of low-maintenance DEWATS in a low-cost housing project
- Innovative, subsidized payment system (pre-paid coupons) for desludging of septic tanks

Weaknesses

- Oversized treatment plant
- Unprofessional design
- Low construction quality (corrosion resistant cement not used)
- No O&M manual or SOP available

Recommendations

- Develop and follow standardized guidelines for design and construction of low-cost DEWATS
- Improve skills of NWSDB construction supervisors

a) DEWATS – Badowita Description

The current system was commissioned by NWSDB in 2016 under the “Global Partnership on Output Based Aid Project.” It connects a simplified sewer system via 3 pumping stations to the conventional sewerage system and MSTP in Moratuwa. The simplified sewerage systems serves 7,000 people in about 1,500 households.

a) DEWATS - Badowita Assessment

Management:
Overall management is with the NWSDB which was also responsible for project implementation under GPOBA.

Costs: 558 Mio LKR (eqv. of $ 3,85 Mio)

Physical Infrastructure: Excellent construction quality of simplified sewerage system, main collection tank and pumping station.

Technical design and treatment efficiency:

Operation & maintenance:
Wetland is poorly maintained and subsurface flow is blocked. Desludging done free of charge by NWSDB (subsidized coupon-based payment system)

Resource Recovery and Re-use:
NA._Faecal sludge transported for treatment to MSTP in Soysapura, Moratuwa.

Strengths

- Piloting and demonstration of low-maintenance DEWATS in low-cost housing project
- Innovative, subsidized payment system (pre-paid coupons) for desludging of septic tanks

Weaknesses

- Oversized treatment plant
- Unprofessional design
- Low construction quality (corrosion resistant cement not used)
- No O&M manual or SOP available

Recommendations

- Follow standardized guidelines for design and construction of low-cost DEWATS
- Improve skills of NWSDB construction supervisors

a) DEWATS – Jaffna Description

Under the Ministry of Housing, Construction and Cultural Affairs, a four-story apartment complex with a total of 160 apartments for 800 people was constructed for Jaffna's fishing community in 2014. Drinking water is supplied from an open well. Water is pumped up into a storage tank located on a tower near the apartment blocks. Domestic wastewater is collected between 2 apartment blocks in open drains (gray water) which is directed into the harbor. The black water is piped into a number of shallow septic tanks (10 apartments share one shallow septic tank with a treatment capacity of 1.5 - 2 m^3; 16 septic tanks with total pre-treatment capacity in total) which are linked to a partially underground DEWATS plant that is positioned beside the apartment complex near a meeting hall and a church close to the sea. From there the effluent is discharged via an underground pipe into the port (see picture on the right below). Due to the high ground-water table, soak-away of effluent is not possible. Residents cover the total costs for operation and maintenance of water & sanitation services by monthly fees.



a) DEWATS - Jaffna Assessment

Management:
Ministry of Housing, Construction and Cultural Affairs is responsible for overall management.

Costs/Income:
Information of investment costs were not provided.

Physical Infrastructure:
Physical infrastructure implemented by government contractor. Poor quality – manholes of septic tanks and open drains are broken. ABR is only partly constructed underground and has no manholes

Technical design and treatment efficiency:
Septic tanks are under-dimensioned and its depth does not comply with SL standards and regulations. 6 monthly desludging intervals at a cost of LKR 10,000 (eqv. $ 60)

Operation & maintenance:
Managed by community-based organisation which also manages the contributions. Main expenses are electricity for the water pump and desludging fees.

Resource Recovery and Re-use:
NA - No FSTP or WWTP in Jaffna. Faecal sludge is disposed at solid waste disposal site.

Strengths

- Low-cost housing project for fishermen with integrated low-maintenance wastewater treatment facilities
- Resident managed operation & maintenance of W&S infrastructure

Weaknesses

- In appropriate size and design of septic tanks, therefore very short and costly desludging intervals
- Septic tanks lids broken
- No treatment of greywater – open discharge
- Faulty ABR construction and design

Recommendations

- Replace existing septic tanks with deeper and larger units to improve pre-treatment and desludging intervals
- Direct grey water from houses into ABR via collection and piping system

a) DEWATS – Panadura Description

The DEWATS plant is an “Oxidation” Ditch type which was originally built in 1992 but then rehabilitated after the Tsunami. The design capacity is 650 m^3 / day, but actually only 400 m^3 / day are treated from 300 low-cost apartments and from 4 nearby factories. The plant does not accept fecal sludge for treatment. 4 staff are employed to operate the plant and the sewage network with 5 pumping stations. According to the officer in charge, monthly operational expenses amount to about LKR 400,000 (eqv. $ 2,500) whereas monthly income from fees is estimated to be about 100,000 (eqv. $ 615) or LKR 100 for each apartment.

a) DEWATS - Panadura Assessment

Management: Management by NWSDB

Costs/Income: NA; plant was constructed in 1992 and then rehabilitated after the Tsunami in 2008 for $140,000; monthly operational cost (labour 2/3, electricity 1/3) amount to $ 2,500 whereas income from residents and factories amount to eqv. $ 600

Physical Infrastructure: Designed treatment capacity 650 m^3 /day, actual treatment capacity 400 m^3 /day; Scraper of clarifier broken, rapid sand-filter out of order for years, only one out 2 mounted aerators in operation.

Technical design and treatment efficiency: Oxidation ditch with mounted aerators and recirculation of sludge from clarifier. Due to broken equipment that has not been replaced / repaired, treatment standards cannot be met.

Operation & maintenance: Carried out by a small NWSDB team – technician, 3 sanitary workers one guard.

Resource Recovery and Re-use: Farmers collect and use dried sludge for coconut plantations. Effluent is discharged via a 2.5 km long pipe into the Thalpitiya Lake.

Strengths

- Integrated liquid-solid waste management concept is followed
- Post-treatment of partly dried sludge in composting plant

Weaknesses

- Effluent quality does not match standards
- Necessary repairs (mounted aerator) not carried out in time
- Neither operation manual nor SOP available for O&M staff.
- No faecal sludge is accepted for treatment

Recommendations

- Carry out necessary repairs within 1 month
- Add an appropriate (50 m^3) faecal sludge disposal/transfer station (with sedimentation, equalising tanks, feeder pump and drying beds .

a) DEWATS – Hikkaduwa Description

The plant went in operation in 2010 and was co-financed with Australian TA funds. The pond/lagoon system consists of 2 facultative and 1 polishing lagoon. Designed treatment capacity is 1.000 m^3 per day. Actual treatment capacity between 800 - 900 m^3 per day from 180 private households and 60 hotels. In addition 40 m^3 of fecal sludge collected by local authorities is treated. Hotels demand expansion of services. Treatment fees amount to 245 LKR/ m^3, calculated WW treatment volume is equal to 80% of water consumption. Main expenses for the plant are for electricity (3 pumping stations) and its 10 staff. According to the plant technicians, the income of the plant (from fees and 2 gully-bowsers) is higher than the expenses. The visual effluent quality is good and effluent discharge standards were met throughout the operation of the plant. A very well managed and sustainable low-maintenance lagoon treatment plant. An extension of the plants treatment capacity may be possible through construction of a additional sedimentation tanks at the inlet of the lagoon and additional aerators.

a) DEWATS - Hikkaduwa Assessment

Management: By NWSDB; Two engineers employed for plant management

Costs / Income: Investment Costs = NA; Operation and maintenance costs = salaries and electricity for 3 pumping stations; sewage treatment fees are linked to drinking the water consumption and amount to LKR 245 / m^3, septage disposal fees amount to LKR 225 / m^3

Physical Infrastructure: Well designed and built physical infrastructure in 2009; designed treatment capacity 1.000 m^3 / day; 80 % of capacity utilized.

Technical design and treatment efficiency: Facultative, aerobic oxidation pond treatment plant type without technical aeration but with integrated faecal sludge disposal station. Variation of the height of a weir at the discharge point allows for reduction and increasing hydraulic retention time. Effluent quality good;

Operation & maintenance: Work is carried out by 8 sanitary workers and 2engineers. Calculated de-sludging interval is 8 years

Resource Recovery and Re-use: During desludging of pond (duration: 4 weeks), sludge is disposed in trenches in nearby plantations.

Strengths

- Well constructed and maintained treatment plant with integrated sludge disposal point.
- Financial sustainability - income from fees (annual income estimated around $ 30,000) covers operation and maintenance costs of the plant.

Weaknesses

- Despite high demand from hotels, no additional sewerage connections and treatment capacity has been provided.

Recommendations

- Increase treatment capacity through technical aeration (raft mounted aerators) and reduced de-sludging intervals by 50%
- Provide appropriate low-cost facilities for sludge drying/composting on the compound

a) DEWATS – Batticaloa Description

The Batticoloa teaching hospital and the provincial prison share a WWTP. The hospital alone has 1,250 beds and 6.500 daily outpatients. Data from the prison were not available. Designed treatment capacity amounts to 750 m³ /day. Treatment modules consist of an oxidation ditch with mounted aerators and floor based diffusers, a clarifier with scraper, a settler for sludge, a chlorination device and a polishing pond before effluent is discharged into the Batticaloa lagoon. Residual sewage sludge is dried on the surface within the WWTP compound. The operator team consists of 4 craftsman (plumber, mechanic, electricians) who are employed by the hospital. Sludge is dried on the ground before being collected by farmers. Additional discharge of wastewater from a new hospital wing under construction will increase hydraulic and pollution loads.

a) DEWATS - Batticaloa Assessment

Management: By the hospitals technical housekeeping department.

Costs: Built and financed under an ADB loan in 2009; Operational costs amount to nearly $ 5.000/month (75 % electricity & fuel, 25% salaries). No financial contributions from prison for O&M.

Physical Infrastructure: The plant covers an area of about 5,000 m^2 in the centre of town near the lagoon. The oxidation ditch treatment system seems to be well worn, but still functioning (no broken aerators or diffusers)

Technical design and treatment efficiency: Aerobic oxidation ditch system with a designed treatment capacity of 750 m^3 / day The plant is at the edge of its capacity and it seems that not all sedimented sludge is recirculated.

Operation & maintenance: A team of 4 hospital employed craftsmen (electrician, plumber, mechanics) are responsible for daily operation. Spare parts are replaced in time, back-up pumps are in stock within hospital.

Resource Recovery and Re-use: Some sludge is dried ad-hoc within the compound and send to the municipal council for sale as organic fertiliser.

Strengths

- Well operated and maintained aerobic treatment plant with technical aeration in large hospital compound

Weaknesses

- Plant will be overloaded after extension of new hospital wing
- Costly operation due to high electricity costs for aeration devices
- Lack of space for expansion of treatment capacity

Recommendations

- Install 2 parallel, deep high volume anaerobic sedimentation tanks as pre-treatment
- Fill up part of maturation pond to install additional WW treatment capacity

a) DEWATS – Passikudah Description

First BOT (20 years) for WWTP in Sri Lanka und the Sri Lankan Tourism Authority. Project has been completed under a JV between Hayley/Puritas and Veolia India in 2012 and is managed by a company established for the BOT, Lakdiyatha. The moving-bed biofilm reactor (MBBR) system has a designed treatment capacity of 750 m^3 /day for domestic wastewater from 14 beach hotels (variation of inflow!). The sewerage line has 5 pumping stations, grease-trap and control chamber are located at hotels. Treated effluent is re-used for irrigation of hotel gardens. 4 operators are assigned to the plant to work 24/7.

a) DEWATS - Passikudah Assessment

Management: Lakdiyatha company is responsible for the general management of the WWTP under an BOT agreement with the Ministry of Tourism Development.

Costs/income: Total investment costs = 185 Mio. LKR (eqv. $1,3 Mio); O & M costs estimated at $3,000 per month; income cover costs.

Physical Infrastructure: Physical infrastructure consists of multi-chamber anaerobic sedimentation tanks which are connected to (out of which residual sludge from the bottom is discharged into drying beds) aerated tanks with MBBR plastic media from where the WW is directed to clarifiers and chlorination tank before effluent is discharged.

Technical design and treatment efficiency: MBBR design prepared jointly by Puritas and Veolia for 13 hotels with a total of 930 rooms equalling 750 m^3 /day.

Operation & maintenance: Plant is well maintained and operated by trained workers from Puritas 24/7.

Resource Recovery and Re-use: Effluent is collected in tanks and pumped back for re-use to hotels. Dried Sludge is dried and collected by farmers.

Strengths

- Exemplary BOT wastewater treatment project in Sri Lanka
- Trained operation and maintenance staff
- Excellent treatment efficiency
- RRR of effluent for irrigation of hotel gardens and reuse of dried sludge
- Financially sustainable
- Compact and power efficient aerobic WWT

Weaknesses

- Regular maintenance of grease traps and grit chambers at hotels is not controlled and led to breakdown of clarifier

Recommendations

- Add grease trap and grit chamber at inlet of MBBR in addition to devices at hotels

Fecal Sludge Treatment Plants (FSTP)

Main characteristics of FSTPs

- Compact open, inter-connected sedimentation tank systems with integrated sludge drying beds (with treatment capacities of 7,5 to 25 m^3 per day) can be found on the waste disposal sites of towns of towns, often integrated within PILISARU waste recycling stations, throughout Sri Lanka. The original design that was initially developed by JICA in cooperation with the Ministry of Local Authorities has undergone a number of variations.
- Large pond-lagoon systems based on anaerobic sedimentation, facultative laggons/ponds (with treatment capacities of 25 – 30 m^3 per day) have been implemented in the northern regions of Sri Lanka. The large compounds are often unguarded and unprotected.
- Co-treatment of FS in Municipal Sewage Treatment Plants (MSTP) is practiced in lagoon-type systems as well as in 2 anoxic-oxic type treatment plants in the Greater Colomboi area (Ja-Ela, Soyzapura). Here, gully-bowser stations take the septage, mix it with treated effluent and direct it back to a separate inlet grit of the MSTP to avoid an inflow of additional solid particles.
- The MSTP in Soyzapura has documented the daily disposal of septage and has analyzed samples of disposed septage in its lab since 2016.
- However, the majority of FSTPs do not document origin and amount of septage disposed.
- The majority of FSTPs managed by local authorities, septage from public institutions (hospitals, army camps, etc.) is disposed free of charge.

Findings and assessment of FSTP

Compact inter-connected open tank-type FSTPs

This type of FSTP consists of the following modules:

1. Discharge tank for gully-bowsers

2. Interconnected, open anaerobic sedimentation tanks (depth = 1.8 m; designed hydraulic retention time appx. 7 days)

3. Interconnected aerobic tanks (depth 1.2 m; hydraulic retention time appx. 10 days)

4. Elevated sludge drying beds (SDB) located above the sedimentation tanks. (depth 0.3 m, calculated drying time of sludge appx. 3 months) Leachate from SDBs is directed back into sedimentation tanks.

FSTP Kurunegala Description

The open-tank FSTP of Kurunegala is located at the Councils site for waste disposal and recycling. According to estimates of the site manager, 15 gully-bowser trucks dispose up to 50 m^3 septage daily into the plant. Spill-over and overflow of raw sewage sludge during the rainy season. Due to overload, all privately operated septage trucks are directed to dispose sludge untreated at the nearby solid waste disposal site on the compound.

FSTP Kurunegala Assessment

Management: Municipal Council - Public Health Department. Medical doctor in charge has limited knowhow about FSM. Operation and maintenance staff not formally trained. About 15 private and public trucks discharge septage into the plant daily.

Costs: Investment Costs in 2014: 7 Mio LKR (eqv. $ 60,000); Operation and maintenance costs are limited to staff at LKR 40,000/month (eqv. $ 220) for one worker

Physical Infrastructure: Physical infrastructure implemented under UNOPS for treatment of 15-20 m^3 /day. Space requirement of existing plant amounts to 500 m^2. No detection of leakage but regular spill-overs.

Technical design and treatment efficiency: Open, inter-connected sedimentation tank design. The plant is overloaded by 100-200%.

Operation & maintenance: Work is carried out ad-hoc by un-skilled staff of the recycling plant/ disposal site. No operation manual, no standardized operational procedures SOP in place.

Resource Recovery and Re-use: Dried Sludge is dried and co-composted with other bio-waste materials within a composting plant nearby on the compound.

Strengths

- Integrated liquid-solid waste management concept is followed
- Post-treatment of partly dried sludge in composting plant

Weaknesses

- Effluent quality does not match standards
- Neither operation manual nor SOP available for O & M staff
- Plant is overloaded by 100-200 %
- Size of drying beds too small

Recommendations

- Construct an additional, compact FSTP on the site in order to stop overloading of existing plant
- Add drying-beds for sedimented sludge to improve effluent quality as ad-hoc activity
- Allow co-treatment of FS in new MSTP by managed by NWSDB to reduce overload of existing FSTPs managed by LA

FSTP Nuwara Eliya Description

According to staff in charge of the plant in Nuwara Eliyah, the FSTP located on the town‘s waste disposal site (PILISARU) is constantly overloaded and needs to be replaced or extended.

Existing open, inter-connected tanks allow only for insufficient mechanical and biological treatment of FS. Required de-sludging of tanks and drying of solids is not done. Marketing of bio-waste fertiliser is not done despite high demand by farmers in the region for organic fertilisers.

FSTP Nuwara Eliya Assessment

Management: Municipal Council - Public Health Department. Medical doctor in charge has limited knowhow about FSM. Current operation and maintenance staff trained on the job. About 44 m^3 septage daily discharged into the plant by public private and gully-bowsers.

Costs: Investment Costs = NA; Operation and maintenance costs are limited to staff at LKR 40,000/month (one worker).

Physical Infrastructure: Physical infrastructure implemented under JICA for treatment of 15-20 m^3 /day. Space requirement of existing plant amounts to 500 m^2. No drying beds for sludge.

Technical design and treatment efficiency: Open, inter-connected sedimentation tank design. The plant is overloaded by 50-100 %.

Operation & maintenance: Work is carried out by dedicated staff of the recycling plant / disposal site. No operation manual, no standardized operational procedures (SOP) for regular and routine work in place.

Resource Recovery and Re-use: According to staff, dried sludge is used irregularly as organic fertiliser in parks of the town.

Strengths

- Integrated liquid-solid waste management concept is followed
- Partly re-use of dried sludge as organic fertilisers

Weaknesses

- Effluent quality does not match standards
- Effluent is discharged into the Bomburuella reservoir together with leachate from solid waste disposal site.
- Estimated overload of plant by 50-100 % based on its designed treatment capacity
- No drying beds integrated within the FSTP

Recommendations

- Construction of drying-beds for sedimented sludge required to improve effluent quality.
- Construction of additional compact and low-cost FSTP besides the existing one.

FSTP Ratnapura Description

The FSTP in Ratnapura with a treatment capacity of 25 m^3/day has been in operation since 2019. The FSTP is part of the waste disposal and recycling station of the town and was constructed on a slope at a corner of the waste disposal site which has an integrated PILISARU waste recycling center. The open, inter-connected tank design seen in other FSTP has been modified (drying beds for sedimented sludge located at lowest point of the plant is fed via mechanical valves) and roofed (against overflow during heavy rains). According to the Public Health Inspector of Ratnapura (a medical doctor), the open tanks were covered with curtains to prevent a spread of diseases by insects.

FSTP Ratnapura Assessment

Management: Municipal Council - Public Health Department. Medical doctor in charge has limited knowhow about FSM. Current operation and maintenance staff were trained on the job.

Costs: Investment Costs LKR 31 Million ($ 170,400); Operation and maintenance costs are limited to on-site staff hired at a rate of LKR 40,000/month (one worker)

Physical Infrastructure: Physical infrastructure implemented under an UNESCAP project for treatment of 40 m^3 septage/day. Space requirement of existing plant = 500 m^2. Location of drying beds for sludge at lowest point of FSTP allows a discharge of sedimented sludge without pumps.

Technical design and treatment efficiency: Open, inter-connected sedimentation tank design. AS drying bed is located at the bottom of the

Operation & maintenance: Work is carried out by dedicated staff of the recycling plant/ disposal site. No operation manual, no standardized operational procedures (SOP) for regular and routine work in place.

Resource Recovery and Re-use: According to staff, dried sludge is used irregularly as organic fertiliser in parks of the town.

Strengths

- Integrated liquid-solid waste management concept is followed
- Partly re-use of dried sludge as organic fertilisers

Weaknesses

- Low visual effluent quality does not match standards
- Plant is overloaded by 50-100 % based on its designed treatment capacity

Recommendations

- Construction of additional drying-beds for sedimented sludge required to improve effluent quality
- Regular removal of settled sludge required to improve effluent quality
- Allow for sludge treatment in new MSTP

FSTP Balangoda Description

Lacking early separation of liquids and solids, series of open inter-connected sedimentation tanks, floating coir-fibers as medium for aerobic bacteria and elevated sludge drying beds characterise this FSTP design. The inter-connected open tanks are difficult to desludge and tend to verflow especially in the rainy season.
The technical design resembles the so-called “covered anaerobic ditch” system, CAD, (a modification of the anaerobic filter system in which coir fibers are used as low-cost filter medium) developed for the natural rubber industry in Sri Lanka during the 1990‘s, without covers.

FSTP Balangoda Assessment

Management: Municipal Council - Public Health Department. Medical doctor in charge has limited knowhow about FSM. Current operation and maintenance staff trained on the job. About 44 m^3 septage discharged into the plant daily by public private and gully-bowsers.

Costs: Investment Costs = NA; Operation and maintenance costs are limited to staff at LKR 40,000/month (one worker).

Physical Infrastructure: Physical infrastructure implemented under UNOPS for treatment of 15-20 m^3 / day. Space requirement of existing plant amounts to 600 m^2. No drying beds for sludge.

Technical design and treatment efficiency: Based on the open, inter-connected sedimentation tank design of JICA. Effluent quality does not match standards.

Operation & maintenance: Work is carried out by dedicated staff of the recycling plant/ disposal site. No operation manual, no standardized operational procedures (SOP) for regular and routine work in place.

Resource Recovery and Re-use: According to staff, dried sludge is used irregularly as organic fertiliser in parks of the town.

Strengths

- Integrated liquid-solid waste management concept is followed
- Partly re-use of dried sludge as organic fertilisers

Weaknesses

- Low visual effluent quality does not match standards
- Plant is overloaded by 50-100 % based on its designed treatment capacity
- Utilizing drying bed requires additional energy

Recommendations

- Construction of additional drying-beds for sedimented sludge required to improve effluent quality
- Regular removal of settled sludge required to improve effluent quality
- Allow for sludge treatment in new MSTP

FSTP Tangalle Description

According to the Secretary of the Urban Council, the Tangalle FSTP has been rehabilitated by JICA for LKR 1.5 Mio in 2011. The open-tank aerobic treatment design of the plant is remicent to other FSTPs visited. The plant receives about 7.5 cbm of fecal sludge from the single gully-bowser truck operated urban council. Private gully-bowser operators have no access. Visual quality of effluent is good. The open tank-system seems to be run at or under-capacity (7.5 m^3 /day). Due to smell and bad hygiene, the original coir-filter was removed and replaced with water hyacinths (its application is not allowed in Sri Lanka!). Tanks tend to overflow during the rainy season. Sludge from sedimentation tanks is being pumped into elevated drying beds, leachate is recirculated. Sludge is dried for 3 months and then sold (auctionned!) to plantations.

FSTP Tangalle Assessment

Management: Municipal Council - Public Health Department. Current operation and maintenance staff were trained on the job. About 7.5 m^3 septage per daily discharged into the plant by public private and gully-bowsers.

Costs: Investment Costs = NA ; Operation and maintenance costs are limited to staff at LKR 40,000/month (one worker)

Physical Infrastructure: Physical infrastructure implemented under UNOPS for treatment of 15-20 m^3 /day. Space requirement of existing plant amounts to 500 m.

Technical design and treatment efficiency: Open, inter-connected sedimentation tank design. Coconut fibre surface filters were removed due to smell and replaced by water hyacinths (despite prohibition)

Operation & maintenance: Work is carried out by dedicated staff of the recycling plant/ disposal site. No operation manual, no standardized operational procedures (SOP) for regular and routine work in place.

Resource Recovery and Re-use: According to staff, dried sludge is used irregularly as organic fertiliser in parks of the town.

Strengths

- Integrated liquid-solid waste management concept is followed (PILISARU)
- Sufficient space (total area = 3 ha)
- Good O & M of facility
- Dried sludge is directly sold (auctioned!) to plantations or co-composted, packed and sold
- Good visual quality of effluent and compost

Weaknesses

- Un-efficient, un-safe FSTP design
- Low capacity (only 7.5 m^3 /day)
- Private gully-bowser services not allowed to discharge septage

Recommendations

- Extension of FS treatment facilities is possible according to demand

FSTP Ampara Description

FSTP is located at the the town‘s solid waste disposal site (total area covers over 10 ha) and material recovery facility. According to staff, it is not known how to operate the FSTP which was constructed with support by UNOPS in 2018. It features an elevated ramp for gully-bowsers with septage discharge point connected to a sedimentation tank. Baffled tanks which are covered with pre-fabricated roofing material, 2 sand filterbeds and polishing ponds for the effluent are additional treatment modules. Due to a lack of pumping equipment, sludge from the baffled tanks could not be pumped into the elevated sand-beds and, hence, the plant was abandonned. Disposal of sludge is now done in the open without any treatment. The operator of the plant reports that no operation manual was provided and no technical support was given during the start-up of the new plant.

FSTP Ampara Assessment

Management: Municipal Council - Public Health Department. Medical doctor in charge has limited knowhow about FSM. Current operation and maintenance staff trained on the job. 2 gully-bowser trucks operated by the municipality.

Costs: Investment Costs were covered by an UNOPS grant;

Physical Infrastructure: Not in operation; construction costs funded by UNOPS; supervision by TSU of NWSDB; landscaping and elevated placement of treatment modules; disposal on top of the FSTP; designed treatment volume for treatment of 15-20 m^3 /day. Space requirement of existing plant = 750 m^2. Solid-liquid separation of septage requires pumping;

Technical design and treatment efficiency: Open, inter-connected sedimentation tank design. Covered by prefabricated roofing. Plant is not in operation due to lack of pump.

Operation & maintenance: Work is supposed to be carried out by staff of the recycling plant / disposal site. No operation manual and SOP.

Resource Recovery and Re-use: If operated, dried sludge could be sold independently or co-composted and sold as bio-waste compost.

Strengths

- Integrated liquid/ solid waste management concept is followed

Weaknesses

- FSTP not in operation due to lack of operational knowledge
- Septage is dumped into the open creating a “lagoon” that may burst

Recommendations

- Rehabilitation and repair of all treatment modules and clean-up of FSTP needed
- Train gully-bowser crews to empty bottom sludge from sedimentation tanks into sand-bed filters
- Allow for sludge treatment in new MSTP

FSTP Trincomalee Description

An open-tank FSTP (similar design as the FSTPs in Nuwara Eliya, Balangoda, Ratnapura, Tangalle, Kurunegala, etc.) was constructed under the previous local administration at the edge of the towns solid waste disposal site. As the elevated sludge drying bed of the plant is unused, it appears that the plant was abandoned at an early stage due to the lack of a sludge pump. Treatment volume of the FSTP is similar to the FSTP observed in Tangalle district (treatment capacity = 15 m^3 /day). Remaining fecal sludge in the plant is completely dried and allows for an easy rehabilitation of infrastructure. No staff is currently employed for the operation of the FSTP by the Urban Council. Septage is disposed by 4 gully-bowsers operated by the Council beside the abandoned plant onto the solid waste.




FSTP Trincomalee Assessment

Management: Urban Council. The Public Health inspector in charge appeared not to have any Knowledge about domestic wastewater of faecal sludge treatment. No one is in charge to operate and manage the facility but 4 gully—bowser trucks operate in town.

Costs: NA

Physical Infrastructure: Physical infrastructure designed and implemented in cooperation with UNOPS. Can be rehabilitated and extended at low-cost. Space requirement of existing plant = 350 m^3

Technical design and treatment efficiency: The designed treatment volume is 15 m^3 / day. 6 open sedimentation and aeration tanks in a row. Elevated sludge drying bed with re-circulation of leachate into the first tank. Sludge pumps needed.

Operation & maintenance: No operational staff employed.

Resource Recovery and Re-use: Dumping practices observed does not allow for drying or composting of FS. Disposed sludge is not utilized.

Strengths

- None

Weaknesses

- FSTP abandoned after start up
- Urban Council takes a passive role
- No staff for O & M employed
- No equipment for basic O & M activities
- Staff of gully-bowsers do not assist in operation of plant

Recommendations

- Rehabilitate existing FSTP infrastructure at a cost of about LKR 3.5 Mio (eqv. $ 20,000)
- Resume operation of the FSTP
- Delegate gully-bowser staff of Council to operate and maintain the plant
- Extend FS treatment to 30 m^3 /day on existing premises

Findings and assessment of FSTP

Lagoon-type FSTPs

FSTP Chillaw Description

The FSTP with a designed treatment capacity for 30 m^3 septage per day was constructed between 2012 and 2014. The investment amounted to LKR 130 Mio LKR or about $1 Mio. The FSTP consists of a disposal inlet for gully-bowser trucks, grit-chambers to remove solid waste, a splitter-box where septage is directed into anaerobic sedimentation tanks (depth = 7 m). Estimated costs for current operation and maintenance of the plant amount to LKR 4 Mio LKR or US $ 30,000 per year, whereas income from sludge collection amounts to LKR 3 Mio per year. The plant is operated by 5 staff for septage collection, 2 gully-bowsers are operated with a staff of 6. The designated sludge drying area (without roofing) of the plant remains un-used as it is flooded regularly during the rainy season. Sludge is accumulated on the premises and not sold. Current annual income of the Council from sludge collection amounts to LKR 3 Mio. The FSTP seems to be overdimensioned; location (built within a depression of the land/scaped area) and design (no roof, flooring with cement block-stones) of septage drying area is faulty; Building quality of the physical structure is good (no cracks); operation and maintenance of the plant – except sludge drying and recovery (sludge is simply dumped after de-sludging of treatment modules into an area that is covered by trees) - by a team of 3 operators is good; effluent quality (visible inspection) is fair.

FSTP Chillaw Assessment

Management: Urban Council; management is done under the Public Health Inspector who has no engineering or technical degree.

Costs/Income: Capital expenditure amounted to $1 million in 2014; operation and maintenance costs amount to $ 25,000, whereas income from sludge disposal amount to about $20,000.

Physical Infrastructure: The large scale, mostly concrete based infrastructure is of good quality

Technical design and treatment efficiency: The treatment system consist of a) discharge station b) grit & rake chamber c) splitter box d) 2 open, anaerobic sedimentation tanks (parallel), e) 3 lagoons (facultative, aerobic)

Operation & maintenance: The FSTP is fenced and guarded. Its daily is operation is carried out 5 unskilled staff which were trained on the job. Only one sedimentation tank is charged while the other is dried out and cleaned

Resource Recovery and Re-use: The area allocated for sludge drying is not used as rainwater does accumulate there. After emptying sedimentation tanks and facultative lagoon, sludge is disposed within bushes at the boundary of the FSTP. It is not reused for agriculture purposes

Strengths

- Solid infrastructure based on low-maintenance pond/lagoon design.
- Secured, clean and well maintained facilities

Weaknesses

- Dysfunctional sludge drying beds
- Oversized treatment design

Recommendations

- Rehabilitation of covered sludge drying area.
- Storage of sludge in windrows
- Sale or auctioning of organic fertiliser

FSTP Puttalam Description

The FSTP with a designed treatment capacity of 25 m^3 / day was constructed between 2012 and 2014 under an ADB project. Capital investment amounted to about LKR 100 Mio LKR or about $ 750,000. The plant is located at the town's solid waste disposal site. The FSTP consists of a disposal inlet for gully-bowser trucks, grit-chambers to remove solid waste, a splitter-box where septage is directed into anaerobic sedimentation tanks (depth = 7 m). Estimated costs for current operation and maintenance and income from sludge collection are unknown. No staff to operate the plant was met. Metallic grits of grit-chamber have been removed, large amounts of plastic waste float in the anaerobic sedimentation tank. The designated sludge drying area (without roofing) of the plant is not utilized. The FSTP seems to be overdimensioned; location (built within a depression of the land/scaped area) and design (no roof, flooring with cement block-stones) of septage drying area is faulty; building quality of the physical structure is good (no cracks); operation and maintenance of the plant – except sludge drying and recovery (sludge is simply dumped after de-sludging of treatment modules into an area that is covered by trees) - by a team of 3 operators is good; effluent quality (visible inspection) is fair.

FSTP Puttalam Assessment

Management: Urban Council; management is done under the Public Health Inspector who has no engineering or technical degree.

Costs/Income: Capital expenditure amounted to $1 million in 2014; operation and maintenance costs amount to $ 25,000, whereas income from sludge disposal amount to about $ 20,000.

Physical Infrastructure: The large scale, mostly concrete based infrastructure is of good quality

Technical design and treatment efficiency: The treatment system consist of a) discharge station b) grit & rake chamber c) splitter box d) 2 open, anaerobic sedimentation tanks (parallel), e) 3 lagoons (facultative, aerobic)

Operation & maintenance: The FSTP is fenced and guarded. Its daily is operation is carried out 5 unskilled staff which were trained on the job. Only one sedimentation tank is charged while the other is dried out and cleaned

Resource Recovery and Re-use: The area allocated for sludge drying is not used as rainwater does accumulate there. After emptying sedimentation tanks and facultative lagoon, sludge is disposed within bushes at the boundary of the FSTP. It is not reused for agriculture purposes

Strengths

- Solid infrastructure based on low-maintenance pond/lagoon design.
- Secured, clean and well maintained facilities

Weaknesses

- Dysfunctional sludge drying beds
- Oversized treatment design

Recommendations

- Rehabilitation of covered sludge drying area.
- Storage of sludge in windrows
- Sale or auctioning of organic fertiliser

FSTP Mannar Description

The FSTP in Mannar consists of a disposal inlet for gully-bowser trucks, grit-chambers to remove solid waste, a splitter-box from where septage is directed into 2 parallel anaerobic sedimentation tanks (depth = 7 m; used and emptied alternately) and then into facultative anaerobic and aerobic ponds. It has a designed treatment capacity of 28 m^3 /day. Plant is located near the town's solid waste disposal site (premises are fenced but numerous donkeys are inside!). According to the Secretary of the Mannar Urban Council, 5-8 gully-bowsers (with 3 and 5 m^3 capacity) dispose septage sludge daily; sludge collection fees are reported to be 1 LKR per liter. Estimated costs for current operation and maintenance are unknown. 2 workers operate the plant. The FSTP seems to be over-dimensioned. Operation and maintenance of the plant – except sludge drying and recovery (paved sludge drying area looks unused) by 2 operators is fair

FSTP Mannar Assessment

Management: Municipal Council - Public Health Department. About 3-5 gully-bowser loads (15-25 m^3) are disposed into the plant daily.

Costs: : FSTP constructed during 2012 and 2014 under an ADB project. Capital investment amounted to about LKR 100 Mio LKR or about $750,000. According to ADB, O & M cost amount to LKR 3,84 million or $20,000.

Physical Infrastructure: The plant is located on an 1,5 ha plot and has a designed treatment capacity of 28 m^3 /day. Low construction quality of the physical structure (sagging of concrete embankment of ponds). Paved area for sludge drying beside the lagoon.

Technical design and treatment efficiency: Very large pond-based FSTP. Effluent quality (visible inspection) in the last pond is good

Operation & maintenance: No operation manual, no standardized operational procedures (SOP) for regular and routine work in place. 2 operation and maintenance staff trained on the job.

Resource Recovery and Re-use: The designated sludge drying area (without roofing) beside the plant is not utilized.

Strengths

- Integrated liquid-solid waste management concept is followed
- Partly re-use of dried sludge as organic fertilisers

Weaknesses

- Low visual effluent quality does not match standards
- Plant is under-utilized based on its designed treatment capacity
- Dysfunctional sludge drying beds

Recommendations

- Construction of additional drying-beds for sedimented sludge required to improve effluent quality
- Regular removal of settled sludge required to improve effluent quality
- Allow for sludge treatment in new MSTP

FSTP Vavuniya Description

The pond-based (anaerobic/facultativ-anaerob/aerobic) FSTP has been designed for a daily treatment of 28 m^3 septage and was constructed under the ADBs Water and Sanitation project during 2012-14. The treatment design is similar to the FSTPs in Chillaw, Puttalam and Mannar with rake/grit chamber, splitter box, 2 open anaerobic sedimentation tank and 2 ponds. As in Puttalam, no operational staff has been assigned by the Council.

The FSTP is badly managed on offers no controlled treatment of septage. As the grounds of the FSTP are not fenced and no operational staff or guards are employed, coloured industrial effluent was disposed into the pond. Tire trucks of gully-bowsers at the embankment of the pond are clearly visible - despite a discharge point near the grit chamber - which indicates a deliberate by-passing of the sedimentation tank in order to avoid any maintenance work.



FSTP Vavunya Assessment

Management: Urban Council; management is done under the Public Health Inspector who has no engineering or technical degree.

Costs/Income: Capital expenditure amounted to $1 million in 2014; operation and maintenance costs amount to $25,000, whereas income from sludge disposal amount to about $20,000.

Physical Infrastructure: The large scale, mostly concrete based infrastructure is of good quality

Technical design and treatment efficiency: The treatment system consist of a) discharge station b) grit & rake chamber c) splitter box d) 2 open, anaerobic sedimentation tanks (parallel), e) 3 lagoons (facultative, aerobic)

Operation & maintenance: The FSTP is fenced and guarded. Its daily is operation is carried out 5 unskilled staff which were trained on the job. Only one sedimentation tank is charged while the other is dried out and cleaned

Resource Recovery and Re-use: The area allocated for sludge drying is not used as rainwater does accumulate there. After emptying sedimentation tanks and facultative lagoon, sludge is disposed within bushes at the boundary of the FSTP. It is not reused for agriculture purposes

Strengths

- Solid infrastructure based on low-maintenance pond/lagoon design.
- Secured, clean and well maintained facilities

Weaknesses

- Dysfunctional sludge drying beds
- Oversized treatment design

Recommendations

- Rehabilitation of covered sludge drying area.
- Storage of sludge in windrows
- Sale or auctioning of organic fertiliser

FSTP Kilinochchi – under construction Description

The 25 m^3 FSTP pond system is under construction by PURITAS, a subsidiary of the Hayleys group of companies beside existing premises of the councils unregulated solid waste disposal site. According to the supervising engineer of WASSIP, construction costs amount to about $ 500.000. Pond embankment has been mechanically compacted, covered with geotextile and then covered by casted concrete. At current, the Council operates 4 gully-bowsers with 5,000 and 3,000 liter capacity and the military operates one (no private service providers). The council employs a total of 48 workers for solid and liquid waste management (mostly street sweepers and gully-bowser crews). According to the Secretary of the Council, income from septage collection amounts to an equivalent of $ 35-45,000 per year. Construction activities related to the FSTP seem to be following high standards. The coarse soil has been professionally compacted with heavy equipment before foundations and embankments were casted with concrete to prevent a future sacking of the soil structure and subsequent crack of concrete lined embankment of ponds. At the top, edge and boardwalks of the ponds are additionally lined with heavy geo-textile foils before concrete cast is applied. According to information provided by the Council, Kilinochi currently operates a sludge collection and disposal systems that generates annual revenues of about $ 3.000 to 5.000 (without expenses for an FSTP!). However, it is estimated that the Council will run a loss after FSTP treatment services commence as the required salaries for a minimum of 2 additional operators (LKR 40,000/month) will amount to $ 5,300. No plans to produce or to sell organic quality fertilizer from dried septage were articulated.



Findings and assessment of FSTP

Co-treatment of FS in MSTPs

FS Co-treatment Hikkaduwa Description

The plant went in operation in 2010 and was supported by Australian TA. The aerobic lagoon system consists of 2 facultative and 1 polishing lagoon. Designed treatment capacity is 1.000 m^3 per day. Actual treatment capacity between 800-900 m^3 per day from 180 private households and 60 hotels. In addition 40 m^3 of fecal sludge collected by public gully-bowser trucks are treated daily, private gully-bowsers are not allowed to dispose septage. Treatment fees for septage amount to 225 LKR / m^3. According to the plant technicians, the income of the plant (from fees and 2 gully-bowsers) is higher than the expenses. The visual effluent quality is good and lab results prove that discharge standards were met throughout the operation of the plant.

FS Co-treatment Hikkaduwa Assessment

Management: By NWSDB; Two engineers and 10 support staff employed for management and operation of the plant.

Costs / Income: Income from septage to LKR 225/ m^3 or $ 1,500 per month.

Physical Infrastructure: Septage disposal station - robust and sturdy construction without electronic equipment and digital infrastructure.

Technical design and treatment efficiency: Facultative, aerobic oxidation pond treatment plant type without technical aeration. Variation of the height of a weir at the discharge point allows for reduction and increasing hydraulic retention time. Effluent quality good and below standards; desludging recommended after 8 years

Operation & maintenance: Work is carried out by 8 sanitary workers and 2 engineers. Calculated de-sludging interval is 8 years

Resource Recovery and Re-use: During desludging of pond (duration: 4 weeks), sludge is disposed in trenches in nearby plantations.

Strengths

- Well constructed and maintained treatment sludge disposal station for 40 m^3 /day.
- Financial sustainability - income from sludge disposal fees estimated at $ 30,000 / year.

Weaknesses

- Septage disposal limited at 40 m^3 /day despite high demand

Recommendations

- Increase treatment capacity for septage through addition of anaerobic septage sedimentation tank
- Provide appropriate low-cost facilities for sludge drying/composting on the compound
- Develop a FS treatment strategy and FS treatment master plan along the South Coast between Bentota and Tangalle districts

FS co-treatment Katharagama Description

The 5 ha oxidation lagoon-based sewage treatment system in the sacred town of Kataragama has a treatment capacity of 3,000 m^3 per day. Financing, planning and implementation was supported by the NWSDB and by Austrian TA. The plant went into operation 2017 and is managed by a DSU of NWSDB (24/7 operation by 4 technicians and 3 workers). The actual treatment capacity of the plant is 400 - 600 m^3 per day, which, according to operating staff, will increase significantly during religous holidays. Maintenance is provided by a private company, treatment fees are estimated to amount to 10-20 % of the drinking water bill.

The MSTP including its pre-treatment modules for septage – an inlet for septage sludge from gully-bowsers, grease trap, grit chamber, sandtrap – consist of state-of-the-art imported equipment. The functions of the plant and can be remotely controlled with PLCs and matching software. <u>The septage disposal unit is currently not in operation as the Urban Council operates its own FSTP at the council`s waste disposal site.</u>

FS Co-treatment Soysapura Description

A sludge disposal station with an effluent mixing and grit chamber is an integrated feature of the Municipal Sewage Treatment Plant (MSTP) at Soysapura. According to the plant manager, 150 m^3 septage is desposed daily into the plant by 20-30 gully-bowsers from areas within a radius of up to 75 km around the plant. Disposal fees for private and public gully-bowser operators is 225 LKR and 175 LKR per m^3. Septage is continously fed into the inlet of the treatment via an additional grit removal station. Private desludging services are only eligeble to register a maximum of two trucks to dispose septage and have to pay a deposit fee of LKR 100,000 ($550). Incoming sludge has been analyzed by the plants laboratory randomly (10 samples per month) since 2016. The MSTP will have a daily treatment capacity of 25,500 m^3 by 2030.

FS co-treatment Soysapura Assessment

Management: National Water Supply and Drainage Board.

Costs: Loans and financial contribution from Sweden. Investment Costs about $ 80 million; Operation and maintenance costs amount to LKR. 39 per m^3 wastewater treated.

Physical Infrastructure: Anoxic/oxic MSTP Construction during 2010-2016 in cooperation with Swedish consultants and contractors.

Technical design and treatment efficiency: An-oxic / oxic treatment plant with nitrogen removal with designed treatment capacity of 25,500 m^3/day.

Operation & maintenance: Operation manuals and SOP available. Disposed FS is diluted with treated effluent at a ratio of 2:1 before it is fed into the plant to avoid "shock loads" of biological treatment modules. Treated sludge is de-watered with mechanical filter press equipment.

Resource Recovery and Re-use: According to NWSDB, de-watered sludge is collected by a private company and then further processed as organic fertiliser.

Strengths

- Co-treatment of up to 150 m^3 / day of septage sludge
- FS disposal fees of about $ 1,700 per month contribute to reduction of subsidies for operation and maintenance of the plant
- Well-trained workforce
- Documentation and quality control of septage disposed

Weaknesses

- Limited space for extension and storage of sludge
- No sludge treatment facilities (anaerobic digestion, drying beds, storage area)

Recommendations

- Develop an FS treatment strategy and FSM master plan for the Colombo Metropolitan area (excluding Colombo municipality)

FS co-treatment Ja-Ela Description

A sludge disposal station with a rake, a grit chamber and a feeder tank are integrated features of the MSTP at Ja-Ela. Septage is continously pumped into the inlet of the treatment plant from the feeder tank. Due to complaints from neighbors, an enzyme solution is used to reduce the smell. About 100 -120 m^3 septage is disposed daily into the plant by about 20 gully-bowser from areas within a radius of up to 50 km around the plant. Disposal fees for private and public gully-bowser operators amount to 265 LKR. Private desludging services receive a fixed monthly quota of sludge volume they are allowed to dispose per month and have to pay a deposit. Incoming sludge has been analyzed by the plants laboratory randomly since the plant went in operation in 2017. Sludge is being de-watered by a filter-press and then dried and stored for further drying on the premises. Due to repairs, a sophisticated sludge drying plant is out of order.




FS co-treatment Ja-Ela Assessment

Management: National Water Supply and Drainage Board.

Costs: Loans and financial contribution from Sweden. Investment Costs about $ 80 million; operation and maintenance costs amount to appx. LKR 39 per m^3.

Physical Infrastructure: Construction time 2008-2015. International Consultants and contractors (Sweden).

Technical design and treatment efficiency: An-oxic/oxic treatment plant with 79 % nitrogen and 96% BOD removal. The plant's designed treatment capacity of 14,500 m^3 /day will be met by 2030.

Operation & maintenance: Operation manuals and SOP available. Disposed FS is pumped into a storage tank from where it is automatically pumped into the inlet chamber of the plant. EA used to reduce foul smell of FS.

Resource Recovery and Re-use: According to NWSDB, de-watered sludge is currently disposed beside the defect sludge drying plant.

Strengths

- Co-treatment of up to 120 m^3 of septage sludge daily
- FS disposal fees of about $ 1,700 per month contribute to reduction of subsidies for operation and maintenance of the plant
- Well-trained workforce
- Regular quality control of influent and effluent

Weaknesses

- Limited space for extension and storage of sludge.
- Sophisticated sludge drying plant is difficult to maintain.

Recommendations

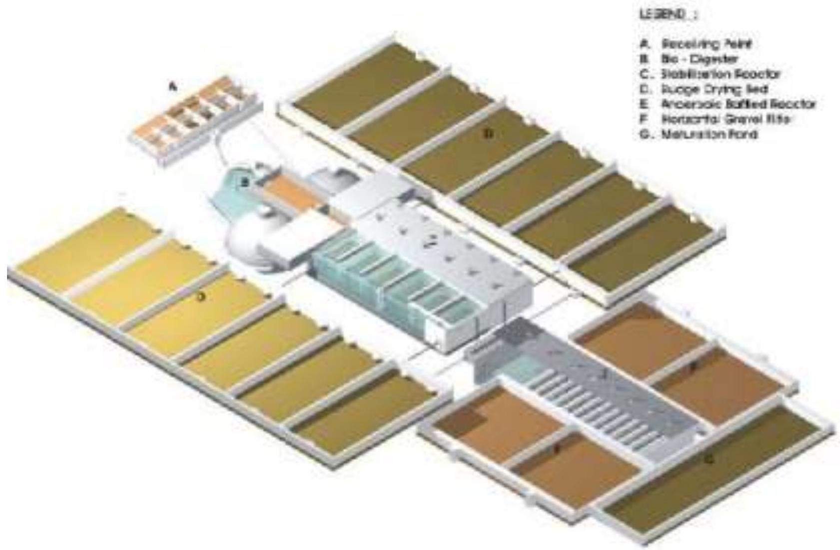
- Develop a FS treatment strategy and FS treatment master plan for the Colombo Metropolitan area

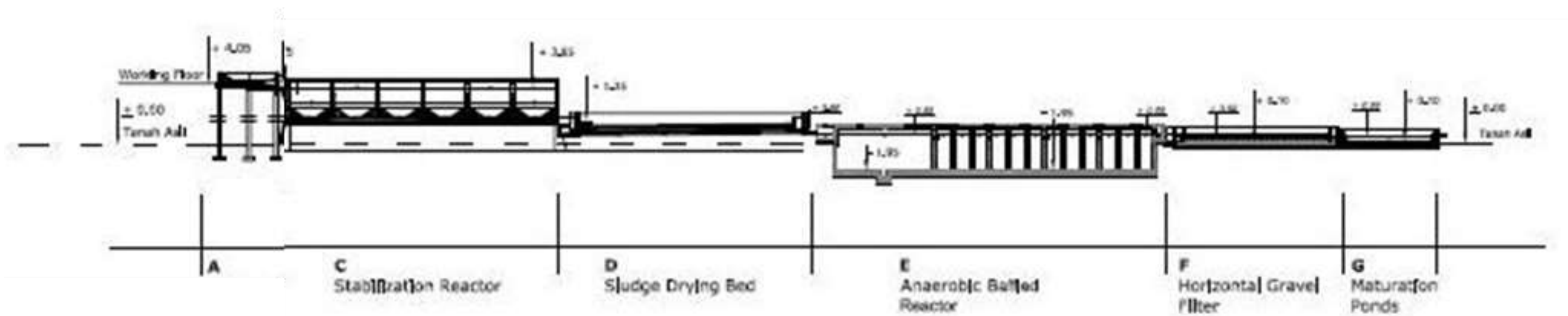
Alternative FSTP technology options

The FSTP with a daily treatment capacity of 80 m^3 was financed by UNICEF to replace the old plant on the same premises that was destroyed by the Tsunami in the end of 2004. The design for the plant was made by Indonesian BORDA partners and construction was carried out by an Indonesian contractor under a BORDA trained construction supervisor during 2005/2006. Operation of the plant started in 2007. The municipality owns, maintains and operates the FSTP. No sales of compost (used for parks and green areas of the city). Financing of the operation and maintenance of the FSTP is paid from municipal budget (annual O & M costs amount to less than $10,000). Septage disposal fees were abolished by the municipality in 2016 to encourage more private gully-bowser operators to dispose septage . **Advantages and problems**: No smell and very low operational costs; no costly expertise needed for operation and maintenance; No additional income created - free tipping and no organic fertilizer sales; no application of dried sludge in farmers' fields application practices: Public parks and gardens.

Elevation & natural gravity design principles

- Covered treatment system
- Allows for elevated disposal chamber (ramp) through landscaping
- Hights of primary, secondary and tertiary treatment modules allow for gravity flow
- In that way all pumping is avoided or at least limited to pump treated effluent





FSTP Banda Aceh Assessment

Management: Managed by the Cleaning Department of the municipality.

Costs: Construction costs amounted to US$ 250,000 in 2007; annual cost for O & M staff $ 7,200; no disposal fees are paid (abolished in 2016);

Physical Infrastructure: Excellent construction quality with few deficiencies: lid of digester is leaking gas; anaerobic stabilization tanks: one connecting pipe to sand-filter broken; planted gravel filter: in working condition but overgrowth shows lack of maintenance;

Technical design and treatment efficiency: Modular design with adequately designed DEWATS treatment modules In good working order; No major defaults or repairs; effluent quality meets discharge standards

Operation & maintenance: Operation manual and standardized operational procedures (SOP) in place. O & M carried out by 2 staff and gully-bowser crews.

Resource Recovery and Re-use: post treatment: Drying of digested sludge in sand beds that have open concrete-block stones as porous foundation allows for mechanical emptying without destruction of floor. Dried sludge is used exclusively for parks and green areas of the city.

Strengths

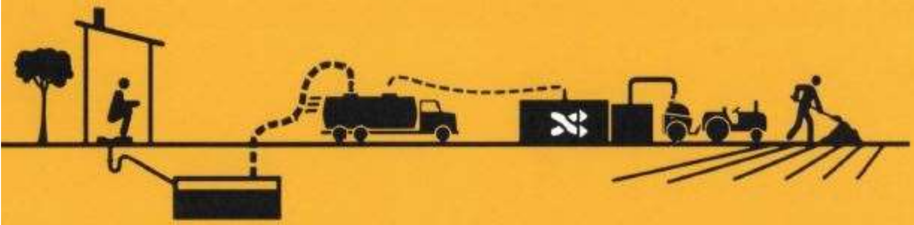
- Integrated liquid-solid waste management concept is followed
- Low-cost, but robust low maintenance design without pumping devices
- Excellent construction quality and robust design: no major repairs during the time of operation

Weaknesses

- Only essential repairs and maintenance work is carried out
- No refinement and utilisation of dried sludge in agriculture

Recommendations

- Additional staff for better operation and maintenance of plant required to increase lifetime of infrastructure



Sanitation Chain

Tamil Nadu, the most urbanised state in India has 664 Urban Local Bodies out of which 528 are categorised as Town Panchayats. A Town Panchayat is a transitional area, i.e. an area in transition from rural to urban. To ensure 100% urban sanitation coverage, the state has decided to implement Fecal Sludge Management (FSM) in most town panchayats.

FSTP Cost:
Rs. 49 Million
(68,865 USD)

As per Census 2011, 40% of the households in Karunguzhi have Individual Household Latrines (IHHLs). A significant number of these households have never emptied their septic/holding tanks and only 3% of the households reported regular desludging. According to government sources, the number of households with IHHL has increased to 90% in 2018 because of the Swachh Bharat Mission (SBM). The first FSTP in the state was constructed in Karunguzhi as a pilot demonstration project.

Fecal Sludge Treatment Plant

The FSTP is built on 2 acres and is expected to treat septage collected from about 3,000 households in Karunguzhi and about 7,000 households in Maduranthagam.

Treatment Process

Septage collected from households or commercial establishments will be processed through the following units of the treatment facility.

1. Emptying raw Fecal Sludge (FS) into the screen chamber
2. Bar screens remove floating debris and other coarse particles
3. FS enters the Sludge Drying Beds (SDBs) & undergoes solid-liquid separation
4. FS is left for drying through natural processes
5. After drying, the sludge is stored in the sludge storage yard
6. The filtrate from the SDBs are conveyed to the Horizontal Planted Gravel Filter (HPGF) reducing the organic matter & nutrients
7. Pathogens are reduced through natural processes in the maturation pond
8. The treated effluent is collected in the filtrate sump
9. The treated water is reused for gardening
10. Co-composting of dried sludge with organic municipal solid waste

Reuse

The treated waste water is being reused for gardening within the premises. The dried sludge is being co-composted with organic municipal solid waste.

O&M Arrangement

Various steps are being taken to ensure sustainable Operation and Maintenance (O&M). The responsibility for O&M is being transitioned from a government department to a private player. A comprehensive service level agreement has been prepared to ensure requisite standards and safety of personnel are met.

FSTP-Karunguzhi , Tamil Nadu

- Well-managed covered sand-filters to de-water fecal sludge and covered storage are for dried fecal sludge;
- Leachate is treated in an anaerobic baffled reactor, planted horizontal gravel filter and maturation pond before discharged

Treatment system modules and dimensions

Daily treatment capacity: 25 cbm

Single drying bed size: 6 x 8.2 m; volume: 25 cbm; drying time: 20 days

HGF: 17 x 8 m; Maturation pond: 7 x 7 m

FSTP-Karunguzhi , Tamil Nadu — Description (2)

- FSTP is based on sand-drying beds; additional composting of dried sludge with bio-residues at micro-composting site
- Only 25% of roofed drying beds (50 sqm each; 23 cbm load volume) are in use; drying time of sludge: 15-25 days; dried sludge stored since 2017
- NGO “Hand-in-hand” is contracted to operate FSTP in small towns, town panchyats manage their own water supply and revenues
- Only 5 ULBs out of 17 in Tamil Nadu rely on state Water and Drainage Board for water supply and tariff structure
- Funding for FSTP from Swach Bharat include investment and costs for one year of operation;
- Test-kits available to test ph and conductivity of in-coming sludge regularly; documentation procedures are followed strictly
- Separate micro-composting unit for segregated bio-waste and dried FS (incl. worm composting)
- 49 further FSTPs in town-panchayats of Tamil Nadu are planned; cluster approach; new sites will combine drying beds and bio-waste composting
- Contracted NGO receives 200.000 Rs per month, including equipment, labor, including door-to-door waste collection (32 employees, 2 supervisors)
- Price of small truck load cow-dung (3 tons) = 1,500 – 2,000 Rs; farmers insist on quality control of fecal sludge compost
- Challenge: on-time payments; operation & maintenance budget;
- Solid waste management is financed by property tax;

FSTP-Devanahali, Karnataka Description

Background

In coordination with Devanahalli's Town Municipal Cooperation (TMC), CDD Society built a faecal sludge treatment plant (FSTP). The plant is successfully handling 100% of the sludge collected in Devanahalli today.

The success of the FSTP motivated the TMC to pass resolutions in order to ensure the plant faces no operational or financial hurdles. The FSTP forms the heart of an end-to-end FSM solution for Devanahalli.

About Devanahalli

12 kms from Bangalore Airport Location	30,000 Population	6,400 Households
94% Access to toilets	0% UGD coverage	90% Septic tanks/ pits coverage

Features-Benefits of the FSTP

Features	Benefits
No direct contact with faecal sludge	Allows for safe operations
Co-composting with Municipal solid waste	Allows for safe reuse
No odour; aesthetically-pleasing facility	Plant can be set up close to the city; reducing distance trucks need to travel
Gravity-based system; low electromechanical equipment	Keeps cost low making FSM affordable for the ULB
Biological treatment: no chemicals used	
Low operation and maintenance; no skilled labour required	

FSM Business Plan

Costs to be incurred:
1. FSTP operations
2. Cesspool vehicle operations
3. Co-composting plant operations
4. Overheads

Possible sources of revenue:
1. Increase in property tax
2. Advertisement hoardings
3. Revenue from truck operations
4. Sale of compost (from treated sludge)

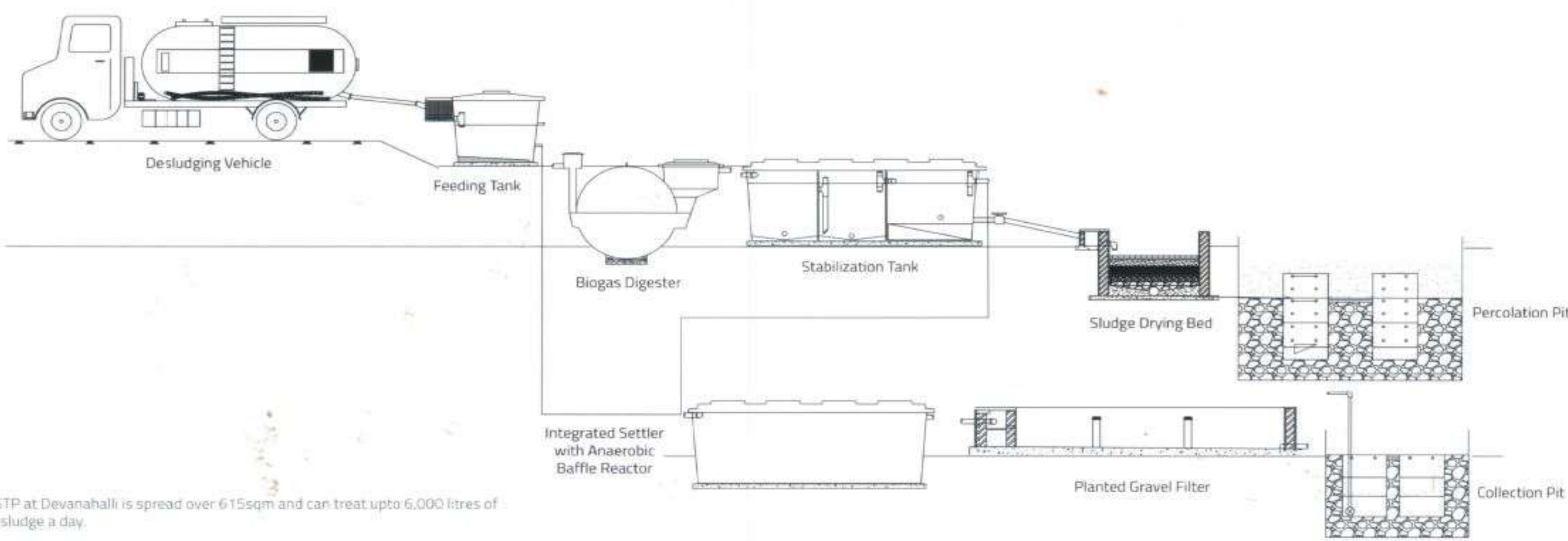
These sources of revenue do cover costs.

Devanahalli's Municipal Corporation has passed 4 resolutions

- Regulating faecal sludge disposal
- Outsourcing of O&M of plant and truck
- Monitoring construction of pits & septic tanks
- Property tax inclusion

Achievements

One-of-its-kind town-scale FSTP
First town in India to implement end-to-end FSM
Utilisation of cesspool vehicles increased 4x
IEC campaigns on FSM and sanitation on-going
A fully-replicable model for towns of this size



The FSTP at Devanahalli is spread over 615sqm and can treat upto 6,000 litres of faecal sludge a day.

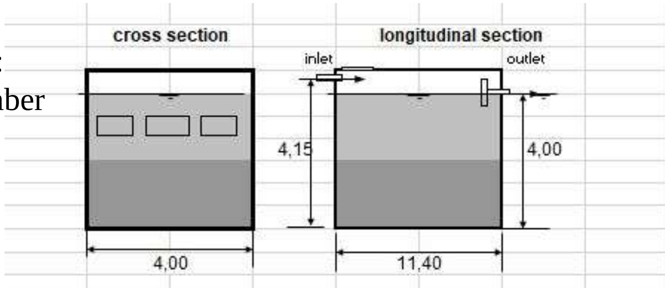
Treatment modules:

- Planted sandfilter-bed
- Planted horizontal gravel filter
- Aeration pond

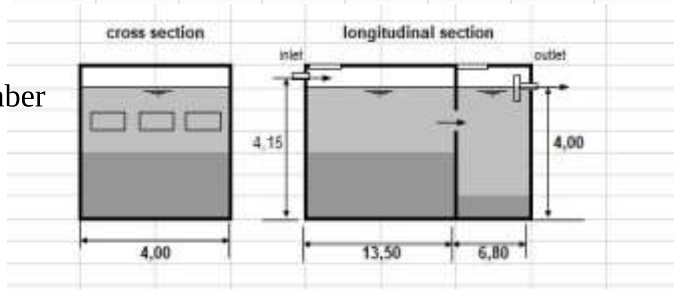
Alternative design: Dimensions of inter-connected FSTP modules required for treatment of 50 m^3 of FS in Sri Lanka

- Area requirement: 3,500 m^3
- Estimated construction costs: US $ 250,000

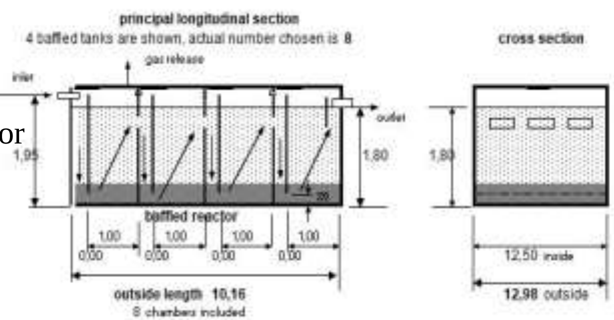
Module 1: One-chamber settler



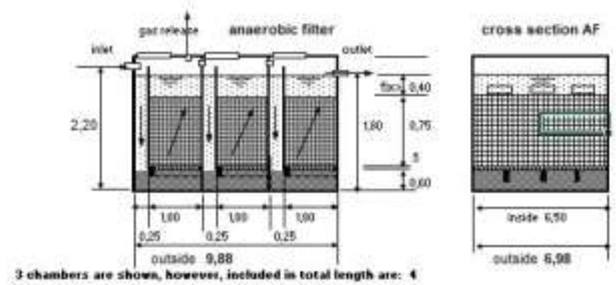
Module 2: Two-chamber settler



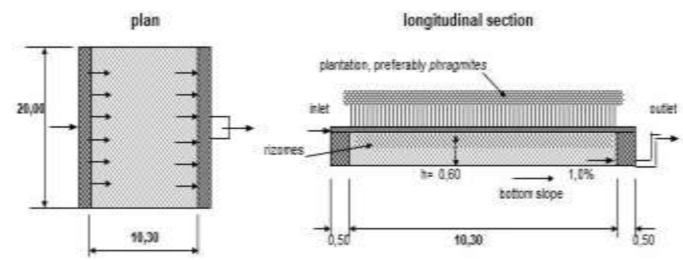
Module 3: Anaerobic baffled reactor (4 chambers with down-pipes)



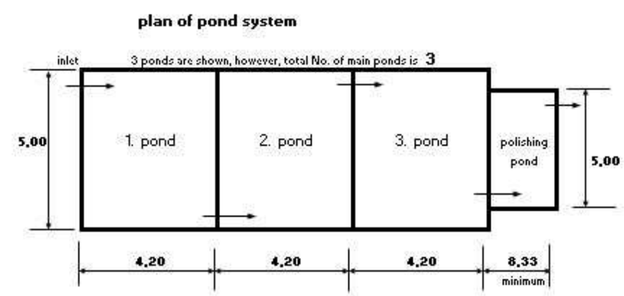
Module 4: Anaerobic filter reactor, ABR, (4 chambers with down-pipes)



Module 5: Planted horizontal gravel filter (PGF)



Module 6: Facultative pnd system



Note: Modules 1 – 4 are connected to solar drying beds

Resource Recovery and Resuse options

RRR- Drying of FS/ Sludge Description

Unplanted drying beds facilitates dewatering through percolation and evaporation. In drying beds sand and gravel act as the media on which, batch loads of septage/sludge are fed (directly from the septic trucks or from the sedimentation tank) and subsequently dewatered. Essentially, three layers of media with different sizes of graded sand and gravel are laid for effective percolation. Upon required drying conditions FS can be manually removed from the drying beds and piled up as necessary for co-composting.

RRR - Drying of FS Assessment

Management: Municipal Councils, Urban Councils, Pradeshyia Sabhas (municipal engineer, public health inspectors).

Costs: cost of labours engaged in collection and grinding of dried sludge.

Physical Infrastructure: covered storage area; drying beds with roofing (this is a component of FSTP), packing station.

Technical design and treatment efficiency:

In a drying bed, the drying period may vary according to the weather conditions in the area (typically 14-21 days in a tropical climate). Sludge layer should be maintained between 0.25-0.3 m.

Operation & maintenance: Each drying bed should be filled within 48 hours and allow for dewatering process.

Reuse: Some LAs sell the dried FS (directly from the drying beds of FSTP) through auctions to farmers (e.g.: Tangalle)

Strengths

- Unplanted drying beds- low cost technology with minimum O&M

Weaknesses

- Non-availability of official guidelines, designs requiring additional pumping of sludge

Recommendations

- Improve designs to simplify dewatering, drying and storage of sludge

RRR - Co-composting Description

Co-composting of dried fecal sludge with organic solid waste is practiced at a number of FSTPs in central and southern Sri Lanka that are part of municipalities waste recycling stations. Organic waste and dried FS are heaped in layers to construct the windrows. After processing for about 3 months including maturation and sieving, the organic fertilisers is either sold in bulk to plantations or it is packed and sold in 5 – 50 kg bags as compost-fertiliser to farmers and private households.

RRR - Co-composting Assessment

Management: Municipal Councils, Urban Councils, Pradeshyia Sabhas (municipal engineer, public health inspectors)

Costs: Labor costs for manual sorting,, mixing, construction of windrows, turning of windrows, and packaging, electricity cost for sieving machine, water for the process

Physical Infrastructure: concrete structures for unloading and sorting areas, Covered areas for compost heaps, storage areas, Mechanical / motorized rotating sieves, office buildings

Technical design and treatment efficiency: process is windrow composting, optimum conditions for composting (temperature, moisture, C:N ratio, turning etc.) should be maintained throughout the process. Typical labour requirement is one labour per one tonne of waste, but can vary depending on the contexts

Operation & maintenance: Turning & watering the piles as required, monitoring the process. Compost piles should be built in right size and height.

Reuse: Co-compost is sold at a higher price (e.g.: Balangoda UC) to the plantation sector and small holder farmers

Strengths

- Reduction of waste disposal volume by 30%
- Value addition to compost that brings additional income generation from RRR
- Low cost technology for nutrient recovery

Weaknesses

- Operational procedures not standardized
- Lack of monitoring & quality control
- Limited knowledge of the reuse market
- Additional space and labour requirements

Recommendations

- Develop, adapt and follow simple guidelines and mechanisms related to operation, process monitoring and quality control
- Develop business models to support LAs to increase the compost sales

RRR – Pelletizing Description

Compost can be pelletized for easy packaging, storing, transporting, handling, and application (farm level). Matured compost (Co-compost) is mixed with binding agents, enrichment agents (optional), and water and afterwards is used as input material for the pelletizer to produce pellets. Pellets are then sieved and dried prior to packing and storing.

RRR – Pelletizing Assessment

Management: Municipal Councils, Urban Councils, Pradeshyia Sabhas (municipal engineer, public health inspectors)

Costs: Labor costs mixing compost and feeding to pelletizer, packaging, electricity cost for pelletizer operation, water,

Physical Infrastructure: Pelletizing machine, covered area to locate pelletizer, storage rooms

Technical design and treatment efficiency:

Pelletizer machines are available in various capacities and types and can be selected according to the requirement. Operational capacity of the machine varies (from the design capacity) with the types of feedstock.

Operation & maintenance: optimum moisture levels should be maintained to , need frequent cleaning after every cycle of operation to avoid clogging

Reuse: In Balangoda, pelletized compost is in high demand by coconut plantations.

Strengths

- Increased marketability of compost (due to reduced bulkiness, easy handling and transporting)

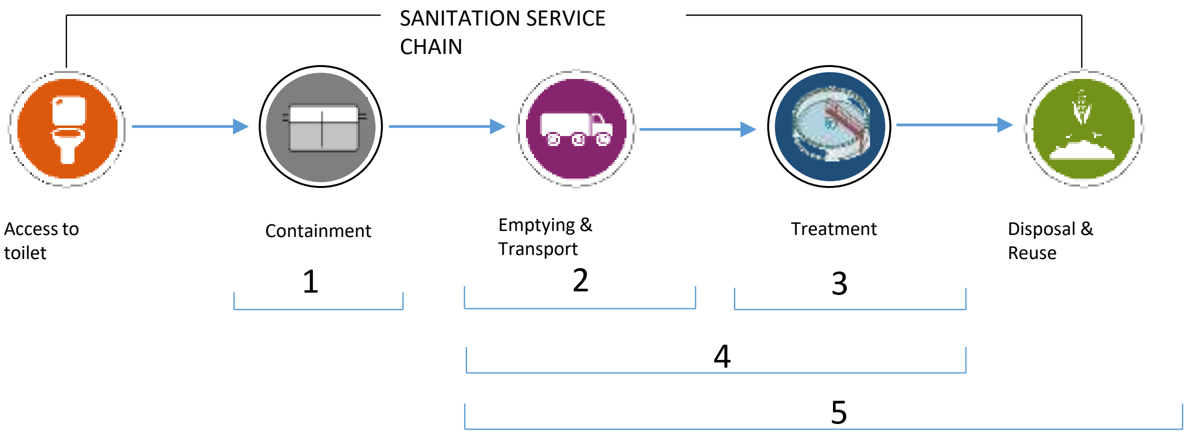
Weaknesses

- High operation cost of the pelletizer
- Lack of training and operational guidelines of the pelletizing process
- Limited knowledge of the reuse market
- Lack of evidence on agronomic trials

Recommendations

- Develop guidelines and training manuals on the pelletizing process
- Build evidence on the performance of the compost pellets through agronomic trials

Assessing the business models related to FSM



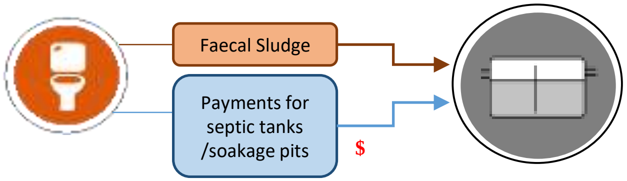
- Sanitation service chains explored in Sri Lanka
  - ➢Containment
  - ➢Emptying & transport
  - ➢Treatment
  - ➢Disposal and Reuse

Business models explored in Sri Lanka

1. Private businesses on Containment – prefabricated septic tanks
2. Businesses on Emptying & Transport – 2 cases (I) private and (ii) public (Urban Local Bodies) operation
3. Business models on treatment facilities – 2 cases of public (NWSDB) operations
4. Business models combining Emptying, Transport and Treatment
5. Business models combining Emptying, Transport, Treatment and Reuse/Disposal
6. Integrated waste management system – combining the sanitation service chain with solid waste treatment and reuse/recycling

Business models related to Containment

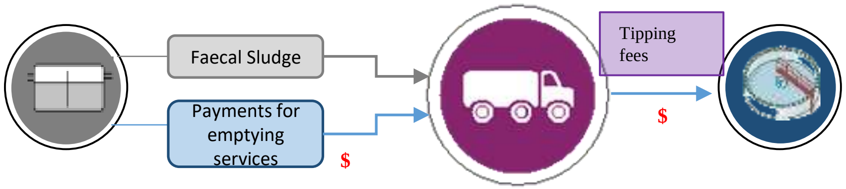
- Model focusses on FS containment business with following value propositions –
  - ✓ *Reduction in contamination of water bodies and land*
  - ✓ *Partial digestion of the FS before treatment*
  - ✓ *Ease of emptying and transportation*
- Business model description – This is a part of a business which deals with construction of prefabricated structures related to houses. Private entrepreneur has the capacity to built and sell prefabricated septic tanks and soakage pits to the households.
- Funding and financing of business model –
  - ***CAPEX –*** loans from banks, typically equity is 20-25%
  - ***OPEX –*** typically financed by revenue generated through the business
- Risks and benefits –
  - Risk of reaching a maximum number of households within a short period, need for diversification
  - Benefit – scalable within a shorter period; promotes safe management of FS
- Business model relevance – suitable for households and low-income settlements (for cluster septic tanks)
- Similar extensions of the model – prefabricated systems using plastics / fibre-reinforced plastic. Presently ANTON® (trade name of septic tank - Biocell) and R. P. C. Polymers (Pvt.) Ltd. manufacture such septic tanks.



Items	Cost in LKR
Capital cost (includes expenditure on moulds, land, office and shed, trucks for conveyance and business registration)	**24,445,000**
Annual Expenses (O&M)	**18,708,400**
Labour charges (6 labour)	3,60,0000
Production cost (materials)	14,634,000
Fuel costs	374,400
Utilities	100,000
Annual Revenue	**19,365,000**
Estimated Profit	**656,600**

Business models related to Collection

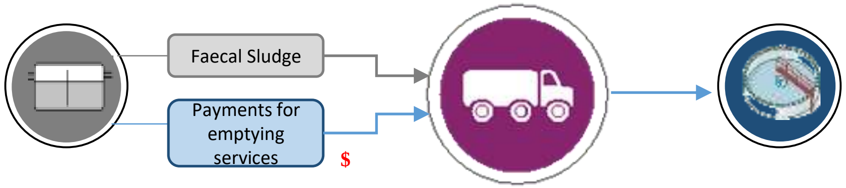
- Model focusses on emptying and transport business owned and operated by private entities with following value propositions –
  - ✓ *Timely and safe emptying and transportation of FS on demand*
- Business model description – This a market driven business model in which desludging vehicles are owned and operated by private entities. The desludging activities are demand based and households pay fees for the services. The desludging trucks empty the FS in treatment plants (usually operated by NWSDB / local bodies) and pay tipping fees.
- Funding and financing of business model –
  - ***CAPEX –*** loans from banks; typically equity is 20-30%
  - ***OPEX –*** typically financed by revenue generated through the business
- Risks and benefits –
  - Risk – market penetration is sometimes limited as it is unaffordable for poor households as well as limited to households with containment facilities; long distances of transport might lead to evasion of FS disposal at treatment site leading to contamination; constraints of operation due to licensing mandate; health and occupational safety of workers
  - Benefit – safe and timely desludging of FS from households
- Business model relevance – applicable for towns/cities with a high demand for desludging
- Business strategy – Larger fleet of trucks with larger volume might make the model financially less feasible



Items	Cost in LKR
Capital cost (includes 1 truck 7,000 litres capacity, office building, tools and equipment and business registration)	**6,520,000**
Annual Expenses (O&M)	**3,564,000**
Labour charges (3 labour)	1,800,000
Maintenance charges	120,000
Fuel costs	234,400
Utilities and other charges	60,000
Tipping fees @ LKR 375/m^3	1,350,000
Annual Revenue	**3,900,0000**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation and 10 years of loan repayment.	**2,742,546**
Break even	**2 years**

Business models related to Collection

- Model focusses on collection business owned and operated by public entities with following value propositions –
  - ✓ *Timely and safe emptying and transportation of FS on demand*
- Business model description – This a market driven business model in which desludging vehicles are owned and operated by public entities. The desludging activities are demand based and households pay fees for the services. The desludging trucks empty the FS in treatment plants (usually operated by NWSDB / local bodies) and pay tipping fees.
- Funding and financing of business model –
  - ***CAPEX –*** typically grant is 100%. However, this is a bankable project where 100% loan from commercial bank can be availed
  - ***OPEX –*** typically financed by revenue generated through the business
- Risks and benefits –
  - Risk – market penetration is sometimes limited as it is unaffordable for poor households as well as limited to households with containment facilities; long distances of transport might lead to evasion of FS disposal at treatment site leading to contamination; constraints of operation due to licensing mandate; health and occupational safety of workers
  - Benefit – safe and timely desludging of FS from households
- Business model relevance – applicable for towns/cities with a high demand for desludging
- Business strategy – In most of the cities, waiving import taxes on trucks cut down the CAPEX and enhancing the fleet by 1-2 truck make the model financially more attractive since the demand is high



Items	Cost in LKR
Capital cost (includes 1 truck 4,000 litres capacity, tools and equipment)	**4,050,000**
Annual Expenses (O&M)	**3,703,799**
Labour charges (3 labour)	1,968,000
Maintenance charges	240,000
Fuel costs	390,400
Interest payments (@ 13% for 5 years)	1,015,799
Annual Revenue	**5,250,000**
Net Present Value (considering 12% as discount rate) Assuming 5 years of operation and 5 years of loan repayment.	**827,255**

Business models related to Treatment

- Model focusses on treatment of wastewater (including faecal sludge) with following value propositions –
  - ✓ *Treatment of FS along with sewage*
  - ✓ *Safe management of the FS preventing contamination of water and soil*
- Business model description – presently in Sri Lanka, sewage treatment plants with a design for FS treatment are operated by NWSDB. FS is collected from households and businesses by municipal or private desludging operators and transported to the STP. (Example – Hikkadua, Kataragama)
- Funding and financing of business model –
  - ***CAPEX –*** STPs are usually constructed from grants / loans from donors. Typically, CAPEX for treatment plants are through loans from unilateral and multilateral agencies which are designed, built and operated by NWSDB. Similarly, gully bowsers owned by the municipalities are obtained from humanitarian donor funds. Grants / loans also cover capital costs for sewerage network.
  - ***OPEX –*** typically financed by revenue generated through the operations
  - ***REVENUE –*** revenue sources – (I) tipping fees from gully bowsers; (ii) charges from households & businesses connected to sewers.
- Risks and benefits –
  - Risk – proper design, construction and operation of the FSTP to be ensured for proper treatment; lower number of sewer connections implies lower revenue; reluctance of municipalities to dispose FS in the STP
  - Benefit – treatment of the FS – lower contamination of soil and water
- Business model relevance – applicable for towns/cities with a high demand for desludging and presence of sewer connection
- Business scalability – Cities with STP can approach for grants / loans for extension of sewer networks

Items	Cost in LKR
Plant in Hikkadua	
Capital cost (includes establishment cost and cost of land)	**437,000,000**
Annual Expenses (O&M) – includes labour wages, utilities, chemicals and misc.	**9,198,000**
Annual Revenue (includes charges from households, hotels and tipping fees)	**12,271,680**
Net Profit	**3,073,680**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation, without adjusting for inflation	**~ 21,000,000**
Plant in Kataragama	
Capital cost (includes establishment cost and cost of land)	**1,672,510,000**
Annual Expenses (O&M) – includes labour wages, utilities, chemicals and misc.	**31,021,200**
Annual Revenue (includes charges from households, hotels and tipping fees)	**3,621,696**
Net Profit	**(27,399,504)**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation, without adjusting for inflation	**~ (189,000,000)**

Possible extensions of the business model

- Case study – Municipality taking a loan for retrofitting the defunct treatment plant e.g. Trincomalee, Batticaloa

Items	Cost in LKR
Emptying, Transport and Treatment by Municipality	
Capital cost (cost of rehabilitating 20 m^3 FSTP; and assuming no land cost)	**2,000,000**
Annual Expenses (O&M) – includes labour wages, fuel and maintenance charges	**2,598,000**
Annual Revenue	**5,250,000**
Net Profit	**2,283,321**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation, without adjusting for inflation	**11,857,043**

- Case study – Municipality taking a loan for building a treatment plant eg Galle

Items	Cost in LKR
Emptying, Transport and Treatment by Municipality	
Capital cost (includes 1 truck 4,000 litres capacity, tools and equipment, cost of 20 m^3 FSTP; and assuming no land cost)	**20,050,000**
Annual Expenses (O&M) – includes labour wages, fuel and maintenance charges	**2,598,000**
Annual Revenue	**5,250,000**
Net Profit	**2,652,000**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation, without adjusting for inflation	**13,506,388**

Business models related to Collection and Treatment (1)

- Model focusses on emptying, transport and treatment along the sanitation service chain with following value propositions –
  - ✓ *Timely and safe emptying and transportation of FS on demand*
  - ✓ *Safe management of the FS preventing contamination of water and soil*

- Business model description – presently in Sri Lanka there exists two different modes of operation –
  - ➢ *Emptying, Transport and Treatment system owned and operated by the Municipalities (eg. Ratnapura)*
  - ➢ *Emptying and Transport by the private operators and treatment facilities operated by Municipalities / NWSDB (eg. Kurunagela, Soysapura)*
- Funding and financing of business model –
  - ***CAPEX –*** business owned and operated by municipality are usually through grants / loans from donors. Typically, CAPEX for treatment plants are through loans from unilateral and multilateral agencies which are designed and built by NWSDB and handed over to municipalities for operation. Similarly, gully bowsers owned by the municipalities are obtained from humanitarian donor funds.
  - ***OPEX –*** typically financed by revenue generated through the business
  - ***REVENUE –*** revenue sources vary with the type of operation. In case gully bowsers are owned and operated by the municipalities, they collect fees from onsite sanitation users for their services. However, when gully bowsers are owned by the private entities, the municipalities collect tipping fees from the private business.

Items	Cost in LKR
Emptying, Transport and Treatment by Municipality	
Capital cost (includes 1 truck 4,000 litres capacity, tools and equipment, cost of 20 m^3 FSTP; and assuming no land cost)	**20,050,000**
Annual Expenses (O&M) – includes labour wages, fuel and maintenance charges	**2,598,000**
Annual Revenue	**5,250,000**
Net Profit	**2,652,000**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation, without adjusting for inflation	**13,506,388**

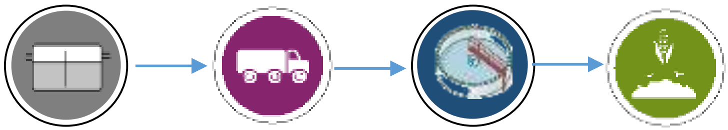
Business models related to Collection and Treatment (2)

- Risks and benefits –
  - Risk – proper design, construction and operation of the FSTP to be ensured for proper treatment; long distances of transport might lead to evasion of FS disposal at treatment site leading to contamination; constraints of operation due to licensing mandate; health and occupational safety of workers
  - Benefit – safe and timely desludging of FS from households; reduction in contamination due to treatment
- Business model relevance – applicable for towns/cities with a high demand for desludging
- Business scalability – Cities without FSTP/defunct FSTP can approach banks for loans to own and operate the gully bowser and treatment plant

Items	Cost in LKR
Emptying, Transport by private gully bowser and Treatment by Municipality	
Capital cost (includes 1 truck 4,000 litres capacity, tools and equipment)	**16,050,000**
Annual Expenses (O&M)	**768,000**
Annual Revenue –from tipping fees	**2,250,000**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation, without adjusting for inflation	**7,153,780**

Business models combining collection, treatment & reuse

- Model focusses on emptying, transport, treatment and reuse with following value propositions –
  - ✓ *Timely and safe emptying and transportation of FS on demand*
  - ✓ *Safe management of the FS preventing contamination of water and soil*
  - ✓ *Recovery of soil nutrient*
- Business model description – This model combines market driven business model of desludging along with treatment and sell/auction of dried FS as soil conditioner. The desludging activities are demand based and households pay fees for the services. The desludging trucks owned and operated by municipalities empty the FS in treatment plants and sell the dried FS to horticultural farms/individual farmers.
- Funding and financing of business model –
  - ***CAPEX –*** business owned and operated by municipality are usually through grants / loans from donors. Typically, CAPEX for treatment plants are through loans from unilateral and multilateral agencies which are designed and built by NWSDB and handed over to municipalities for operation. Similarly, gully bowsers owned by the municipalities are obtained from humanitarian donor funds.
  - ***OPEX –*** typically financed by revenue generated – (I) household charges for emptying; (ii) revenue for sell of dried FS
- Risks and benefits –
  - **Risk** – market penetration is sometimes limited as it is unaffordable for poor households as well as limited to households with containment facilities; long distances of transport might lead to evasion of FS disposal at treatment site leading to contamination;
  - **Benefit** – safe and timely desludging of FS from households; treatment of FS and disposal
- Business model relevance – applicable for towns/cities with a high demand for desludging and requirement of soil nutrient for plantation
- Business strategy – In most of the cities, (I) enhancing the fleet by 1-2 truck make the model financially more attractive since the demand is higher; and/or (ii) sell of dried FS to plantations



Items	Cost in LKR
Emptying, Transport, Treatment & Reuse by Municipality	
Capital cost (includes 2 truck 4,000 litres and 3,000 litres capacity, tools and equipment, cost of 20 m^3 FSTP; and assuming land cost)	**235,500,000**
Annual Expenses (O&M) – includes labour wages, fuel and maintenance charges	**4,116,000**
Annual Revenue	**6,700,000**
Net Profit	**2,584,000**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation, without adjusting for inflation	**13,137,176**

Integration of solid-liquid waste management system

- Model focusses on integrating solid-liquid waste management owned and operated by public entities with following value propositions –
  - ✓ *Solid waste management along with timely and safe treatment and disposal of FS*
  - ✓ *Reduction in soil and water contamination*
  - ✓ *Recovery of soil nutrient*
- Business model description – This is a combined model catering to solid and liquid waste management owned and operated by public entity. The organic fraction of MSW is segregated for composting along with dried FS.
- Funding and financing of business model –
  - ***CAPEX –*** In most of the municipalities, compost plants are funded by multilateral grants / loans. Similarly, FSTPs are through loans from unilateral and multilateral agencies which are designed and built by NWSDB and handed over to LA for operation.
  - ***OPEX –*** typically financed by revenue generated through the business
  - ***REVENUE –*** sources are (I) gully bowser services, (ii) sell of recyclables, (iii) sell of compost
- Risks and benefits –
  - Risk – market penetration of compost is limited by several factors like quality, certification, subsidy to fertilizers, behaviour and traditional practice of farmers
  - Benefit – safe and timely desludging of FS from households; recovery of soil nutrient from waste
- Business model relevance – applicable for towns/cities with existing MSW compost initiatives and a high demand for desludging
- Business strategy – recycling is an important component which can be outsourced to the private

Items	Cost in LKR
Integrated Solid-Liquid waste management by Municipality	
Capital cost (includes MSW component; 2 trucks with 4,000 litres capacity, tools and equipment, cost of 20 m^3 FSTP)	**117,575,000**
Annual Expenses (O&M) – includes labour wages, fuel and maintenance charges	**30,738,000**
Annual Revenue	**3,544,787**
Net Profit	**(27,193,203)**
Net Present Value (considering 12% as discount rate) Assuming 15 years of operation, without adjusting for inflation	**~ (318,000,000)**

Note:
The model is financially feasible only if part of property tax is used to cover costs of SW collection and segregation.

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