TREATING UD FAECAL WASTE USING BLACK SOLDIER FLY (BSF): A MUNICIPAL, RESEARCHER AND CONTRACTOR PARTNERSHIP

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The Bill & Melinda Gates Foundation in conjunction with DFID requested proposals from Cities to test Business Partnerships such as service level contracts and incentivised contracts to deliver sustainable sanitation services. The eThekwini Water and Sanitation Unit identified the removal of faecal waste from over 85 000 Urine Diversion (UD) double vault toilets as a key sanitation service that could allow for the testing of various business partnership options. The key objective of these business partnerships would be to improve sanitation service for poor and marginalised communities, reduce service costs to the Municipality and create jobs and economic opportunities for small businesses.

The programme was divided into two elements which require some form of business partnership; (i) removal of faecal waste from the toilets and either burial on site with tree planting or transport to a processing site; and (ii) design and development of a processing plant for the production of marketable products from the faecal waste – the selected technology was Black Soldier Fly (BSF) larvae.

During the planning phase the procurement options available to the Municipality were explored and the institutional requirements identified. Two business partnership options were selected for the project; (i) an incentivised contract using standard tender processes for the removal, disposal and transport aspect; and (ii) a service level agreement (SLA) for a 5-year period for the BSF plant operation.

A number of challenges arose during the business partnership establishment such as obtaining all the necessary approvals and the use of an innovative technology for the processing of UD waste. This paper aims to highlight the different procurement options available to a municipality wishing to create business partnerships, the reasons for the selection of the current model, the lessons learnt during this project, how the challenges were overcome and the key success factors.

INTRODUCTION

Commencing in 2002, eThekwini Metropolitan Municipality installed over 85 000 Urine Diversion (UD) double vault toilets at households (see Figure 1). This technology was selected to replace Ventilated Improved Pit Latrines (VIPs) as the municipality's basic onsite sanitation option for rural households at a density of more than 75m between household units (1). Waste is deposited in the chamber and dry absorbent organic material, such as wood ash, straw or vegetable matter is added after each use to deodorise decomposing faeces and/or control moisture and facilitate biological breakdown (composting). Urine is separated/diverted through use of specially adapted pedestals. This may be collected and used as a fertiliser. In desiccation systems, ventilation encourages the evaporation of moisture (2).

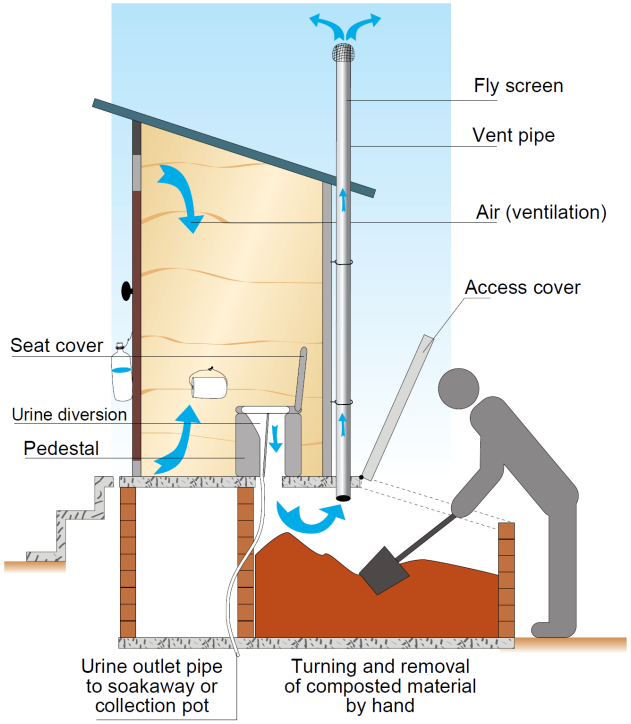

Figure 1: Schematic of a Urine Diversion Toilet (2)

Traditional rural households in the Municipality consist of a cluster of multi-generational extended families of variable size. If the family consists of more than eight people, two UD toilets are generally supplied. During the initial design and implementation phase it was expected that the UD systems would produce a degraded sludge which could be safely removed and buried onsite by the resident. This approach eliminated the challenges and costs encountered when servicing VIP systems, which included access to pits and sites, removal of sludge containing solid waste, and transport and disposal of sludge.

However, a number of concerns arose in 2015 with the operation of UD toilets. These included health risks to residents when handling possible pathogenic sludge and dissatisfaction amongst householders over the expectation that they will remove the faecal sludge from their systems themselves while other recipients of basic sanitation receive a free removal service from the municipality. Dissatisfied householders may convert to a preferred (but non-standard) waterborne system with concomitant regulatory and possible health challenges, placing an increased burden on the water supply and eliminating the possibility of source separated resource recovery.

A further concern was that some UD back panels are missing or broken or the sliding mechanism is not operational. This has resulted in additional health risks to the community through exposure to the contents of the vaults.

The municipality is thus faced with the problem of identifying ways in which a safe, economically feasible UD toilet waste removal system can be provided to over 85 000 UD toilets. Challenges include the difficulty

in accessing sites and limited space for onsite burial where there are dense housing settlements. In addition, a dual stakeholder engagement process is required as these areas have both a municipal (ward councillor) and a traditional (tribal) authority structure.

In summary, the key problems for an acceptable technique were:

- Health and environmental risks and regulations covering the removal and transport of faecal waste from households
- The costs associated with transport of waste over long distances from remote rural areas to decentralised processing plants
- Finding cost effective ways to use the toilet waste beneficially (creating value)
- Meeting the expectations of communities with regard to an acceptable waste removal system
- Identifying the right incentives that will ensure the participation of residents and a cost effective delivery process by private sector contractors
- Identifying sustainable local business entities working in the sanitation sector

As a result of the challenges that have arisen in the past with full Urine Diversion) systems, EWS(in full) has made a commitment to develop a municipality-wide initiative to co-ordinate the emptying of solids from UD toilets.

In 2014 the Bill & Melinda Gates Foundation (BMGF) in partnership with the UK's Department for International Development (DFID) invited proposals from cities to test business partnerships such as service level contracts and incentivised contracts to deliver sustainable sanitation services. This call for proposals fitted well with the approach of EWS when undertaking new projects; i.e. start with a pilot project, design the system, implement on a limited scale, evaluate and redesign as required. EWS, together with a project team comprised of consultants and research partners, therefore submitted a proposal to investigate the development of business partnerships for the UD toilet emptying programme.

There were two phases to the project, with the first phase involving an assessment of the readiness of the city to implement such partnerships and an in-depth proposal as to how this would be taken forward to the implementation stage. eThekwini was one of the cities selected for the second phase of the project whereby funding is provided to test the proposed project on a pilot scale.

This project aims to explore opportunities for the management of UD toilet products and testing various systems for removal and beneficial use using incentivised contracts with private organisations or individuals to ensure a safe, efficient, quality service. In addition, the high rates of population growth in both the urban and rural areas of the municipality is leading to increased housing densities. As this trend continues, there may come a point in the future where on-site burial of waste is no longer acceptable. This project provides the municipality with the opportunity to pilot an alternative solution. The municipality also realises that long term sustainability of onsite sanitation is not possible as a subsidised service unless the costs are strictly controlled through innovative partnerships and obtaining value from the waste. This is addressed within the project.

METHODOLOGY

In order to meet the challenges of undertaking the UD toilet emptying programme, two scenarios are being tested; (i) where there is space on site, burial on site with tree promotion; and (ii) where there is no space on site and no land available nearby, the transportion of waste to a decentralised processing plant for development of valuable by-products. The steps followed in implementation of the project are summarised in Figure 2.

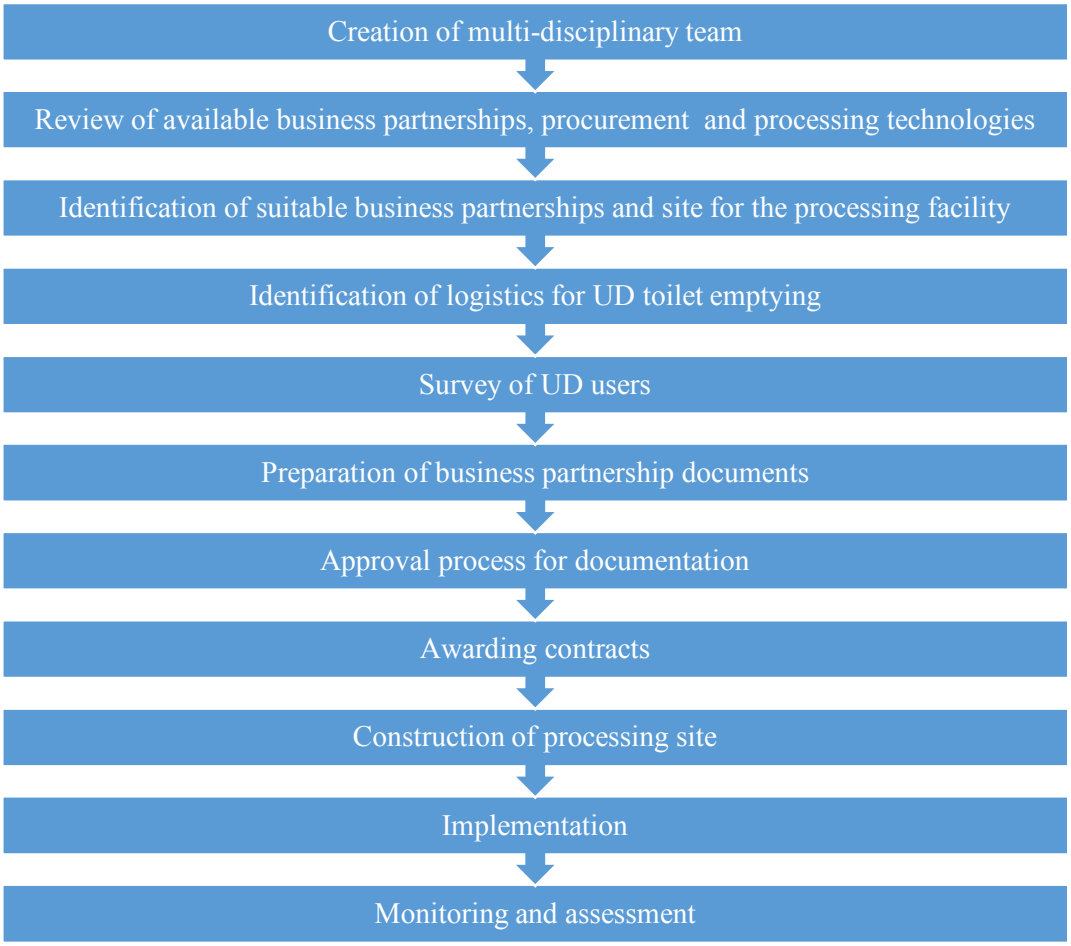

Figure 2: Summary of methodology

A multidisciplinary team was assembled in order to drive this project. This team consists of representatives from EWS together with consultants (Khanyisa Projects (Principal Agent)) in association with Partners in Development (PID)), and a research organisation (University of KwaZulu-Natal's Pollution Research Group (PRG)). All members of the team have experience in addressing sanitation issues within the municipality.

Each scenario required some form of business partnership such as service level agreements and contracts formulated to encourage efficient completion of tasks in order to achieve value from the waste products and improve the sustainability of municipality- wide sanitation services. One of the first steps was to identify the most suitable type of business partnership for this project. This was achieved by undertaking a review of existing partnerships within the municipality and identifying the advantages and disadvantages of each.

As many of the UD toilets are located in rural areas with limited access for transport, a decision was taken that where space was available the UD solids would be buried on site. In areas where space was limited and vehicle access was possible, the solids would be removed and transported to a central processing facility. A review of different processing technologies was therefore undertaken in order to identify the most suitable system for the treatment of UD waste. At the same time the municipality identified the most suitable site for the development of the central processing facility which took into account aspects such as space, ease of access and security.

A further key step was to obtain an understanding of the logistics of emptying the UD toilets such as the number of toilets requiring emptying, ease of access, time to empty the solids, and time to bury the solids on-site. This information was gathered by undertaking a geographical information system (GIS) survey of the location of UD toilets, the number of toilets with full vaults, how easy the vaults were to access. In addition, a full trial was undertaken to evaluate the average time needed to empty and bury the contents. This information was then used in the design of the tender and contract documents.

In order to determine the effectiveness of the UD emptying campaign in terms of social impact, it was important to obtain an understanding of the view of the users as to their acceptance and use of the UD toilets before and after the campaign. A survey was therefore carried out among groups of users in different areas.

Once this background information was obtained, the documentation was developed and modified through a series of iterations before the final versions were acceptable to all parties. These were then submitted to the Municipality to secure the necessary statutory approval.

Construction of the central processing facility was due for completion in August 2016 with the product processing equipment due for installation in September 2016. The UD emptying programme was due to begin in July 2016. Once underway, a monitoring and evaluation programme will be undertaken in order to assess the success of the project. This will include aspects such as a follow up survey of the UD user groups to determine if there is an increase in acceptance and use of the toilets now that they are no longer responsible for emptying the vaults, as well as laboratory analysis of the UD solids before and after processing to ensure that all pathogens are destroyed and the BSF technology is operating efficiently. Analysis of the end products will also be undertaken. A key additional evaluation area will be an assessment of the business viability of the processing facility and the cost to the Municipality.

A number of challenges were experienced at each stage of the process which had to be overcome and these are discussed in more detail in the following sections.

RESULTS AND DISCUSSIONS

Choosing a business partnership model

There are four main ways in which projects can be undertaken by private parties for the municipality. These are listed in Table 2 together with a summary of the advantages and disadvantages of each.

Table 2: Possible processes for interaction between municipalities and private partners

Process	Description	Advantages	Disadvantages
Tender process	• Tender document specifying the work needs to be prepared and approved • Tender evaluation approved by committee and award by tender adjudication committee	• Valid for up to 3 years • Used successfully for the Municipal VIP emptying programme • Allows for an incentivised or task-based approach	• Approval processes can cause delays • Tasks need to be defined and bidders must have exposure in providing these services e.g. should have been undertaken before
Service level agreements	• Legal document which defines the terms of a service based contract needs to be prepared • Process needs approval from Council and municipal legal departments, and National Treasury must be informed	• Allows O & M responsibilities to be specified • Allows innovative financial models to be utilised	• Negotiations can be time consuming
Section 36: Deviation from Policy	• Can be used in a number of situations but requires approval from various committees • Situations include - Emergencies or where there cannot be delays - Where there is only one service provider available	• Allows the appointment of specific contractor	• Need to prove that there is no other available option • Price negotiation with one contractor can be challenging as the contractor will aim to reduce risk and maximise profit
Public Private Partnership	• Extensive process • Needs approval and input from National Treasury	• Valid for 15 to 20 years • Scope must be well defined so that private sector willing to take risks and invest capital	• Time consuming process • Places risk on the private operator • Can be costly

Based on a review of the various options and on experiences within the municipality of dealing with all these types of partnership agreements, a decision was made to use the standard tender process for the UD toilet emptying contract.

For the management of the BSF processing plant, a Section 36 appointment was required as there is only one service provider with this experience in South Africa. A Service Level Agreement (SLA) was drawn up between the municipality and the service provider which specified the terms of the contract.

Choosing an appropriate processing technology

Within eThekwini, the treatment options available to the municipality for UD toilet solids were burial on site, disposal at a wastewater treatment works or hazardous waste site, or processing via the latrine dehydration and pasteurisation (LaDePa) technology used for processing VIP sludge. Where space was available, burial on site was chosen as the first option. However, in many cases this is not possible and the solids need to be transported off site to a central processing facility. Based on previous experience where VIP sludge was discharged to a wastewater treatment works resulting in the breakdown of the treatment process, this option was not considered viable for the disposal of the UD toilet solids. Processing at the LaDePa is also not feasible due to the lower nutrient content (as there is less urine) and the UD toilet waste contains a large amount of cover material resulting in a drier less *sticky* sludge that cannot be extruded. Disposal at a hazardous waste site is feasible but is costly (over R900 per ton). Therefore the municipality had to investigate alternative and innovative treatment options that resulted not only in the hygienic processing of the waste, but also the production of usable end products.

Based on a review of treatment processes within Africa and other developing countries, it was felt that the Black Soldier Fly (BSF) technology was an option that could effectively transform the UD toilet waste to produce a useful end product. Although studies done so far on BSF larvae have been using fresh faeces as a feed (3), the drier state of UD sludge mixed with other organic waste makes this a viable feedstock. Within South Africa this technology has been used successfully to convert food waste into animal feed using BSF larvae (4, 5).

The BSF technology for processing organic waste involves the breeding of the BSF and the use of its larvae to process the waste. BSF are a non-pest species as the adult flies do not eat or congregate around a food source as with other fly species. The by-products are the mature larvae, larvae oil and residue soil conditioner or biochar. The value of the products is in the sale of the larvae to livestock and fish farmers and the sale of the soil conditioner as a form of compost or sale of biochar briquettes. The use of the technology to process faecal waste is shown in Figure 3 while the detailed larvae processing elements and estimated production rates on a 20 ton a day plant are captured in figure 4

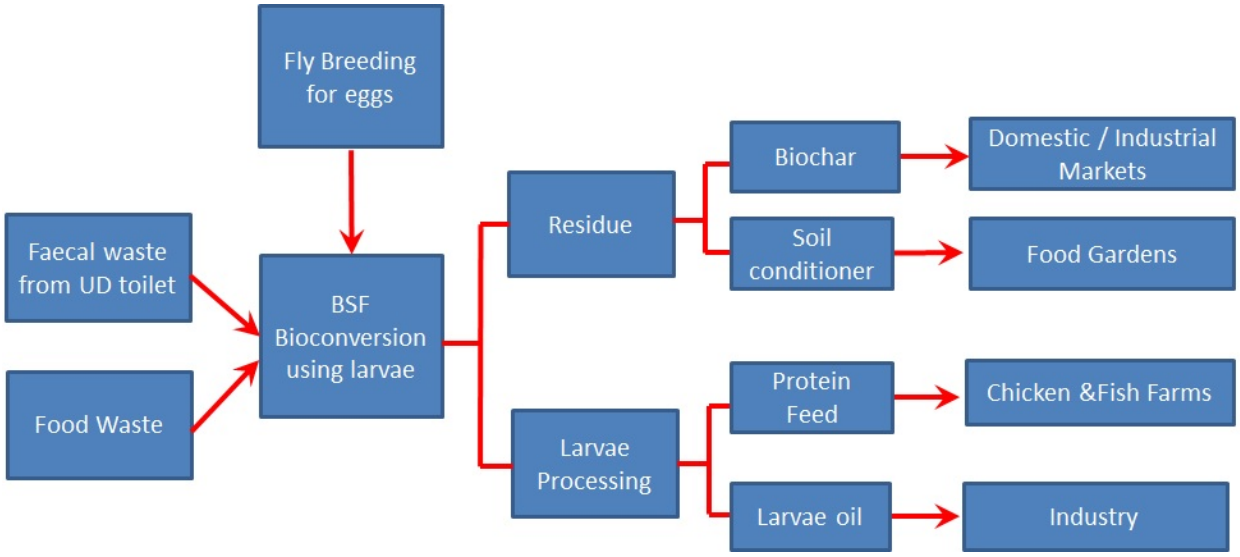

Figure 3: Processing of waste with Black Soldier Fly technology

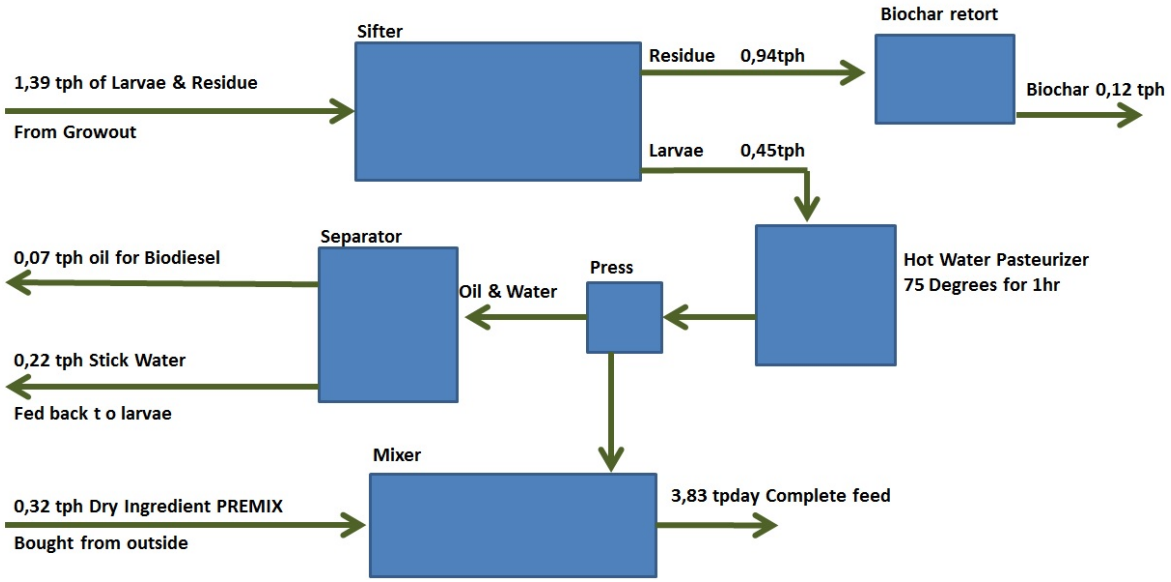

Figure 4: BSF Processing Flowchart

Food waste is added to the faecal waste in order to ensure a balanced food source for the larvae and that the time to reach maturity or an acceptable size is in the order of 20 days. Adult flies live between four and eight days while the pupae and larvae live an average of four to six weeks in which they increase their weight up to 150 fold (6).

A South African based organisation by the name of Biocycle, currently operating in tandem with Agriprotein, a livestock feed company, has been piloting the BSF technology in order to process food and faecal waste to produce saleable products. A process to engage with Biocycle was therefore initiated in order to develop a business model to use this technology to process UD faecal waste in the eThekwini Municipality.

Development of documentation

Developing the documentation for the two business partnerships proved to be a time consuming and challenging task. One of the key requirements from the BMGF was that in formulating the programme that an *incentivised* approach was used. This condition therefore guided the project team in the development of the relevant documents.

UD toilet emptying contract: The eThekwini Municipality aims to empty the UD toilets every 2 years. One of the aims of the municipality is to support local emerging businesses and it was initially planned to design the programme to enable a number of small businesses to service specific areas. However, due to the difficulty in determining an equitable rate per area due to the diverse terrain and location of the UD toilets, and a concern over smaller businesses not being aware of proper health and safety requirements, a decision was made that for this first round of the programme a managing contractor would be appointed who would then be responsible for employing teams of people, or contracting and mentoring emerging companies, to empty the UD toilets in the different areas.

In order to incorporate an incentivised approach, the project team first had to determine how many UD toilets were being used and how long it took to empty a UD toilet and either bury the waste on site or transport it off-site. On average it takes two labourers two and a half hours to remove and bury waste in a pre-excavated hole. The time varies significantly depending on how full the chambers are. A survey of all the UD toilets was initiated in August 2015 in order to map the location via GIS, number the toilets, determine which toilets were used / not used and which had full vaults, and to determine the condition of the panels covering the vaults (Where panels are missing or damaged but the sliding mechanism is operational, the panels will be replaced with a new more robust panel. Where the sliding mechanism is not operational

panels will be bolted to the side of the chamber). Some initial emptying trials were also undertaken. The GIS survey is on-going but as of July 2016, 23 000 toilets had been mapped and initial analysis indicates that on average 77% of toilets will require emptying.

Trials on the contents of the UD toilets were also undertaken to assist with the tender specifications. Contents are generally much drier than VIP toilets as the urine is disposed of separately in a soakpit. The contents will be removed manually by means of long handled spades. Where the contents are being transferred to the processing plant, excessive solid waste (detritus) will be removed separately and disposed at solid waste sites.

Payment will be based on the number of UD toilets emptied and the waste either buried on site or transported to a pick-up point; the number of back panels replaced; and the mass of UD waste (in tons) delivered to the BSF processing plant. This approach allowed for the measurement of completed tasks and this, in turn will incentivise the contractor to complete the tasks efficiently and thus increase his profit margins.

A draft tender document for this programme was first prepared in February 2015 and submitted for approval by the Bid Adjudication Committee. The aim was to advertise in May 2015 and have a contractor appointed by the 1st week in July 2015. However, a number of changes were made to the tender document as the process unfolded. These included incorporating changes to the requirement for replacing faulty covering panels; increases in the labour rate and requirements for the managing contractor to employ local contractors from each area as requested by councillors. Tenders were finally closed in July 2015 and were evaluated. Of the 12 tenders submitted, only 8 met all the requirements. The evaluation report was submitted to the committee for approval in September 2015, and appointment of the contractor was finally made in June 2016. This has resulted in a delay of more than 12 months but has allowed the project team some time to address other issues.

BSF Service level agreement: Developing the SLA with Biocycle has involved a number of meetings, discussions and iterations. The requirement for an incentivised approach meant that Biocycle had to be motivated to ensure the treatment process operates effectively and efficiently and a key requirement in the SLA was that a portion of the income to Biocycle came from the sale of the end products, rather than only from a gate fee charged to the municipality for treating the waste. As this is the first BSF in South Africa to be treating faecal sludge, there is a significant risk to Biocycle in operating the process – the funding from the BMGF assisted in removing some of this risk through the provision of capital for the building of the plant. The potential profit from the operation of the plant will be shared 50/50 between Biocycle and the Municipality. The profit accruing to the Municipality can be used to reduce the cost of the agreed gate fee. This is shown in Figure 5.

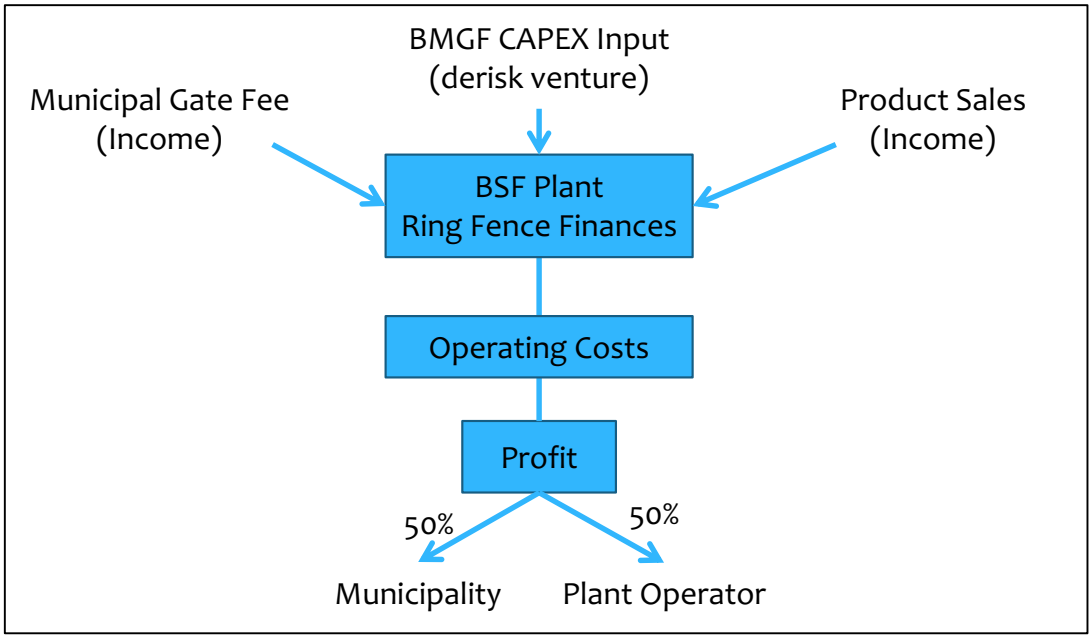

Figure 5: Business partnership model for the black soldier fly plant

A series of business models were developed by the project team with input from Biocycle, based on a 20 ton per day operation and a 40 ton per day operation. Both options assumed a feed stock of 50% UD toilet waste and 50% food waste. The final business model was assessed by a business feasibility specialist to determine the viability, costing and revenue assumptions, scheduling and procurement approach. This information was captured in the SLA.

The SLA has undergone a number of iterations during the course of 2015, with addendums being added to further reduce the risk to Biocycle and to reflect changes in the budget. These documents, together with letters to the Co-operative Governance and Traditional Affairs (COGTA) and National Treasury, and an advertisement for objections were submitted to the Bid Adjudication Committee in November 2015. The SLA for the appointment of Biocycle was approved by the Bid Adjudication committee that same month and the SLA has since been signed by all parties.

Various tenders for the construction of the BSF plant were awarded early in 2016. The following have been completed:

- All civil works
- Construction of growout and processing sheds
- Nursery (using agritunnel option)
- Weighbridge and offload area
- Offices and storage
- Mixing device

The electrical contract was completed in July 2016 and the product processing equipment is due to be installed during September 2016.

Overcoming challenges

A number of challenges have been experienced during this project, resulting in a delay in its implementation. These are discussed below together with the key factors that assisted in overcoming them.

1. Approval processes within a municipal system can be onerous and time consuming. This needs to be taken into account in designing any projects that involve the need for approval. It is also essential to have a dedicated team of municipal employees who are able to guide the project through the process and who have sufficient authority to interact with municipal political leaders.
2. The location of all the UD toilets was unknown at the start of the project, with many roads not being marked and the non-existence of property cadastrals or comprehensive numbering. The project team had to develop a detailed mapping and identification programme (including use of geographic pockets) in order to number each of the UD toilets for the project.
3. Balancing environmental and health compliance with budget constraints. Additional budget is being sourced.
4. Non-compliance of several emerging contractors in the tender process prevented qualification due to reasons such as lack of experience, incorrect documents etc. Therefore the appointed contractor will be required to appoint emerging contractors to assist with the removal process in different areas.
5. Capacity levels of some procurement officials
6. The BSF technology is currently implemented by only one company in South Africa and therefore there was no competition to aid the negotiation process with regard to costs and time line.
7. Gaining support from senior municipal roleplayers for a new financial approach
8. Increase in budget due to cost of labour for the UD contract, and changes made to the design and operation of the BSF plant after CAPEX budgets were initially approved. BMGF and the Municipality are assisting with this matter.
9. Challenges in the building of the BSF plant at the selected site (Isipingo Wastewater Treatment Works) due to infrastructural issues resulting in the need for redesign and increased costs. A request has been made to BMGF for additional CAPEX budget

10. A challenge that has not as yet been addressed is the willingness of communities to make use of end products manufactured from faecal sludge. Close monitoring of the efficiency of the plant and analysis of the end products to ensure removal of pathogens will assist in reducing these concerns.

Key success factors

The lessons learnt from this process have highlighted the key success factors in moving the project forward. These include:

1. A multidisciplinary team made up of partners from the municipality, consultants and researchers.
2. Dedicated EWS officials working on the project.
3. Ensuring that correct and relevant information was included in the tender document by undertaking the GIS survey to identify toilets requiring emptying and where panels required replacement; and carrying out trials to determine the details of the various tasks. This aided in preparing the budget.
4. Having a partnership with a research organisation capable of undertaking laboratory tests on faecal sludge and providing input into the monitoring and evaluation requirements.
5. Keeping an open mind to changes throughout the process and accommodating requests where possible.
6. A Municipality with business partnership experience and a willingness to learn from previous projects in order to ensure the success of subsequent projects.
7. Working with a municipality that has mature procurement policies and processes
8. The willingness of the municipality to explore an innovative approach to treating UD toilet waste such that useful end products are produced and the health risks to the communities using the toilets are reduced.
9. Identifying an operator which has both technological and business experience in the particular processing field.

CONCLUDING REMARKS

The next steps in the project involve finalising the awarding of the UD emptying tender and implementation of the BSF plant SLA scheduled for September 2016.

It is the aim of the municipality that in the future the emptying programme will be rolled out directly with capacitated emerging contractors and that future contracts may have agreed removal rates per area and a tendered rate will not be required. Training and mentoring of these emerging contractors is a key aspect of the roll out.

Ongoing monitoring and evaluation of the project will take place in order that the lessons learnt at each stage of implementation will be documented.

If this project is successful from a financial and technical feasibility perspective additional processing plants may be built in the west and north of the city to service those areas. A full public private partnership where the private sector puts up the capital may be an option.

Finally, this paper has illustrated that innovative approaches to addressing sanitation challenges affecting the poor can be implemented when the right partnerships are in place.

RECOMMENDATION

As the project progresses, lessons will continue to be learned and recorded through effective monitoring and evaluation processes. Municipalities and cities in South Africa as well as other parts of the developing world should take note of the partnership approach adopted and the lessons learned.

ACKNOWLEDGEMENTS

The funding from the Bill & Melinda Gates Foundation is gratefully acknowledged.

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