Towards sustainable pit latrine management through LaDePa

This paper shows the LaDePa machine to produce organic fertilisers from faecal matter and describes a potential contractual model for servicing areas using VIPs in eThekwini municipality.

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Abstract

Urban pit latrines and their associate challenges, in particular the disposal of sludge, are ubiquitous to the developing world. eThekwini Water and Sanitation (EWS), the municipal entity responsible for providing sanitation services to Durban and its surrounds, has co-invented and piloted an inexpensive, mobile, containerised technology, called LaDePa that can convert pit latrine and other sludge into a usable, pasteurized, dry product, beneficial for all agricultural. By utilising inexpensive, simple and robust mechanics this technology not only addresses the five major technical challenges of sludge management, but also address some environmental and socio- economic challenges in the communities where pit latrines are encountered. EWS intends privatising its pit emptying program anchored on the LaDePa technology. The low capital cost of LaDePa and its mobility obviates the necessity to enter into a Public Private Partnership (PPP) governed by the South African National Treasury regulations. This paper briefly discusses the technology, its environmental benefits, the challenges it addresses, and provides an overview of the procurement model that complies with standard Supply Chain Management requirements.

Introduction

The millennium goal to eradicate the backlog of sanitation, and the setting of Ventilated Improved Pit latrines (VIP) as the minimum basic sanitation standard in South Africa, has seen a proliferation of VIPs being constructed in South Africa and many other parts of the world with very little consideration being applied to how they are going to be serviced, particularly in dense urban settlements, which have their own particular set of servicing challenges. Fifteen years after establishing VIP as the minimum basic sanitation standard in the country, the social and health problems associated with over full VIPs is beginning to emerge.

Further, the legislation governing government procurement and the natural environment, in South Africa has create a legal environment that is generally not conducive to simple VIP servicing solutions.

eThekwini Municipality, the municipal entity that services Durban and its surrounds, in conjunction with Particle Separation Solutions (Pty) Ltd (PSS), a private company operating in the minerals field, have developed a LaDePa (Latrine Dehydration and Pasteurisation) machine which converts VIP sludge into low grade fertilizer. The relatively low capital cost of this machine, employing basic mechanical and electrical technology, is robust, simple to operate and service and can be containerized for mobility. These features make it compatible with the environments where VIPs are generally encountered in urban situations.

Key facts:

- The LaDePa (Latrine Dehydration and Pasteurisation) machine produces hygienically safe organic fertilizer from faecal sludge at low costs.
- It is shown that LaDePa technology is financially feasible when treating more than 2000 tons faecal sludge a year.
- A contractual model between eThekwini municipality and service providers for servicing areas using VIPs is proposed

eThekwini Municipality have piloted this machine and now intend outsourcing their VIP management anchored on the LaDePa machine. The purpose of this paper is to provide an overview of:

- The challenges associated with VIP servicing in South Africa
- The workings of the LaDePa machine
- The contracting model that eThekwini Municipality intends using and
- The reasons for choosing this contracting model

with the view to illustrating how many of the procurement and environmental issues can be overcome by anchoring the servicing around the LaDePa Machine. This paper will also illustrate how compatible the servicing model is with many of the social issues encountered in the communities where VIPs are generally provided. One of the side issues that this paper raises is the need to consider the method of servicing in the design of the VIP structure.

Overview of the Wastewater Technology

The Social Environment

Like most of the developing world South Arica has and still is experiencing a major migration to the urban centers. This has resulted in many informal settlements, which are subsequently being upgraded into low cost housing. Up until recently this housing, in the main, has been dense single level accommodation. The rate of urbanization, the historic backlogs, the lack of resources and the political urgency and ambition not to resettle has meant that urbanization has developed in an environment where the consideration of provision of services has taken a back seat.

Migratory urbanisation has meant that many of the skills that may have been developed in the rural environment are not applicable in the urban one. Further the education level of the migrants is generally poor, leading to poor employability, (particularly at the higher levels), and consequently poor employment levels.

Challenges Associated with the Material

Traditionally servicing of pit latrines has been by relocation (rebuilding) once they were full. However in dense urban locations this is usually not an option due to space constraints. Consequently VIP emptying is the only option in most urban situations. However some of the major challenges associated with the VIP sludge handling, are a direct consequences of the nature of the material itself.

In South Africa where most of the VIP users are "wipers" rather than "washers" the material is generally an odorous, sticky paste with a solids content in the region of 30 %. Due to the lack of affordability, the anal cleaning material is seldom toilet paper, and due to ignorance and lack of services, large quantities of foreign materials and objects, known as detritus, are encountered in the pits. Further, the pits are a major main receptacles for human pathogens.

The nature of the material complicates both the pit emptying and disposal options.

Sludge Disposal Challenges

Apart from the traditional relocation of pit latrines, up until the advent of LaDePa, there have been only a limited number of environmentally acceptable disposal options:

- Burial on site
- Deep burial on a remote site. (Deep trench burial for silviculture)
- Disposal via a sewage treatment works and
- Disposal to a solid waste landfill site.

Deep trench burial for silviculture is still being piloted for SAPPI and the Water Research Commission (WRC) by Dave Still.

eThekwini Municipality piloted disposal to a sewage treatment works with disastrous consequences. Loading of 1,5 cubic meters of VIP sludge per day is approximately equivalent to a capacity increase of one mega liter of wastewater per day on the sewage treatment works. VIP sludge is virtually stable by the time it is removed from the pit, so little further beneficiation to the sludge occurs at a wastewater treatment works: Passing it through a sewage treatment works, increases the load on nitrification and the sludge handling facilities. Further, it also makes little sense in adding water to a relatively dry sludge if the ultimate intent is to dewater it again.

Sewage sludge is considered infectious in terms of the Regulations promulgated under the Environmental Management Act and consequently can only be disposed to a hazardous landfill site. In addition, from an environmental perspective, disposal of sludge to landfill sites wastes phosphates, (a scare and diminishing resource), and other nutrients.

The Environmental Licensing Challenges

The classification of VIP sludge as being hazardous due to it being infectious, raises licensing issues. In terms of the Waste Management Act, licenses are required for both the storage and treatment of hazardous materials. However there is a minimum capacity threshold limit on sewage treatment works of 2000 cubic meters a year, below which Waste License and Environmental Impact Assessments (EIAs) are not required.

The Major Health and Safety Concerns

Human pathogen transmission can occur as a result of

- Overfull pit latrines
- Emptying process
- Uncontrolled disposal methods
- Uncontrolled agricultural use.

Compliance with the Occupational Health and Safety (OHS) Act can also be difficult with poorly educated labour.

The Major Procurement Challenges

The emptying and servicing of VIPs is not technically particularly challenging and is thus suitable for job provision and entrepreneur development in the communities where VIPs are encountered. However the contracting environment around outsourcing such services is fraught with challenges in an environment where the treatment technology is expensive and/or complex. On the one hand, in terms of the Municipal Finance Management Act (MFMA) the maximum span of a contract is three years unless special arrangements are made with National Treasury. While on the other hand, the capital cost of most of most of the established human faecal sludge treatment or recovery plants is high, requiring long term financing arrangements.

This dichotomy of short contracts with long term financing, leads to any number of potential contracting models, but each has its own set of risks to the municipality. The following list of contractual arrangements highlights some of these challenges:

- In the first model the municipality owns an expensive, complex treatment facility but outsources the operation of the plant and the VIP emptying service in a typical three year contract. In this arrangement, the contract period is too short to source and train contract operators on a complex facility, and further, there is little incentive for the operator to operate and maintain this facility in a manner that is compatible with its long service life and financial cost recovery.
- In the second model, the municipality owns and operates the treatment facility, but outsources the VIP emptying operation. However there is a risk to the municipality in that the highly skilled and costly operation of the facility is prone to disruption by under production of a low skilled contractor.
- A third model is to enter into a Public Private Partnership (PPP) where the term of the contract is sufficient for the contractor to purchase, own and operate the treatment facility for a sufficient period for him to enter into a long term financial arrangement, source and train operators and undertake the contract. In South African Common Law, non-removable property automatically becomes the property of the land owner. Thus financial institutions are reluctant to invest in fixed property on public land without rigorous guarantees and sureties. This arrangement, in the main, excludes the very community that the opportunity is intended to serve.

In setting up an outsourcing contract, other important considerations include:

- determining the mode of operation,
- the unit of payment and
- keeping records of the VIPs that have been emptied.

eThekwini's experience is that emptying by sweeping whole areas of VIPs is more efficient than operating on an individual call-out basis. However this means that either some of the VIP are overfull when the sweep occurs or that the process is inefficient because too many half full pits are being emptied. In the most recent sweep eThekwini used the pit as the unit of payment, however on the next round the intention is to pay by volume of material delivered to the disposal facility, provided its moisture content, sand and detritus content is within the acceptable range.

In eThekwini's case, keeping records of the VIPs that have been emptied has been captured by Global Positioning System (GPS) and stored on GIS. Follow up monitoring, based on this GIS record, will be undertaken by the Municipality as a check of the thoroughness of the sweeps in future.

Summary of the Major Challenges

In summary the major challenges associated with VIP management in South Africa are:

- Space and Access – prevents relocation of pit latrines in dense settlements and access for large scale mechanical equipment
- Material handling difficulties associated with the "stickiness" of sludge
- Added transport costs associated with water in the sludge
- Safe affordable, sustainable (both environmentally and financially) disposal options (usually compromised by detritus and pathogen counts in the sludge)
- Human pathogen transmission
- Environmental licensing
- Procurement and contracting.

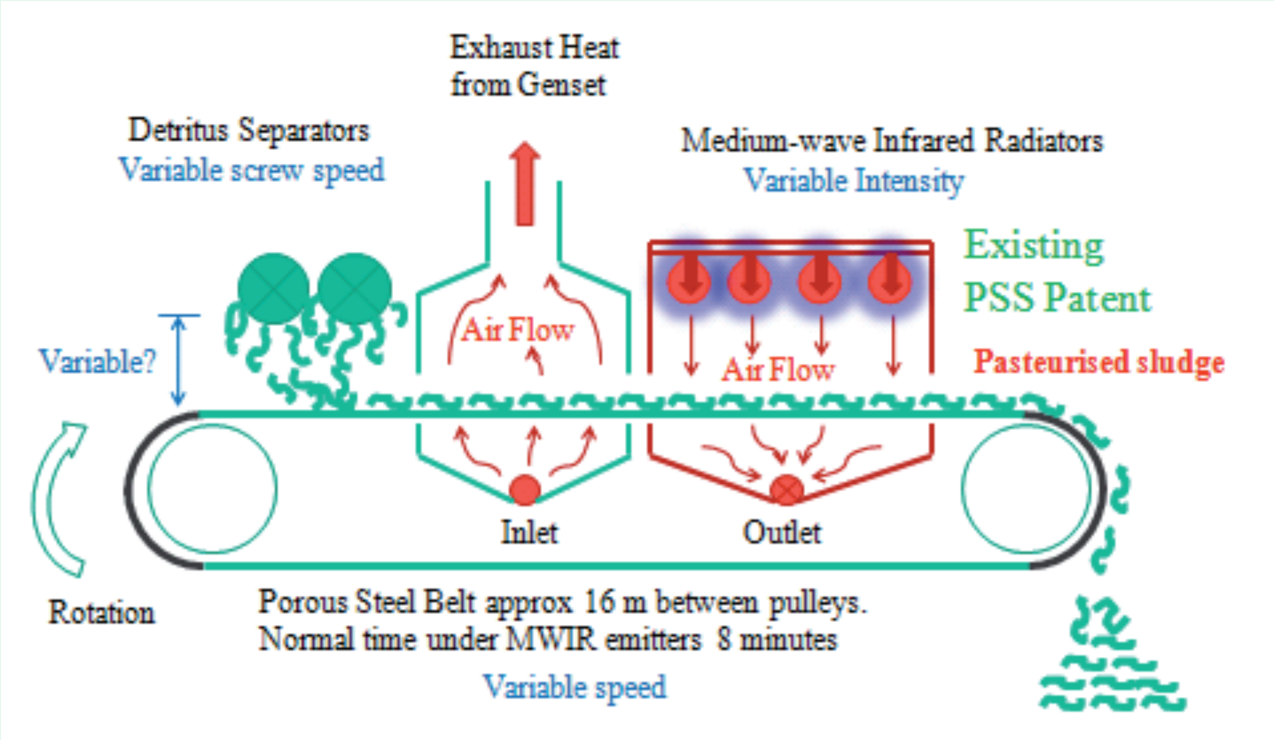

Figure 1 – Diagrammatic view of the LaDePa machine process

Description of the LaDePa Machine

Figure 1 provides a diagrammatic illustration of the functioning of the LaDePa machine. The machine separates the detritus from the sludge by compressing the combination of sludge and its associated detritus in a screw compactor with lateral ports, through which the sludge is ejected, and is then deposited in a 25 to 40 mm thick layer of open pored matrix, onto a porous, continuous steel belt, while the detritus is ejected through the end of the screw conveyor. After pre-drying, using the waste heat from the internal combustion engine of the drive plant, the sludge on the belt, is conveyed through PSS's patented Parceps Dryer where it is subjected to pasteurisation, which also provides sufficient drying to take the sludge through the "sticky" phase making handling simple. PSS's Parseps Dryer technology uses Medium Wave Infrared Radiation and a vacuum to draw air through a porous material or one with an open matrix.

The end product is a low grade organic fertiliser, with about three percent active ingredients. It is free from gross detritus as the holes through which the sludge is extruded are 6 mm diameter, it is free of pathogens and is consequently suitable for all edible crops. When leaving the machine the moisture content is generally in the order of 60 % solids, but is dependent on the influent moisture content. At this moisture content the material is friable, and is well past the sticky phase of sludge.

Figure 2 – The LaDePa machine assembled in a container.

Figure 3 – The LaDePa machine inside the container.

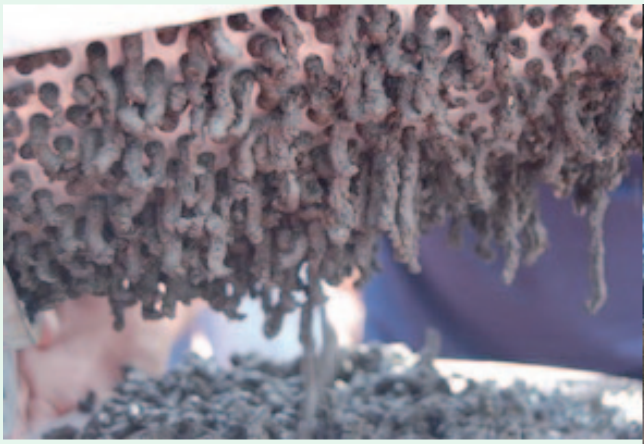

Figure 4 – Pasteurised matter before drying.

If further drying is required, the material is amenable to sun drying. At this point it is no longer regarded as waste or hazardous in terms of the Waste Management Act and therefore storage and sun drying do not require licensing provide basic house cleaning rules are applied

The process can be containerised and powered by an internal combustion engine and generator for mobility. The technology employed is, in the main, straight-forward basic mechanical and electrical engineering, suitable for low skills operation and maintenance by artisans with basic qualifications.

The energy consumed by the plant per person equivalent is approximately half that consumed on a conventional activated sludge plant.

The simplicity of operation allows for simple integration of the sludge treatment process with community needs, as it can be fed by simple pit emptying technology, which in turn provides jobs and up-skilling opportunities to the under skilled.

The Contractual Model

Figure 6 illustrates diagrammatically the contractual relationships that eThekwini intends setting up to outsource its VIP servicing. The Municipality will let two contracts: One with the Managing Contractor who will provide the VIP servicing operation. The second contract will be with the Technology Contractor who will supply the process technology and the machine.

The Managing Contractor will be responsible for:

- managing the VIP latrine emptying process in a safe responsible manner, using a number of small BEE VIP Emptying Subcontractors (VESs) based in the communities they service,
- operating the sludge processing machine and
- disposing the sludge by marketing it as a fertilizer and disposing the detritus to landfill.

Figure 5 – Final product - organic fertilizer from faecal sludge.

In ensuring that the emptying process is safe and responsible the Managing Contractor will be required to train the VIP Emptying Subcontractors and this training will extend to teaching basic business skills to these Subcontractors.

Payment for service will be on volume of sludge delivered, but adjustments will need to be made for sludge that is either too wet or has too much detritus. Both of these risks are seen as risks to the Municipality rather than the Contractor and consequently the Municipality will need to cover any additional costs to the contractors and institute management measures in the form of education campaigns to alleviate the problem in the future. The main contractor will also be responsible for marketing the fertilizer, the income from this being an off set to the contract price. The main reason for payment on volume of sludge delivered is to ensure that the sludge arrives at the machine where it can be disposed of responsibly. With payment based on the number of pits emptied the sludge could land up being unsafely at any convenient disposal point in the environment.

The Technology Contractor will own the technology, the machines and the registration of the fertilizer, but the Managing Contractor will operate the machine. The Technology Contractor will provide the maintenance and servicing of the machine, but there will be a penalty and/or reward to the Managing Contractor to protect

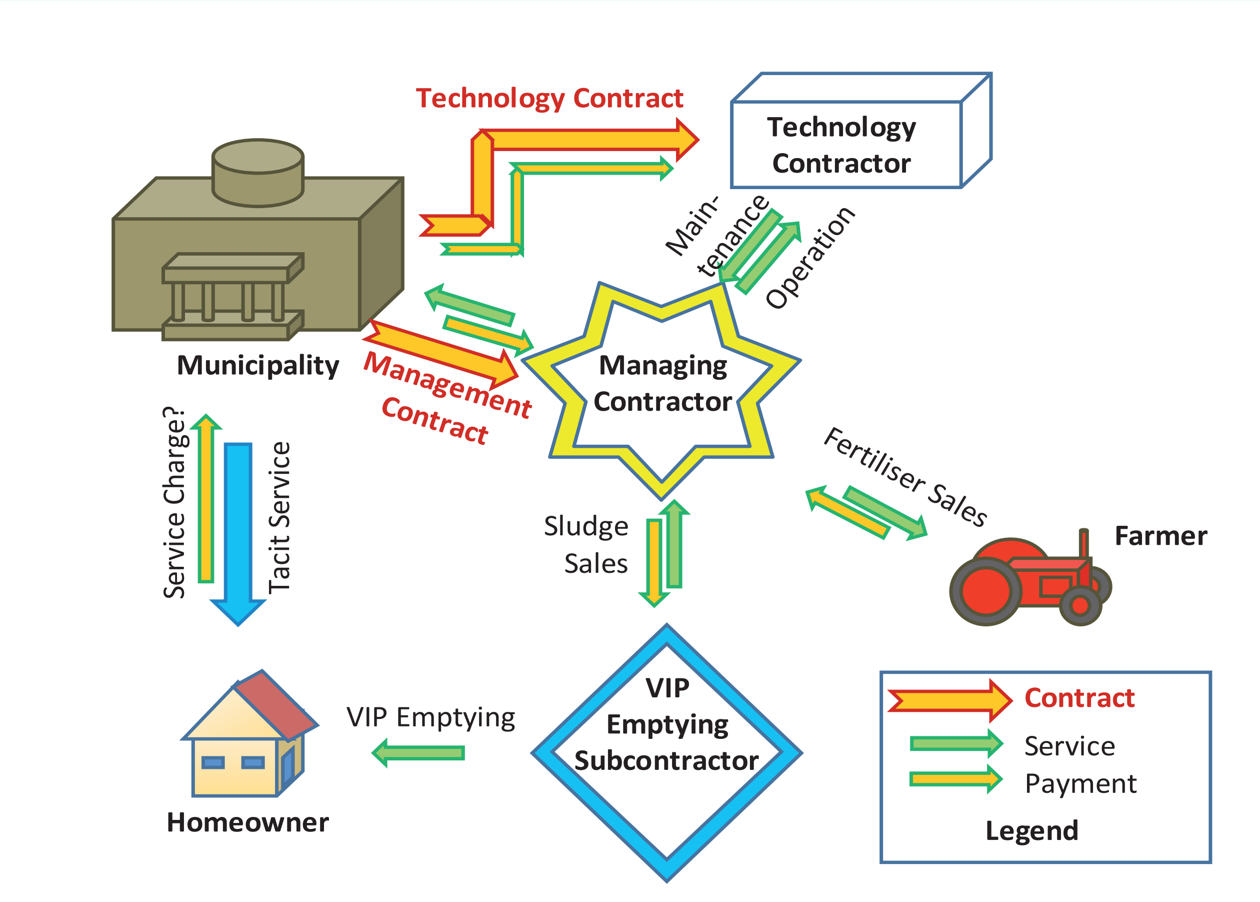

Figure 6 – Contractual Relationships

against abusive operation. Having the technology Contractor take responsibility for registration of the fertilizer, ensures that there are no startup delays due to the registration of the fertilizer.

The equipment is specialized and therefore the Technology Vendor is unlikely to keep equipment this large and specialized as stock items while he is waiting for a contract. There is subsequently likely to be some delay between the award of the Technology Contract and the practical start date of the Management Contract while the Technology Vendor builds his plant. It is for these reasons that it is practical to have the two contracts as separate contracts, as the Technology Contract inessence can now, in the main, be structured as a "lease agreement" with the start of the lease coinciding with the start of the Managing Contract in order to achieve a full three years of production out of the contracts. The delay between award and start date of the Technology Contract allows time for a description of the chosen technology to be included in the Management Contract description at tender stage. Separating the contracts also allows the Municipality the control on the technology choice. At the same time this ensures that the Technology Subcontractor, who rightly should carry the risk for the technology being successful, remains competitive, on subsequent contracts even if the Management Contractor is replaced.

It is worth noting that due to the scarcity of suitable treatment technologies, the Technology Vendor is more valuable to the Municipality and the Country than the Managing Contractor. Separating the two contracts obviates the risk of the Managing Contractor putting the Technology Vendor at risk due to the Management Contractor's default.

This contractual model is based on the objective of distributing the risk to the organization most able to control the risk and in so doing provides the opportunity to control those risks through incentives or penalties. For instance, the distribution of risk suggests that the Technology Contractor should be responsible for the maintenance of the machine. However the productivity of the machine relates to day to day operation of the Managing Contractor and his ability to deliver sludge to the machine and the risks (or reward) associated with the sludge emptying should be carried by the Main Contractor and his VIP Emptying Subcontractors. Similarly, the condition of the sludge (moisture and detritus content) relates among other things to the relationship between the Municipality and its customers, and consequently the Municipality needs to carry this risk.

Income and Savings

The benefit of recycling the sludge also needs to make sense economically, and costs associated with recycling certainly should not exceed the alternative option of disposal. The following compares the costs savings using a LaDePa to treat 2000 tons a year against disposal to a landfill site in eThekwini. There is an economy of scale, and 2000 tons per year is a relatively small plant but has been chosen to show that even at the level at which licensing is not required there is still a saving.

It needs to be noted that this benefit does not allow for delivery cost or the cost of preparing the site for the LaDePa plant.

Other Benefits of LaDePa and the Contractual Arrangements

By removing the detritus, rendering the pathogens sterile and taking the sludge moisture content past the “sticky” phase so that it is easily workable, the LaDePa Machine provides the opportunity to recover the nutrients from the sludge by converting it into a saleable fertilizer. This not only generates additional income to offset some of the VIP servicing costs but it also saves on the disposal costs of an otherwise unsavory waste and thereby saves on the environmental cost. This in itself is a significant breakthrough in VIP servicing.

The low capital cost and the compactness of the LaDePa Machine that allows it to be containerized, obviates the necessity for long term contracts with their associated onerous conditions and the difficulty, in South Africa, of raising private loans secured on public fixed property. Maintaining the sludge processing below the licensing ceiling of 2000 tons a year and maintaining good housekeeping rules, obviates the necessity for a Waste License. Solving these challenges has opened up a myriad of potential contracting models.

The contracting model that eThekwini proposes using in conjunction with the LaDePa Machine, is designed primarily to provide low skill work and up-skilling opportunities in the communities where VIPs are generally encountered in the urban situation. This model makes use of a Main Contractor to provide the up-skilling and take responsibility of the day to day running of the contract. This is achieved as a result of the savings in disposal cost and the additional income from sales of fertilizer. At the choice of the Municipality, subsidized fertilizer sales to community market gardeners can also improve food security and

Table 1: Cost benefit analysis

Disposal cost savings	
2000 tons at R1012 /ton	R 2 259 000
Less 20 % detritus	R 404 800
Income due to sale of product	
Input = 1600 cu m at 20 % solids = 320 cu m solids	
Output = 320 cu m at 80 % solids = 400 cu m (ton) product	
Income = 400 cu m at R 500 / cu m	R 200 000
Total Income and Savings	**R 2 054 000**
Additional Operating Costs (Annual)	
Forman at R 10 000 per month	R 120 000
Labour 4 No. at R 135/day at 260 work days /annum	R 140 000
Diesel at 12 l/hr at 8 hrs/d at 260 work days/annum at R10/l	R 250 000
Pickup Truck at R 450 / day at 260 days	R 117 000
Total Additional Operating Cost	**R 627 000**
LaDePa Annual Cost	
Annualised establishment cost	R 500 000
Maintenance and Royalty	R 600 000
Total Annualised LaDePa Costs	**R 1 100 000**
NETT FINANCIAL BENEFIT	**R 327 000**

Conversion rate: 10 R (Rand) ~ 1 Euro

secondary low skill agricultural jobs. But this is at the expense of the income generated by the sale of the product

The three year contracting cycle for municipalities and the 2000 tons a year environmental licensing ceiling confine the extent of the contract to a population of approximately 50 000, (based on a VIP filling rate of 40 liters per person per year), a third of whom are serviced in each year of the three years cycle. In the event of a hiatuses in the changeover of each three year contract, there may be a need to reduce the magnitude of the population serviced under each contract, and the VIP emptying skills of the Subcontractor may also be lost. However this can be overcome by timeous tendering and procurement before the expiry of the previous contract.

Issues Unresolved

The procurement and contracting model in conjunction with the LaDePa machine does not solve all problems, particularly those issues associated with dishonesty. It is therefore imperative that the client maintains a continuous watchful presence on proceedings in the form of a clerk of works or similar.

It is the intention of Thekwini Municipality to pay the VIP Emptying Subcontractor via the Main Contractor on the volume of sludge removed rather than on number of VIPs emptied. In this instance it is relatively easy for the VIP Emptying Subcontractor to add water, sand or detritus in order to bulk the sludge. At the same time it is the municipality's risk if the sludge is bulked by these components as a natural course of events. Devices are in the early stages of development that will enable field moisture and detritus measurement to be estimated. It is imperative that these measurements are taken both at the VIP site and at the input to the LaDePa machine. In eThekwini's case it is also important that the GPS co-ordinates of each VIP are recorded as they are emptied, as this information is vital in determining the program for subsequent VIP emptying contracts in the area.

Another important issue that is emerging relates to the design of VIPs. In the past VIPs have typically been designed with a deep vault of large volume in order to reduce the frequency of emptying as, until the advent of LaDePa, there has not been a genuine solution to the transport and disposal problems. Deep vaults with difficult access make emptying extremely difficult. In future VIPs designs, more attention needs to be paid to the emptying aspect and where possible it may be pertinent to modify existing VIPs.

Conclusion

In conclusion, the LaDePa plant provides the opportunity for recycling valuable nutrients from the sludge that would otherwise go to waste. At the same time this process is financially more feasible than the alternative disposal option. It also supplies a number of permanent low skill jobs, and has the potential to creates a number of secondary low skill jobs in the agricultural industry. The pasteurization of pathogens improves the human health risks of the product and the reduction of the moisture content makes the material easily workable and also reduces both environmental and financial transport costs.

All these factors contribute enormously to improving the viability and sustainability of the recycling waste in general but feacal waste in particular. It also, for the first time in a water scarce country offers the potential of a viable, dry sanitation alternative to a wasteful waterborne system.

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