FSM4

Abstracts of presentations given within Track 3: Industry

Content Page

Industry 3.4: FSM Finance & Marketing

City Scale Sludge Treatment Plant in Faridpur, Bangladesh: Plan to Action

A Al Mamun*, S Ali, UK Saha*, H Jahan*, R Islam

Practical Action Bangladesh
House # 28/A. Road # 5, Dhanmondi, Dhaka - 1205, Bangladesh
Abdullah.AlMamun@practicalaction.org.bd

Keywords: Design and development of Sludge Treatment Plant

Conference Track: FSM Industry and Exhibition Track
Track Topic: Treatment and Reuse
Personal Preference: Oral presentation

This paper shares the learning from action researches on appropriate and affordable sludge treatment technologies to produce organic compost. The paper describes how this learning was useful for the design and construction of a city-scale sludge treatment plant in Faridpur. The paper also highlights the processes, factors and context that were considered in designing this plant.

Background and context

Bangladesh has achieved outstanding successes on “Access to Sanitation for All”. Currently more than 99% people use toilets or fixed points for defecation. The options are mostly on-site which have pits or tanks to accumulate wastes and have limited storage capacity. These facilities require frequent emptying and safe disposal of sludge. Very limited emptying services are available mostly in urban centres either by municipalities or by self-employed private cleaners. Both the city and private groups dump collected sludge in nearby drains, water bodies and low-lying areas because of not having any land and treatment plant. A big portion of the city’s people also illegally connect the outlet of toilets with storm water drainage. Safe management of human sludge is a considerable threat and treated as 2nd generation challenge in the sanitation sector of Bangladesh. This was the case in Faridpur city until FSM development cooperation with Practical Action, which started in 2008/9.

Action Research on Sludge Treatment Technology

Practical Action and Faridpur Municipality jointly launched action research in 2010 to explore appropriate and affordable technologies for sludge treatment, and tested the idea of turning sludge into organic fertiliser. To do so some brick-made rectangular chambers were constructed, where different size and proportions of sand, stone chips, brick bat are used as filter materials. White parabolic-shaped celluloid polythene was added on top of each bed which increases the temperature up to 70° Celsius within 15 days. The compost was tested and it was found that this treatment removed harmful pathogens and produced nutritive and marketable compost. Requirement of lands and capital costs are issues for scaling. Alternatively, planted drying beds with filter materials were demonstrated and found satisfactory but business viability and duration of treatment were the challenging issues. The research findings were shared with national and international experts, professionals and practitioners, and facilitated their field visits in Faridpur and most of the experts recommended both planted and un-planted drying system with continuous research provision for city scale treatment facilities.

Sludge Situation in Faridpur

A situation analysis of the faecal sludge system carried out with the support of the Bill and Melinda Gates Foundation in 2014 and found that

Toilets in Faridpur municipality: Pits are on average 2 cum capacity and generate 68% of the city’s sludge, while septic tanks have average 4 cum capacity and generate the remaining 32% of sludge. Desludging is required once every 18 months. Both the municipality and informal self-employed groups provide limited services (55% individual

81% institutional) mostly at night and the rest of the consumers illegally disposes in drains and water bodies. The customers pay 1200 BDT as emptying fee and have willingness to pay more 2000 BDT if they get quick, hygienic and reliable service. The municipality has lands and agreed to provide for sludge treatment plant.

The study concluded that the construction of a treatment plant was one of the highest priorities for action.

Faecal sludge treatment plant (FSTP)

Findings from sludge situation analysis, building on experience from action researches and learning from international experiences, Practical Action started the design of FSTP of 24m^3/day capacity (6 days in a week) and finalised the below operational diagram in early 2015 and decided to name of this treatment plant as Compost Research and Training Centre (CRTC). Our paper will describe in more detail the elements of this design, and how its operation is expected to scale up over time.

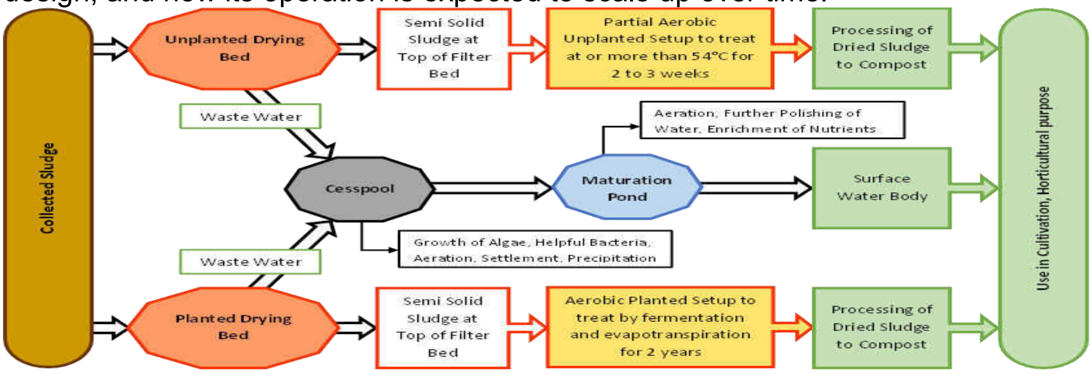


Figure: Operational flow diagram.

The study considered below design criteria:

The plant is designed considering the collected sludge have 1.5% solid contain that means 15 kg TS/m^3 and the maximum loading thickness is 20cm which needs to dry 15 days in unplanted drying bed. We estimated below requirement for developing physical facilities for sludge treatment plant:

Components	Units	Dimensions	Treatment capacity (cum/day)	Required drying/ retention time
Unplanted Drying Bed	16 nos.	10.75 m X 3.75 m X 1 m	6	15 days
Planted Drying Bed	12 nos.	8 m X 8 m X 1.9 m	18	1 year
Cesspool	1	21.5 m X 12.25 m X 1.4 m	18	7 days
Maturation Pond	1	10 m X 12.5 m X 2 m	18	12 days

Construction of Sludge Treatment Plant: Currently, around 90% of construction work is completed and experimental disposal has been started in August 2016.

Management of Sludge Treatment Plant: The plant is managed by SDC (a social enterprise in Faridpur) and they are responsible for production and sell of standard compost. The Municipality monitors both the treatment and business performance of the plant.

Business Planning and Performance based Contracting

SDC has estimated the possible operational expenditure including the safe transfer incentive (which they need to pay for delivering sludge to treatment plant by emptier groups) and revenues from sale of compost. The draft plan found that they will need around 6,50,000 BDT for first two years as subsidy from municipality but later on they can continue with the income from CRTC. The municipality has agreed to pay the required subsidy considering the performance in production and sale of standard compost and now both parties are discussing for a win-win mutual propositions to agree and the signing agreement by October 2016.

A Systematic Approach Adopted by Government of Maharashtra Scale up FSM services

Authors: Mr. Dhruv Bhavsar *, Ms. Utkarsha Kavadi, Ms. Dhanshree Zende***

***** PAS Project**,** Center for Water and Sanitation, CEPT University, Kasturbhai Lalbhai Campus, University Road, Navrangpura, Ahmedabad
**RCUES, All India Institute of Local Self-Government, Mumbai

Keywords: Fecal Sludge Management, Open Defecation Free (ODF), Policy, Regulation, Financing, Monitoring

Conference track: FSM Industry and Exhibition Track
Track topic: Programs, regulations and financing of FSM
Personal Preference: oral presentation

Background

Fecal Sludge Management (FSM) has been a neglected area in most Indian states and cities. It has not received attention because of poor understanding of fecal sludge/ septage, lack of proper technical guidance, absence of state level policy guidelines, regulations, program for cities and a complete absence of reliable finance for sanitation sector. Maharashtra is the third most urbanized State in the country with population of 50 Million (45%). It comprises of 36 districts, 357 sub-districts and 259 Urban Local Bodies. It faces tremendous challenges for provide adequate and sustainable sanitation for its growing population.

In most cities, toilets are connected to onsite sanitary disposal systems such as septic tanks and soak pits. In these cities, emptying septic tanks with vacuum emptier machines is common practiced. Septage treatment is rarely seen in smaller ULBs wherein, practice of disposing off septage in open dumps, water bodies or vacant lands outside the city limits is more prevalent. While there are good regulations for design of septic tanks, a majority do not seem to confirm to prevailing standards and regulations.

FSM landscape study in Maharashtra carried out by CEPT University, shows that the greater scope for FSM services, which is required for all cities in the state. About 61% urban state population needs to be served by FSM services.

Enabling policy framework and regulations for FSM services

Government of Maharashtra has adopted systematic approach by keeping in view city as a unit and encouraging city managers for moving towards improved sanitation by prioritizing access to own toilets and implementing plans for safe management of septage. Under Swachh Maharashtra Mission (Urban), Government of Maharashtra (GoM) envisages ODF, ODF+ and ODF++ cities by addressing entire value chain of sanitation rather than focusing only on toilets constructed in the cities. ODF+ cities are those cities where 80% residential properties will have access to own toilets and remaining population will have access to public/community toilets and there would also be safe collection, conveyance and treatment / disposal of faecal matter.

Septage Management Guideline and Guidebook on Septage Management for ULBs

To scale up citywide FSM services in Maharashtra, Government of Maharashtra has framed state level guideline for FSM, which directs Urban Local Bodies (ULB) to take up citywide FSM services, advocates scheduled emptying services, implement septage treatment facility, robust taxation structure for sanitation etc. The state government recently, launched a guidebook for ULBs to implement septage management plan. This guidebook is a step by step approach, which guides ULBs in terms of various aspects than need to be assessed and plan for septage management. GoM has envisaged that cities that become ODF will move towards becoming ODF+ by improving access to own toilets and implementing Feacal Sludge Management Plan. 100 cities have become ODF as on October,2016 and now these cities will be moving towards becoming ODF+.

Financing for FSM services

GoM issued a circular with a mandate of using 50% of the 14th Finance Commission funds for implementing various activities for sanitation including septage management. The guidelines for use of 14th FC funds at ULB level also emphasizes on implementing septage management related activities which will enable cities to address issues with entire value chain of sanitation and help them to move towards ODF+. GoM has also announced an incentive scheme for ODF cities to encourage ULBs to implement FSM related services and achieve next step of move towards ODF+/ODF++. GoM is giving incentive funds of Rs. 20 Millions for Class A; Rs.15 Millions for Class B and Rs. 10 Millions for Class C for cities which are declared ODF. Cities may also access the capital grant to implement septage management under Government of India's (GoI) AMRUT programme. GoM's septage management guideline suggests ULBs to levy a sanitation tax for septic tank emptying service and effective operation and maintenance for septage treatment facilities.

Capacity Building Workshop for Local government for FSM

The capacity building workshops were organised for ODF cities to introduce operational guideline for septage management at city level. It covered the various aspects on preparation of FSM plan, need and process of safe management of septage and upcoming technologies in FSM etc to the ULBs. This made the ULBs aware about the need for action across entire value chain of sanitation. With support from CEPT University through its PAS Project[1], GoM is developing a course on FSM for city officials also providing detailed handholding and technical support to two cities on a pilot basis in implementing septage management plans in their cities. The FSM technology selection workshop is planning to conduct for ULBs in Maharashtra.

Monitoring of revised Service Level Benchmarks for On-site sanitation system

CEPT University has developed a new set of performance indicators within the framework of Government of India led Service Level Benchmark (SLB) indicators. This has been used in Maharashtra since last two years. The revised SLBs on sanitation system provide a new framework of citywide sanitation by capturing the onsite sanitation systems along with the conventional sewerage systems. The use of the revised SLB framework will help state and city governments in monitoring sanitation improvement. It also helps cities choose various options for sanitation improvement planning based on local priorities and availability of finance. Importantly, the framework makes it possible to assess the improvement in service performance by making smaller investments in onsite sanitation system.

References

2016, “Guidelines for septage management in Maharashtra”, Government of Maharashtra (Link)
2016, “Guidebook for urban local bodies to implement septage management plan”, Government of Maharashtra
2016, “Making cities open defecation free – Systematic approach in Maharashtra”, Government of Maharashtra (Link)
2009, “Handbook of Service Level Benchmarking”, Ministry of Urban Development, Government of India
2014, “San Benchmark Citywide assessment of sanitation service delivery - Including on-site sanitation” (Link)
Performance Assessment System (PAS) Project, Website: www.pas.org.in

[1] www.pas.org.in

Title: Operation of a fecal sludge management utility at scale in the US: The case of FloHawks

Authors: JR Inman

Keywords: pit emptying; business development, septic tank emptying

Conference Track: Industry Track

Track Topic: FSM profitable business model

Personal Preference: oral presentation

ABSTRACT: Successful / evolving business model of a service, maintenance, & sanitation company in the United States.

Northwest Cascade / FloHawks is a service, sanitation, and civil construction company that has worked in the State of Washington for 50 years. Core work includes, septic & grease tank pumping, pump repair, plumbing & drain cleaning, vault cleaning and portable restrooms. FloHawks currently serves 27,500 households & business annually, averaging 110 services per day. Its gross revenue is $15.4 million US with a gross profit of $2.4 million US or 19%, using a fleet of 38 vacuum trucks & vans. It currently employs over 75 employees. the waste disposal plant processes over 800,000 gallons per months or 9.6 million gallons per year. (36 million liters or 36, 000 cubic meters per year)

The case study focuses on the development of a diverse group of small businesses that have grown over the last years in many different ways. The paper includes many different topics such as; company diversification, marketing, sales, dispatching, customers service, call handling, driver training & certification, safety, equipment, use of electronics, GPS, disposal options, and regulations.

The paper is based on experiences in many different parts of the USA and in other parts of the world where problems and issues are both similar and can also be very different. This case study provides an opportunity for many to see how the company has grown and the struggles and success that go along with evolution. It also describes operations today and current work in the USA that is applicable to countries improving FSM.

Collection Logistics and Waste Pre-Processing: Cross-learning

V. Gardiner*, I. Purves**, J. Young**

Keywords: Containment; Pre-Processing; CBS

Conference Track: (3) Industry and Exhibition Track
Track Topic: *Emptying and Transportation*
Personal Preference: *Oral Presentation*

Context: Current Waste Containment Methods

Faecal sludge waste streams are frequently contaminated by inorganic material or objects which are not easily treated in waste-to-value systems, and / or require particle size reduction to enter such systems. This problem impacts a range of toilet and treatment systems currently being operated in the field:

a) Omni-processing systems often require particle sizes <10mm for waste conveyance;
b) Anaerobic digestion systems often require particle sizes <10mm for waste conveyance;
c) Organic treatment technologies require the removal of inorganic wastes;
d) Other treatment technologies (such as pyrolysis) can require the removal of certain pollutant wastes;
e) All toilet systems that use inorganic materials, such as polymer films, for hygiene, containment, and/or transport will require separation of large objects and/or inorganic materials before waste treatment.

Regarding (a)-(e), it is widely understood that faecal sludge from most sources is likely to be contaminated by inorganic matter and in some cases large objects and/or materials that either enter the waste stream through actions of the toilet users, or are built into the containment and/or transport system. At traditional large waste water treatment (WWT) facilities these materials are removed from the waste stream through a series of large-scale screens and separators that require a very dilute waste stream and significant input energy. Further technical development is required to adapt such solutions to decentralized Faecal Sludge Management plants for developing countries, where energy and water are often in relatively short supply.

On the topic of point (e) above, Cartridge-Based Sanitation (CBS) systems in use with several BMGF-funded urban practitioners such as Sanivation, Sanergy, X-Runner and Loowatt all use polymer film bags (in some cases PE and in some cases biodegradable) to hygienically contain and transport waste. Separation and treatment of such film bags is a challenge in the systems that are currently treating waste from household and public toilets in SSA countries and Latin America. Combined, these companies currently treat the waste of an estimated 40,000 toilet users each day.[i] The majority of these operations then rely on basic and unsanitary means for separating polymer film from faecal sludge waste streams—manual removal through squeezing waste out of the bags and into treatment systems, and in most cases, subsequent incineration of PE bags outsourced to poorly regulated contractors—which is not sustainable or scalable. Despite this, for valid reasons there is continued interest in CBS systems as a possible route to widespread impact in developing urban areas.[ii] Therefore better technology solutions are needed to strengthen this link in the sanitation value chain.

Loowatt IBS Technology

Loowatt has approached the development of a polymer film packaging toilet with a technology- and design-led approach, and now has a toilet product which not only meets WHO standards but is highly valued. Household customers in Antananarivo, Madagascar, have shown enthusiastic willingness to pay through the regular purchase of toilet film refills.

Loowatt's same technology is built into toilets in the United Kingdom for outdoor events, with customers happily paying a premium (£3/visit) to use Loowatt toilets because they are odourless and pleasant, on par with a flush toilet. Our UK operation supports our ability to finance and grow our company to enable long-term global impact. Research & Development in both Madagascar and the United Kingdom, supported by the Bill & Melinda Gates Foundation and InnovateUK respectively, as well as private investment, have enabled Loowatt to benefit from valuable cross-learning as we are operating fundamentally the same system in two very different commercial and physical environments.

Figure 1.1 The IBS at Thames Water Utilities

An example of this cross-learning is presented in the Industrial Bag Shredder-Separator (IBS) which we designed, specified and constructed in 2015-16. The IBS is now operational at a UK facility operated by Thames Water Utilities, and being used to pre-process Loowatt organic waste before feeding into Thames' anaerobic digestion systems. The IBS provides a hands-free operator experience, taking in packaged waste and processing this through a shredding system, manifold and dewatering auger-compactor. After shredding all materials, it optionally separates organic waste from polymer film to enable different treatment methods. The IBS currently requires an average power input of 3.2kW, and can process up to 1 tonne-per-hour. The energy input therefore currently stands at 3.2kWh/t of wet feedstock (less than the gross energy content of a single m^3 of biogas). The unit weighs just 1.5 tonnes and can fit inside a 20ft shipping container. At the time of writing it has processed approximately 20 tonnes of UK festival waste, containing over 9000m of Loowatt's biodegradable film liner.

Feeding the IBS with waste from UK events has involved complex logistics to transport waste between the event and treatment sites (see below). Metrics related to waste transport and value-generating treatment at this scale of operation offer valuable insights pertinent to the rollout of urban sanitation in developing countries. Further, polymer films separated by the IBS in 2016, all classed EN13432 (European standard for compostability), have been treated in experimental processes including composting, anaerobic digestion and feeding to Black Solider Fly Larvae. Results from these experiments, still in analysis as of this writing, will be included in the presentation.

Table 1.1 Example Waste Movements and Processing: Summer events. Refill L=16M

Event	Days	Toilets	refills/t/d	Barrels	Transport	Processed	Time
Port Eliot	3.5	32	1.43	160	10' container	4 Tons	7 hours
Wilderness	3.5	34	1.07	120	10' container	3 Tons	6 hours
Festival N6	3.5	28	1.98	195	10' container	4.8 Tons	8 hours

Film as portion of total waste stream

	Total waste (kg)	Film dry weight (kg)	% film
Port Eliot	4000	102	2.6%
Wilderness	3000	81.5	2.7%
Festival N6	4800	124	2.6%

References

[i] Practitioner data: Sanergy, Sanivation, X-Runner, Oxfam iHub Meeting April 2016

[ii] Roma, E. and Curtis, V. (2015) Mapping Sanitation Solutions: A Report in Collaboation with LSHTM and Domestos

Logistic Tool to improve Fecal Sludge Management Business Model

Thammarat Koottatep*, Atitaya Panuvatvanich*, Kristina Thapa*, Huayna Paola Villarraga Morales*, Yuttachai Sarathai*.

* Environmental Engineering and Management, Asian Institute of Technology, Thailand

Keywords: Logistic tool, Fecal sludge Management (FSM)
Conference Track: Exhibition Track
Track Topic: *Emptying and transportation*
Personal Preference: *Paper presentation*

Background

Fecal Sludge Management (FSM) service chain consists of household level users, private collection and transport businesses and treatment facility. FSM is different from the traditional vehicle routing and even from solid waste collection system in terms of dynamic collection points, the urgency of getting the service and diversity of demand. Treatment plant usually are located on the outskirt of the city thus travel time and the travel distance of the vehicle is generally large. Therefore, the need of the minimizing the travel time, travel distance is necessary keeping in mind the capacity of the vehicle. To address these vibrant factors logistic tool is developed by Asian Institute of Technology and bring them under the same umbrella. This tool will optimize the tour based on the customer order and available vehicle on that specific date ensuring maximum utilization of resources with minimum cost. User of this toolbox will be the municipality and or service provider who is collecting fecal sludge from door to door.

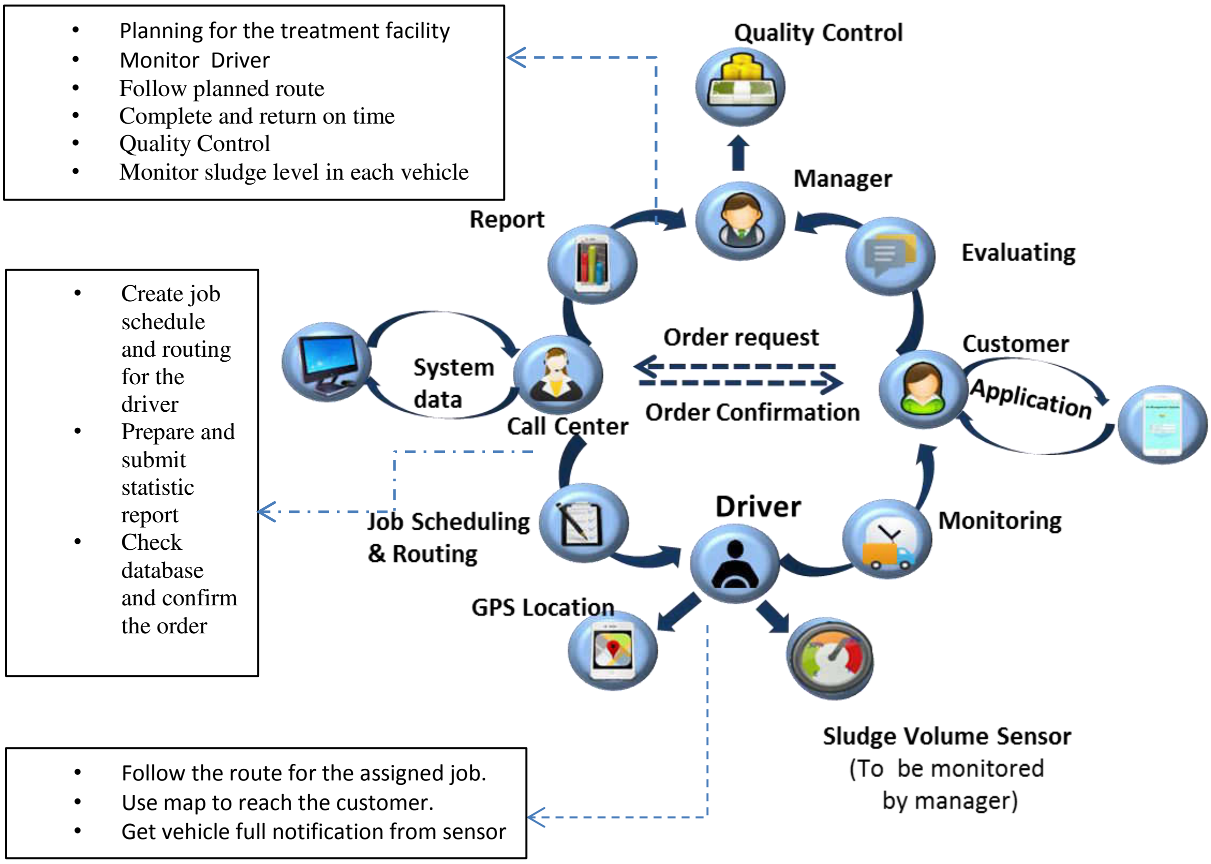


Figure 1: Logistic Tool for FSM

To list down some of the major benefits which logistic tool can bring to service providers are:

- It has the capacity to prioritize the customer's order based on urgency
- Potential customer (who got the service already before that specific time) will be visible on the map which will guide the authority in getting more customer.
- Mobile app for logistic tool will assist the managers and drivers in proper management of the collection vehicle and time.
- This tool will assist service providers in choosing best order to serve the customer following shortest path to reach them.

Nonthaburi as a case study

Logistic tool was tested in one of the municipality of the Thailand named Nonthaburi. After 6-month observation it was found applying logistic tool overall distance to be travelled by driver was decreased. Estimates fuel saved by **47.98**% from current fuel consumption, improving business model for service providers. Figure 2 illustrates business model for Nonthaburi including logistic tool.

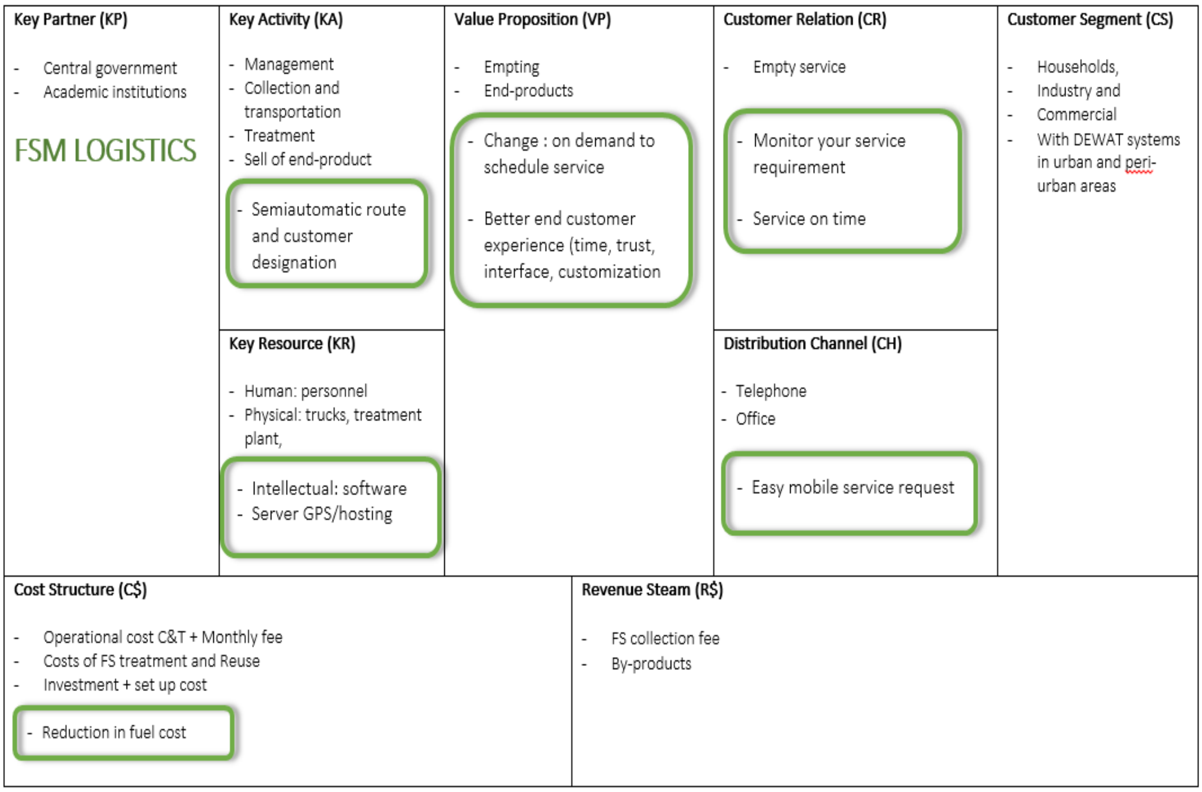


Figure 2: Business model canvas (Nonthaburi) (Osterwalder 2010)

References

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: a handbook for visionaries, game changers, and challengers. John Wiley & Sons.

Applicability of Innovative Possibilities for Faecal Sludge Collect and Transport Services In Perception of Service Operators & Experts

Anh H. T.[1], Koottatep T.[1], Polprasert C.[2], and Panuvatvanich A[1]

(1) School of Environment Resources and Development, Asian Institute of Technology: P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand
(2) (2) Department of Civil Engineering, Faculty of Engineering, Thammasat University: 99 Moo, 18 Phaholyothin, Khlong Luang, Pathumthani 12120, Thailand

Keywords: Innovation possibility, Collection and transport, Perception
Conference Track: FSM Industry and Exhibition Track
Track Topic: Emptying and transportation
Personal Preference: *Anh H. T.*

Introduction: Innovation solutions are lacking in the business of Faecal Sludge Collection and transports services as several innovation possibilities have not been tested (Chowdhry S. & Koné D. 2012). Using the questionnaire to test the international service operators and experts` perception, this study suggested the applicability of the innovative possibilities to be apply with a minimum failure.

Methods: Through literature review about the innovation possibility for Faecal Sludge Collection and transports, this research assessed eight cases within five municipalities in Thailand, six cases in Vietnam to suggest eight innovative possibilities. These cases was chosen based on service location base, type of ownership and business size. These eight possibilities were tested by international survey with online and mail questionnaires with the response of 224 service operators and experts in 25 countries. The data was analyzed by SPSS 16 to conclude about the applicability of the innovative possibility.

Results: A frequency analysis was conducted for the characteristic related to the surveyed services. Most of the service has the capital less than 200.000USD. There were three main groups of services basing on truck numbers: from 1 to 2 truck, 3 to 5 trucks and 6 trucks and more. One hundred and twenty services (53.6%) have more than 10 years history. The rest service has less than 10 year’s history. The respondents contained two groups 169 Operators (75.4%) and 55 Exerts (24.6%). There were 75% respondents has he working years more than 3 years. The applicability was measured with the Likert scale: 1 is Minimum Value of applicability and 7 is Maximum Value of applicability. The results were shown in the table 1:

Table 1: Innovative possibilities rating

Innovative possibilities	N	Minimum Value of applicability	Maximum Value of applicability	Mean Value of applicability	Standard Deviation value
1. Using improved truck(s) with FS treatment function	224	1	7	4.89	1.664
2. Technology application. Using logistics planning tools and GPS application to track the truck routing and find the optimum transport route	224	1	7	5.08	1.564
3. Cooperative model to link the service providers	224	1	7	5.01	1.421

4. Collection sludge volume pricing with volume measure device	224	1	7	5.38	1.374
5. Transport distance pricing by on routing application	224	1	7	5.20	1.497
6. Environment friendly branding	224	1	7	5.65	1.328
7. Transfer station / and transfer truck	224	1	7	5.12	1.583
8. Customer relationship management with customer data profile management	224	1	7	5.42	1.330

The solutions could be used to optimize operating cost and generate more revenue for the better service performance. When the services are improved, the customer satisfaction levels are increased, the environment are protected. Because of technological barrier, among eight solutions, the highest applicable is Environment friendly branding (5.65) and the lowest applicable is improved truck (4.89). The solution could be adapted into business model of Faecal Sludge collection and Transports as shown in Figure 1

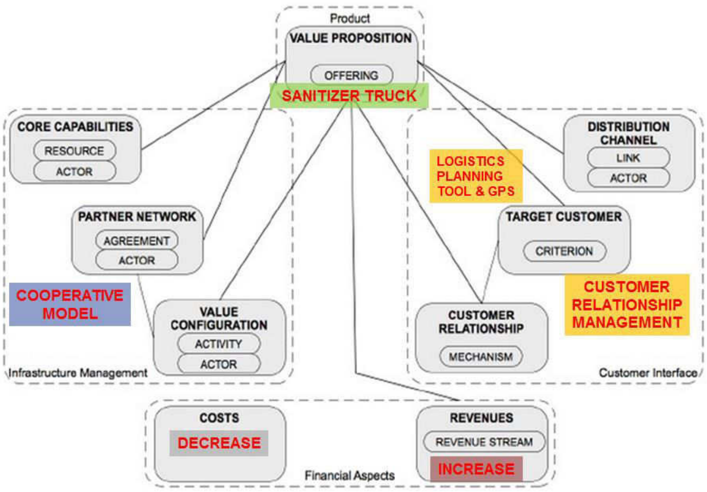


Figure 1: K**ey** possibility for innovative solutions adapting to Business model of Faecal Sludge Collect and transports services

The main benefits of practical application are explained according to the stakeholders: Service operators can operate the service more efficiency and effective with least burden causing to the environment by the services. Business owner can earn more profit and economic value which can be contribute to the society by tax contribution. The authority, municipality, city managers can improve their monitoring activities and support the service development better with the innovative technological tools. The environment can be protected better with less illegal discharged activities. Energy consumption is decreased due to less transport routes.

References

1. Chapman, R. L., Soosay, C. & Kandampully, J. 2003 Innovation in logistic services and the new business model: A conceptual framework. *Managing Service Quality: An International Journal*, **12**(6), 358 - 371.
2. Chowdhry S. & Koné D. 2012 *Business Analysis of Faecal Sludge Management: Emptying and Transportation*, Report, Bill & Melinda Gates Foundation, USA

3. Mbéguéré M., Gning J. B., Dodane P.H. & Koné D. 2010 Socio-economic profile and profitability of faecal sludge emptying companies. *Resources, Conservation and Recycling*, **54**(2010), 1288–1295.
4. Osterwalder A. & Pigneur Y. 2010 *Business model generation*, first edition, John Wiley and Sons, Inc., New Jersey

Faecal Sludge Management Human Resource Training through Online Education

A. Manandhar Sherpa*, M. Ronteltap**, M. Mulenga**, D. Brdjanovic**

*500B Solutions Pvt. Ltd., Kathmandu, Nepal
**UNESCO-IHE Institute for Water Education, Delft, The Netherlands

Keywords: faecal sludge management; online course; partnership

Conference Track: (1) Research Track
Track Topic: *please select in the track-topic you are applying for with your paper*
Personal Preference: O*ral presentation*

Background

Over the years, there have been large investments to provide access to safe sanitation for more people - for a major part under the influence of the Millennium Development Goals. This large boost of mainly onsite sanitation facilities has not only led to an increased global access to improved sanitation, but also to an increased amount of faecal sludge requiring collection and treatment. Adequate management is of key importance in order to prevent the collected sludge from becoming a health hazard in whichever location it is stored or disposed of.
Adequate faecal sludge management covering global access requires a significant amount of trained professionals. Recently, the International Water Association IWA calculated that for universal coverage for water and sanitation in developing countries, 3.3 million professionals more are needed (IWA, 2014). Lack of capacity and the challenges facing the water sector require design of adequate training tools and innovative learning approaches to enhance the competencies of staff as well as strengthening institutional capacity (WWAP, 2016).

In response to this dire shortage of skilled people and limited knowledge on the subject, one of the innovative learning approaches, an online course (OLC) on FSM was recently developed by UNESCO-IHE Institute for Water Education in partnership with educational institutes and FSM experts. The initiative benefitted from the financial support of the Bill and Melinda Gates Foundation. The FSM book entitled “Faecal Sludge Management: System Approach for Implementation and Operation”, published through joint collaboration between Sandec of the Swiss Federal Institute for Aquatic Sciences and UNESCO-IHE, was the prime reference for the OLC on FSM. This paper consolidates the methods and experiences of developing and delivering the OLC on FSM and recommends measures for future improvements.

Online Course on FSM

The OLC is designed for professionals dealing with planning, promotion, design, operation or management of FS for residents in urban, peri-urban, slum or rural areas. Like the book, the course presents the current state of knowledge on FSM through an integrated approach to technology, management and planning. It addresses planning and organization of the entire FSM service chain, from collection to enduse, and deals with details of operational, institutional and financial aspects. Guidance is provided on planning up to a city-level FSM project with the involvement of all the stakeholders.
Students spend around 8 hours per week over a period of 16 weeks, in which they read, watch videos, study, and write assignments. One week typically covers one book chapter. If they choose to take an online exam and pass, 5 credits of the European Credit Transfer and Accumulation System are earned. The course is part of the Graduate Professional Diploma Programme on Sanitation/Sanitary Engineering offered by UNESCO-IHE.

Course Delivery Method

From January – June 2016, UNESCO-IHE delivered the first course, simultaneous with five institutes from Africa and Asia (Figure 1). The benefit of delivery of the course by 6 partners is that many participants can join the course at the same time. In addition, because the courses are given by institutes in specific regions, participants may also be able to communicate in their own language, or discuss issues applicable to their own region. Many experts in the field of FSM contributed to the course in the form of key note lectures: short videos introducing the "hot topics" in the course discussed. This exposure to well-known experts with a motivating message was very well received by the participants, as were the case studies prepared by the partners: videos showing current situations and practices from all over the world, zooming in on stakeholders, technologies and solutions.

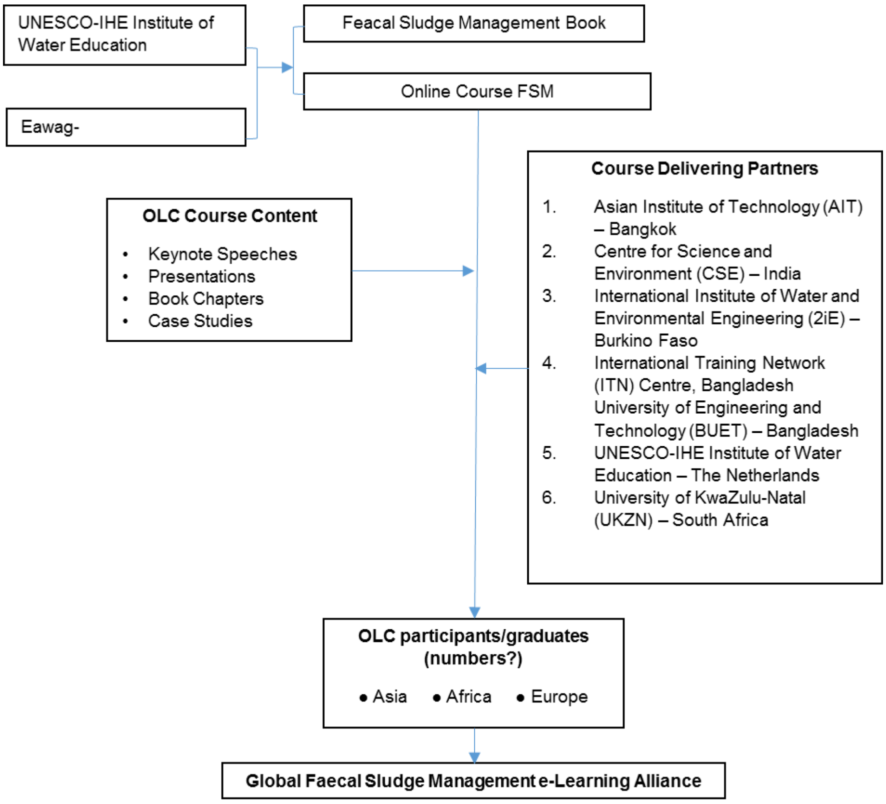


Figure 1 Schematic diagram on online course development and delivery

Outcomes and way forward

Close to 400 people from all over the world participated in the course of which at least 300 successfully completed the course. To ensure continued learning and sharing of ideas on FSM, the participating institutions have created a new network platform to which all FSM OLC graduates will become automatic members: the Global Faecal Sludge Management e-Learning Alliance. This platform facilitates development and empowers the dissemination of knowledge on faecal sludge management (FSM) through online education, so that the sanitation challenges can be embraced with deeper insight, advanced knowledge and greater confidence. In the next phase of course delivery the partners plan the following updates: (i) addition of information more relevant to a particular local context, (ii) adding more case studies and including key notes from local experts, (iii) forging partnerships with other institutes or government agencies to widen the audience, (iv) packaging the course into shorter courses focused on specific FSM topics to address precise needs of some participants and organisations.

More details will be shared during the presentation, to inspire the audience to contributions, participation and feedback.

References

IWA (International Water Association) (2014) An Avoidable Crisis: WASH Human Resource Capacity Gaps in 15 Developing Countries. London, IWA Publishing. http://www.iwa-network.org/downloads/1422745887-an-avoidable-crisis-wash-gaps.pdf

Strande, L., Ronteltap, M. and Brdjanovic, D. (eds) (2014). Faecal Sludge Management: Systems Approach for Implementation and Operation. IWA Publishing, London. ISBN13: 9781780404721.

WWAP (United Nations World Water Assessment Programme) (2016). The United Nations World Water Development Report 2016: Water and Jobs. Paris, UNESCO.

Equipping local governments with the skills to implement scheduled desludging

F. Mills*, J. Willetts*, K. Abeysuriya* and A. Kome **

* Institute for Sustainable Futures, University of Technology Sydney, PO Box 123, Broadway, NSW 2007, Australia
**SNV Development Organisation, Parkstraat 83, 2514 JG, The Hague, The Netherlands

Keywords: scheduled desludging; capacity building; faecal sludge management

Conference Track: Research or Case Study
Track Topic: Education or Pilots
Personal Preference: O*ral presentation*

Introduction

With only a small proportion of on-site sanitation safely managed (World Bank 2014), significant improvement in faecal sludge management (FSM) will be required to achieve the Sustainable Development Goals. While national governments have the obligation to meet the human right to sanitation for their citizens, the practical responsibility for sanitation service provision frequently falls on local governments. Development partners have a key role in equipping government with the information, skills and decision making tools to develop and implement FSM programs.

This paper shares SNV's experience as a development partner seeking to improve FSM in four cities in Indonesia, Nepal and Bangladesh as part of their broader urban sanitation program. It draws on a review and synthesis that identified key features of SNV's approach, conducted by the Institute for Sustainable Futures UTS. It brings together illustrations of SNV's strategy to involve local government in all stages of program design and development, with a strong focus on stakeholder engagement. The purpose of the paper is to examine SNV's approach as a means to facilitate 'experiential learning' for local government (Kolb 1984) and in doing so develop insights on how development partners and national governments can best support acquisition of relevant skills by local governments to develop and implement successful FSM programs.

Research cities

This research draws from SNV's programs to support urban sanitation from 2014 and 2016 in:

- Kalianda, Sumatara, Indonesia: Sub-district of 121,188 inhabitants including urban and rural areas. Local government operates an emptying truck and have a new sludge treatment plant.
- Khulna and Kushtia, Southern Bangladesh: Cities of 1.5 million and 238,065 inhabitants respectively. Local government and community organisation manage emptying trucks and an official disposal site, although manual emptying by a "sweeper" is common.
- Birendranagar, Surkhet District, Nepal: Municipality of 106,557 inhabitants. Municipality has an official disposal site while emptying is conducted by one private operator.

Key features of the approach to build local government capacity

The following sections highlight four key features of SNV's approach applied in these locations and the ways in which experiential learning was facilitated.

Understanding the legal landscape for FSM

In each country, the program commenced with a legal review to gain an understanding of national and local regulations and policies applicable to all stages of the FSM service chain. It enabled SNV to engage with national government towards strengthening national coordination and to support local governments to design programs that were compliant with local requirements.

Rapid data collection to inform decision making

The Rapid Technical Assessment (RTA), originally developed by David Robbins (Oxfam 2016), was adapted to suit each city and conducted early in the program to ensure that decisions regarding project scope and approach reflected local conditions. The RTA is a specific FSM data collection tool to capture information about the containment system and access for emptying necessary to design sludge emptying programs. The RTA was conducted with a small team over

3-5 days using smart phones so that data was immediately available online. With a well-designed sampling method and adequate training of survey staff, the RTA was able to quickly capture sufficient information at program inception and at a lower cost than community-wide census. Although there are limitations of collecting data from a small sample when designing city-wide programs, the data was deemed sufficient to enable the first step of program design. Once government is committed to a scheduled emptying approach, more extensive data collection can be conducted focused on the selected pilot areas and to suit the customer database format. Although local government were integrally involved in the data collection and analysis, some cities faced challenges local government motivation to independently implement the second phase.

Local government engagement in all steps and decisions

Through application of the "Septage Management Decision Support Toolkit" (Oxfam 2016), the technical requirements and costs are calculated based on the RTA outputs, financial data and decisions on program delivery. SNV used a participatory approach to apply the toolkit to ensure the proposed option was locally appropriate and acceptable while increasing government understanding of the often complex requirements of a regular emptying program. Beyond engagement in the toolkit and RTA, SNV has facilitated different programs in each city, where program choices were not only dependent on technical conditions but also on local government capacity, preference and vision. Differences included: private sector involvement, asset ownership, costs to be recovered and tariff categories. To improve ongoing commitment and increase likelihood of successful implementation, these decisions should not be made with technical input alone by external experts. Engaging local government in all steps and decisions allowed them to arrive at the realisation that FSM services could recover costs, and trigger increased local government support and engagement.

Small early pilots

Another feature to quickly inform decision making and increase local government understanding of scheduled emptying requirements were the rapid pilots conducted in Khulna Bangladesh. In contrast to pilots occurring as the final step once program decisions are finalised, SNV conducted intentionally small scale and short pilots early in program development. Two pilots were conducted over 2-4 days, including 60-65 households in promotion and emptying 3-15 systems using community development committee and government trucks. Although these numbers were small, the pilots proved valuable in testing assumptions and identifying technical and capacity gaps early. This meant they could be addressed or the approach reoriented before scale up. Although the pilots found that the community organisations severely lacked capacity to manage scheduled desludging programs, since they own the trucks the proposed approach was not changed.

Significance, conclusion and implications

The synthesis of SNV's programs to develop scheduled sludge emptying in four cities highlighted two key approaches to ensure locally appropriate programs and increase local government capacity and support. First was the use of rapid data collection and short pilots to gather practical information early in program to inform decisions and design. The second was local government engagement in all steps and decisions, which increased understanding of the complexities of scheduled desludging, built capacity to collect data and make decisions independently, and improved ownership and acceptance. Although focused on scheduled emptying, problem solving the multi-faceted aspects of FSM contributes to skills development applicable to delivering other citywide sanitation services. Development partners and national governments looking to support local government action on scheduled emptying programs will need to both focus on facilitating practical experiential learning such as facilitated by SNV, as well as address common barriers to local government engagement such as staff turnover and development of institutional incentives.

References

Blackett, I., Hawkins, P., & Heymans, C. (2014). The missing link in sanitation service delivery: a review of fecal sludge management in 12 cities. Washington DC: WSP-World Bank Research Brief.

Kolb, D. A. (1984). Experiential learning: Experience as the source of learning and development. New Jersey: Prentice-Hall.

Oxfam (2016). Septage Management Leader's Guidebook - Philippines Edition. Oxfam, UK.

Assessing city-level FSM needs to build capacity

L.E., Kohler*, T.K.K, Ngai*, S. Philippe*, L. Boudreau*, P.D. Dey**, D. Kapur**, J. Dash**, A. Gupta**

*CAWST, Upper 424 Aviation Road NE, Calgary, AB T2E 8H6 Canada
**National Institute of Urban Affairs, India Habitat Centre, Lodhi Road, New Delhi, India

Keywords: Needs assessment; FSM, capacity building

Conference Track: Case Study Track
Track Topic: *At scale city-wide or nationwide FSM services*
Personal Preference: *oral presentation*

SCBP Background

Recognizing city-level capacity limitations for decentralized sanitation planning and implementation in India, the Ministry of Urban Development (MoUD) appointed the National Institute of Urban Affairs (NIUA) as the anchor organization for a Sanitation Capacity Building Platform (SCBP) to support cities in their sanitation planning and implementation. NIUA partnered with CAWST, a capacity development organization, to design and initiate the SCBP with the goal of building the capacity of cities and relevant stakeholders working in urban sanitation. This effort is to ensure improved delivery of sanitation services through decentralized approaches, namely Faecal Sludge Management (FSM). At the program's outset, MoUD identified 6 cities in 3 states to support in delivering FSM. The 6 cities include Unnao and Ghazipur in Uttar Pradesh, Proddatur and Gudur in Andhra Pradesh, and Hajipur and Bhagalpur in Bihar.

To support these cities in the planning, design, implementation and continued operation of FSM the first function of the platform is to understand the structure of the city, to determine existing sanitation services, and to assess the knowledge and attitudes of municipal staff and public administrators related to FSM. This paper examines the process of implementing such an assessment—the research, planning, outcomes, and the lessons learned--that could be used to inform and improve future city assessments in India. The objective of this paper is to first guide the SCBP in executing future state- and city- level assessments to develop a comprehensive capacity building programmes for successful FSM implementation. A second objective is to support other organizations and platforms conducting city-based needs assessments in sanitation.

Data Review

To design the tools required, CAWST and NIUA first reviewed existing documents and research within two main streams, the sanitation status of India and the SCBP's 6 cities, and from previous capacity building initiatives in India. Lessons learned from previous national missions such as the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) were incorporated, including 18 studies on training needs assessments of Urban Local Bodies (ULBs). 13 Shit Flow Diagrams (SFD), existing state-level sanitation strategies, and City Sanitation Plans (CSP) were all used to further identify country-wide trends and clarify points of departure for developing the templates. Meetings were then held with the 8 SCBP partner organizations. The partners were identified based on 10 criteria including each partner's capacity building mandate and their decentralized sanitation experience within India. All 8 partners have experience working with capacity building, ULB support, or decentralized sanitation. Their observations of the implementation challenges provided a baseline of the barriers that exist throughout Indian cities and were used to corroborate key challenges identified within existing research. The key challenges were divided into four main areas – managerial, technical, financial, and institutional level capacities. These were then sub-divided into 21 main challenges, including but not limited to staff turnover, lack of motivation, understanding of decentralized sanitation, contract preparation, competing priorities with centralized solutions, land availability, and lack of institutional capacity and resources.

Questionnaire Design

The findings were consolidated and used to develop a series of questionnaires to guide meetings with the various stakeholder groups involved at both the state and city-level in the provision of FSM. Stakeholder questionnaires included questions to gauge each group's knowledge about sanitation, particularly decentralized solutions such as FSM and decentralized wastewater treatment systems (DEWATS), their attitudes toward such solutions, and the current designs for the city's onsite sanitation technology (OST) and their management practices.

State and City Visits

The final phase of the needs assessment was to conduct visits to the states and cities to directly explore their needs in terms of sanitation, make observations, and to identify and reach ULB stakeholders involved in sanitation service delivery. Representatives of the SCBP from NIUA and CAWST met first with officials in each state capital to understand the FSM mandate of the state, the level of support available to the ULBs, as well as to orient state officials in order to facilitate meetings with officials at the city level. State level officials included those responsible for state level sanitation planning such as the coordinators for Swachh Bharat and AMRUT missions, senior technical advisors, and engineers to assess the FSM knowledge and interest of the state. At the city level, SCBP representatives were interested in meeting the City Commissioner responsible for city planning, the mayors who typically influence what infrastructure is built in the city, city engineers or staff from health or engineering departments to gauge their understanding and experience with FSM. City OST masons and/or installers, and the OST service providers such as emptiers were also interviewed where possible.

Assessment Outcomes

Several key lessons were learned during the state and city visits. Attendance varied greatly, the time granted was often delayed and shorter than the time assigned, and the movement of attendees to and from meetings restricted their structure. As a result, data collected varied in quality and quantity depending on the city and state. We quickly realized the benefit of using the questionnaires to guide these initial discussions rather than restrict the exchange to only those questions on the template. This allowed us to adapt conversations to gather the most information possible within a short timeframe.

Despite some of the visit challenges, 6 common FSM implementation barriers were identified in the ULBs. Those barriers included land availability, motivation to implement or acceptance of decentralized sanitation solutions, capacity in terms of the number and qualification of staff in the municipality to support FSM implementation, OST installation & management referring to OST design and emptying frequency, knowledge management (i.e. availability of sanitation related data), and competing priorities such as the construction of sewer networks and centralized wastewater treatment and solid waste management.

Land availability was identified as a major barrier to the implementation of FSM due to the lack of space for both Fecal Sludge Treatment Plants (FSTPs) and individual household septic tanks and latrines. Five of the 6 cities mentioned that land availability was a concern in terms of constructing an FSTP. Demonstrated interest in FSM and capacity building were the second most cited challenges. Based on these considerations, 3 of the 6 cities were identified as promising based on their expressed interest in working with the SCBP to plan and deliver FSM services and that they had required staff available to do so. With these 3 cities, SCBP partners will be involved in a more targeted assessment specific to the identified capacity gaps. This will help develop a comprehensive capacity building program for each city, and the SCBP's partners will coordinate to deliver customized support to relevant actors. In the remaining 3 cities, it was clear that sewer networks and centralized treatment are currently a priority over decentralized solutions. These cities require a more complete assessment of their interest and further exposure to FSM before moving forward to the capacity building program phase.

Improving SuSanA's Knowledge Management and Collaboration Platform to Benefit Faecal Sludge Management Practitioners

A. Rosemarin*, A. Panesar**, A. Oko-Williams***, J. Parkinson****, D. Kellogg*****, E. von Muench******, K. Andersson*, S. Dickin*, A. Tempel**, C. Rodrigues**

*Stockholm Environment Institute, Linnégatan 87D, 10451 Stockholm, Sweden
**GIZ, Dag-Hammarskjöld-Weg 1-5 65760 Eschborn, Germany
***WaterAid, 47-49 Durham St, London SE11 5JD, United Kingdom
****Oxfam, Oxfam House, John Smith Dr, Oxford OX4 2JY, United Kingdom
*****Kellogg Consultants, Boston, USA
******Ostella Consulting, Eschborn, Germany

Keywords: Knowledge management; FSM community of practice; Sustainable Sanitation (SuSanA)
Conference Track: Exhibition & industry
Track Topic: Knowledge management
Preference: Oral presentation

Overview

A consortium of SuSanA (Sustainable Sanitation Alliance) partners has been working since October 2016 on a large 3-year knowledge management and collaboration project funded by the Bill and Melinda Gates Foundation. This project will further strengthen and expand SuSanA's capacity to serve the sanitation sector as a knowledge management organization and online platform. The topic of FSM is central to this project, since it is a vital component to the achievement of the SDG Target 6.2 on sanitation. Concurrently the users of on-site systems are expected to double by 2030. This is a third phase of development that has been funded by the Gates Foundation to improve and extend the SuSanA platform. This phase will make improvements to increase the value to users and the longevity and sustainability of the platform and analyze the impact SuSanA is having on the work of the sanitation community of practice.

The presentation will report on the consortium's vision for how the SuSanA platform can be more effective in accomplishing SuSanA's overall mission. Three major studies will be conducted to serve as a foundation for decision-making and implementation planning. One will analyze the online user experience and recommend improvements to deepen impact and usability. The second will be a marketing study to better understand the knowledge and networking needs of the global WASH community which will result in a new communications strategy and implementation plan. The third will be an organizational study to ensure long-term sustainability. All these findings will form the basis for follow up actions required to make significant and measurable improvements to SuSanA.

The project will yield more insight into the knowledge management needs of the sanitation community of practice working with FSM. Success will be measured by how much positive impact SuSanA has on the work of the broader community of sanitation practitioners. The project will also make the online SuSanA platform easier to access, more robust and provide new knowledge services. ***We welcome all FSM4 attendees to initiate a dialogue with SuSanA regarding their individual needs for knowledge management and collaboration on best practices, case histories, business solutions and development opportunities.***

Background on SuSanA

Currently, SuSanA is an open international alliance, a network of over 7300 individual members and 277 partner organizations dedicated to understanding sustainable sanitation solutions. SuSanA's mission is to link on-the-ground experience with an engaged community of practitioners, policy makers, researchers, and academics with the aim of promoting innovation and best practices in sanitation policy, programming and implementation.

The overall goal of SuSanA is to contribute to the achievement of current and future sustainable development goals by promoting a systems approach to sanitation provision taking into consideration all aspects of sustainability. The presentation will summarize the history, leadership and funding that made, and continues to make, SuSanA possible.

SuSanA Activities that Benefit FSM Work

We plan to make KM and collaboration tools even more well known and valuable to FSM work. The platform intends to improve learning across projects and contexts, thus enabling all to differentiate or integrate FSM under the broader sanitation umbrella. Some of the SuSanA activities of benefit to FSM include:

1. Discussions of FSM topics on the SuSanA discussion Forum. These can be moderated and time-bound, or not time-bound: http://forum.susana.org/component/kunena/53-faecal-sludge-management
2. SFD (Excreta Flow Diagrams) Portal where FSM information and resources at a city level can be found: http://sfd.susana.org/.
3. Project Database which provides details for sanitation projects worldwide, many of which relate to FSM: http://www.susana.org/en/resources/projects
4. SuSanA Library with over 2000 publications, many with a strong focus on FSM: http://www.susana.org/en/resources/library
5. SuSanA Working Group Wikis which offer a platform for collaborative efforts to create website pages relevant to FSM topics using "Wiki technology".
6. Updates to articles in Wikipedia which deal with FSM-related topics. For example, the main article on FSM: https://en.wikipedia.org/wiki/Fecal_sludge_management
7. Regular webinars run by the secretariat of SuSanA which deal with FSM topics. SuSanA also offers a platform for Thematic Discussion Series (TDS) focussing on FSM: http://www.susana.org/en/resources/thematic-discussion-series

Three Primary Project Outcomes

The work will involve the SuSanA community in a concerted effort to move closer to accomplishing SuSanA's mission. The specific outcomes around which the project will be focused are:

- Improved use of the SuSanA Platform by identified target groups, through a clear communications plan and platform improvements.
- Demonstrable improvements in the impact that the use of the SuSanA Platform has on members' work in sanitation.
- Strengthened governance and institutional sustainability of SuSanA as reflected in an operational and funding plan

Consortium Partners

Stockholm Environment Institute (SEI) is the lead organization and will manage the work of the project in close collaboration with GIZ, where the SuSanA Secretariat is housed (and funded by BMZ of the Government of Germany). SuSanA partners Oxfam and WaterAid will implement the communications strategy and outreach to more deeply engage existing and new members, with a particular emphasis on increasing participation of the "global south." A special focus on private sector involvement and contribution to the platform will be spearheaded by U.S.-based Kellogg Consultants.

Creating Demand for Sanitation and FSM Through Exposure: Evidence from Bihar

Sanjay Singh*, Aprajita Singh** Putul Thakur*** Jennifer Marcy****

* sanjaysingh@psi.org.in **aprajitasingh@psi.org.in ***putul@psi.org.in ****jmarcy@psi.org

Keywords: Bihar, portable toilet cabins, demand, exposure

Conference Track: Case Study Track
Track Topic: *Pilots showing promise*
Personal Preference: *Oral presentation*

Introduction

In rural areas quality and affordable options for FSM are non-existent. "Prasadhan," a project funded by Bill and Melinda Gates Foundation and implemented by PSI India, increases access to and use of quality sanitation and FSM services by, 1) Facilitating linkages between a local sewage treatment plant, tanker operators, and households, and 2) Tackling the social norm of open defecation by creating demand for sanitation and fecal sludge services by exposing households to quality, portable toilets cabins (PTCs) and regular emptying services. PSI hypothesized that households who were exposed to PTCs and emptying services would be more likely to construct and use a more permanent latrine.

Background and Context

Bihar has among the highest rates of open defecation in the world, with 82% of the rural population defecating in the open. Resulting environmental fecal contamination increases the risk of morbidity, including enteric illness and poor linear growth, in young children. Due, in part, to the unhygienic conditions created by open defecation, Bihar also has one of the highest rates of childhood chronic malnutrition in the world. While national and state efforts exist to improve sanitation coverage, faecal sludge management (FSM) is neglected.

Prasadhan targets key issues affecting sanitation uptake in Bihar which stem from low exposure to toilet use and poor awareness of available FSM options. This is done by placing quality, aesthetically pleasing PTCs in rural villages for free trial periods. Each PTC is shared by 4 households, placed for 3 months, and is emptied free of charge every other day. The service provider also regularly washes the facility to maintain the positive experience associated with toilet use. The waste is taken to a privately owned STP with a 15,000L capacity, which currently accommodates two fleets of tankers for safe disposal of their waste. Sludge is collected from the PTC sub-structure every other day and is emptied and transported to a STP free of charge.

After trial, households are offered the opportunity to purchase a permanent toilet and optional bundled pit-emptying service.

Methods

The pilot study was conducted in the suburban block, Phulwari, in Bihar's Patna District. A total of 17 PTCs were installed for three continuous months, with each PTC serving 4 households, or a total of 68 households (directly exposed group). Initially the toilets were used by the group of households while later stages only by the single family. The indirectly exposed group consisted of nearby households who could see the PTC and emptying services but did not receive them.

Results

It was observed that the PTCs are used consistently, by all members (men, women and children) of the household. To date, there have been three cycles of PTC installation. Of the Data from the first two phase was used to calculate the odds ratio of PTC purchase by directly exposed users versus indirectly exposed users. Directly exposed users, i.e., households that had the free trial PTC and emptying services, were five times more likely to construct a toilet ($p<0.05$).

Conclusions and Recommendations

The experience of the PTC trials underway provide promising initial results that toilet exposure, coupled with a positive experience, can be an effective approach to overcome demand-side barriers to toilet uptake in areas such as rural Bihar, in which open defecation is the social norm. To tap this demand, however, innovative business models are required to incentivize private sector engagement, and the government plays a critical role in providing an enabling regulatory environment.

Institutional Capacity Building Of Ganga Basin Cities For Their Journey Beyond ODF

S.K. Rohilla*, R. Nair*, R. Sardar* and R. Gupta*

*Centre for Science and Environment (CSE), 41 Tughlakabad Institutional Area, New Delhi, India

Keywords: Faecal sludge management; Capacity building; City sanitation plan

Conference Track (2) Case Study Track
Track Topic: *At scale city-wide or nationwide FSM services*
Personal Preference: O*ral presentation*

Context

Effective and equitable access to sanitation is at the very core of sustainable development, where the Sustainable Development Goal (SDG) 6 - "Ensure availability and sustainable management of water and sanitation for all" underpins achieving most of the 2030 agenda (UN Water, 2015). In 2015, only 68 per cent of the global population had access to improved sanitation facilities, however the poor management of faecal waste continues to present public health and environmental risks to communities (UN, 2016). Statistics at present do not seem to ease the situation as current trends in developing countries such as predicted economic and population growth will only increase the need for improved excreta and wastewater management. For instance, the sanitation and excreta management nexus in India has suffered from lack of political and regulatory prioritization, further complicating already complex challenges.

Contemporarily, urban cities in India lack adequate facilities for collection, treatment and safe disposal of urban domestic excreta or faecal sludge. In the absence of any consolidated faecal sludge management (FSM) practices, surface water bodies and groundwater resources continue being degraded (CSE, 2011). Onsite sanitation systems are the most common forms of urban sanitation facilities in India; however ignorance towards the design, construction, operation and maintenance due to lack of knowledge and capacity of local bodies often result in the accumulation of sludge, hence overloading which ultimately causes system failure. In addition, private operators often do not transport and dispose sludge efficiently, however instead dump it in drains, waterways, agricultural fields, which ultimately impacts on public health and surroundings. The unsafe disposal of faecal sludge / septage in Ganga Basin states is approximately 90-95 percent higher compared to the national average of 81 per cent. Alarmingly, 90 percent of the wastewater is untreated and is disposed off in local areas or surface water bodies. In India, FSM has not gathered much attention till today, hence there are barely any well defined guidelines, policies and regulations and capacity building for FSM, which most often creates hurdles for urban local bodies to implement correct practices in the field.

Methodology

Centre for Science and Environment (CSE), New Delhi is a public interest research and advocacy organization that has been advocating policy intervention and implementation opportunities for pollution abatement (through FSM) in the cities of the Ganga River Basin by converging the key objectives of national programmes such as Swachh Bharat Mission, AMRUT, Smart cities and National Mission for Clean Ganga at city level. Ten cities from the Ganga basin states have been selected to gear up for FSM interventions through a five stage handholding process (refer to Figure 1.1) that has been tailor-made for urban local bodies (ULBs) to become capacitated to execute FSM interventions in their cities by implementing City Sanitation Plans (CSP) with a focus on effective and implementable FSM.

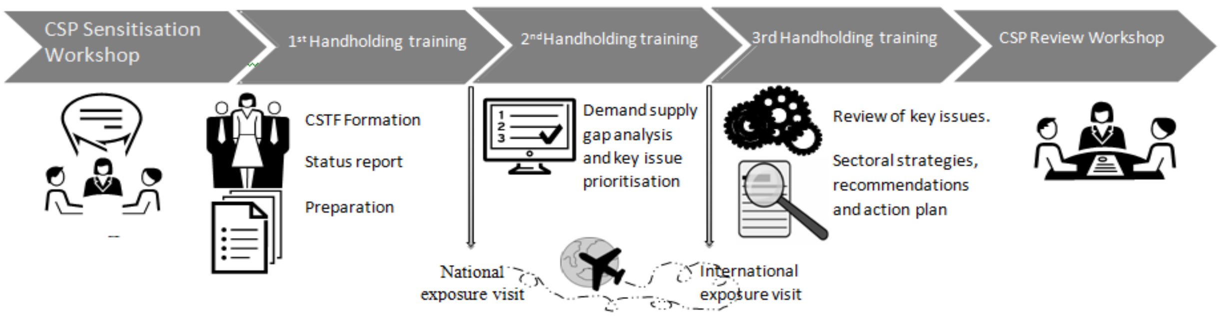


Figure 1.1 Five stage handholding process for preparation of CSPs.

The aim of this five stage handholding approach is to build capacities for ULBs to implement city owned CSPs with a focus on FSM as one of the prime objectives. Communities / stakeholders are also involved through the formation of a "City Sanitation Task Force" (CSTF) for an inclusive and integrated planning and implementation process. The handholding approach discusses the process of implementing interventions at city scale through vigorous status assessment and gap analysis followed by strategy formation and implementation of an action plan, in consultation with CSTF. The trainings are targeted towards mayors, commissioners (key decision makers), city engineers, urban planners and sanitary inspectors (technical staff) from the select cities to undergo the handholding process. In addition, this strategy has not only focused on the implementation of CSPs, but has also provided technical & documentation support to pilot/model projects that offer on-site & off-site demonstration of various technologies and develop technology options, testing protocols, monitoring and data validation procedures for wastewater treatment and FSM.

Results and Discussion

Within a period of nine months, CSE has been interacting directly with the ten cities, understanding the problems and challenges on ground and coming up with strategies with the which would cater the needs of short term, mid-term and long term goals as per the CSP. The main focus has taken the whole sanitation value chain into account thereby extending handhold support to ULBs to choose appropriate/economically viable and robust technology options for FSM/ Septage Management.

Conclusion

The trainings have made selected cities embark on their journey beyond ODF cities by recognizing the objectives and benefits of national programmes for citywide sanitation by focusing on stakeholder involvement to achieve improved urban sanitation interventions. Hence, cities have realized that innovative solutions are required for achieving this objective which not only focus on technical options but also to create an enabling environment for local governments to attain the FSSM goals.

References

Centre for Science and Environment (2011). *Policy paper on Septage Management in India.*
Centre for Science and Environment (2012). *Excreta Matters- 71 cities: a survey*.
Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) GmbH (2016*). Introducing City Sanitation Plan: Practitioners Manual.*
Ministry of Urban Development (2015*). Atal Mission for Rejuvenation and Urban Transformation: Mission and Guidelines*. Available from http://amrut.gov.in/writereaddata/AMRUT%20Guidelines%20.pdf
Ministry of Urban Development (2014). *Guidelines for Swachh Bharat Mission (SBM).* Available from http://swachhbharaturban.gov.in/writereaddata/SBM_Guideline.pdf
Ministry of Urban Development (2008). *National Urban Sanitation Policy*. Available from http://moud.gov.in/sites/upload_files/moud/files/NUSP_0.pdf
United Nations (2016). *Sustainable Development Goal 6*. Available from https://sustainabledevelopment.un.org/sdg6
United Nations Water (2015). *Water in the 2030 Agenda for Sustainable Development*. Available from http://www.unwater.org/sdgs/en/

Tools for faecal sludge management planning in small towns: case study of Bignona, Senegal

Sonko, Eh. M.*,**, L.*, Strande, L.*

*Eawag: Swiss Federal Institute of Aquatic Science and Technology, Sandec: Department of Water and Sanitation in Developing Countries. linda.strande@eawag.ch
** Institute of Environmental Sciences (ISE), Faculty Sciences and Technics, Cheikh Anta Diop University of Dakar, Senegal

Key words: Assessment of the Initial Situation; market driven approach; Shit Flow Diagram

Conference track: Case study struck
Track Topic: At scale city-wide or nationwide FSM services
Personal Preference: Oral presentation

1. Background and context

Access to sanitation has improved in Senegal over the last decade, increasing from 56.7% in 2004, to 62.4% in 2013 (PEPAM, 2015).However, access to sanitation in rural areas remains low (35.6%), and faecal sludge management (FSM) remains marginalized throughout Senegal. To address this, the non-governmental organization ACRACCS initiated a sanitation project in Bignonga[1], a town of 50,000 residents where 47.5% have access to improved sanitation (H2O and I&D 2014). The goal of the SENSAN Project is to promote better access to improved sanitation by promoting the vitality of the sanitation market under the new governmental measures of rural sanitation, and address all segments of sanitation and FSM service chains. ACRACCS partnered together with Eawag and University of Dakar to employee new and innovative tools to evaluate solutions for FSM. This presentation will include the results of an Assessment of the Initial Situation, Shit Flow Diagram (SFD), Market Driven Approach (MDA), and how these tools were used to derive recommendations.

2. Methodology

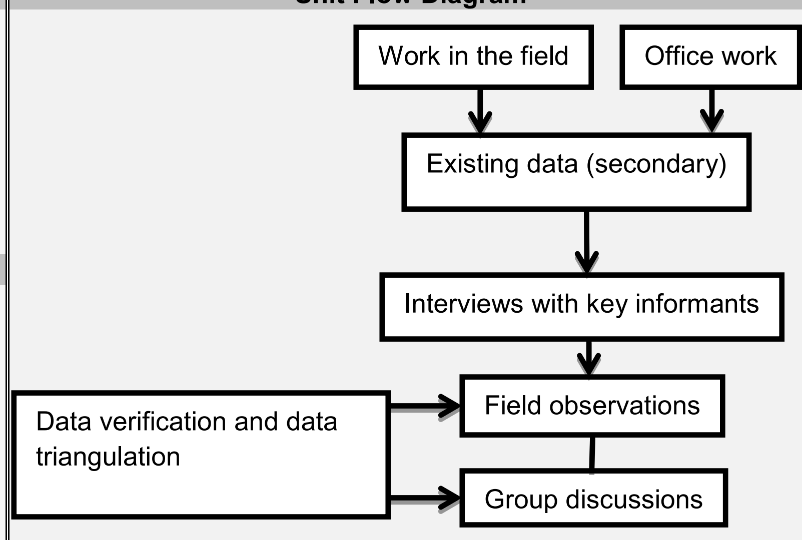
Assessment of the Initial Situation

- ✓ Literature review
- ✓ Semi-structured interviews
- ✓ quantitative surveys
- ✓ Qualitative field observations
- ✓ Laboratory analyses
- ✓ Strengths, weaknesses, opportunities and threats analysis

Market Driven Approach (8 steps)

Step1: Preparation of the study
Step2: Target market analysis
Step3: Market players analysis
Step4: Market sizing
Step5: Adjustment Factor
Step6: Market growth
Step7: Market attractiveness
Step8:Market strategies
(Schoebitz et al. 2016)

Shit Flow Diagram



[1]*The area referred to as Bignona includes the municipalities of Bignona and Tenghory Transgambienne.*

3. Results

Results of the SFD analysis indicated that66% of FS is poorly managed (Figure 1.1).The assessment of the initial situation confirmed the poor management of faecal sludge (FS) including lack of adherence to, and ignorance of, laws and regulations; absence of emptying companies; and lack of financial, human and material resources at the municipal level. Results of the MDA indicated that animal fodder, fish (aquaculture) and soil conditioner are the products with the greatest potential for financial viability from resource recovery (in this respective order). Based on the results of the MDA, planted drying beds producing fodder and soil conditioner were the most promising treatment technology. This was used together with the determination of quantities and characteristics of incoming FS and, a comparative analysis of the FS treatment technologies. The final recommendation for treatment was a combination of vertical flow planted drying beds for dewatering and stabilization, and horizontal flow planted drying beds for treatment of leachate. Plans of the treatment plant are being validated by Senegalese National Sanitation Utility (ONAS) and the budget for construction is already allocated in the project budget.

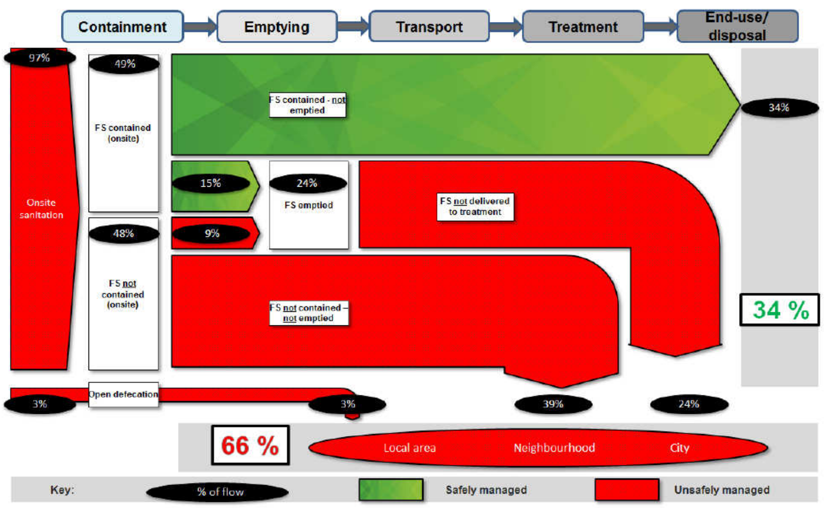


Figure1.1 : Shit Flow Diagram forBignona (Ndoula et al. 2016)

4. Conclusions

Use of these newly developed tools were useful to guide the process of deriving solutions for FSM in a small town like Bignona, where there is a lack of available data for decision making. These tools provided a way to visualize the sanitation situation in Bignona, and the benefits that will be experienced following development. These tools were used for advocacy, and they enabled the enthusiasm of stakeholders during workshops, contributing to improved acceptance of the project. The result was that sites to build treatment plants were allocated by the municipality for free. These studies also aided in the selection and communication of FS treatment technologies. For more information on methodologies, see www.sandec.ch/fsm_tools

5. References

H2O & I&D 2014. Analyse Situationnelle du Secteur de l 'Assainissement dans la commune de Bignona et Transgambienne (Sénégal). Senegal: ACRACCS.

PEPAM 2015. Programme d'eau potable et d'assainissement du Millénaire /Potable Water Program and the Millennium sanitation. http://www.pepam.gouv.sn/ensemble/agences.php

Ndoula , J., Schoebitz, L., Sonko, Eh. M., Strande, L. (2016)SFD Promotion Initiative, Bignona Senegal Final Report. 32p

Schoebitz, L., Andriessen, N., Bollier, S., Strande, L.,. Market Driven Approach for Selection of Faecal Sludge Treatment Products,Eawag/Sandec report 2016

Tools for the Assessment and Development of Sustainable City-wide FSM Services

R Scott*, P Hawkins**, I Ross***, I Blackett****
* r.e.scott@Lboro.ac.uk, Water, Engineering and Development Centre, Loughborough University, UK
** phawkins@worldbank.org, World Bank Global Water Practice
*** Ian.Ross@opml.co.uk, Oxford Policy Management Ltd., UK
**** iblackett@worldbank.org, World Bank Global Water Practice

Keywords: Institutional, planning, diagnostics
Conference Track: Industry and Exhibition
Track Topic: Planning and communication tools for FSM
Personal Preference: Oral presentation

Background

These FSM diagnostic and decision-support tools, developed by the World Bank, are designed to inform the non-technical aspects of city-specific FSM intervention options, considering economic and political economy realities. The tools support a sanitation situation diagnosis and the preliminary selection of intervention options, bringing a focus to each part of the sanitation service chain. They are useful in project identification and preparation, and the data collected can also inform the design of interventions. The tools have been applied and refined using primary and secondary data in five case study cities: Balikpapan, Dhaka, Hawassa, Lima and Santa Cruz, and are now being used to support the design of World Bank funded investments in Benin, Haiti, Ethiopia and other countries.

The tools assess at city level:

1. The existing context within which services are delivered;
2. The political economy affecting services, through a “prognosis for change” analysis; and
3. Options for the institutional interventions and their implementation.

City Service Delivery Assessment

The City Service Delivery Assessment (CSDA) assesses the quality of the existing enabling environment for sanitation and FSM services, the extent of FSM services development, and the likely sustainability of FSM services in the target city. It provides a structured assessment, based on objective questions on FSM service delivery through all stages of the service chain. This supports the identification of priority areas for action on institutional issues, at both local and national level, which require development alongside improvements to infrastructure and other technical components.

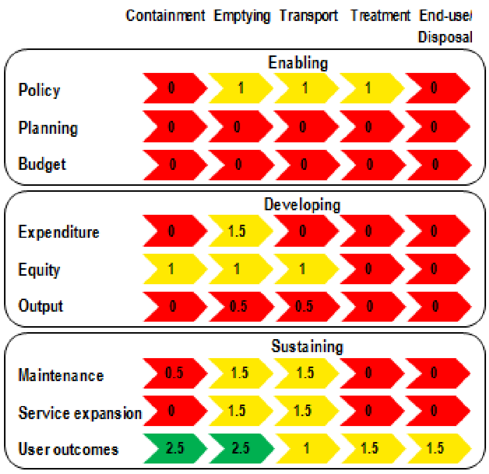


Figure 1 CSDA scorecard for Balikpapan, Indonesia

A key output from the CSDA process is the scorecard (see Figure 1)**Fehler! Verweisquelle konnte nicht gefunden werden.**. The ***process*** of developing the CSDA is as useful and important as the resulting scorecard. The process requires key stakeholders to discuss the full service chain to agree scores, based on the current situation. This can help resolve the usual lack of clarity on institutional roles and responsibilities for “non-networked” sanitation.

The evidence is based on key informant interviews, secondary literature, focus group discussions, and field-based observations. An initial stakeholder mapping exercise is necessary to ensure that interviews are targeted at those best placed to inform and to generate unbiased scoring. The scorecard shows areas of strength and weakness in relation to FSM services, from which priority areas for local or national level action can be identified. For example, Figure 1, prepared for Balikpapan, Indonesia, shows that poorly-performing aspects of FSM which should be prioritized for intervention are to establish plans and associated budgets to improve FSM services; and to make poor-inclusive technical interventions to deliver services to all.

Prognosis for Change

The CSDA needs to be undertaken in an iterative process which also takes into account the local political economy of FSM. A Prognosis for Change (PFC) assessment is a political economy analysis in which delicate topics are addressed sensitively, so that the analysis can be shared and discussed with all stakeholders. A PFC considers the various stakeholders, institutions and incentives involved.

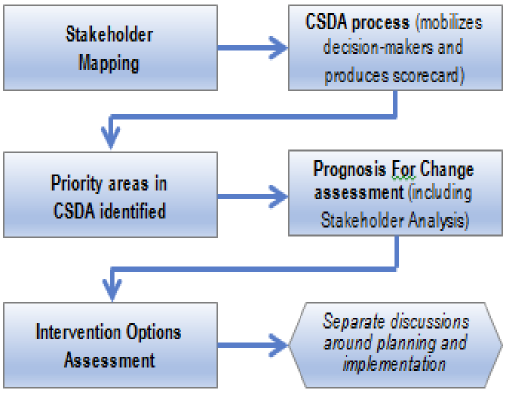


Figure 2 Linkages between the CSDA and PFC

Figure 2 summarizes this interlinked process, starting with stakeholder mapping. Once priority areas have been identified in the CSDA, a political economy analysis of priority areas is undertaken.[1] This informs the assessment of intervention options to check their viability in the context of the city's political economy realities.

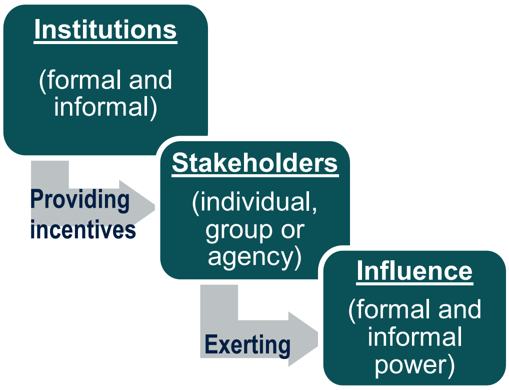


Figure 3 Three key concepts in the PFC assessment

Figure 3 shows that a PFC helps understand firstly, how "institutions" (the rules and norms governing human interaction) function, rather than just how "organizations" work. Institutions can be formal, such as the regulation of fecal sludge dumping, or informal, such as what tankers *really* do with the sludge. Secondly, a PFC considers the incentives which the institutions provide to stakeholders. In FSM, relevant stakeholders *may* include sludge truck companies, manual emptiers, the Municipality, line Ministries, and slum-dwellers. Finally, a PFC considers how stakeholders exert influence (formal or informal power) to cause or prevent specific outcomes.

Service Delivery Action Framework

The outputs of the CSDA, PFC and other supporting diagnostic and decision-support tools (including a fecal waste flow diagram) provide information to inform institutional interventions to ensure that the infrastructure and technical interventions work properly. This is systematized in the Service Delivery Action Framework (SDAF), which sets out various interventions that may be appropriate based on the current status of FSM services. Actions are grouped into three stages – Basic, Intermediate or Consolidating – according to how developed the enabling environment currently is, as characterized by the CSDA. The framework is based on wide experience, and informed by the realities of the target city, and addresses each aspect of the enabling environment, with the aim of improving FSM service delivery.

Presentation: Use of Tools and Implications for Implementation

The oral presentation will explain the FSM tools and show how they can guide a logical sequence of incremental steps, aimed first at making basic FSM services available, then developing, and finally consolidating them. This is placed in the context of urban development and the diversity of local situations which all change over time at different rates, along with the development of sewerage and other complementary urban services. Learning outcomes include knowledge of the FSM tools; when and how to use them in the project cycle; where to access them; and how to seek help and assistance.

References

Blackett, I, Hawkins, P (2016) Fecal Sludge Management: Diagnostics for Service Delivery in Urban Areas. Summary Report, World Bank

[1] **Political economy analysis** about the interaction of **political** and **economic processes** including distribution of power and wealth between groups and individuals, and processes that create, sustain and transform relationships over time." OECD-DAC, UNDP, 2016

Cooperation AIT – BORDA On The Application Of FSM Toolbox In Project Cities (Baseline Assessment)

Thammarat Koottatep*, Yuttachai Sarathai*, Atitaya Panuvatvanich*, Nitasha Arora*, Marina Brueckner-Supriyono**, Bounchan Khamphilayvong***, Yengher Vacha****
*Asian Institute of Technology (AIT), 58 Moo 9, Paholyothin Highway Klong Luang, Pathumthani 12120, Thailand
**BORDA Indonesia, Jalan Kaliurang km 6,6 Gang Kayen Raya No. 176, Yogyakarta, Indonesia
***BORDA Laos, 008/01 Donnokkhoum Rd, Thongkang Village, Sisattanak District, P.O.Box 2579, Vientiane, Lao P.D.R
**** Luang Prabang Province, Urban Development and Administration Authority, PADUL-IIA2 Project Building 03/1V, Muenloukthao Street, Viengmai Village, Luang Prabang District, Luang Prabang Province, Lao P.D.R

Keywords: FSM Planning, Baseline assessment, Local Governments

Conference Track: (2) Industry Track
Track Topic: *Pilots showing promises*
Personal Preference: *oral presentation*

Abstract

Faecal sludge management (FSM) is playing an increasing role on local governments' sanitation agendas in various countries in Southeast Asia. However, decision makers and implementers are facing the challenge of developing and applying comprehensive planning tools, conduct proper implementation and ensure sustainable operation and maintenance.

FSM Toolbox

In the interest of experts' and practitioners' urgent needs to develop appropriate FSM assesment and planning tools which follow a holistic and systematic approach, AIT and its partners initiated a better organization of existing FSM knowledge into an user-friendly toolbox and developed the FSM Toolbox.

The FSM Toolbox is a demand-driven "One-stop-database", incooperating regulatory, institutional, technical, financial, monitoring, advocacy and Capacity Building aspects. It provides access to tools, templates and guidelines based on the practical needs of key practitioners (donors, city planners, consultants) for planning well-functioning FSM projects.

FSM projects often begin with identifying issues, planning strategies and implementing the set of actions, followed by the evaluation of the project. These series of stages provide a structure which is defined as a FSM program workflow in the FSM Toolbox and all comprehensive collections and developed information have been placed in the FSM program workflow stages.

During the baseline assessment local conditions (e. g. sanitation status, water pollution, demography, urban growth), issues and needs, available data and information are assessed. The assessment result indicates gaps, deficiencies and priority areas to be addressed and enables the user to formulate a matrix of intervention strategies.

Sanitation situation in Sleman and Luang Prabang and Local Governments' Sanitation Plan

In Luang Prabang (Lao P.D.R.), a UNESCO World Heritage site with 60.232 inhabitants, sewerage wastewater is discharged into the environment without any treatment. Most households are equipped with a septic tank according to the National Government's standard design. A mechanism to control the quality of construction and operation is not in place. The city provides desludging services for septic tanks with vacuum trucks. The sludge is disposed into facultative aerobic lagoons without any treatment. The Urban Development and Administration Authority of Luang Prabang has developed the Master Plan for Drainage and Sewerage System in 2013. The plan provides a practical framework and methodology for the development of drainage, sewerage system and wastewater treatment options.

In Sleman district (Indonesia) septic tank coverage on household level is around 78% (total population: 1.134.157 inhabitants). Regulations on septic tank standard design are 15 years old and stipulate an overdesigned and expensive solution with little flexibility. Desludging services are provided on on-call base. The sludge is partially treated at a regional wastewater and sludge treatment plant which is situated 30 km distant in another district, larger amounts are improperly disposed. A faecal sludge treatment plant is not in place yet in Sleman district. Under the framework of the National Acceleration of Sanitation Development Program, Sleman district developed a City Sanitation Strategy (SSK). The SSK aims - inline with the National Midterm Development Plan (2015-2019) - for 100% sanitation coverage including faecal sludge management until the end of 2019. Septic tank coverage is planned to be increased to 83.38%. It is intended to implement faecal sludge treatment plants.

Overview on results of introducing the FSM Toolbox

1) The application of the FSM Toolbox triggers the need for interventions or improvements.
2) The FSM Toolbox synchronizes the needs of local governments for comprehensive FSM planning tools and provides academia with practical experiences of practioners gained through the application of the FSM Toolbox. These experiences are essential for the further development of the FSM Toolbox.
3) Due to its extensive understanding of the realities of FSM, the FSM Toolbox enhances the capacities of local governments in planning comprehensive fecal sludge management at local level.
4) By applying the FSM Toolbox an accommodation of local governments' flexibility needs should be guaranteed in terms of:

- Competing FSM (planning) concepts and approaches on the market
- Existing local governments' targets (planning strategies, scope of intervention and priorities), set of actions, planning, design and / or implementation
- Progressive Implementation.

5) The FSM Toolbox requires and ensures a participatory application.

Overview on results of application of baseline component

The *baseline* component provides a comprehensive orientation for local governments' FSM planning. Through the baseline data collection local governments can complete or verify existing data. Specific data collection approaches due to missing data which are relevant for the baseline assessment, inaccuracy of these existing data or unclear circumstances, should be developed by local governments. The *baseline* component demonstrates the complexity of FSM planning and thus the importance of a comprehensive assessment before engaging in detailed planning and engineering design.

Lesson learnt

- Application of the baseline component should be done as early as possible.
- Assessment and participatory involvement of all relevant stakeholders is crucial.
- Local governments need to develop approaches how to guarantee availability and accuracy of baseline data.
- Depending on the initial status of FSM, a bottom-up (demand creation due to issues) or a top-down approach (review of existing targets, planning etc.) has to be applied.
- Couching by 3rd parties (e.g. professional civil society organizations such as BORDA) of local governments by applying the tool is a supporting factor
- Advocacy and awareness raising media and the baseline assessment can assist in the decision-making progress:
  - To revise or validate existing planning targets.
  - To develop additional tools for specific needs (e.g. Septic Tank Assessment).

Conclusion and outlook

The FSM Toolbox will be continuously further developed by AIT and its partners. The AIT-BORDA Regenerative Sanitation Hub (Bangkok) together with partners in the region and in cooperation with UNESCAP as well as other stakeholders will develop a comprehensive system solution approach for managing urban waters, including FSM as an essential module amongst other wastewater management instruments and methods. Within this context the FSM Toolbox will be applied in several case studies in Indonesia, Laos and other countries of the region in the upcoming years.

SimpliSafi: an off-site sanitation system that vertically integrates waste collection and sludge processing for informal settlements

R Solanki*, S Willis*, L McGoff**, J Mullett**

*Bottom Up Ventures, 31 Long Lane, Willingham, Cambs, United Kingdom, CB24 5LA
**Sustainable OneWorld Technologies C.I.C., 31 Long Lane, Willingham, Cambs, United Kingdom, CB24 5LA

Keywords: urban; sanitation; anaerobic digestion
Conference Track: (2) Case Study Track
Track Topic: Pilots showing promises
Personal Preference: Oral presentation

The Challenge

There is no existing affordable, technically feasible, or aspirational sanitation solution for the urban poor. In Dar es Salaam, Tanzania, 80% of residents live in low-income, high-density settlements that suffer from lack of adequate sanitation. Pit latrines are widely used but lack of space to dig new ones means pits must be emptied. Expensive, unsafe, and infrequent emptying make this solution inadequate. While recent solutions – the Gulper for cheaper emptying, eco-san toilets, WaterAid's pit emptying scheme, and high-profile developments like Sanergy – have attempted to 'upgrade' on-site solutions, they have not provided affordable and truly complete sanitation. Subsequently, sludge runs in the open: where adults work, children play, and families eat. Current government policy – private purchase of household septic tanks – fails to address the needs and limitations of these communities.

The Consequences

The implications in Dar es Salaam are severe:

1. Outbreaks of water-borne and faeco-oral diseases occur frequently – 20% of under-5 deaths are due to preventable diarrhoea and up to 33% are due to poor hygiene.
2. Women and girls feel unsafe going to the toilet – high rates of UTIs, instances of sexual violence, and a severe lack of dignity are apparent.
3. Poor sanitation induces a high economic loss – healthcare expenditure, productivity loss, and premature death cost Tanzania more than 130 million USD per annum.

The Innovation: SimpliSafi

SimpliSafi is an off-site sanitation solution that vertically integrates network-based waste collection and sludge processing. Key to the innovation are its individual components:

1. Simplified Sewerage Technology – a proven sanitation solution that uses smaller pipes at shallower depths which significantly reduces cost and improves ease of construction compared to conventional sewerage. It provides significant cost-savings compared to on-site solutions in densely packed communities.
2. The Flexigester Anaerobic Digester – a low-cost per unit volume, easy to install and maintain anaerobic digester composed of butyl rubber. It can be designed in any shape and size and includes a distribution mechanism by which biogas can be stored in transportable, volume-discrete bags and sold as clean fuel for cooking.

By connecting local simplified sewerage networks to modified pour-flush latrines, waste will be collected and transported to the anaerobic digester, enabling sludge processing *in situ*. SimpliSafi is therefore able to provide an aspirational sanitation solution that fits within the space constraints of urban informal settlements and is financially self-sustaining through raised demand and cost recovery from biogas sales.

The Kombo Affordable Sanitation Pilot

In 2015, SimpliSafi was piloted in the urban informal settlement of Vingunguti within Dar es Salaam. 200 people were connected to the network. This was implemented in partnership with the Cambridge Development Initiative and Dar es Salaam Water and Sanitation.

Our Innovative Methodology

The success of our pilot depended heavily on our strategy for implementation:

1. Locally-led community engagement – key community gatekeepers engaged directly with us to introduce the idea and manage its implementation within the community.
2. Creation of a Sanitation Users Association – a community-elected committee oversees the network and manages repairs, payments, and health awareness.
3. Behaviour change workshops – to ensure that the system was used effectively, blockages were minimised, and hygiene education was improved.
4. Sanitation microfinance loans – to allow for community members to finance their contribution.
5. Construction driven by the community – community technicians were trained by local and international University engineering students to design and install the network. Members from each household of the network participated in the construction.

Financial Structure

SOWTech and its partners paid for the main trunk sewer line and the anaerobic digester. Community members received a loan from project partners to pay for their connection to the network and upgrade/construct household latrines. Small monthly fees (~1.50 USD) are paid by all households to use the network. A local community technician manages the anaerobic digester and receives part of the profits from sale of biogas.

The total cost of the pilot project reached 15,000 USD – this includes transport, raw materials, and funds for the microfinance loan.

Results so Far

1. Satisfaction is high – over 95% are very happy with the network.
2. Loan repayment is on track for 95% of households.
3. Incidences of cholera have fallen to almost zero.
4. The system has only suffered four blockages over 14 months, each quickly resolved by the community.

Local Entrepreneurs: A Model for Scale

In the future, we see SimpliSafi networks within communities run jointly by local entrepreneurs and community associations. By building the anaerobic digesters locally, training local entrepreneurs and community mobilisers, and providing a revolving fund for community loans, we hope to expand city-wide and, later, beyond Dar es Salaam. Estimates reveal that, as a business model, SimpliSafi networks would break-even between 1.5 to 4.5 years after installation.

Challenges and Next Steps

1. Completing the value chain – the slurry output of the anaerobic digester is currently siphoned into a city's waste stabilisation pond. We are currently testing methods to further process this into a biofertiliser to be used for agriculture.
2. Collect more rigorous monitoring and evaluation data regarding health metrics.
3. Expand our pilot to more regions of Dar es Salaam to test robustness of the model.

References

Jenkins, M., Cumming, O. and Cairncross, S. (2015) 'Pit Latrine emptying behavior and demand for sanitation services in Dar Es Salaam, Tanzania', International Journal of Environmental Research and Public Health, 12(3), pp. 2588–2611. doi: 10.3390/ijerph120302588.

Corburn, J. and Hildebrand, C. (2015) 'Slum sanitation and the social determinants of women's health in Nairobi, Kenya', Journal of Environmental and Public Health, 2015, pp. 1–6. doi: 10.1155/2015/209505.

Douty, C. (2015) A Demand-driven Approach for Adoption of Simplified Sewerage in Dar es Salaam. Cambridge: University of Cambridge.

Mara, D., Sleigh, A. and Tayler, K. (2001) PC-based Simplified Sewer Design. Leeds: University of Leeds.

Thomas, J., Holbro, N. and Young, D. (2013) A REVIEW OF SANITATION AND HYGIENE IN TANZANIA. msabi.

Laurent SOHIER, Ph. D., CEO of HELIO PUR TECHNOLOGIES SAS. 139, rue Philippe de Girard, PERTUIS, 84120, France

Bio-Solar Purification a new process to treat domestic wastewater and to turn water and wastes in a safe and reusable form

Today, the wastewater treatment for urban domestic sewages, is performed before discharge in aquatic environments and is built in 3 stages:

- A primary treatment stage to separate inorganic or organic-biodegradable solids (wood, paper towels, sand, gravel, etc.). This primary treatment step uses screening or decantation and produces sludges.

- A secondary treatment stage to treat suspended organic matters in a physicochemical (floculation) or a biological way (conventional activated sludges, Sequential Bio-Reactor, fixed bed reactor, Membrane Bio-Reactor…).

- An optional tertiary treatment phase to reduce residual organic matter and some dissolved hazardous compounds. Tertiary treatments are often applied when secondary treatment is insufficient to meet regulatory requirements for discharge into aquatic environments. Tertiary treatments can be extensive in ponds and wetlands or intensive through filtration (Micro Filtration, Ultra Filtration). Extensive tertiary treatment needs a lot of space and generates evaporation and recontamination (animal dejections). Filtration tertiary treatment generates side sewages and needs energy for pumping and filtering.

Domestic wastewater treatment for reuse or recycling

Using conventional treatments + advanced treatments

To reuse or recycle wastewater, it is necessary to supplement these primary, secondary and tertiary treatments with treatments known as "advanced" that remove some dissolved salts or hazardous microorganisms still present in the water after primary, secondary and tertiary treatment.

Most employed “advanced” treatment are UV (Ultra Violet), RO (Reverse Osmosis) or ozonation. UV and RO need very clear water and a lot of energy to be efficient. They need also consumables and maintenance.

When you want to reuse domestic wastewater with conventional centralized solutions you need to invest in a collection network and then you need to buy a complete plant with a lot of concrete basins and tanks able to perform primary, secondary, tertiary and advanced treatments. Thus investment is high and your plant has to be upgraded with larger basins if you change the flow rate.

HelioPure solutions

The Bio-Solar Purification process

HelioPure solutions are based on a new patented wastewater treatment process called Bio-Solar Purification (BSP). This process only needs sunlight and CO_2 coming from a pre-treatment or from a flue-gas. Thanks to photosynthesis, microorganisms developing in wastewater exposed to sunlight and CO_2 produce a lot of oxygen degrading all the organic matter, fixing heavy metals and killing all the bacteria coming from the digestive tract of humans or animals.

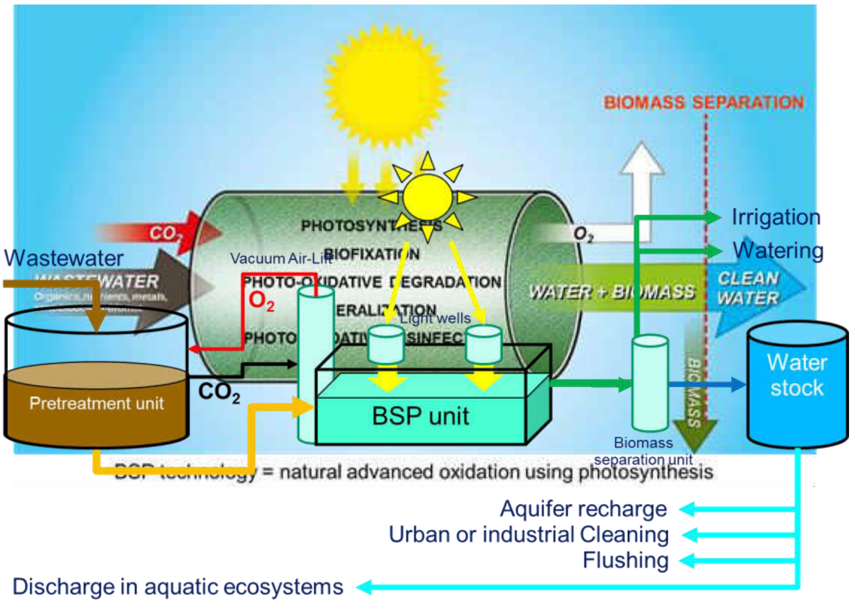
Those phenomena exist at the air-water interface of aquatic ecosystems since 2 billion years and can be intensified in special tank design or tubular design photoreactors developed by HelioPure. Our modular systems performed natural advanced oxidation using photosynthesis and are able to treat wastewater for reuse in less than one day.

The BSP process is a two phase process with differences between day and night. During the day, photosynthesis produces oxygen continuously from CO_2, NO_3, PO_4 and SO_4 from the wastewater. During the night a special vacuum air-lift maintain the circulation and aeration in the photoreactor.

HelioPure
Beyond Water Recycling

HelioPure® systems

HELIO PUR TECHNOLOGIES is a French company created by scientists and engineers specialized in wastewater and nutrients recycling. HelioPure® systems integrate a pre-treatment (primary decantation, septic tank, primary digestion, bed filter, lumbrifilter, reed bed filter) and a BSP unit integrating Vacuum Air-Lift to circulate wastewater in a photoreactor, inject microbubbles of CO2 enriched air and recover oxygen (during the day) or only air (during the night).



Advantages of HelioPure solutions compared to existing solutions for wastewater treatment and reuse are:

1. Low investment due to only one stage that can be without civil works (tubular reactor), mobile or with limited size digging (compact buried reactor)
2. Decentralized solution that can be installed in blocks, buildings, small communities with small connecting pipes and without smell or gases.
3. Low operation cost due to low energy consumption on one stage and use of sun and CO2 to produce oxigen and treat wastewater.
4. Low maintenance due to the fact there is no consumable and no daily cleaning.
5. Low global cost due to 100% water recovery without side sewages, without evaporation minimizing water losses. Global cost on treatment for reuse is based on water recovery yield.
6. Production of biomass (300g/m3) that can be used as fertilizer with the water or can be separate for other uses (animal feeding, fertilizer, energy).
7. Recoverable oxygen produced that can be used for primary aerobic treatment lowering energy consumption for aeration.

Biomass Steam Processing (BSP) – Conversion of Biomass to Coal by Steam Conditioning

J. Steinbrück*, H. Bockhorn**, L. Walz***, G. Francis*

* Live Energies GmbH, Echterdinger Str. 30, 70599 Stuttgart, Germany
** Karlsruhe Institute of Technology, Kaiserstrasse 12, 76133 Karlsruhe, Germany
*** Energie Baden-Württemberg AG, Durlacher Allee 93, 76131 Karlsruhe, Germany

Keywords: Biomasses; Carbonisation; Waste treatment

Conference Track: (3) Industry and Exhibition Track
Track Topic: Innovative and practical solutions
Personal Preference: *Oral presentation*

Problem statement

In view of the scarcity of fossil resources and the progressive climate change, the interest in energy carriers from biomasses is increasing. The use of carbohydrate-based organic residues, such as straw, wood scrap and waste, grass clippings, vegetable waste or of sewage sludge as an energy source is highly desired to promote an integrated bio-economy.

The above listed biomasses have a high content of chemically bound water and moisture. This results in a low mass-related energy content. In order to increase the energy density of biomass, various methods are available. Depending on parameters such as temperature, pressure, reaction time and biomass fraction, solid carbonaceous materials, liquids or gases can be gained. With increasing severity of the reaction conditions, especially temperature and reaction time, the tendency for the formation of gas is increased, and also smaller organic molecules are formed.

Carbon is a versatile and effective energy storage medium. Processes that target the conditioning of biomasses to carbon encounter growing interest. In pyrolysis the carbon content of the biomass is converted into solid char by thermal treatment in an inert gas atmosphere. Hydrothermal carbonization (HTC) uses hot and pressurized liquid water. Both pyrolysis and HTC involve unfavourable reaction conditions to achieve high carbon contents in the char and produce low char yields. In pyrolysis reaction times range from hours to days and in HTC pressurized water at high temperature in combination with salts contained in the biomasses results in high demands on the reactor materials.

Biomass Steam Prossesing (BSP) – quick and easy

In order to circumvent the above mentioned disadvantages of HTC and pyrolysis an alternative method to convert biomasses to carbon has been developed. Through this method, the feedstock is treated under atmospheric pressure with steam at temperatures between 300 °C and 400 °C for reaction times from minutes up to a few hours. This process, the "Biomass Steam Processing" (BSP) produces a biochar similar to lignite with substantially lower process complexity than the HTC and at much shorter reaction times compared to pyrolysis. The BSP reaction conditions can be better controlled and the elemental composition of the biochar is variable. The BSP-process has been investigated theoretically and experimentally with model and real biomasses such as straw, wood, grass, and orange peels, vegetable wastes or sewage sludge and mixtures of them [Steinbrück 2012, Steinbrück 2015].

After experiments in laboratory scale a pilot plant for the BSP process with a throughput of up to 50 kg/h, which is the last stage before a market launch, has been successfully put into operation. A schematic drawing of this plant is given in Figure 1. By recycling the condensed bio-oil and the carbon-containing vapor phase, the yield of carbon in the biochar can be further increased. Thanks to its simplicity, the method can be easily used in mobile systems, so that organic waste can be processed economically and in an energetically sensible manner to coal directly where it is incurred.

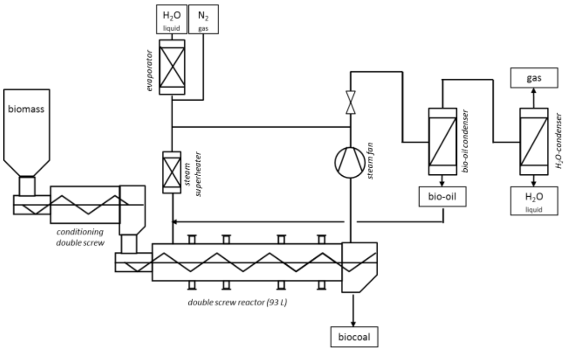


Figure 1: Schematic drawing of the pilot plant for the BSP-process.

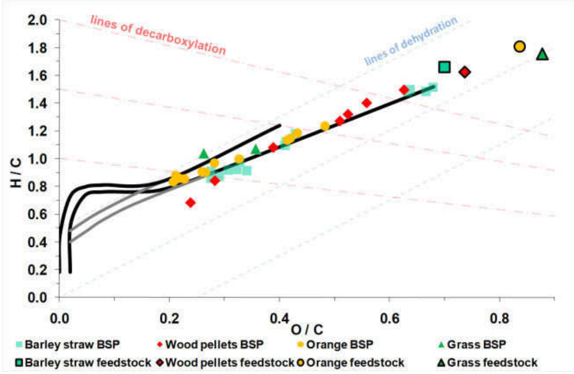


Figure 2: Carbonization fate of various biomasses.

The pilot plant has been put into operation in a 7 day continuous test. Mixtures of sewage sludge with wood pellets and sewage sludge with organic waste were processed.

In a typical BSP experiment with wood pellets with a reaction time of 0.6 hours and a temperature of 350 °C, about 54 percent of the employed chemical energy can be recovered in the biochar, whereby the calorific value has increased by over 60 percent. With wheat straw as a feedstock and milder conditions (temperature 300 °C and reaction time 56 min) similar energy efficiencies can be attained. A part of the input energy is recovered as chemical energy in the condensable organic molecules. Additionally, about three percent of the introduced chemical energy has to be spent for heating up the biomass and the moisture to the reaction temperature. A two-stage condensation of the reaction water and small organic condensable molecules, for example hydroxymethyl furfural, are positively effecting the energy balance through the recovery of their sensible heat and heat of condensation.

The carbonization process follows the natural carbonization as illustrated in Fig. 2. Some characteristics of the obtained biocoals from different input biomasses are given in Table 1.

Table 1: Characterization of some biocoals from the BSP-process.

biomass	conditions	elemental composition			HHV	CR
	°C/min	C	H	O	$MJ \cdot kg^{-1}$	mol-% C
wheat straw	untreated	40,3	5,7	48,6	15,7	-
wheat straw	300/56	54,3	4,4	27,6	20,7	55,5
wood pellets	untreated	46,6	6,4	45,7	17,8	-
wood pellets	350/34	71,7	4,8	21,8	28,2	45,5

The project has been funded by EnBW AG and Stiftung Energieforschung Baden-Württemberg.

References

[Steinbrück 2012] Steinbrück, J., Reichert, D., Genova, B., Rossbach, M., Walz, L., & Bockhorn, H.: Biomass Steam Proccessing on the Pilot Plant Scale. 20th European Biomass Conference and Exhibition (EU BC&E 2012). Milan.

[Steinbrück 2015] Steinbrück, J., Walz, L., Bockhorn, H.: Biocoal in minutes: quick and easy source for carbon materials. 6th International Conference on Carbon for Energy Storage and Environmental Protection (2015).

Business Model Development for Fecal Sludge Management Insights from Bihar, India

Sanjay Singh*, Aprajita Singh** - Population Services International (PSI)

* sanjaysingh@psi.org.in **aprajitasingh@psi.org.in

Keywords: Bihar, market development approach, private sector, tanker operators, sewage treatment plant

Conference Track: FSM Industry and Exhibition
Track Topic: Business Models for FSM
Personal Preference: *Oral presentation*

Purpose:

Bihar, India accounts for about a third of global open defecation (OD) and is facing a sanitation crisis. Sanitation improvements in Bihar [2] are critical for global achievement of sustainable development goal (SDG) 6 [3] for sanitation. Fecal contamination accounts for both high rates of infant mortality and stunting in children [4]. The situation is particularly worse in rural areas with broken supply chain systems and markets distorted by public subsidies. In peri-urban and rural areas where long distances and high fuel costs create few incentives to carry waste to the urban treatment facilities, there is no system for Fecal Sludge Management (FSM).

Focus/Content:

Since 2012, Population Services International (PSI) has been implementing Project 3SI [5] in Bihar to increase access and use of toilets in rural areas. The project team quickly identified that without a safe emptying solution, the project would only serve to delay the fecal contamination of the environment. In 2014, PSI began implementing Project Prasadhan to address critical gaps in FSM.

Prasadhan deploys a Market Development Approach (MDA) to address barriers that cause market failures. It facilitates linkages between a local sewage treatment plant (STP), supply chain actors, and households, and deploys a decentralized model to align capacities and incentives for FSM in Bihar. Leveraging on-going private sector interest, PSI supported the construction of a local, small-scale sewage treatment plant which now has the capacity to treat 25,000 liters of waste per day. PSI is also testing a tiered payment system in which operators receive an increasing payment for every full tank of waste they safely dump [6].

Significance:

To date, PSI has facilitated the safe collection and treatment of over 5 million litres of fecal sludge, serviced 1200 households and sold 1062 bundled services in which households purchase both a toilet and regular pit emptying. PSI is working with the government to gain support for a favorable policy environment and FSM business models that are scalable, sustainable, and complement the on-going government efforts. The early results from the intervention in Bihar demonstrate the potential of strengthening existing markets to find decentralized low-touch solutions.

---

[1] Spears, D., Ghosh, A., & Cumming, O. (2013). Open defecation and childhood stunting in India: an ecological analysis of new data from 112 districts. PLoS One, 8(9), e73784.
[2] Bihar has some of the poorest sanitation indicators: 78% of rural households and 36% of urban households have no toilet facilities, Census 2011
[3] http://www.unwater.org/sdgs/en/
[4] Spears, D., Ghosh, A., & Cumming, O. (2013). Open defecation and childhood stunting in India: an ecological analysis of new data from 112 districts. PLoS One, 8(9), e73784
[5] 3Si stands for Supporting Sustainable Sanitation Improvements in Bihar
[6] Earlier none of the sludge from the surrounding areas was treated.

Improving practitioners Knowledge of Market Development Approaches for use in FSM Programmes

J. Sauer*, J. Parkinson**, A. Oko-Williams***, R. Miskelly***, E. Shaylor**,

*PSI, USA
**Oxfam, Oxfam House, John Smith Dr, Oxford OX4 2JY, United Kingdom
***WaterAid, 47-49 Durham St, London SE11 5JD, United Kingdom

Keywords: Sustainable Sanitation (SuSanA)
Conference Track: Exhibition & industry
Track Topic: Knowledge management
Preference: Workshop

Overview

There has been increased recognition of the value of market systems or market development approaches (MDA) in WASH and FSM programming and the need to route programmes in addressing the root causes of why the market is failing to serve the poor, ensuring that capacities and incentives are aligned for the market players (direct and indirect), and ensuring that the supporting and rules functions are operating sufficiently to allow for adequate demand and supply of FSM products and services.

Background on SuSanA and WG 2

Currently, SuSanA is an open international alliance, a network of over 7300 individual members and 277 partner organizations dedicated to understanding sustainable sanitation solutions. SuSanA's mission is to link on-the-ground experience with an engaged community of practitioners, policy makers, researchers, and academics with the aim of promoting innovation and best practices in sanitation policy, programming and implementation.

The overall goal of SuSanA is to contribute to the achievement of current and future sustainable development goals by promoting a systems approach to sanitation provision taking into consideration all aspects of sustainability. The presentation will summarize the history, leadership and funding that made, and continues to make, SuSanA possible.

WG 2 has a specific focus on market development around sanitation. Currently the working group provides a forum for interested practitioners to discuss the wider topic of market development and how this impacts on current practices and research. The working group uses an online forum as the main interface, but as opportunities arise face-to-face meetings are utilised, the last of these was held at World Water Week in Stockholm.

WG 2 Activities that Benefit FSM Work

At the last meeting a number of key points were raised that it was felt the WG should address, these were:

1. Communication - There is a need to articulate 'market development' clearly and consistently without over-simplifying its complexity and breadth of opportunities whilst demonstrating its value and applicability at different stakeholder levels
2. Role - we need to more clearly understand what role the sector is best suited to play if supporting market development, i.e. how do we shift to a more facilitative role to support the market system and value chain to operate more effectively.
3. How our roles shift according to market system / WASH value chain maturity - coming to the last point raised, how do we support market development where value chains are weak or non-existent
4. Emphasizing the need to get market systems and needs/user/consumer analysis right and how to do it; to inform where we need to support market development within the market system and how to best design those programmes selected

The Focal persons of this WG would like to use the opportunity of FSM4 and having so many colleagues in one location to address these points in relation to FSM.

Objective

Educate practitioners on market development approaches (MDA), including the approaches, the components and the existing best practices, and influence wider adoption in sector of MDA.

Three Primary Workshop Outcomes

The intention is to carry out a workshop with interested participants that will ensure:

1. An understanding of the basic concepts and definitions relating to MDA
2. Definition of roles and responsibilities of different actors and stakeholders in the sanitation market place and supply chain (with a focus on those present and how they impact on their work)
3. For persons present to better understand how MDA could support/benefit their work and how to find out more/who to contact to further explore possibilities

The Blue Water Company: Operating and Maintaining City-Scale Faecal Sludge Management Systems

T Segev*, M Rath**

*Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139
**Blue Water Company, A-10 Ruturaj, Juhu Tara Road, Juhu, Mumbai 400049 India

Keywords: Business model; faecal sludge management; Public-Private Partnership
Conference Track: Case Studies Track

By 2020, over 70% of urban India's toilets will be connected to on-site sewage systems (**OSS**) including septic tanks or pits. It will therefore be critical to provide good quality faecal sludge management (**FSM**) and treatment systems to improve sanitation and protect the environment. Today, nearly 100% of faecal sludge is dumped into fields, open land and water bodied, untreated—a leading cause of water supply pollution, and risk to agricultural supply chains and public health.

Manual scavenging to clean OSS has been made illegal since 2009 though the practice continues to some extent. Today, OSS emptying and faecal sludge transportation services are readily available in most towns, offered by private players and municipal bodies using mechanized trucks with suction pumps. In most cases, however, the quality of service is poor. Operators are not trained properly, trucks may not be functioning perfectly, there is almost no scheduling or standardization of service processes, and in the absence of regulatory oversight, customers have no one to complain to in case of problems or mishaps.

The second key problem is that the number of proper faecal sludge treatment plants (**FSTP**) can be counted on fingers. Thus, new treatment plants have to be built to deal with the existing and growing volume of faecal sludge.

As the Indian Government is quickly accepting Faecal Sludge Management as a necessity and willingness to invest in it increases, the private sector needs to support the government in three key ways.

1. **Know-how and Technology:** As this is an evolving sector, the government does not understand yet how to conceptualize and run an end-to-end FSM system. Private parties can bring this knowledge and expertise.
2. **Robust and Reliable Operations and Maintenance:** Government and Municipal authorities are institutionally not designed to provide a daily, recurring service to citizens. Private players can build systems, invest in technology and deliver a reliable, consistent service, 365-days of the year, to citizens, under the right selection and contracting processes by the Government.
3. **Capital and Finance:** Many Indian cities do not have adequate funds to invest into the capital expenditure (CapEx) and Operating Costs (OpEx) of these systems over a period of time.

Blue Water Company (**Blue Water** or **BWC**) is an entrepreneurial, privately owned business that provides turnkey, end-to-end FSM and FSTP solutions particularly to smaller towns and cities, typically with population under 350,000 people. Its primary services will include:

i. Operating and managing de-sludging cesspool vehicles
ii. Building and managing FSTPs and other de-centralized sewage treatment plants

BWC will have **3 business models**, based on the needs of the local government and market conditions.

A. **Service Contracts:** Where the Government has already procured or built the infrastructure (cesspool truck and FSTP), BWC will seek service contracts to operate and maintain these assets properly. The Government will pay a fixed or variable fee to BWC for the services offered and typical contract periods are 3-5 years.

B. **Public-Private Partnerships (PPP):** Where the infrastructure does not yet exist and the government does not have adequate funds, BWC will create PPPs with State and Local Governments to invest in, develop and manage FSM systems.
The Hybrid-Annuity Model is viable wherein the Government invests about 30-50% of the project cost and BWC will invest the remainder. BWC will have a long-term contract, typically 12-15 years, to operate the system and then transfer it to the Government, which pays a fixed fee that covers cost of services provided and return of invested amount.

C. **Independent FSM Services:** BWC can purchase operate de-sludging trucks and even build FSTPs on private land, where market demand exist but the local government is uninterested in supporting FSM.

BWC has started partnerships with local service providers who lack the management ability to scale their business or the competence/capital to deploy productivity-enhancing technologies. Through such JVs, BWC aims to improve the quality of service available to customers while providing the kind of oversight and compliance that local governments seeks to protect the environment.

Regardless of the business model, there are **five key goals**:

a. Ensure reliable, convenient and good quality de-sludging services to citizens
b. Ensure faecal sludge is transported safely to the treatment plant and not dumped in the wrong locations by using technology
c. Treated faecal sludge properly to meet environment standards
d. Protect the health of sanitation workers
e. Provide reliable data to local governments on de-sludging activities and impact on environment

This paper will discuss how BWC will establish control centers, and use GPS tracking systems, GIS Maps, customer relationship management software and other tools to deliver world-class FSM services in India. FSM requires an investment of $12-20 per capita, and thus significant capital has to be deployed into this sector. Through strong management systems and skilled teams, the right technology and partnership with private players and Government, BWC aims to become a leading partner for effective, efficient and reliable faecal sludge management and treatment services across India.

Onsite Domestic Wastewater Treatment Using A Modified Septic Tank – Effect of Hydraulic Mixing on Pollutant Removal

Ramamoorthy, Rajesh rajesh.ramamoorthy@gmail.com
Keywords: Decentralized, Onsite treatment, Septic tank **Conference Track:** (2) Case Study Track
Track Topic: *Pilots showing promises* **Personal Preference**: *oral presentation*

Onsite domestic wastewater systems have a significant role to play in addressing India's sanitation crisis. As per Census of India 2011 report, nearly 35% of households in the country use a form of onsite wastewater treatment system be it septic tanks, pit latrines or other options. Wastewater treatment at source when properly managed can not only be effective but also reduce costs for downstream secondary treatment.

Standard septic tanks use a T-shaped inlet device that dissipates the kinetic energy of the incoming sewage to create a dormant tank which maximizes the settling process consequently limiting solids' digestion rate (Bounds 1997; Kumar et al. 2006; Pérez-Elvira et al. 2006). Another disadvantage of the septic tank is its incapability to handle hydraulic shock loads (Sharma & Kazmi 2015). Previous studies have investigated the use of either mechanical or air mixing to improve digestion performance but these are not practical as the cost and operational requirements are high (Picot et al. 2003; Kumar et al. 2006; Pérez-Elvira et al. 2006; Novak et al. 2011).

Hydraulic mixing is a passive technology that utilizes the kinetic energy of the incoming sewage to create a small mixing zone where organic matter and bacteria will be in contact for a longer time improving digestion and reducing sludge accumulation (Almomani 2015). Clearford Water Systems Inc. provides a decentralized wastewater management solution comprising of a Smart Digester followed a Small Bore System (SBS) used to transport the sewage and a final secondary/tertiary treatment package. The Smart Digester is essentially a septic tank with two mechanical components installed - A patented hydraulic flow mixer to enhance the digestion of solids within the tank and a patented flow attenuator to buffer the flow of the liquid leaving the digester. The objective of this study is to examine the performance of the modified septic tank component of Clearford's system with respect to pollutant removal efficiency.

The study site is located in the Agra Cantonment area which is part of the city of Agra, Uttar Pradesh. Three homes with a total of 14 residents were part of this study; they were previously using an open drain to discharge their wastewater into a nearby pond. Piped water supply of about 100 lpcd is supplied to the homes that use a pour flush toilet and a bucket for their showers. A standard underground septic tank of 4000L capacity was constructed, installed with two inlet hydraulic mixers and one flow attenuator.

Between January to April 2016, composite sampling was carried out twice a week during the first month, once a week in the second month and fortnightly for the third and fourth months. Samples were analysed for physico-chemical parameters such as BOD, TSS and COD as well as Total Nitrogen (TN), Ammonical Nitrogen (NH_4N) and Total Phosphorous (TP).

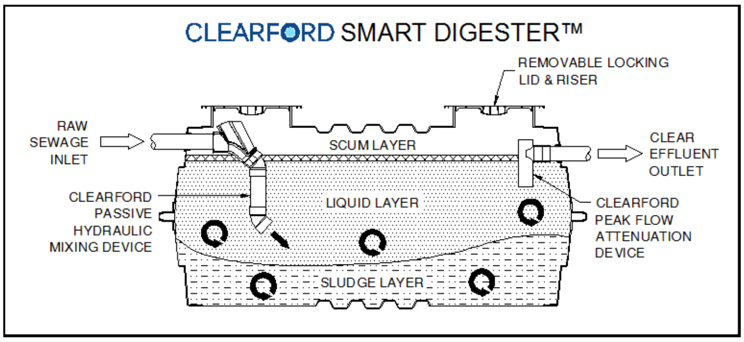


Figure 1: Modified Septic Tank **Source:** Clearford Internal

Table 1 Influent and Effluent characteristics (mg/L)

	TSS		BOD		COD		TN		NH_4N		TP	
	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent	Influent	Effluent
Min	126	60	99	41	285	110	58	38	26	16	1	1
Max	1288	276	1250	370	3453	1095	140	118.2	116	87	11.6	8.4
Avg	557	137.4	412.6	117	1140.6	328.2	82.9	70.2	60.5	52	5.4	3.7
SD	409.6	67.6	381.6	79.5	1057.2	227	20.9	20.8	20.3	18.3	3.7	2.1

Results

As per Metcalf & Eddy 2003, the influent can be classified as medium to high strength sewage. The septic tank with a hydraulic mixer delivered 61-67% removal efficiencies for BOD, TSS and COD parameters. In general, the performance of septic tanks depends on the influent sewage characteristics, tank design and operational temperature. The environment within the septic tank can only act in converting the influent organic-N to ammonium, thus achieving minimal TN removal (Beal et al. 2005; McCray et al. 2005; Almomani 2015). The removal of phosphorous might be attributed to its utilization for biomass growth, precipitation and entrapment within the digested sludge (Sharma & Kazmi 2015).

Table 2 Pollutant removal efficiency (in percentage)

	TSS	BOD	COD	TN	NH_4N	TP
Min	36.5	37.0	35.9	0	0	0
Max	86.8	91.7	90.6	48.7	71.4	70.4
Avg	66.7	62.4	61.3	17.5	20.9	31.7
SD	16.4	16.0	16.3	18.1	21.9	26.6

Conclusion

Based on the results obtained during the initial phase, hydraulic mixing technology can be considered a feasible alternative to conventional septic tanks. Typically, pollutant removal efficiencies increase as the system matures. Thus, a longer term study is required to realize the full potential of the modified septic tank system.

References

Almomani, F., 2015. Field study comparing the effect of hydraulic mixing on septic tank performance and sludge accumulation. *Environmental Technology*, 3330(September), pp.1–14.

Beal, C.D., Gardner, E.A. and Menzies, N.W., 2005. Process, performance, and pollution potential: A review of septic tank–soil absorption systems. *Soil Research*, 43(7), pp.781–802.

Bounds, T.R., 1997. Design and performance of septic tanks. *American Society for Testing and Materials, Philadelphia, Pennsylvania*, (818), pp.1–21.

Eastman, J.A. and Ferguson, J.F., 1981. Solubilization of particulate organic carbon during the acid phase of anaerobic digestion. *Journal (Water Pollution Control Federation)*, pp.352–366.

Kumar, N., Novak, J.T. and Murthy, S., 2006. Effect of secondary aerobic digestion on properties of anaerobic

digested biosolids. *Proceedings of the Water Environment Federation*, 2006(5), pp.6806–6829.
McCray, J.E. et al., 2005. Model parameters for simulating fate and transport of on-site wastewater nutrients. *Ground water*, 43(4), pp.628–639.
Metcalf, E., 2003. Wastewater Engineering: Treatment, Disposal, Reuse, Metcalf and Eddy. *Inc., McGraw-Hill, New York*.
Novak, J.T., Banjade, S. and Murthy, S.N., 2011. Combined anaerobic and aerobic digestion for increased solids reduction and nitrogen removal. *Water research*, 45(2), pp.618–624.
Pérez-Elvira, S.I., Diez, P.N. and Fdz-Polanco, F., 2006. Sludge minimisation technologies. *Reviews in Environmental Science and Bio/Technology*, 5(4), pp.375–398.
Picot, B. et al., 2003. Biogas production, sludge accumulation and mass balance of carbon in anaerobic ponds. *Waste Stabilisation Ponds: Pond Technology for the New Millennium*, 48(2), pp.243–250.
Sharma, M.K. and Kazmi, A.A., 2015. Performance evaluation of a single household anaerobic packaged system for onsite domestic wastewater treatment. *Desalination and Water Treatment*, (April), pp.37–41.

Low-cost pre-cast toilet designs for households and institutions in Ugandan small towns and low income areas

Patrick. Mass* and Prit. Salian**

* GIZ-Uganda, RUWASS, Plot 128, Luthuli Avenue, Bugolobi, PO-Box 10346, Kampala, Uganda
** Prit Salian, i-San Consulting, Zehntgasse 23B, 76646, Bruchsal Germany
Conference Track: (3) Industry and Exhibition Track
Track Topic: Safe capture and containment that facilitates faecal sludge emptying
Personal Preference: oral presentation

Keywords: lined latrines, modular design, precast toilets, FS emptying

1. Background

Over 90% of the urban population of Uganda relies on onsite sanitation systems (pit latrines). Only 10% of these latrines can be emptied as most of them are not lined/sealed (MWE 2016). Unlined pit latrines are abandoned after they are filled up and new ones are dug in the adjacent space (GIZ/USAID 2015). This practice increasingly becomes a challenge due to limited space in dense urban agglomerations of small but rapidly growing towns in Uganda and poses the risk of ground water pollution in high water table regions.

Municipal and town councils are now making lined/sealed and emptiable latrines mandatory, but the lack of design standards and a fragmented sanitation market in Ugandan small towns results in very expensive construction costs of toilets. A single lined pit latrine costs between 6 to 8 million UGX (USD 1,800 to 2,400) compared to a range of 1.5 to 2 million UGX (USD 425 to 575) in Kampala (Ulrich *et al*. 2016). These high costs discourage home owners to build lined toilets, which hampers the upscaling of Faecal Sludge Management in Ugandan towns.

2. Context and objective

GIZ, with co-funding from USAID, has undertaken a city-wide sanitation planning project in six small and medium sized towns in Northern Uganda. One component of this project is to develop and promote low cost toilet designs that can facilitate emptying, transport and treatment of faecal sludge in these six towns. The designs had to fulfil following requirements:

- Reduced costs of construction for lined toilet facilities
- Increase of durability and quality of construction
- Development of modular systems to facilitate upgrades of chosen technologies
- Integrate hand washing facilities and menstrual hygiene management within facilities for institutional toilets
- Designs should provide a basis for standardisation, meeting the expectations of relevant ministerial bodies

3. Methodology

Shortcomings and challenges of existing practices in toilet constructions were identified and analysed based on literature research, market analysis and interviews with relevant actors in Uganda and specifically in the Lango Sub-region. Based on the findings, the designs were developed by i-San consulting in close cooperation with GIZ and in partnership with the Water and Sanitation Development Facility-North (implementing body of the Ugandan Ministry of Water and Environment) and local private enterprises. Combining local and international expertise and participative meetings with relevant practitioners, solutions were developed in an iterative manner, leading to a series of innovations that are presented in the findings.

4. Findings / Promoted innovations:

Reduced cost of construction: The cost reduction is achieved if toilets are pre-cast and assembled on site. Cost of a single lined pit latrine can be as low as 1.5 million UGX (USD 400) and cost of a ten stance institutional toilet (schools, public places and health facilities) can be under 30 million UGX (USD 7500).

Increase of durability and quality of construction: Durability and quality of construction can be achieved by the use of pre-cast components which are produced by concrete block manufacturers. Elements that can be utilised include for example inverted concrete culverts (usually used for road construction). These can be used as water tight holding tanks to contain urine and faeces underground. Walls and ceilings are made from pre-cast ferro-cement sections that are thin but durable and placed between pre-cast concrete columns.

Modular systems to facilitate upgrades: Depending on the availability of financial resources, the presence of constant water supply and the needs of the users, the designs incorporate innovative options that allow upgrading with minimal financial requirements. The costs for converting a dry pit latrine into a water-borne toilet with a septic tank system would be less than USD 100.

Integrate hand washing facilities and menstrual hygiene management within facilities: Hand washing tanks can be constructed using inverted 400 mm concrete pipes that can store up to 127 litres of water (adequate for 425 students). Additionally, the use of concrete reduces the risks of theft and vandalism. The designs for institutional toilets are integrated with Menstrual Hygiene Management facilities that include a wash room and an incinerator.

Basis for standardisation: Pre-cast toilet components can provide standardised dimensions, quality assurance and guarantee consistency of components. If standardisation of toilet designs is achieved at a city-wide, regional or national level, it could drive down the costs of emptiable toilets and enhance scaling up of FSM in the long run.

5. Conclusion

Currently two school toilets and five demonstration toilets for households are being constructed. Learnings from these pilots will be presented in the Joint Sector Review of the Ministry of Water and Environment for further consideration as standards for low cost emptiable toilet designs to be promoted in all urban settings of Uganda.

The six town councils have modified their existing by-laws and building code regulations to make emptiable toilets mandatory. The town councils are also promoting the designs of toilets via media campaigns to households and schools.

GIZ is currently working towards developing capacities of two medium scale private enterprises in manufacturing pre-cast modular toilets. To achieve promotion at scale in six towns, a franchise model is envisaged where smaller private entities will be engaged for marketing, assembling the manufactured toilets and emptying of toilets using semi-mechanised equipment. The emptied faecal sludge will then be transported to a treatment plant servicing three towns within a radius of 30 km to keep transport costs low.

6. References

- MWE (2016) Water And Environment Sector Performance Report 2016. Ministry of Water and Environment of The Republic of Uganda, page 96
- GIZ/USAID (2015) Development and Implementation of Town Sanitation Plans. Baseline reports of Apac, Aduku, Oyam, Kamdini
- Ulrich et.al (2016): Study Report - Assessing the Costs of on-Site Sanitation Facilities, Eawag, Dübendorf, Switzerland

Three Years of Field Experience Piloting the Anaerobic Digestion Pasteurization Latrine

A.A. Forbis-Stokes*, B. Hunter, L. Rocha Melogno, K. Jooss, M.A. Deshusses**

*Dept. of Civil and Environmental Engineering, Box 90287, Duke University, Durham, NC 27708-0287. USA
+1-919-660-5480; +1-919-660-5219 FAX. *aaron.forbis-stokes@duke.edu or **marc.deshusses@duke.edu

Keywords: Anaerobic digestion; Pasteurization; Pathogen removal

Conference Track: (2) Case Study Track
Track Topic: Pilots showing promises
Personal Preference: Oral presentation

The Anaerobic Digestion Pasteurization Latrine (ADPL) is a self-contained and energy neutral on-site faecal sludge treatment system using anaerobic digestion of human excreta to generate biogas, and then uses the biogas to pasteurize the digester effluent at 65-75 °C to produce a safe effluent. The ADPL is a simple system, with no moving parts and relying on gravity-induced flows (Figure 1.1). Initial lab-scale proof-of-concept results and early results from field implementation were presented at earlier FSM conferences (Colón et al. 2012; Forbis-Stokes et al. 2015). This presentation will focus on the progress of ADPL field implementations of five prototypes in Kenya, India, and the Philippines.

In June 2013, two ADPL systems (referred to as North (N) and Central (C)) were installed in a peri-urban area outside of Eldoret, Kenya, each serving around 25 people. Each ADPL includes three toilet stalls with plastic pre-fabricated latrine slabs (squat pan style as preferred by residents). The built ADPL can be seen in Figure 1.2. Typical operating parameters are shown in Table 1.1. Residents were instructed to use 1 L pour flush when defecating. Obtaining an accurate sample of the influent was not possible due to its heterogeneity, so the organic loading was assumed to be 42,000 $mg_{COD}\ L^{-1}$ based on expected characteristics (400 g_{feces}, 1 L_{urine}, 1 L_{flush} daily). The highest consistent biogas production rates at N and C were >290 and >458 $L_{biogas}\ d^{-1}$ or about 17 and 13 $L_{biogas}\ p^{-1}\ d^{-1}$, respectively (Forbis-Stokes et al. 2016). Effluent COD concentrations were on average 4,500 and 6,500 $mg_{COD}\ L^{-1}$, removal efficiency of 89 and 85%, respectively. Biogas was collected in a floating dome and stored at a pressure of 3.7 cm H_2O. Initially, gas flowed continuously through an iron scrubber for removal of H_2S and condensation and into a Bunsen burner. Gas flow was determined by trial-and-error to reach desired heater temperature range (65-75 °C) without using more biogas than produced through digestion. The flow used for the majority of this study was 288 $L_{biogas}\ d^{-1}$. The heating system achieved greater than 5 log reductions of faecal coliform (FC) (non-detectable) in the heater when temperatures were greater than 65 °C. In April 2016, digesters replaced with custom-built baffled digesters based on computational fluid dynamics, and low-cost controls were installed to improve pasteurization reliability and provide continuous real-time temperature and flow data monitoring and remote access to data. The controller also turns the biogas burner on or off, depending on the heater temperature.

The ADPL implementation in the Philippines was in partnership with the Tesari Foundation. The technology demonstration is part of a holistic sanitation program that includes a preliminary baseline health study, sanitation education campaign, and eventual widespread sanitation intervention. The ADPL was first prototyped at Tesari facilities in 2014-2015 (Forbis-Stokes et al. 2015). Two ADPL systems were installed in July 2016 by the Tesari Foundation on residential plots in a peri-urban area outside of Toledo City, Cebu, Philippines, based on the protocol in Kenya. At each site two 1.2 m^3 digesters were installed in series to treat a volume of undiluted human waste equivalent to 9-13 residents per day (21-31 L d^{-1}). Preliminary data shows average production at each site is 19 and 38 $L_{biogas}\ p^{-1}\ d^{-1}$. Temperature and flow data are monitored and manually recorded daily, and system operation and maintenance reports are sent weekly.

An ADPL was connected to a dormitory on campus of the Indian Institute of Technology Madras (IITM) in Chennai, India, in July 2014 but remained mostly dormant until moved to another dormitory at IITM in November 2015. The 2 m^3 baffled bioreactor treats a volume faecal waste equivalent to 42 users per day which is pumped from the bottom of a collection and settling tank that receives the waste from flush toilets. The digester is fed ~100 L d^{-1} of waste with 30-40 g_{COD} L^{-1} since September 2016. Preliminary results show 93% COD removal efficiency has been achieved while producing 380 L_{biogas} day^{-1} (limited to 4 weeks of data). Real time temperature data is recorded online, and weekly lab analyses are conducted by collaborators at IIT. Updated results will be shown at the conference and the system will be available for a site visit.

The ADPL is an emerging technology that is in operation and being tested at multiple scales and in multiple contexts. Long-term results in Kenya show that anaerobic digestion of minimally diluted faecal waste can produce more biogas than is required to power the pasteurization tank, indicating that the ADPL is a self-sustaining system that can remove pathogens from faecal waste before entering the environment. The system is replicable in many contexts, using simple and readily available materials. ADPL installation costs across locations ranged from $1,600-2,600, or $0.03-0.07 p^{-1} d^{-1} based on expected lifespan. Users have provided positive feedback due to the system having little to no odour or flies, and they have expressed interest in using any excess biogas for domestic use as well as treated effluent as fertilizer. Up-to-date observations, lab results, and key findings of field operation of Kenya, India, and Philippines systems will be presented and discussed at the conference.

Table 1.1 Typical ADPL operational parameters.

Typical Parameter	Value
Organic Loading Rate, OLR ($kg_{COD}/(m^3\text{-}d)$)	1-3
Hydraulic Retention Time (days)	18-60
Biogas Yield (L_{biogas}/(person day))	12-42
CH_4 (% vol.)	60-65
COD Removal (%)	70-90
NH_3-N out (gN/L)	3-7

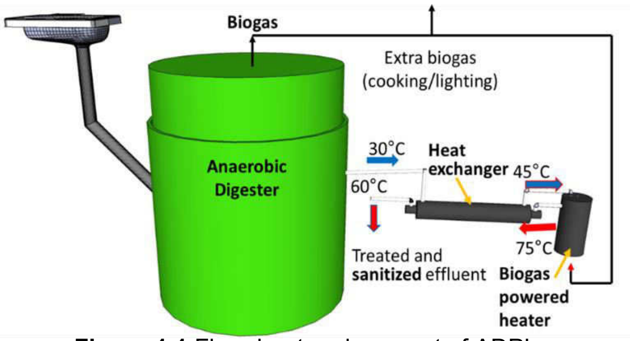


Figure 1.1 Flowsheet and concept of ADPL.

Figure 1.2 Installed ADPL systems in Kenya (left), Philippines (middle), and India (right).

References

Colón, J., Forbis-Stokes, A. A., Ouksel, L. S., and Deshusses, M. A. (2012) Effective Sewage Sanitation with Low CO2 Footprint. Second International Faecal Sludge Management Conference, 1–7.

Forbis-Stokes, A. A., Ouksel, L., O'Meara, P., Simiyu, G. M., and Deshusses, M. A. (2015) Anaerobic Digestion-Pasteurization Latrine (ADPL): Sanitation in Multiple Contexts. 3rd International Faecal Sludge Management Conference, FSM3, Hanoi, Vietnam.

Forbis-Stokes, A., O'Meara, P., Mugo, W., Simiyu, G., and Deshusses, M. (2016) Onsite fecal sludge treatment with the Anaerobic Digestion Pasteurization Latrine. Environmental Engineering Science (online, ahead of print).

DEFAST: From Research To Market

O. Atwijukye*, C. Nimanya*, B. Achiro*, S. Sugden*, G. Mumbo* P. Ogwang**

*Water For People
**Agency For Sustainable Rural Transformation

Keywords: DEFAST, Market, Briquettes

Conference Track: Industry and Exhibition Track
Track Topic: *Treatment and Reuse*
Personal Preference: *oral presentation*

Introduction

Since 2013, the Water Research Commission (WRC) has been supporting the Water For People (W4P) Kampala Sanihub project to develop faecal sludge management technologies. The low cost decentralized faecal sludge treatment (DEFAST) system is among the most successful projects that have gone beyond technology testing to now market testing. The DEFAST idea was borrowed from the DEWATS Concept by BORDA in a bid to have a low cost, entry point, treatment package within the financial reach of entrepreneurs. In addition, the Sanihub has developed other products that could improve financial viability of DEFAST, they include briquettes, aquaculture and poultry feeds, biochar and compost. W4P and partners like (agency for sustainable rural transformation) AFSRT, Kole district has embarked on exposing the DEFAST to market conditions under the project 'my waste my mint' that was partly funded by ICCO.

DEFAST Description

The DEFAST in Kole district Northern Uganda has the following units; the inlet unit which has a screen to remove non-biodegradable solids, the presettling tank, two anaerobic baffled reactor tanks (ABR), two anaerobic filters (AF), a planted gravel filter (PGF), an algal pond and drying bed. A separate reuse section has been setup with a capacity of 500kg/d of carbonized briquettes in order to demonstrate appropriate reuse of FS. In addition a black soldier fly system is being setup to make aquaculture and poultry feeds. The plant has a capacity of 10m^3/d FS which is adequate for most growing towns of about 20,000 people. All the anaerobic units are made using rota mould plastic tanks and designs are available for even large towns that can generate 50m^3/d.

Objectives of 'my waste my mint' project in Kole were to;

- Identify and train a local business development partner that will in turn recruit and train entrepreneurs for project sustainability.
- Construct a DEFAST with at least 500kg/d briquette facility using carbonised FS as alternative energy source for the communities and industries in Lira town.
- Support entrepreneur groups like recently formed Sani-Waste Solutions that provide affordable pit emptying services using tricycle franchise model.
- Create Northern Regional Sani-technology learning and transfer centre to skill the youth to serve the entire region on a business approach.

Approaches and Activities

- Establishment of low cost decentralized faecal sludge treatment (DEFAST) plant

- Training in pit emptying using a gulper
- Introducing the transport system for the gulping entrepreneurs
- Business development and sanitation marketing.

Approach: Sanitation as a business approach (SAAB) and testing the tricycle franchise model. Locals are trained and given equipment which should be able to produce other equipment for the group after a set period of time normally a year.

Lessons learned

- Various youth have realised need to be enterprising as they promote sanitation as opposed to waiting for formal employment.

- Well thought Decentralised FS management creates more entrepreneur opportunities around emptying, treatment and reuse hence, profit driven sanitation services.

- With decentralised FS treatment, private sector can be fully involved in FSM given the opportunities hence, reducing the burden on governments.

- Using low cost materials like plastic tanks can greatly reduce the cost and time needed to establish similar plants using other materials like concrete.

- Companies dealing in plastics should start manufacturing special tanks/ systems to minimise need for modifications of water tanks.
- Anyone planning to do reuse of FS, should plan right from capture methods, through collections and final treatment and reuse, this helps to avoid foreign substances that affect quality of FS products and make it hazardous.

- One key challenge in Lira and Kole are the depth and unlined pits. This not only complicates full emptying but also pollutes ground water resources.
- Much solid waste is evidenced in pits which are as well another hindrance.

Achievements

Over 20 youths have taken on the project as full time employment into mainly pit emptying, briquette production and sale. In addition the project is attracting influential partnerships like government, private sector organizations in and outside the country. The initiative has also attracted national media http://www.monitor.co.ug/Business/Prosper/Kole-residents-human-waste-/688616-3387356-14dsc2az/index.html

http://www.nbs.ug/2016/09/12/fecal-sludge-management-turning-human-waste-into-money/

Conclusion

At the moment briquettes are being sold in Lira at about 0.3USD/ Kg mainly in Lira town and from cooking tests it was observed that while using briquettes, one uses half the money he/she would spend on charcoal. Incorporation of pit emptying, treatment and reuse helps cover up the extra costs in maintaining the plant since only dumping fees are normally inadequate for all operation and maintenance costs, hence good step towards ensuring sustainability. There is need for studies on best ways to avoid or manage foreign materials like solidwaste in pits.

Findings of The Shit Flow Diagram Developed for the City of Durban, South Africa

XHA Roux
BA (MFA) (Hons), B.Sc. (Civ Eng) (Hons, *cum laude*, M.Sc. (Environmental Science)
Snr Lecturer in Environmental Engineering
1 Jan Smuts Avenue, Johannesburg, South Africa, University of Witwatersrand

Keywords: Shit Flow Diagram, Sanitation, Case study
Conference Track: (2) FSM Case Study Track
Personal Preference: Oral Presentation

Introduction: Context for the SFD

Faecal sludge management (FSM) is not an attractive topic for politicians and financiers; it is neglected and hidden in the already marginalized field of sanitation (Mara, Lane, Scott, & Trouba, 2010; WSP, 2014). To make headway in combating FSM problems and poor sanitation in developing countries, the Water and Sanitation Program (WSP) of the World Bank Group developed an advocacy tool to express the problems in the sanitation network visually, for decision-makers to understand the implications of neglecting FSM and to provide a tool for more concerted attention on policy options (SuSanA, 2014). This advocacy tool is the Shit Flow Diagram (SFD) and accompanying Service Delivery Analysis Report. The specific data required to develop the SFD is the contribution of excreta from each off- and on-site sanitation technology in a given city and a big picture analysis of the consequences under current policy choices.

Context for the City Under Study

South Africa is a middle-income country significantly divided between rich and poor (The World Bank Group, 2016). Since 1994 national policies support major investment for more equitable services to redress the policies of the Apartheid era (South Africa, 1997a).

The eThekwini Municipality area in KwaZulu-Natal is amongst the top 3 most populous conurbations in South Africa. The eThekwini Municipality Water and Sanitation (EWS) is the water service provider for the eThekwini area of 2 300 km^2 serving 3.5 million people (eThekwini Municipality, 2015a). Urbanization is abundant, with poor and marginalized communities increasing and urban sprawl occuring further and further away from the city centres (eThekwini Municipality, 2015a). Environmental pollution is becoming a major issue in South African cities with a significant impact.

Study Objective

In order to better understand the sanitation systems and current state of FSM in Durban, South Africa, the Pollution Research Group (PRG) in the University of KwaZulu Natal (UKZN), in collaboration with Eawag (Swiss Federal Institute of Aquatic Science and Technology) and EWS developed a SFD for the eThekwini municipal area. The objective of this study was to get a clear and simple visual tool that expressed the percentage of people's faecal waste that is safely managed before disposal or reuse in order to be able to accurately address these areas in future sanitation decisions. This paper is a presentation of the findings from this SFD study that was developed over a 4-month period in early 2016.

Case Study Methodology

The SFD development process consists of data collection, stakeholder engagement to understand the sanitation systems and then assessment of the fate of excreta using the SFD Microsoft Excel © calculation tool. This is accompanied by the development of a service delivery analysis report using the information collected (SuSanA, 2015).

Lessons Learnt

The study found that 74% of excreta is managed safely in Durban, with 48% coming from waterborne toilets on the central sewer network. The bulk of the excreta that is not safely managed derive from the 17% of households that do not have improved toilet facilities or access to an emptying service, as well as the estimated overflow from blocked sewer lines.

The containment systems for the 42% on-site sanitation are in the form of septic tanks, conservancy tanks (sealed tanks), UD toilets and VIPs. The off-site sanitation goes through the sewer network to the wastewater treatment works (WWTW). Emptying and transport of FS from containment systems is well managed and considered to be a strong private and public industry. The other FS is taken to the centralised treatment facilities and is either sent out to sea through the sea outfall (considered safely disposed of by the legal regulations) or treated at the WWTW.

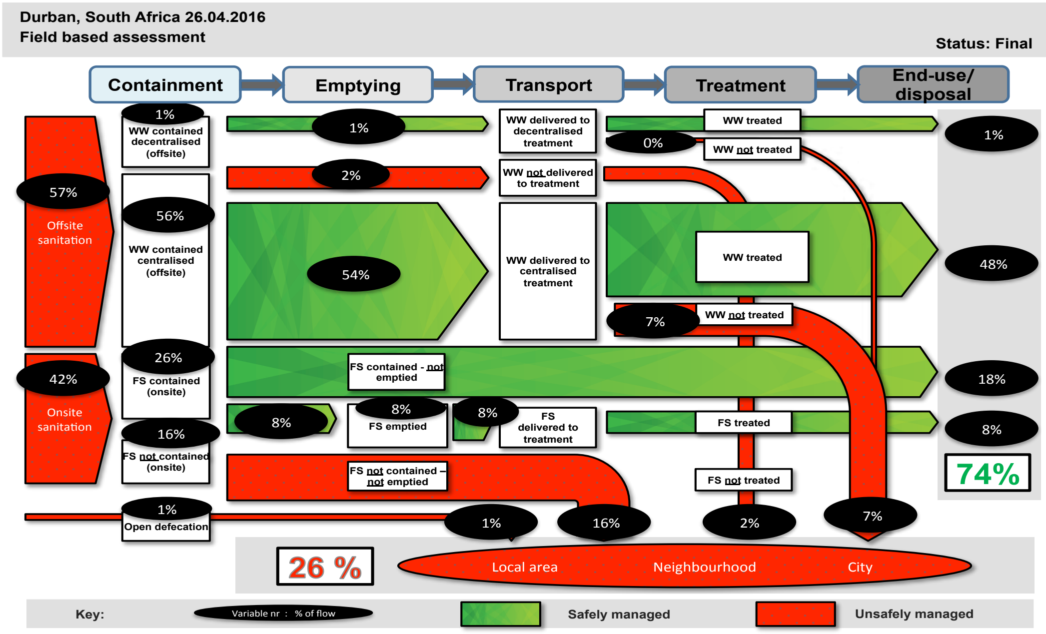


Figure 1: SFD for Durban, South Africa, 2016

Conclusion and Recommendations

The study showed the significant need to reduce the backlog of basic services provided to the indigent people of the city and a need to measure and control the sewerage overflow during blockages. This is important now, at a time when the RSA government is rethinking its sanitation policy

Significance in the FSM4 Conference

The results of a SFD in a middle-income country with a strong tradition of problem-solving raises a different set of issues and contributes to Sustainable Sanitation Alliance's (SuSanA) commitment to develop an analysis on FSM in every city in the world.

References

eThekwini Municipality. (2015a). Integrated Development Plan 2015/16. eThekwini Municipality. Durban: eThekwini Municipality.

Mara, D., Lane, J., Scott, B., & Trouba, D. (2010). Sanitation and Health. PLoS Medicine , 7 (11), 1-7.

South Africa. (1997a). The National Water Policy for South Africa.

SuSanA. (2014). Shit Flow Diagrams: SFD Promotion Initiative. Retrieved 11 07, 2015, from SuSanA: http://www.susana.org/en/forum/96-shit-flow-diagrams

SuSanA. (2015). Manual for SFD Production: Version 1.0. Retrieved January 2015, from SFD Promotion Initiative: http://sfd.susana.org/

The World Bank Group. (2016). GINI index (World Bank estimate). (T. W. Group, Producer) Retrieved 02 24, 2016, from The World Bank: http://data.worldbank.org/indicator/SI.POV.GINI/countries/1W-ZA?display=map

WSP. (2014). The Missing Link in Sanitation Service Delivery: Review of Fecal sludge Management in 12 Cities. Water and Sanitation Program. WSP.

Lessons learnt from developing SFDs at scale

O. Veses*, C. Furlong**, B. Evans*, S. Bieker*****, B. Luthra***, S. K. Padhi***, A.R. Panesar*****, C.M. Rodrigues*****, S.K. Rohilla***, L. Schoebitz****, R.E. Scott**, L. Strande****

*University of Leeds, **WEDC, Loughborough University, ***CSE: Centre for Science and Environment, ***EAWAG/SANDEC, ***** GIZ: Gesellschaft für Internationale Zusammenarbeit GmbH

Keywords: faecal sludge; urban sanitation; sanitation service chain

Conference Track: (3) Industry and Exhibition Track
Track Topic: *Planning and communication tools for FSM*
Personal Preference: *oral presentation*

Introduction

Today, a huge number of people have limited access to sanitation. Particularly in low-income and rapidly expanding cities, faecal sludge (FS) represents a growing challenge, generating significant negative public health and environmental risks (Peal et al. 2014a). The excreta-flow analysis (SFD or Shit-flow or Faecal/Fecal-flow Diagram) aims to illustrate how the wastewater and FS moves within a city or town (Peal et al. 2014b). In 2012-2013 the Water and Sanitation Program (WSP) of the World Bank carried out an analysis of excreta management in 12 cities. Based on this work, a consortium of partners, under the name of SFD Promotion Initiative (SFD-PI), was initiated by the GIZ (Gesellschaft für Internationale Zusammenarbeit GmbH) and supported by the Bill and Melinda Gates Foundation in 2014 to further develop the analysis of the service delivery context of FS and wastewater in urban areas and to produce the SFDs in a standardized manner, to make the approach broadly available (SuSanA, 2016). The consortium includes GIZ, the University of Leeds, SANDEC/EAWAG, WEDC at Loughborough University, the Centre for Science and Environment (CSE) and the World Bank's WSP. The SFD-PI has been working with over forty cities and towns since 2014 to pilot a methodology which enables an analysis of current urban sanitation services in terms of the ultimate fate of excreta. This paper reviews the learning gained for the piloting of this methodology and highlights research which is required in this field.

Methodology

The SFD PI methodology relies on: (i) review of secondary literature, (ii) key informant interviews/focus discussion groups with service providers and stakeholders and (iv) structured observations and direct measurements. The methodology allows for an analysis of the context in each city which, when considered in conjunction with the SFD, can be used to reveal critical points of failure in the provision of urban sanitation services in any given city or town. Modifications of the method are being used to generate the first generation of national estimates for the percentage of the population with access to 'safely managed sanitation' (Sustainable Development Goals, Target 6.2).

Results and discussion

The SFD PI webportal (http://sfd.susana.org/) contains detailed information on the extent and nature of excreta management in cities and towns in five continents. The cities and towns range in size from rural growth centres to major capitals. Some are wholly reliant on onsite systems while a smaller number have significant sewered systems. Most contain a range of different systems operating in parallel. In each case the SFD analysis reveals the extent to which sanitation systems are operating and the percentage of households whose excreta are managed safely from containment, through emptying and transport to treatment and reuse or disposal. In most cases the results are disappointing (Figure 1.1). Even where access to sanitation at the household level is high, many cities experience a failure in all or part of the systems for emptying onsite systems, transportation of excreta whether in piped systems or road-based systems, and inadequate treatment.

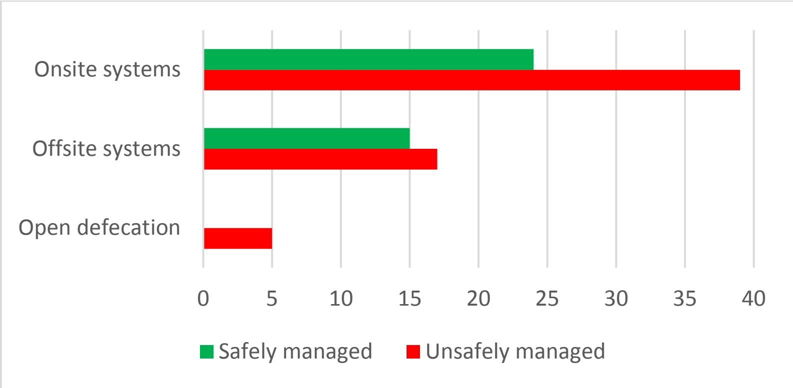


Figure 1.1 Excreta disposal (% of totals) in 48 cities from South and Central America, Africa and Asia.

The lessons learnt during this period focus on several aspects: (i) SFD report (context and diagram) production methodology, (ii) data-graphics conversion tool, (iii) data sources and different types of assumptions, (iv) stakeholder engagement and (v) use of SFD as a tool for advocacy and communication around improved city sanitation programming. These lessons are illustrated by going through examples on a few study cities in different contexts.

The wide range of conditions found in the study cities suggests that a generalized data-graphic converter which can produce consistent results is challenging. Good examples of this include (a) the review of 'collection' facilities, revealing that many assumed 'septic tanks' are in fact open bottomed pits or sealed vaults and (b) the assessment of groundwater risk, which was challenging in some cases, especially in those cities where data were not available.

The Indian cases are based to a large extent on official Government census data for containment systems. It is also notable that there is often an assumption of 100% treatment performance in most cases. Some of them also represent FS discharging from septic tanks and being transported via drainage networks to a disposal site/sewerage treatment plants (i.e. as an offsite system).

The lack of reliable data is well illustrated in a number of towns and cities where very little data is kept on faecal sludge management and field trips are necessary to produce the SFD. In such cases, the total amount of FS collected can be used to estimate the percentages of safe and unsafe FS disposal, leading to some uncertainties in the final SFD.

Conclusions

The methodology and tools provide a sound basis for completing an SFD analysis in any type of city or town, having a significant value in triggering local dialogue and discussion which challenges standard 'preconceptions' about how services are delivered. Finally, the collected results from city SFDs provide a valuable picture of prevailing conditions in typical cities and towns globally. The quality of this analysis will improve as the number of completed and approved SFDs continues to rise.

References

Peal, A., Evans, B., Blackett, I., Hawkins, P. and Heymans, C. (2014a). Fecal sludge management (FSM): analytical tools for assessing FSM in cities. Washdev 4 (3) 371-383.
Peal, A., Evans, B., Blackett, I., Hawkins, P. and Heymans, C. (2014b). Fecal sludge management: a comparative analysis of 12 cities. Washdev 4 (4) 563-575.
SuSanA (2016). SFD webpage (http://sfd.susana.org/) consulted on 10/10/2016

What is the future of pit emptying and faecal sludge treatment in emergencies?

J. Spit*, J. Heeger**, W. Carter***, A. Bastable***

* WASTE COOP UA, Lange Houtstraat 26, 2511 CW The Hague, The Netherlands
** NL Red Cross, The Hague, The Netherlands
*** International Federation of Red Cross and Red Crescent Societies, Chemin des Crêts, 17 1209 Petit, Saconnex, Geneva, Switzerland
****Oxfam GB, Oxford, UK

Keywords: emergency sanitation, pit emptying, faecal sludge treatment

Conference Track: (3) Industry and Exhibition Track
Track Topic: *Emptying, Transportation, Treatment*
Personal Preference: *oral presentation*

Background and context

The safe emptying and treatment of the collected faecal sludge rank amongst the top WASH challenges in emergency situations (Bastable and Russell, 2013). The Emergency Sanitation Project, S(P)EEDKITS and HIF-funded project on speedy sanitisation and stabilization, have developed basic options to deal with some of these challenges. An interesting spinoff of these projects is that the options are currently mainly being deployed in the non-emergency ('development' sector: ROM desludging unit, Flexigester) or on a small scale in the emergency context (simple biochemical treatment systems). One the one hand, more promotion, marketing and 'proof on concept' is needed to assure that the equipment and methodologies become better known and well trusted by the organizations and staff involved in emergency sanitation (IFRC, Oxfam, MSF, UNICEF etc.). On the other hand, the conditions in the field are so diverse that the 'standard' options cannot cope them. Hence diversification is required. We describe the options and present the recommended diversifications.

Raised Latrines

Having received good feedback from the trials in South Sudan & CAR of the raised latrines the products from Dunster House and Flexxolutions have been modified and now need to be used in other countries. The aim is now to promote the use, knowledge and awareness, of these raised latrines by installing them both in a number of countries where it is not possible to dig pits and there is a viable desludging option locally available. They are already part of Oxfam's emergencies stocks, which are available for any agency to buy.

Rapid Superstructures

Under ESP two most appropriate designs were identified but then some suppliers responded to the challenge by producing better designs. A quick re-evaluation is required before ensuring that they are promoted and trailed in relevant contexts.

Emptying of pits in 'difficult' areas: ROM desluding unit

The ROM desludging unit has a high-pressure pump with lances and nozzles to fluidise 'difficult' faecal sludge and has a 800 or 1,000 litres holding vacuum tank with a manhole to collect and transport sludge. Testing in Malawi has learned that most, if not all, latrines require extensive 'fishing' to take out the large amount of rubbish before the vacuum can be used to empty the pit. Recommended diversifications:

- A smaller unit that can be deployed in high-density areas. The unit should still contain the essential parts of the desludging unit: fluidiser, vacuum, holding tank.
- More efficient tools to fish out and deal with the rubbish in the pits.

- A larger unit that can be pulled behind a tractor and uses the engine of a tractor to operate.
- Use of transfer stations that can also be used to (pre-) treat faecal sludge.

Anaerobic treatment of faecal sludge in the Flexigester.

The Flexigester is a simple way to capture human waste, isolate it and decompose it in a gas-tight liquid environment. The Flexigester is a self-mixing butyl rubber vessel that is installed in a trench with simple pipework connections. Human waste is input to below the liquid level to maintain a gas-proof seal. The waste comes either from toilets connected by pipework, or from container-toilet collections. The direct transfer of waste into the sealed vessel removes any odour nuisance and prevents vectors gaining access to the waste. The Flexigester operates as a plug flow reactor, and it releases the same volume of treated material via an outflow as that input into the vessel at any one time. The system installations are designed for an average retention or treatment time of between 30 to 60 days. The unit comes in different sizes with the smallest being 10 m^3 capacity. The anaerobic digestion process breaks down the waste and generates biogas, which can be collected and used as a replacement-for-wood cooking fuel. The digestate output can be used as an irrigated bio-fertilizer for crops such as fruit trees or it can be further integrated into other processes. Being a membrane structure, the units are readily transportable, and can be deployed and in use within hours of delivery to site. Current Flexigester installations vary between 10 and 80 m^3 capacity and are located in 5 African countries.

Simple biochemical treatment of faecal sludge

Three Emergency Faecal Sludge Treatment Options have been investigated through small-scale experiments using Fresh Faecal Sludge over the past 3 months in Blantyre, Malawi. Preliminary testing has indicated that Lime, Ammonia, Lactic Acid, Ikati and Soda Treatments all have the potential to treat fresh faecal sludge to meet WHO guidelines within a treatment period of approximately one week. Further upscaling and scientific testing is required to ensure that these treatment methods can consistently meet sanitation requirements and a robust procedure that safeguards public health during an emergency situation can be established

Diversification of on-site containment and treatment

In the framework of ESP2 (IFRC, Oxfam, WASTE and Netherlands Red Cross) that started in October 2016, amongst others, the following innovations are foreseen:

- Excreta disposal in difficult locations (urban, high water table / flooding) aiming at improved ability of field teams to be able to install toilets in difficult locations. These latrines should require less operational and maintenance than the common models while they should be easy to transport.
- Latrine emptying and desludging aiming at simple and scalable equipment is available for faecal sludge treatment in raised latrines and **onsite** faecal sludge treatment;
- Centralised excreta disposal options aiming at turning sludge treatment methods into deployable kits and then test how the different methods complement each other and aiming at simple and scalable materials and knowledge is available to set up rapid deployable and mobile sludge transfer stations.

References

Bastable, A and Russell, L. (2013) Gap Analysis in Emergency Water, Sanitation and Hygiene Promotion, Humanitarian Innovation Fund.
WASTE, NL Red Cross (2014), Testing and developing of desludging units for emptying pit latrines and septic tanks, Findings Field work in Blantyre

Management Information System for Integrated Faecal Sludge Management Services in Tamil Nadu

Mr Kowshik Ganesh*, Ms Deepa Karthykeyan**, Mr Amarsh Chaturvedi***, Mr S.L.Sathiya Nesan****, Ms Uzra Sultana*****

* Consultant, Athena Infonomics India Private Limited, kowshik.g@athenainfonomics.in
** Co-Founder & Director, Athena Infonomics India Private Limited, deepa.k@athenainfonomics.in
*** Director, Transerve Technologies India Private Limited, amarsh@transervetechnologies.com
**** Director, Leaf Society, leafsociety@gmail.com
***** Manager - Urban WATSAN Programme, Arghyam Foundation, uzrasultana@arghyam.org

Keywords: Management Information System (MIS); Faecal Sludge Management (FSM); faecal sludge collection system (F.S. Collection System)

Conference Track: (3) Industry and Exhibition Track
Track Topic: *Monitoring and evaluation of FSM*
Personal Preference: *Oral presentation*

Background

On-site sanitation is and will continue to remain a critical link in the Indian sanitation scene. However, despite rising recognition on the need for pro-active management of on-site systems, city governments continue to grapple with the realities of a sector that is driven by non-governmental actors who are mostly informal and fragmented.

Local governments in India lack the frameworks, capacities and tools to monitor construction, maintenance, management and safe disposal of faecal sludge from on-site systems. While states like Tamil Nadu have attempted to provide for a state-wide framework and a set of operative guidelines for management of on-site systems, the translation of these frameworks and guidelines into action plans and investments in cities remain limited owing to a dis-connect between local capacities, knowledge and tools and the stated objectives enunciated in the guidelines.

In an attempt to provide a fillip to the pace of implementation of the guidelines for improved management of on-site systems, Project TUYMAI was conceptualized by Arghyam and launched in partnership with the Government of Tamil Nadu. A key objective of the initiative to develop a simple and user-friendly “Sanitation - Management Information System” to empower city governments to effectively implement the operative guidelines and better design, manage and monitor on-site systems of waste management.

Sanitation Management Information System

The Sanitation Management Information System (S-MIS) is an integrated platform that is designed to help city government. Key features of S-MIS tool are

- Empower cities to take an integrated view of the entire FSM value-chain and track its performance vis-à-vis the delivery of FSM services at every stage of the value-chain and overall (S-MIS tool tracks real-time data across the FSM value chain at a city / district / state / country level based on authorized user credentials)
- Enable real-time learning and dissemination (S-MIS tool establishes linkages between S-MIS tool and Knowledge Management portals, tracks best performing cities across metrics and conducts real-time performance evaluation of cities and enables effective dissemination of best practices between ULBs)
- Enables cities to conduct targeted interventions (Geocoded information systems enables city government to conduct customized subsidy targeting, asset creation, IEC and behavioural change campaigns to catalyse improvements in sanitation sector)

- Real-time pricing in relation to shifting market trends for greater private player participation
- S-MIS tool aggregates data at multiple frequencies based on the nature of the data. The tool is designed to be highly interactive and supports multiple functionalities such as real-time-queries and demand-supply matching between private sector operators & households.

Figure 1.1 Illustration of S-MIS Tool Dashboard View.

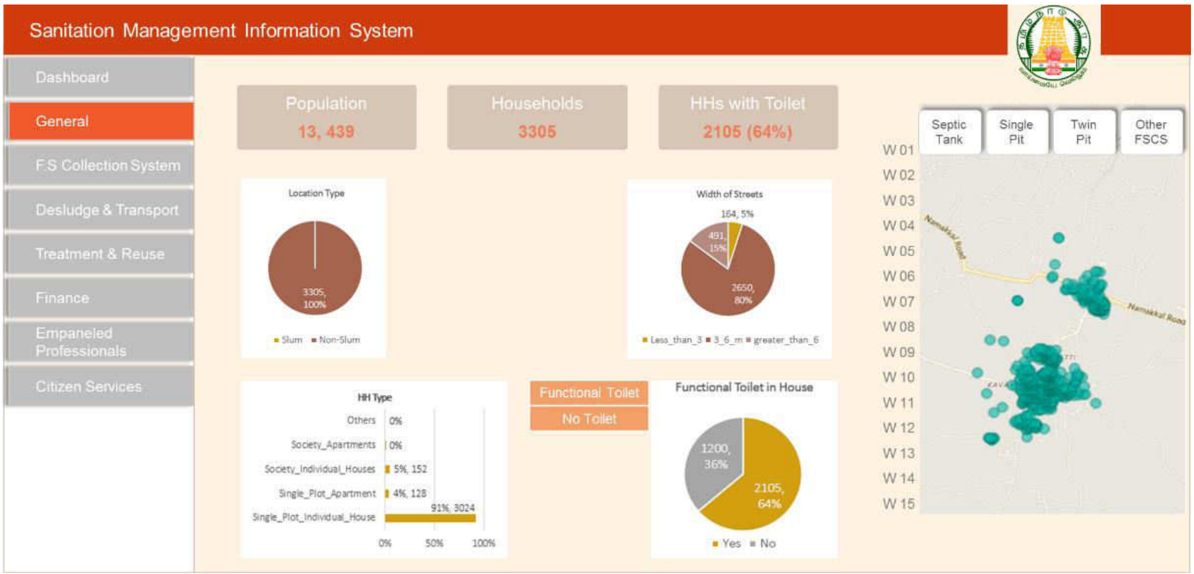


Figure 1.2 Illustration of S-MIS Tool General Page.

Project Progress

Project TUYMAI has successfully developed the S-MIS tool blueprint. This tool is designed to be modular and can be easily scaled up and customized to meet the requirements of cities at different levels of FSM maturity. The paper will present the details of the tool and its applicability in ULB contexts for FSM management.

The pit falls and problems of monitoring a growing pit emptying process

Author Name*, Steven Sugden

Keywords: monitoring, pit emptying,

Conference Track: (2) Case Study Track
Personal Preference: *oral presentation*

Introduction

The FSM landscape has changed over the last ten years. Original discussions focused solely on technologies, such as power versus manual devices and methods of treatment, but these have gradually morphed into the issues surrounding how to develop and grow commercially viable businesses. Neither the technical or business aspects of pit emptying have been fully resolved and there are still many areas for improvement, but the debate within Water for People at least, has moved on to the next, possibly final and most difficult, stage; how to facilitate safe sustainable pit empting businesses over an entire city without creating dependency on Water For People. In turn, this asks the questions, how do we know when it has been achieved and what is the best way to monitor performance. The way forward is to first consider the often asked question, what is scale?

What is Scale?

Scale has proved to be difficult to define in a way which is relevant across the wide range of approaches and contexts. Absolute numbers don't allow comparisons, for example building 300 latrines in Bolivia is a major achievement whereas in West Bengal it is insignificant. In Water For People we are beginning to regard scale as a process or mind-set which if followed, naturally leads to significant impact and scale.

> *"Scalability is a characteristic of a system, model or function that describes its capability to cope and perform under an* ***increased or expanding workload****. A system that scales well will be able to maintain or even increase its level of performance or* ***efficiency*** *when tested by larger operational demands. …* ***a scalable company is one that can maintain or improve profit margins as the sales volume increases".***

The key phrases in the statement are 'efficiency' and 'increased or expanding workload'. In the context of sanitation, sales volume is equivalent to the number of pits emptied or latrines built and 'profit margin' equates to the money spent by Water for People in facilitating the process.

Existing water based monitoring methods are inappropriate

For water supplies and latrine building Water for People use a household survey and spatial data based techniques, but these do not work of pit emptying because

1. It is very difficult to obtain accurate information over the use of the service. Households mistrust the evaluators motives and will respond by giving low risk answers, such as *"We use a tanker'* or '*We have never emptied*"
2. Spatial data maps showing customer locations are hard to produce because the pit emptying companies / operators gain no value from telling the truth. Why should they reveal their valuable confidential customer data to an INGO?
3. It creates an expectation that Water for People may at some stage be offering more tangible support and inadvertently creates feelings of dependency

In addition, these two water supply based techniques allow the gap between existing coverage and full coverage to be measured, so it becomes possible to objectively verify how the 'gap' changes over time and for an organisation to measure its progress toward reaching 'Everyone'. The equivalent in pit emptying would require an accurate assessment of the total amount of sludge a city produces on an annual basis, but with sludge build up rates reportedly been between 4 and 40 litres per person per year, the margin of error is too great to give any degree of confidence over any calculated figure.

An alternative approach based on efficiency and estimating expanding workload

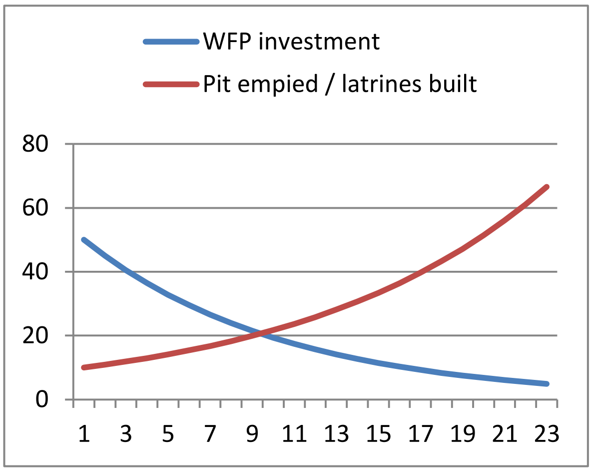
> *A scalable business is one that focuses on the implementation of processes that lead to an* ***efficient operation.*** *The workflow and structure of the business allow for scalability.*

The efficiency of a sanitation program could be defined as the amount of money Water for People spends per latrine built of pit emptied.

$$\text{Sanitation program efficiency} = \frac{\text{Money spent by Water for People}}{\text{Number of latrines built or pit emptied}}$$

If Water for People spends $15,000 on salaries and support and this results in 250 latrines being built (in a sustainable manner), this gives rate of $60 per latrine. If in the following year it spends $17,000 and builds 350 latrines, this gives a rate $48.57 per latrine. The unit cost rate per latrine has improved by $11.43 and this could be regarded as a 19% increase in efficiency.

An approach which is on the right track to make a significant sustainable impact should be following be curves in the graph on the right.



High efficiency alone is not enough. In Blantyre the team has been supporting Matias and other pit emptying companies for around four years. With each passing year Matias has grown his customer base and emptied more and more pits, whilst at the same time Water for People have given him less and less support. This creates a good efficiency trend line because smaller investments are bringing greater returns; the problem lies in the total number of pits which are emptied are not increasing in line with market uptake curves as predicted under the diffusion of innovation theory developed by E M Rogers. The solution is for Water for People to set incremental increasing pit emptying targets based predicated market up take curves as opposed to trying to relate it to the total volume of sludge a city may or may not produce. The targets will have a large margin of error as they will be based on a number of factors, all of which have similar large margins of error, but considering the pit falls of other methods of measuring impact and when combination with the efficiency calculations and historical data, the result should be 'good enough' to show the trend towards achieving what will eventually be regarded as scale.

Monitoring Safely Managed Sanitation in the 2030 Agenda for Sustainable Development – Experience from Uganda (2 of 2)

T. Kyomugisha*, R. Matua*, C. Tindimugaya*, L. Schoebitz**, A. Peal***, K. Medlicott****

* Ministry of Water and Environment, Government of Uganda (Trinah.Kyomugisha@mwe.go.ug)
** Independent consultant, Zurich, Switzerland (lars@lse.de)
*** Independent consultant, Macclesfield, UK (andy.peal@ntlworld.com)
**** WHO, Geneva, Switzerland (medlicottk@who.int)

Keywords: sanitation service provision; global monitoring; Uganda

Conference Track: (2) Case Study Track
Track Topic: *Emerging FSM services*
Personal Preference: *oral presentation*

Introduction
Uganda is one of six countries selected for proof of concept (PoC) testing of methodologies developed for the targets agreed under goal 6 of the United Nations (UN) 2030 Agenda for Sustainable Development. The proposed Sustainable Development Goal (SDG) indicator 6.2.1 is the 'percentage of population using safely managed sanitation services' includes assessment of safe treatment of both wastewater and faecal sludge, which furthermore informs indicator 6.3.1, the "proportion of wastewater safely treated", providing a common methodology to streamline data collection (UN-Water, 2016).
In Uganda, the Ministry of Water and Environment of the Government of Uganda has taken overall lead responsibility in coordinating the efforts during the PoC phase. This paper presents and discusses results of implementing the framework for indicator 6.2.1 and 6.3.1 in Uganda, both closely related to faecal sludge management and of global relevance in terms of implications for replication in other countries and regions.

Methods
The PoC phase was implemented between June and December 2016. An inception workshop for all targets under goal 6 was held in June. Coordinated by the Ministry of Water and Environment and following the workshop, relevant local stakeholders and institutions were identified. These institutions and the National Water and Sewerage Corporation (NWSC), a government-owned utility operating and providing water and sewerage services in the larger urban centres of Uganda, were requested to nominate task teams for each of the targets under goal 6. In August, first inception meetings were held with technical support from the World Health Organisation (WHO) regional office, specifically to introduce the details of the methodology for indicator 6.2.1 and 6.3.1. Following this, data sources were identified and where possible secondary data obtained.
Data for household access to improved sanitation facilities will be assessed by existing demographic surveys and population census, as done prior to the SDGs under the Millennium Development Goals and updated for post-2015 by the JMP. Data beyond the household and along the sanitation service chain, however, requires innovative approaches to be implemented for monitoring of "safely managed sanitation" and "safely treated wastewater". A primary data collection survey is being implemented between October and November 2016 and data analysis under way. The survey consists of three questionnaires for (1) households, (2) emptying and transport service provider, and (3) treatment service provider.

Results and Discussion
Implementing the necessary steps from identifying relevant institutions to the actual planning of primary data collection has provided valuable insights for future implementation in other countries in 2017. Presented in Figure 1 is the institutional set-up. The Directorate of Water

Resource Management was initially identified to lead on target 6.3. Due to the existing mandates of the directorate, increased efforts were made on implementation of indicator 6.3.2 (ambient water quality) and less on indicator 6.3.1 (safely treated wastewater). Indicator 6.3.1, however, is closely linked to indicator 6.2.1 (safely managed sanitation services), for which the Directorate of Water Development was identified as the lead institution. Additionally the NWSC, service provider for water and sewerage in Uganda in 171 towns in Uganda, identified a team leader for goal 6 and a task team leader for each individual target in support of the ministries.

Target	Indicator	Definition	Ministry Lead	Support	Data need
6.2	6.2.1	Hygiene + Sanitation Services	Directorate of Water Development	Service Provider National Water and Sewerage Corporation	Treatment (wastewater + faecal sludge)
6.3	6.3.1	Wastewater treatment	Directorate of Water Resource Management		Treatment (wastewater + faecal sludge)
					Treatment (economic activities)
	6.3.2	Ambient water quality			Water Quality

Figure 1 Institutional set-up for target 6.2 and 6.3 in Uganda.

Collection of available and unpublished secondary data provided a detailed overview of existing information, as well data gaps. The most critical identified gap is at the step of emptying and transport of faecal sludge. The vast majority of emptying and transport services is operated by private emptying service provider, who are not regulated and have incomplete or non-existent records of service provision. In cases where records are accessible through treatment service provider, such as NWSC, the actual source of faecal sludge is not recorded and can therefore not be linked to a household using a particular type of sanitation facility. This information may be available in areas classified as urban, which however only represented 20% of the total population of Uganda in 2014. For the remaining 80% of the population that lives in rural areas, the most apparent data gap is the percentage of population where faecal sludge is safely emptied and then safely disposed in situ (UBOS, 2016). Performance data from all wastewater and faecal sludge treatment plants is being collected and analysed to identify the proportion of safely treated wastewater and faecal sludge. PoC testing initiated discussion on aligning national level monitoring with data needs for SDG reporting.

Conclusions

Key conclusions of implementing the step-by-step methodology for SDG indicator 6.2.1 and 6.3.1, include:

- Strong institutional leadership for each individual indicator is necessary
- Collaboration between indicator 6.2.1 and 6.3.1 is of major importance
- Methodology and tools are considered useful for implementation and progressive realisation of monitoring “safely managed sanitation services” and “safely treated wastewater”
- While current availability of data appears low, it can be expected that more data becomes available as Uganda aligns in increasing data collection to account for faecal sludge management on the Agenda 2030

References

UBOS 2016. The National Population and Housing Census 2014 - Main Report. Kampala, Uganda.

UN-WATER. 2016. Metadata on Suggested Indicators for Global Monitoring of the Sustainable Development Goal 6 on Water and Sanitation. Available: http://www.unwater.org/publications/publications-detail/en/c/296330/ .

Encouraging Participatory Financing for Scaling Urban Sanitation Solutions in Growing Cities

L. Stradley
Sanergy Limited, P.O. Box 25423-00100, Nairobi, KENYA

Keywords: Emerging FSM services; participatory financing; waste reuse
Conference Track: Industry and Exhibition Track
Track Topic: Emerging FSM Services
Personal Preference: Oral presentation

Introduction

In order to increase access to hygienic sanitation solutions in urban informal settlements, Sanergy is developing a model that accomplishes two objectives: (1) significantly reduces the overall cost to deliver sanitation services across the full value chain and (2) incentivizes participatory financing from actors at each stage of the sanitation value chain. By developing a suite of waste management solutions, Sanergy is containing, collecting, and treating as much waste as possible from the communities it serves. By converting waste into safe, high-quality agricultural inputs, Sanergy is introducing new ways to ensure the sustainability of urban sanitation provision.

Background and context

Throughout the developing world, 1 billion people–approximately one-third of the urban population–live in slums. As cities grow, so do these informal settlements; slum populations are projected to double in the next 15 years. Communities around the world are unable to build and scale the infrastructure necessary to serve their growing populations.

In most developing cities, sewerage infrastructure is sparse, costly to install and poorly maintained. In Dakar, Senegal, for example, maintaining an aging sewerage system costs USD 54.64 per person per year (Dodane 2012). However, most municipalities don't have that amount to spend on their populations; in Kenya, for example, current municipal spending on sanitation is USD 3 per person per year (WASREB 2015), and the Kenyan Ministry of Health has pledged to raise the amount to USD 12 per person per year by 2030 (Kenyan Ministry of Health 2016). As a result of this funding gap, over 90% of Nairobi's fecal waste is dumped back into waterways untreated.

The UN Sustainable Develop Goal 6 aims to achieve universal access to adequate and equitable sanitation and hygiene by 2030. In order to achieve this in urban areas, developing cities need an integrated waste management solution that does three things in an effective and cost-efficient way:

1. Safely capture, treat, and convert more waste into usable end-products;
2. Sustain communities' investment in waste management solutions; and
3. Develop waste-derived end-products that meet market demands

The Sanergy Model

In Nairobi, Kenya, Sanergy is pioneering a new waste management model to serve these growing areas. Sanergy catalyzes participation at every step of the process by providing customer-centric waste-management products and services in which residents can invest and by converting the waste collected into valuable agricultural inputs that help drive a sustainable agriculture sector.

Sanergy takes a full value chain approach to the management of fecal sludge in urban informal settlements: it has built a franchise network of high-quality, low-cost sanitation structures called Fresh Life Toilets, run by operators to whom Sanergy provides a variety of support services; on a regular basis, Sanergy safely and professionally collects the waste from the toilets, removing it from the community. The waste is then processed into high-value agricultural inputs, including organic fertilizer and insect-based animal feed, which are sold to Kenyan farmers.

Innovations in Sanitation Financing

Sanergy is pioneering two financing innovations to develop a scalable model for urban sanitation solutions. First, by developing a lean and effective system for the containment, collection, and treatment of waste, Sanergy has reduced the per-person cost of sanitation provision to USD 23 per year. This is less than half of what sewerage systems cost and is much more effective at preventing leakages throughout the value chain.

Second, by cultivating a customer base for end-products derived from the waste colleced, Sanergy is introducing a new and sustainable source of financing for the sanitation value chain; the end-users are now willing to shoulder some of the cost of collecting and removing the waste from the communities served. And through the franchise system, Sanergy is demonstrating that the users are also willing to pay for sanitation solutions that work to keep them healthy and their communities clean. As a result, only about 50% of the total cost of the Fresh Life network – or USD 12 per person per year – needs to be covered by public funds, as opposed to 94% of the cost for sewerage systems.

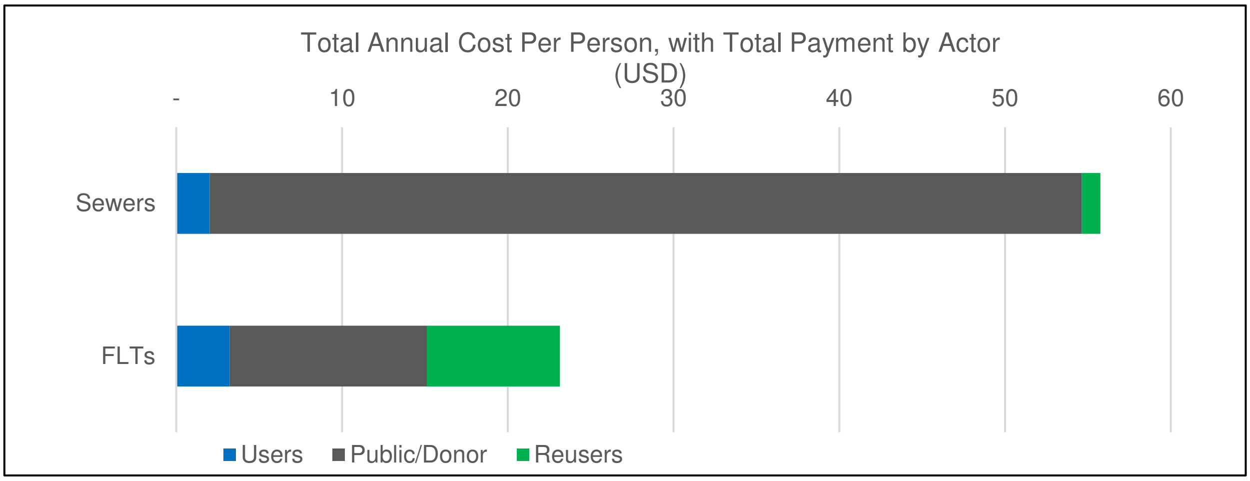


Figure 1 Sanergy reduces the overall cost of sanitation provision, while simultaneously introducing participatory financing to distribute the cost across a variety of payers.

Future Plans

In addition to scaling our Fresh Life Network, Sanergy is exploring alternative ways to capture and collect the waste produced in slums. Sanergy is piloting a variety of solutions, including a fee-for-service distribution model for our Fresh Life Toilets, wherein franchisees would only pay the costs associated with servicing the toilet; an in-home toilet model to increase access to hygienic sanitation where people want it most; servicing of pit latrines; and converting pit latrines to Fresh Life Toilets. Finally, Sanergy is also working closely with government partners to develop the enabling environment necessary to scale these alternative sanitation solutions in urban slums.

Conclusion

By demonstrating that our solutions at scale are cheaper than existing alternatives and by developing a suite of effective hygienic sanitation solutions, Sanergy has a sanitation solution that growing cities with tight budgets find attractive and effective for keeping their burgeoning populations healthy and productive.

References

Dodane, Pierre-Henri; et. al. Capital and Operating Costs of Full-Scale Fecal Sludge Management and Wastewater Treatment Systems in Dakar, Senegal. Environ. Sci. Technol. 2012 Apr 3; 46(7); 3705-3711.

Kenyan Ministry of Health. Kenya Environmental Sanitation and Health Policy 2016-2030. May 2016.

Water Services Regulatory Board. Impact: A Performance Review of Kenya's Water Services Sector 2013 - 2014. August 2015.

VIA Water Innovations: marketing of faecal sludge valorisation end-products and how these products contribute to a successful sanitation chain

W. Nagel*, J. Spit**, E. Woods***, A. Vallabhaneni****, A.M.J. Mooijman*****

* VIA Water, Westvest 7, 2611 AX Delft, The Netherlands
** WASTE COOP, Lange Houtstraat 26, 2511 CW The Hague, The Netherlands
*** Sanivation, PO Box 262, Naivasha, Kenya 20117
**** Sanergy Limited, PO Box 24523-00100, Nairobi, Kenya
***** Annemarieke Mooijman Consulting, WASH Specialist, Bunderstraat 15, 6231EH Meerssen, The Netherlands

Keywords: innovation; faecal sludge management; biological sanitation; Africa
Conference track: (2) Case study track
Track Topic: Pilots showing promises
Personal Preference: oral presentation

Background and context

VIA Water is a Dutch programme that supports innovative solutions for urban water and sanitation problems (‘pressing needs’) in seven African countries: Benin, Ghana, Kenya, Mali, Mozambique, Rwanda and South-Sudan. The Dutch Ministry of Foreign Affairs funds the programme and UNESCO-IHE Institute for Water Education in Delft hosts it. The fund is managed by Aqua for All in the Netherlands. VIA Water started in 2014 and will end in 2018. Amongst the 24 pilots running so far in the programme, 7 are dealing with piloting solutions on (a component of) Faecal Sludge Management challenges. The programme supports the start and potential upscaling of the individual pilots, aims to learn within each project and the projects from each other in the programme. The learning can be on the process, the products, the business and communication, etc.. We present three VIA Water pilots and concentrate in this abstract on market acceptance of end products.

Nature of the issue

Valorisation of faecal sludge is seen as an important factor for the successful implementation of the sanitation chain: products such as briquettes and compost have a certain value and sales of them (or savings on expenses for cooking and fertilizer) contribute to covering the implementation, operation and maintenance costs of improved sanitation. The end products of the three VIA Water pilots discussed here differ and we will discuss how the products contribute to the successes of the sanitation businesses. Obviously, the market/demand of the product differ. Hence, we also discuss the market/demand of the different products.

Pilots explained

Biological Urban Sanitation (BUS) project in Maputo – by Annemarieke Mooijman Cons in cooperation with LCS Promotion in Mozambique. The starting point of this project is to convert existing and/or new latrines from being traditional pits for accumulation of faecal matter into small on-site sludge treatment stations where the faecal sludge is converted to CO_2 and into seepage water, which can be infiltrated, using the impressive appetite of a Black Soldier Fly larva. Using the right techniques this is also accessible and affordable to the lowest income groups, especially in urban areas. Where laboratory tests show the feasibility of the approach, this is the first in-situ project aiming to make marketable designs (new and transformation kits to change traditional sanitation into biological sanitation) and develop strategies to allow for scaling-up and sustainability.

In-home sanitation for tenants and labour camps in Naivasha – by Sanivation in Kenya Sanivation has had success with home dwellers as customers for toilet services. By solar heat-treating faeces they transform it to a binder used in the production of sustainable briquettes. Over the past 8 months they have sold over 35 tons at $200/ton in Naivasha, Kenya. Current Kenyan annual consumption for charcoal is 1.6 million tons; of which the vast majority is illegal and unsustainable production.

Exploration of sales channels for organic fertilizers for smallholders in Nairobi – by Sanergy Ltd in Kenya. Sanergy produces a high-quality bio solids-based organic fertilizer called Evergrow. With depleting soil health threatening Kenya's food security, farmers need organic fertilizer to restore nutrients and increase crop yields. However, most farmers are not accustomed to using organic fertilizer, opting instead to use harsh chemical fertilizers or cow manure. Sanergy has trialled a variety of sales channels to market the product to small- and medium-sized farms across Kenya. In 2016, through traditional sales channels and these new interventions, Sanergy has sold over 200 tons of Evergrow Organic Fertilizer to farmers throughout Kenya.

Lessons learned so far

For the Biological Urban Sanitation project in Maputo, the fact that the toilets need no emptying (= no physical contact) is the main value added on the users side. In addition it has an environmental impact, because the pit sludge does not need a safe discharge and storage. The demand for these 'eternal' toilets in urban areas is not yet known but the initiative had been received very positively in the sector and is supported by the Centre for Investigation and Transfer of Technologies for community development (CITT), a centre within the Ministry of Science and Technology of the Government of Mozambique.
Sanivation has developed a briquette that replaces the demand for charcoal in local restaurants and households. It is more sustainable, lasts twice as long and has less emissions than charcoal, but at current scale it is operating at a financial loss. In the future, financial projections show sales of faecal briquettes to operate profitably thereby paying for parts of the operation and maintenance of the sanitation chain.
Sanergy has garnered several key insights about how best to reach their target market and to help farmers understand the value of organic fertilizer. By establishing a customer base of over 300 farmers and by cultivating long-term relationships with them, Sanergy is demonstrating a growing demand for waste-derived end-products, thus developing a sustainable model for urban sanitation provision.

Impact of this presentation on the case study track

During the conference presentation we will introduce the 3 innovative VIA Water pilots that contribute to solving part of the urban faecal sludge management challenges in 7 countries in Africa. These show the next generation innovators that can make a difference in the sanitation sector. The expert on FSM, Jan Spit from WASTE, will present cross-cutting issues of the different solutions and discuss the potential of the various case studies for the participants of the conference on filling gaps in the circular economy. The funding of VIA Water facilitates the innovators to prove their concepts and helps them in finding investors for upscaling.

Conclusions

- Valorisation of faecal sludge can lead to product and services that are in high demand, and varies from one community to another;
- The sales of end products cover part of the costs of the operation and maintenance of the sanitation chain.

Development Impact Bonds For Faecal Sludge Treatment

T.Outlaw*, L.Patel*, P.Nicholas**, D.Hull**
* USAID,1300 Pennsylvania Ave NW, Washington, DC 20004, USA
** Social Finance Ltd, 131-151 Great Titchfield Street, London, W1W 5BB, UK
Keywords: Impact; Innovative; Finance
Conference Track: Industry Track
Track Topic: Pilots showing promise
Personal Preference: Oral presentation

Background

Several new technologies are emerging for cost-effective urban faecal sludge treatment that also generate outputs including fuel, electricity and water. These include two pilots supported by the Gates Foundation and others that are currently in trial stage:

(1) The *Janicki Omni Processor*, being trialled in Dakar, is intended initially for medium-sized communities (the example used here is for a population of 100,000). The Omni Processor is designed to improve affordability and sustainability by generating both water (70,000 litres per day) and electricity (250kW continuous), as well as having potential for ash sales. The processor requires propane/butane for start-up, but thereafter runs on its own power.

(2) *PivotWorks*, being piloted in Kigali, is intended initially for larger communities (for example 500,000 people). PivotWorks is designed to generate sufficient fuel sales to cover operating costs, and potentially contribute to the costs of faecal sludge collection and delivery. Dewatering is by sunlight in greenhouses, so PivotWorks is most effective in locations with a high proportion of hot and sunny days.

Financing the Omni Processor and PivotWorks

The two pilots have indicated that both approaches offer strong potential to achieve medium-term sustainability through sales of fuel, electricity, water and/or carbon credits without the need for ongoing donor subsidy, and both have the potential to deliver significant city-scale improvements in FSM. However, the relatively high up-front capital costs (in the millions of dollars), combined with the as-yet relatively unproven technology, present a key barrier to further testing and expansion of these models. In order to finance further development, several obstacles need to be overcome, given that the Omni Processor and PivotWorks technologies:

- Are unproven, though high potential, technologies.
- Require significant up-front capital.
- Need medium-term financing before full sustainability is reached.
- Require large-scale, but affordable, faecal sludge collection in what are often challenging environments.

Traditional financing modalities, including results-based financing, are not well-equipped to address these multiple challenges in a way that is cost-efficient for governments, donors and beneficiaries. We have developed an innovative potential solution to this financing challenge, using a Development Impact Bond, an approach now being explored in a wide range of sectors with support from organisations such as USAID, the Global Fund and the World Bank.

Development Impact Bonds

DIBs are an innovative financing mechanism that provides up-front investor finance for the capital and/or the recurrent costs of development projects, with donors guaranteeing payments to the investors if, and only if, the project succeeds in achieving independently assessed results. Returns to investors are linked to the extent to which agreed results are achieved. In this sense DIBs are like traditional results-based aid, except with the addition of up-front external working capital to ensure finance at affordable rates for service providers. But DIBs differ more fundamentally from traditional results-focused lending in that external investors are typically much more comfortable with – and indeed expect to see – changes in design and implementation modalities as analysis of real-time data reveals what is working well and what is not – often called “adaptive management” or “course correction”.

Use of Development Impact Bonds for FSM

Our DIB proposal is well-suited to address the four obstacles identified above:

- *High potential but unproven, technologies*. Impact Bonds attract social investors who want to finance projects with a controlled risk but potentially high returns (both financial and social), as well as a broader demonstration effect for the future.
- *Large up-front capital need*. The costs of a faecal sludge treatment plant, while large in the context of a typical FSM project, are very small in relation to the amounts of social capital available for socially productive investments.
- *Need for medium-term financing*. There is strong potential for ongoing costs to be covered by carbon credits and sales of fuel, electricity and water, but there is also a need to cover the period between initial expenditures and the plant operating at full potential and generating revenues. A DIB can provide the bridge financing to cover this multi-year lag through the provision of working capital.
- *Large-scale but affordable faecal matter collection*. The adaptive management inherent in a DIB is ideally suited to ensuring that collection incentives and modalities, as well as plant management and operation, are able to adapt to new environments and challenges through rapid analysis of data on what is working and what is not – and most importantly quick course corrections based on that data.

The flowchart below draws these strands together and shows indicatively how a DIB might work in the context of PivotWorks’ technology.

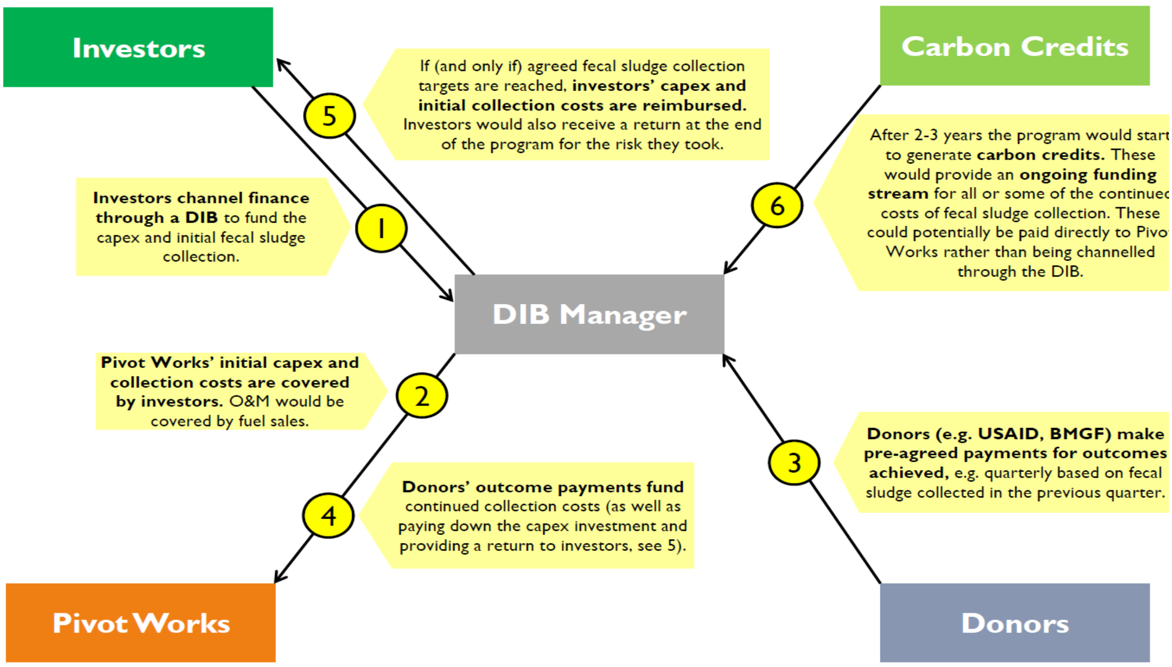


Figure 1: Pivot Works – Illustrative Impact Bond Structure

Significance for the FSM4 Conference

Our DIB proposal offers a promising opportunity to expand and further test the financial viability, cost-effectiveness and sustainability of these two innovative technologies. The proposal is the result of six months of scoping work and engagement with experts in WASH and FSM, including discussions at recent World Water Week and UNC Water & Health Conference panels. We now have a robust proposal for an Impact Bond, and FSM4 offers a valuable opportunity for participants to exchange views, and for us to gauge interest in taking the Impact Bond forward. The location of the conference also makes it highly relevant as we are envisaging focusing initially on India, so we would welcome the opportunity to discuss the DIB proposal with Indian FSM experts.

Enabling Viable Public-Private Partnerships in Resource Recovery and Reuse for Improved Faecal Sludge Management

K. Felgenhauer*, O. Cofie*, B. Tuffuor**

* International Water Management Institute, Accra, Ghana
** Training Research and Networking for Development (TREND), Accra, Ghana

Keywords: public-private partnerships

Conference Track: (2) Case Study Track
Track Topic: Pilots showing promises
Personal Preference: oral presentation

Background

With growing population and rapid urbanisation, effective and sustainable waste management solutions are indispensable. Resource recovery and reuse (RRR) can ease the waste burden and generate additional income. Recycling of faecal sludge (FS) should be preferred to disposal as products from treated FS can generate revenues (Klingel et al., 2002). Organic fertilizer and other waste-based products have the potential to develop viable value chains.

The International Water Management Institute (IWMI) is exploring technologies and business models, including PPPs, to enhance the recovery and reuse of carbon, nutrients and water from FS. In particular, a composting process can convert FS and organic municipal solid waste into a safe nutrient-rich fertiliser. The material, 'Fortifer©', is produced in various formulations and is able to improve yields and soil while reducing urban waste (Cofie et al., 2009). Septage sludge from households and public toilet septic tanks is dewatered, sanitized through thermophilic heap composting and then further enriched with nutrients to suit specific plant and soil needs. Pelletisation reduces product volume and dust generated during application, thus making it safer, easier to handle and more effective (Nikiema et al., 2013). In Ghana, the product has been certified for commercial production and distribution to farmers.

Setting up public-private partnerships for resource recovery from faecal sludge

IWMI is assessing the potential to scale the Fortifer© development process as well as the fertiliser use itself. IWMI is therefore setting up production of such compost fertiliser derived from waste and faecal sludge in Ghana. These ventures link municipalities and business through public-private partnerships (PPP). In Tema, a co-composting facility has been constructed to process faecal sludge into Fortifer© with a capacity of 500 metric tons per year. The corresponding public-private partnership agreement between the Tema Metropolitan Assembly and Jekora Ventures Ltd. involves contributions, including co-funding, from all parties. Similar efforts are being undertaken in Yilo Krobo municipality, Eastern region in Ghana, to produce 200 tons of safe compost per year.

Through this experience IWMI has observed that both the private and the public sector lack skills and management capacity to run PPP effectively and efficiently. Differences in mandate, strategic focus, procedures and interface management complicate partnership building. Through IWMI's projects, the following observations have been made (Impraim et al., 2014):

- The identification and attraction of suitable private partners can be challenging. Only few private entities have experience in all relevant sectors along the value chain, i.e. in sanitation, waste management as well as agriculture.

- Communication across sector boundaries bears transaction cost which are often not accounted for during project planning and staffing.
- The setup of new processing facilities requires solid but risky upfront investment. Donor support facilitates the process.
- Insufficient involvement of and alignment with stakeholders throughout the inception and implementation processes can hinder synergies and put the project at risk.

Strengthening capacity for public-private partnerships

Based on these observations, IWMI is developing tools and recommendations for RRR practitioners to enhance PPP viability in faecal sludge management. Strengthening the capacity of public and private sector actors is key to setting up and managing PPP in RRR more effectively and more efficiently. IWMI has analysed success factors and bottlenecks to viable PPP in RRR taking into account all stages of PPP management, including partnership brokerage, feasibility assessment, contract management, objectives-oriented planning, partner management, business models, financing options, execution, monitoring and evaluation, risk management, and options for being more gender-inclusive. Framework conditions are being screened for pull and push factors as well as barriers to full stakeholders' involvement.

Key recommendations to be argued at FSM4 include:

- Partnership brokerage requires investment of time and skills – by the partners themselves or by moderating third parties – to bring the best suitable associates together.
- Capacity among partners to negotiate between sectors needs to be built across operational and leadership functions. Joint management and supervisory bodies can lower transaction costs.
- PPP models are not restricted to two-way partnerships. Multi-party cooperation across sectors can fill critical gaps in skills or resources but raise the transaction costs of managing the partnerships.
- The development of functional cost- and risk-sharing mechanisms requires full cost and benefit transparency between stakeholders. The willingness to cooperate is fundamental but subject to various risks, especially over time.
- Market linkages for RRR products need active support when value chains are not well established. Marketing, supply chain development and logistics are key components of PPP inception and implementation.

Acknowledgement

IWMI draws on research on Resource Recovery, Water Quality and Health and the IWMI-led CGIAR Research Program on Water, Land and Ecosystems (WLE).

References

Cofie, O., Kone, D., Rothenberger, S., Moser, D., and Zubruegg, C. (2009) Co-composting of faecal sludge and organic solid waste for agriculture: Process dynamics. Water Resources, **43**, 4665-4675. http://dx.doi.org/10.1016/j.watres.2009.07.021.

Impraim, R., Nikiema, J., Cofie, O. and Rao, K. (2014). Value from faecal sludge and municipal organic waste: fertilizer cum soil conditioner in Ghana. Presentation at: 7th WEDC International Conference, 15-19 September, 2014, Hanoi, Vietnam.

Klingel, F., Montangero, A., Koné, D., and Strauss, M. (2002) Fecal sludge management in developing countries: A planning manual. EAWAG/SANDEC, Dübendorf, Switzerland.

Nikiema J., Cofie O., Impraim R., and Adamtey N. (2013). Processing of fecal sludge to fertilizer pellets using low-cost technology in Ghana. Environmental Science and Pollution, **2**(4), 70-8.