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FAECAL SLUDGE MANAGEMENT

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INTRODUCTION

WASAZA has the responsibility to plan and execute the pilot phase of Faecal Sludge Management Project in conjunction with training for engineers and technicians. The project is implemented by Lusaka Water and Sewerage Company (LWSC) and financed through Water and Sanitation for the Urban Poor (WSUP).

FINDINGS FROM PREPARATORY STUDIES

This chapter deals with the findings which were made for the Faecal Sludge Management project by WASAZA/BORDA in the last two month.

Pit Emptying and Sludge Marketing in Kanyama

The review of the three reports conducted has given WASAZA a good orientation for the work.

One of the recommendations is to rather not consider ECOSAN toilets as an option, as they do not perform satisfactory. Furthermore anaerobic digestion with a 20 day retention times and drying of the effluent in drying beds is considered as a good method for hygienization.

- In approximately ten joint sessions WASAZA has experienced different aspects of the **pit-emptying work.**
- For the current job the professionals use various tools to do the job. Next to the pit a hole is dug and the wall is chiselled open (30cmx30cm). The sludge is transferred to the hole using sticks to pull and push the sludge through the chiselled hole and lots of water to dilute the pit content. An alternative emptying method by using the gulper was tested three times in the field (Kanyama) and continuously at WASAZA. In most test cases the gulper turned out to be insufficient. Too many plastic and fibre items were in the pits clogging the valves and the screen of the gulper frequently. Details are provided in the gulper report, attached to this (attachment 2). An earlier assumption that the pit waste is usually liquid was proven to be wrong through sample test during this last rainy season. Also the figures given on how much water is required to be able to steer up the pit content proved to be by far too low. What was assumed to be 100 litres of water was at the end more than 500 litre.
- The categories of toilets cannot precisely be specified as among 25 toilets seen we could not identify a toilet type which follows a standard drawing. This is typical for peri-urban areas in Zambia as the encroachment is unplanned. Most toilets are raised out of the normal underground water level since the stony underground makes digging a challenging long taking job. Quantifying toilets in the pilot phase area was not done since a final decision for the transfer station has not been made yet. Furthermore the number of toilets in the vicinity of the transfer station cannot allow concluding that from all these toilets all content is finally taken to the transfer station. Nevertheless the target is to serve 40.000 inhabitants in the pilot phase and it can be concluded that this target is reached if the emptying is done for around 4.000 toilets (target). The time in which the emptying for all these 4.000 toilets are accomplished can also not be predicted as sizes of substructures and emptying levels alter extremely. These experiences will be made and documented in the pilot phase.
- The **willingness to pay** is ranging a lot and has been depending on the ability to pay of the pit owner. Though, numbers given by the professional pit emptier say that they charge 400.000ZMK for removing the sludge. Additional costs arise for digging the hole. 300.000ZMK for 2m depth and 350.000ZMK for 3m depth. Consequently the total cost turns out to be 700.000ZMK-750.000ZMK depending on the depth of

the hole which needs to be dug. These cost are likely to be covered by the house owner rather that the tenant. Anyways, the pit emptier also say that the prices have ranged from 200.000ZMK to 1.200.000ZMK (40 – 240 US$). This indicates that the ability to pay is part of the price making policy. However theses prices seem not to be calculated in detail, they result from a discussion with the client. People would prefer to pay less, no doubt, if a cheaper service would be offered.

- **Final disposal** of pit latrine content is just beside the pit that has been emptied. Unfortunately even the sludge of pits that are built 3 – 4 steps above normal ground level and above underground water level gets in contact with flood water and can spread diseases. This is clearly caused by the sludge management methods applied. No pit emptier reported that sludge is transported anywhere.

Figure 1: Hole dug next to pit latrine

- For none of the involved stakeholders faecal sludge in or removed from the toilets had any **value**. There was no attempt to use a bit of it to fertilize a plant, bush, shrub or tree. It was the opposite if burying would be no option, people would rather pay for getting rid of it. For WASAZA the 320 litre sludge transported to the office after the second gulper trial had a value (not calculating the transport effort). The sludge was gradually tilted into the biogas plant and generated a shock production of biogas and a continuous discharge of a sludgy, clean material used on the garden land to build up a higher organic matter content in the topsoil. While the fresh material had plenty maggots the effluent had none and did also no attract flies which is caused by the production of vitamin B12 in the digestion process. Vitamin B12 is an insect repellent.
- The **operators** of the sludge showed a certain level of **health concerns** which was not quite in line with their shown behaviour. They were most of the time wearing long sleeve gloves. To avoid breathing in bad fumes them were given filter masks which due to the warm weather could not be kept on. It is hard to tell which of the protective behaviour is due to the presence of assumed authorities and which was a desire based on being convinced that without the measures there is an enormous health risk. A consideration of threat for the operators could not be observed. The smell disturbance of the pit emptying work was astonishingly small, if not neglect able. The environmental threat, though not perceived by the operators, was on the one hand the ground water pollution threat caused by the position of sludge disposal. On the other hand the danger of contaminating surface runoff can be seen more serious. Since it would find it's shortcut to the shallow wells. Furthermore the non-degradable substances removed from the pits can easily melt into the general level of dirt in the compound and could add to the unpleasant view of the surrounding. Furthermore there could be a certain danger of spreading pathogens e.g. to playing children through such dirty items.

- The findings show that the **pit emptying** depends to a large extent on the present climate and weather. During an intensive rainy season period the pit contents will be more liquid. This is on the one hand very disturbing for the toilet users, but on the other hand there will consequently be more business for the pit emptier (Transport will be slower though, thus this will lead to less feeding for the transfer station). On the average the pits seen were much dryer than anticipated. Liquefying pit content so that the pit can be pumped empty originates as a method from the use of machines for pumping and transport. If the same thinking is applied for hand operated tools the work load increase and therefore the cost for pit emptying rises at many interfaces: Water cost and transport, steering, pumping, transporting the liquid discharge, treating the mix and separating surplus water out again, until the final product is dry enough to be bagable, and marketable.

  The suggested pit emptying method is the alternative would be to concentrate on methods where the pit content is taken out as it is. This would be the dry pit emptying method. This requires a number of tools which can handle this. WASAZA has therefore modified a series of tools and tested them. In practice this would mean that the pit emptier assesses in advance with which tool set he will tackle the emptying of a certain toilet and will come with the right mix of tools the next day. The gulper would be required for septic tanks (preferably removing only the sludge and not the entire water body) or for pits which prove to be liquid enough. For any intermediate condition the method of chiselling a hole in the side of the toilet looks to be reasonable and functional. If not liquefied with water, the pit content can be scooped in 60l containers with a wide opening of 30cmx30cm. It is possible to fill drums of this size without spilling the material, by use of dippers, shovel, hooks or forks (*Figure 2*). As tools should have long handles there is an element of adapting tools or making the handles extendable. There could also be situations where a shorter handle is preferred.

Figure 2: Left Gardening tools for pit emptying; Middle: Dipper for more liquid content; Right: Access to pit latrine

  The people who transport heavy material in respective compounds have to decide how they want to do that. Anything sophisticated could easily develop to be not maintainable or excepted.

- Assessing the **real market value of the sludge** remains a risky statement. The step from the raw material to marketable products, namely *biogas* and *soil conditioners* can only be achieved with considerable investments. Biogas would bear the chance to not suffer under the stigma of being a health risk while it is difficult to achieve that for organic matter which is broken down and stabilized to be a soil conditioner. Composting would also require the involvement of structure material composting the sludge in a semi dry form, could still be difficult.

- **Trials on faecal sludge management** can focus on offering different tools to the pit emptier which are commercially operating. The target of the tools would be to speed up the work and partially either earn more or also reduce the price of the service and increase the number of people serviced. In this respect the gulper report (*attachment 2*) as well as the report from Mark provides suggestions on the route to take. The transfer station itself will be discussed in the next chapter. In addition to the common pit emptier community WASAZA identified the premises of Kanyama Water Trust to accommodate the pilot project. This will be explained in more detail in the next chapter.

Transport, Treatment of Faecal Pit Sludge and Septic Tank Wastes

- The ZBDC study states that cleansing of faecal pit sludge can be achieved through a two-step biological treatment. The first step is anaerobic digestion with a 20 day retention time (it has to be considered here that the majority of the material has already been broken down in the pit) while the second step is done with sludge drying beds. While this refers to the entire treatment process the infrastructure of Kanyama would require that the transfer of the material is done in two steps. The first step is done with smaller, muscle operated carts which transport the sludge to the transfer station. These can be a 200l drum hand cart or the widely-used modified wheel barrows in Kanyama or shown in Figure 3.

Figure 3: Left: Showing a heavily used cart in Nairobi. Plastic sheet is sealed over the top of the drums with a rubber tie or rope to stop its contents from sloshing out. Right: Common wheel barrow used in Kanyama

The pit emptier would need to be the transporters as is also the case in the Nairobi FSM project. The decision on transport depends on whether a new transport tool like the 200l drum hand cart would need to be especially constructed for the job or if one would use the existing wheel barrow transport with which 2-3 60l drums can be transported. A bigger push cart with a transport capacity above 200l (Figure 4) might turn out to be too heavy because of the steel frame in addition to the weight of the sludge. This will make it very hard for pushing/pulling the cart through the muddy roads, especially during rainy season. The transport possibilities will be tested in the pilot trial.

Figure 4: Push cart for transporting more than 200l

From the transfer station the accumulated and further-treated sludge can be accessed by a vacuum truck, which carries it to the final treatment location. Regarding sewage from septic tanks the transfer station can also accommodate this material. In this pilot stage it has to be learned how much of respective watery sewage can be accommodated.

- In respect of **quantities** being discharged, a slight orientation comes from the studies which suggest that the faecal matter alone is in the range of 50kg per person served per year. For calculating the total volumes required WASAZA has created an interactive excel sheet which allows establishing different scenarios. The calculation runs by the following estimations which were taken to design the digester for the primary treatment.

Table 1: Assumed parameters for digester design

Variable	Assumption
Sludge/person/year	50kg
People served	35.000
People per pit latrine	10
Max. pit emptying/Group/day	1
Max. pit emptying groups	4
Max. Inflow/day	3,7t/day
Min. Inflow/day	3,5t/day
Max. retention time	15 days
Min. retention time	10 days
Max. gas production	20m³/day
Min. gas production	15m³/day
Max. gas connections	14
Min. gas connections	10

The **quantities** to be collected depend on many factors there are two methods of estimating this.
The pragmatic multiplication factor: people to be served multiplied by the average excreta data lead to maximum of 3,7t faecal matter per day. This is under the assumption that no water is added in the emptying process but a small amount is added through rainwater and washing water at the digester. Non organic items thrown in pit latrines which have to be removed with the excreta can only be estimated in this stage. At 150kg per day (200g dry material/adult female, removed in wet stage) to the site. An

uncontrolled item is modern diapers for babies which can cause an extra burden. The information on what should go in the toilet and *what not* needs to be transmitted to people involved in the pilot project from the onset. It's not very likely that toilets are used for other forms of solid waste disposal, with certain exceptions of course. Rags found in toilets originate from cleaning and particularly from menstrual hygiene practices.

The other way to calculate this is based on the observation that one team can only clean one toilet on an average per day. We are assuming a maximum of 3.500 pit latrines (35.000 people/10 people per pit) in the targeted area. In addition not all pits are filled up and the fill up time ranges from three up to ten years. Furthermore we assume that there are approximately 300 working days per year. This leads us to the conclusions that a maximum of 4 teams (probably less) per transfer station would eventually be required. These teams bring at most 2t/day and not less than 1t/day of material to the transfer station. This refers to a maximum of 8t/day (probably less because of fewer teams) collected in total. The operation of the pilot installation will show which seems to be the more realistic way of calculation is.

This will be further fine-tuned in respect of findings during the planning phases of this project.

- The **quality** of the pit latrine content can occur in a wide range. It is not very likely that the content is liquid and can be pumped. The liquefying often originates from rainwater entering the pit through the squat hole in cases the toilet has no roof which has been often observed. Roofed toilets usually have a very dry content which is even with the addition of water very difficult to get to a condition where it can be pumped. The most disturbing condition is the tremendous amounts of torn clothes found in the pits. These originate from menstrual hygiene methods or cleaning (*gulper report)*. The material is also likely to be contaminated with plenty fly larvae (maggots). It was also found that the dry pit content did not contain anaerobic bacteria, which indicates that the material was dry enough to contain air which then led to aerobic conditions in the pit (like compost). The total solid content as an average of the pits observed is far above 10%. It cannot flow. Multiple tests with diluting the sludge and filling it in test bottles showed in all cases good performance in terms of liquid/solid separation and gas production. The gas production which has been taken place in the pits is significant, even though there has been no way of measuring to what extend that has happened. The samples are too diverse and the mix of fresh and old material is at no standard. Experiences show that the practical pit emptying always refers to the top part being removed first. The sludge gathered is rather on the fresher side than on the old side. This is different if it comes to emptying of septic tanks with a vacuum tanker or a gulper (depending on the length of the gulper) as in both cases the bottom accumulation is removed with priority. A container with a preliminary watery milieu will accumulate digested and stabilized material at the bottom.
- Kanyama provides sufficient space to establish several **transfer stations** within the compound. WASAZA suggests setting up the transfer station behind the premises of Kanyama Water Trust (KWT). Since KWT will be in charge for the maintenance of the faecal sludge management within Kanyama it is recommended to keep the treatment facility directly next to KWT.

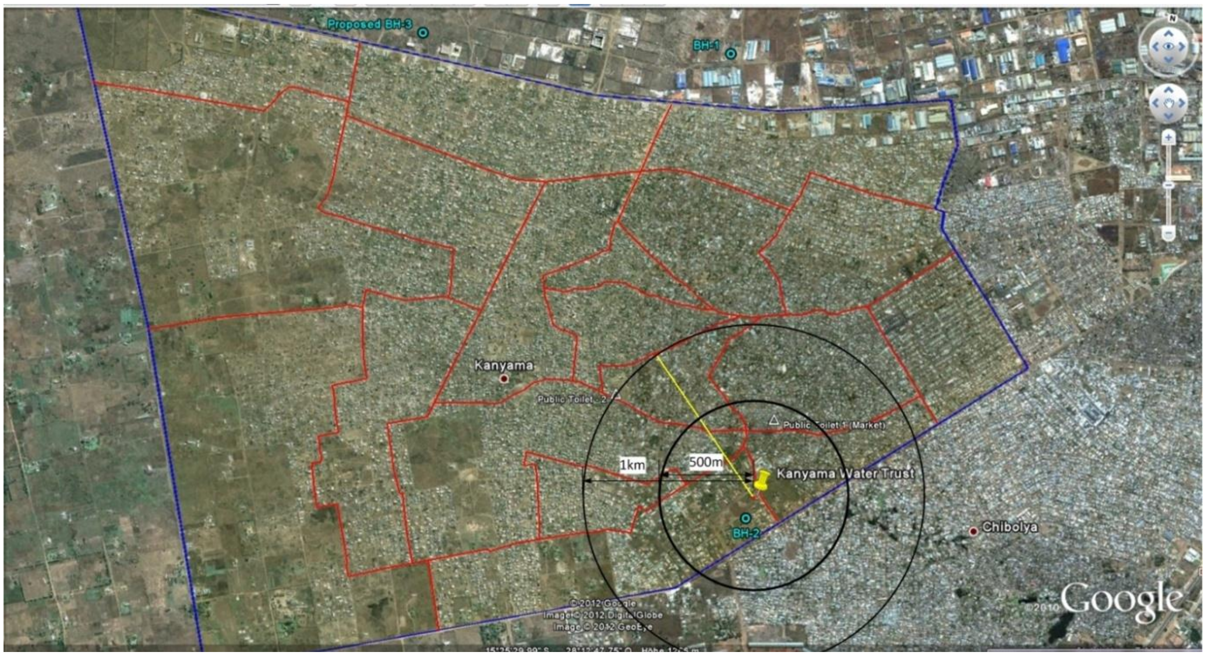

Figure 5: Location of Kanyama Water Trust with primary treatment facility

KWT is located in the south of Kanyama. If we take a maximum transport distance of 1km into respect then parts of Chibolya could be also emptied. Furthermore "Old Kanyama" with the market area falls under the catchment area of the primary treatment facility. In addition the area is not densely populated, which allows appropriate space for the handling of faecal material.

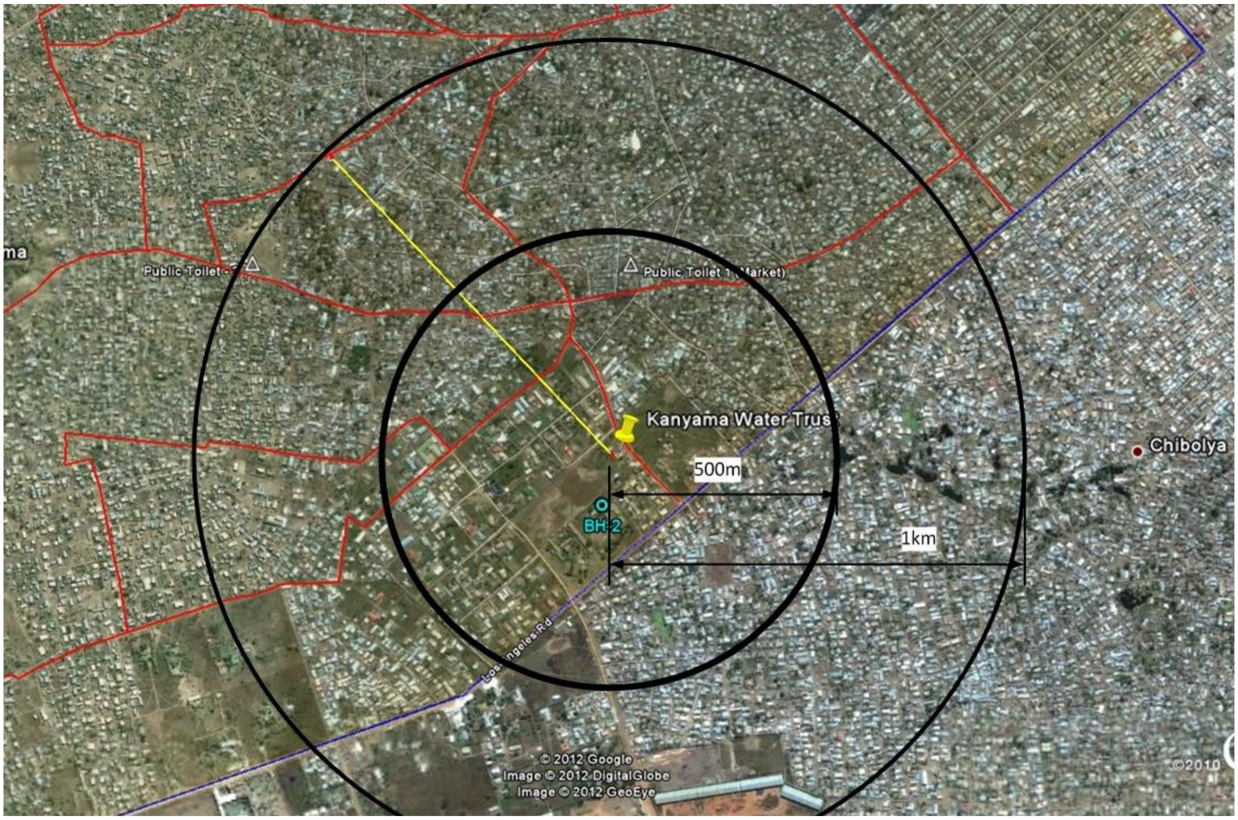

Figure 6: Closer view of suggested primary treatment facility at KWT

- The original fear that this will lead to a smell thread to the area is less of a problem than previously anticipated. This is based on the fact that very little chemical cleaning agents are entering the toilets. The typical smell of sewage originates partially from chemicals. When operated somehow clean as far as surface spillages are concerned, the transfer station would not cause any persistent smell. One location within Kanyama would provide sufficient space for a pilot treatment operation with the potential to come to a full treatment within the compound (piloting). And it seems worthwhile to try such an approach as the process would be much cheaper.
- The **process design** suggested refers to a pilot transfer station dealing with the faecal sludge of an area in which approximately 35.000 people are living. The planning parameters are the following:
    - Amount of sludge collectable
    - Space available
    - Retention time in primary collection biogas plant transfer station
    - Necessity to further concentrate on solid discharge rather than liquefaction
    - Non organic solid waste handling
    - Particular adaptation to conditions and requirements
    - Gas use, gas use reliability
    - Effluent characteristics
    - How to minimize transport efforts and cost
    - Levels of the system

- Management team
- Access

<u>Other Findings</u>
Gathering practical data on the faecal sludge management practices is in the Zambian context a topic with particular challenges:

- The majority of the stakeholders involved in the exercises reported about, are shy to be close to faecal sludge and practical work. The exception here is of course the professional pit emptier.
- The tools tested are unavoidably getting dirty and need to be cleaned at the site before they are transported. This will to some extend contaminate the surrounding.
- During the gulper trial phase faecal sludge was spilled inside the super structure and outside the pit latrine due to missing experiences of how to operate the gulper.
- Protective gloves are likely to be worn by the pit emptier but protective mouth masks are considered to be a burden and are not likely to be worn. They may also not really be necessary.
- The amounts of water required to stir up the pit content and to be able to pump with the gulper are much higher than formerly declared by people involved in the practical work execution.
- The present toilet emptying method is sufficient but not sustainable and dangerous in terms of spreading diseases in the rainy season.
- Neither the gulper nor the classical method used by the pit emptiers are considered as practical to empty out the pit. The material is too solid.
- The time spent for emptying a pit in total is much longer than what the respective people count. There is preparatory contact to the client, the digging of the hole at the side wall, chiselling it, and filling water continuously inside the pit while emptying it.
- Laboratory tests have shown that e-coli as indicator bacteria is present in fresh sludge (9000/g) as well as in digested sludge (8000/g).
  This finding does not allow concluding on the presence or absence of pathogens.
- Even though it is wise to consider the work of pit emptier as dangerous, reports on frequent infections of people regularly exposed to the work were missing.
- It was also evident that sun drying in the rainy season with high water saturation in air, cannot lead to a product with more than 35% total solid (65% water).
- Flat spreading of slurry of 2 cm height dries very quickly. The thicker the spread the slower the drying.
- A report on converting faecal sludge to earth (in German language) added a very much different scenario of faecal sludge treatment to all other sources.

ASSESSMENT

WASAZA sees the biggest challenge in the ownership of the faecal sludge management method. This refers to all steps of procedure, the involved people and tools. Kanyama Water Trust (KWT) has until now no experience with the management of faecal sludge. They have been responsible for the water supply for this region which is very different, as it is a much cleaner job than the management of faecal sludge. The benefits for KWT need to be very clear to turn the FSM-project into a sustainable beneficial FSM-service. KWT needs to be the owner of the service. This means that they are responsible for making the pit emptying service a respected and demanded business by the potential customers. An efficient and accepted pricing system for the job is therefore required. It recommended not to rise up the water bill to finance this service otherwise there is a high potential that the service gets rejected by the community.

The project faces lots of technical challenges which need to be experienced in the pilot phase. These are especially the transport of the faecal matter and the emptying. These two working steps will be done within the community. Through those we will get a view of how the work will be accepted. Transporting drums filled up with faecal sludge through the Kanyama area needs to be experienced to find out which further challenges will come with it. Also the procedure of emptying is not finalized yet. WASAZA is sure though that the pit emptiers will have a number of tools, where they can decide which tool is most sufficient for which kind of pit content. These tools are under construction and they are getting currently tested.

CONCLUSION

The conclusion elaborated here is the result of intensive discussions between WASAZA and Lusaka Water and Sewerage Company. The pilot aspect of the next phase of the FSM project refers to a transfer station which allows to experiment with a number of suggestions. During the pilot phase for a period of time the full sludge treatment can also take place in the suggested compound. This has the advantage that it can be experienced what is possible and what not, without that a whole new infrastructure with fence and walls, road access etc. has to be established. There are a number of challenges that have to be faced and solved. These refer in particular to team setup, cooperation of different stakeholders directly involved in the project.

The pilot site

The pilot site can be erected within a premises attached to KWT office, owned by KZT. A 50 m^3 digester will be the core piece of the transfer station. It will be established in a way that multiple experiments can be conducted so that from this experience an appropriate solution also for similar conditions can be found. Figure 7 shows the location of the transfer station from a bird's eye view. The inlets of the digester as well as the sludge chamber are accessible to the road. The sludge chamber is $15m^3$ and separated in three chambers, $5m^3$ each. One vacuum tanker can load $5m^3$ of sludge. It is expected that the vacuum tanker needs to come every second day. That way the sludge discharge beds have a security extension of one week/three truck loads. The single chambers can then be pumped out separately. Furthermore there will be a second sludge discharge pipe to trial the use of drying beds besides the digester inside the compound. In the case that this is tested successfully the premises provide enough space to extend the drying beds. In addition there is large space ($4200m^2$) for more modifications and extensions (additional digesters).

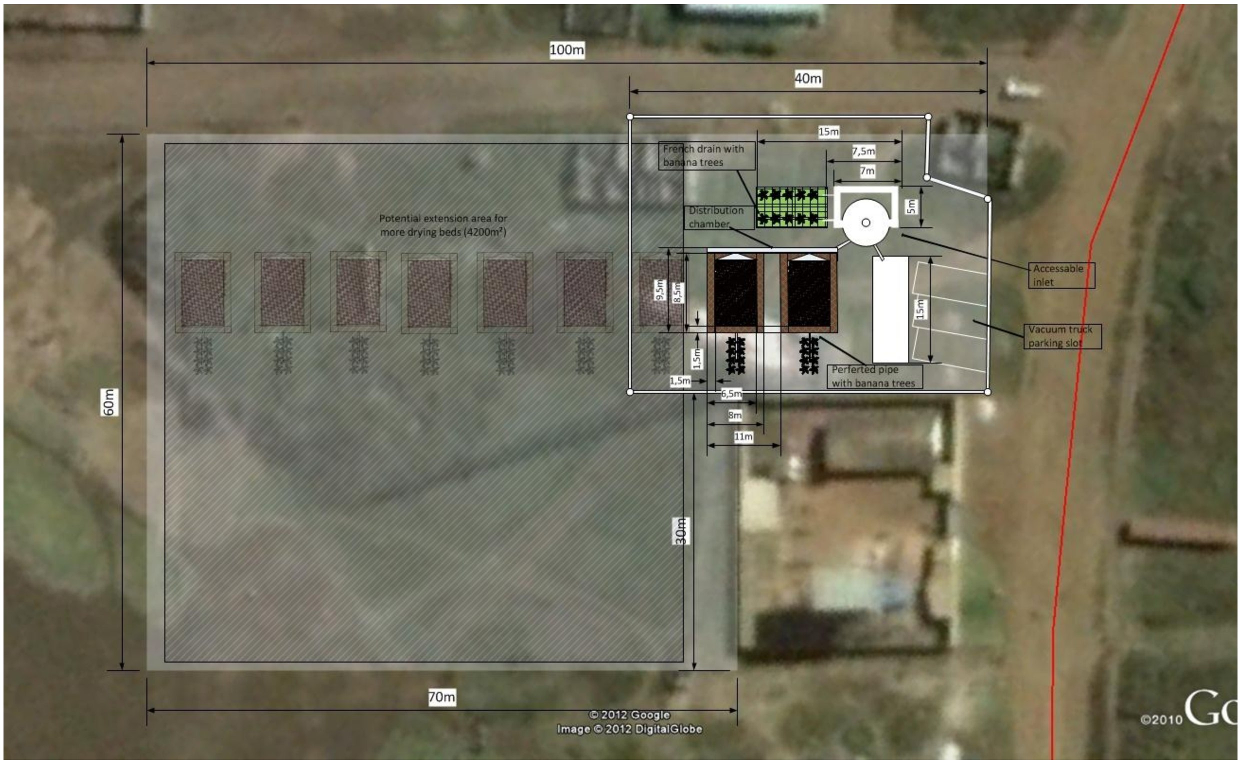

Figure 7: Pilot transfer station at KWT. There is enough space for modifications and extensions.

Arriving at the transfer station with a load of 60, 120l (2x60l drum), or a 200l, the drums will be tilted into a receiving bay and immediately washed down in a digester. The digester will quickly separate liquids from solids whereby the regular overflow of the digester discharges primarily water. The water will be taken from the outlet of the digester, so that the liquid can be taken for liquefying the inflow while the next step of processing the effluent will operate entirely with the rather solid sludge. At the conical bottom of the digester a sludge discharge pipe will only discharge material with a high total solid content (either by gravity or by a vacuum tanker) to proceed. The TS content of the sludge would be relatively dense close to 10% TS. Also sand will be discharged in smaller quantities from there. As long there is majorly recycled water entering the digester there is no need to transport separated water with a vacuum tanker. This concept economises particular on all transport efforts.

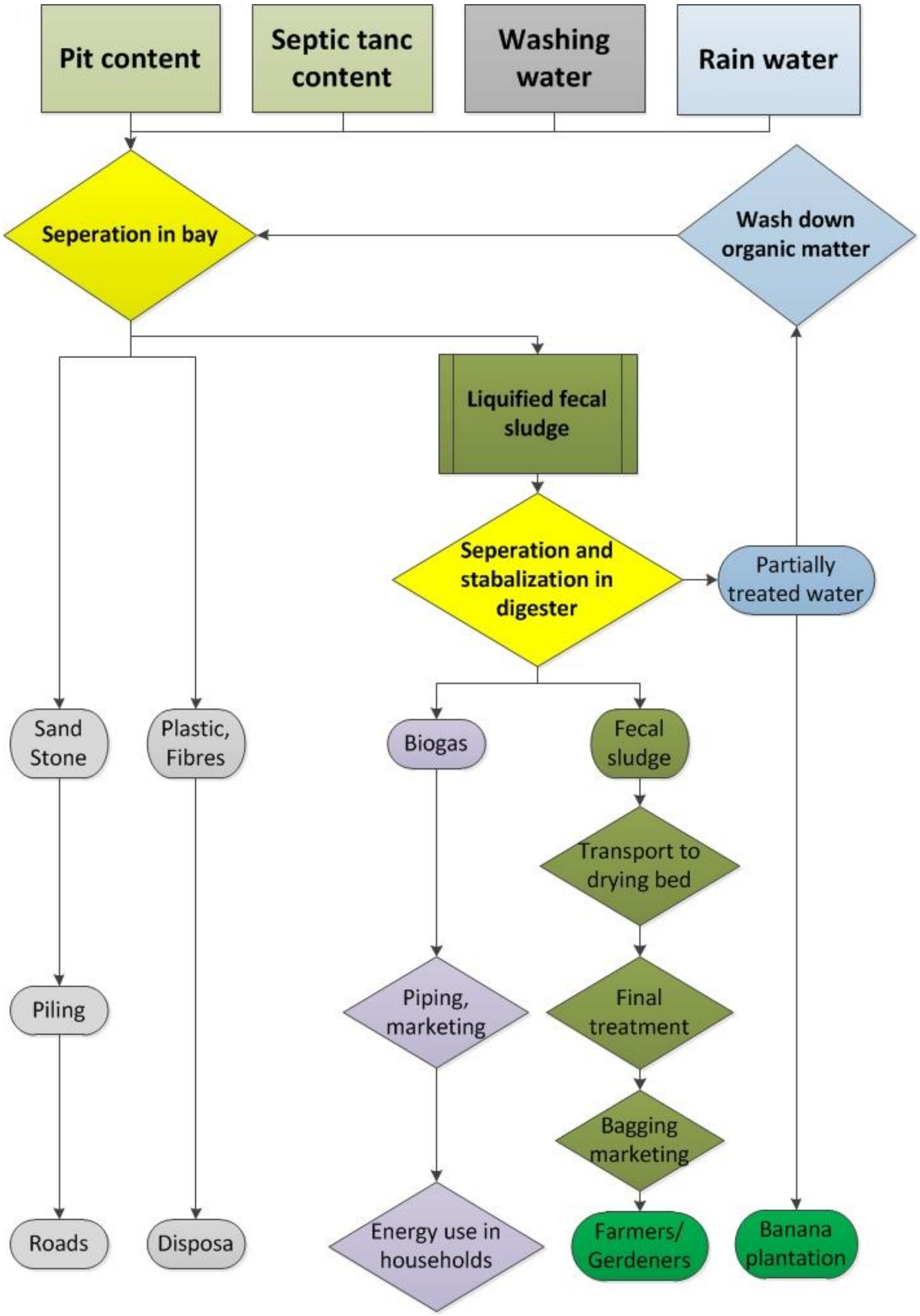

Figure 8: Flow chart of pilot transfer station technical concept for FSM management

Training

As the pit emptying involves people who are already doing such work, it is suggested to conduct training in two steps:

1. For emptying toilets four existing emptying teams have to be identified to join experience *exchange training*. Precondition is that the teams usually operate in the vicinity of pilot transfer station compound. The four teams are equipped with the same tool set and are encouraged to empty the toilets in the stage *as found*. A renting system where the pit emptiers rent the tools from KWT is suggested. That way the tools would be kept at one place and due to the renting costs KWT can makes sure that the tools will be returned. The principle emptying method is through the hole chiselled in the side. No water is added. This process will be monitored closely during the pilot phase.
    - The content is taken to the transfer station as convenient as possible for the workers. Different transport methods can be piloted. Also the team setup is piloted.
    - The hole in the toilet sub-structure is closed again. This will be done either with lean cement or mud mortar (mud mortar might be preferable if done safe and sufficient, because of less cost and easy continuous access).
    - The whole pit content can in most cases not be collected. A maximum of $2m^3$ per pit is is likely to be collected.
    - One team of toilet emptiers will on the average clean out one toilet per day.
    - Thus 3,9tons (changing the assumptions will lead to different figures) (see attachment 3) of excreta are collected per day from the 3.9 tons material arriving at the station 150 kg are wet fabric and plastic.
    - Thus the remainder is 3.7 tons
    - Achieving a retention time of 15 days one would need a digester volume of 50m3 under the condition that water is guided in a cycle.
    - Non digestible items should not enter the digester
    - The material taken away would only be sludge discharged from the bottom of the digester.
    - Surplus water may be available in the rainy season, can be infiltrated in the underground with the help of a french drain.
    - Arrived at the transfer station the material is tilted in the receiving bay, the container is washed with recycled water, pumped from the displacement tank. This is the second time that training input is required. This will have to take place at a later stage as the digester has to be constructed first. It could also be considered to involve some of the pit emptiers as helpers in the construction of the digester. This will lead to a different level of ownership.
    - The initial filling of the $50m^3$ digester originates either from filling up the digester with water or septic tank content for a pressure test.
    - The position of the outlet in the digester will lead to a discharge of water first, as long as there is a watery component in the digester. With its expansion channel the digester guides the displaced effluent towards the inlet. The displacement tank has two overflows from where the effluent can discharge overfilled water, like during rainy season or in cases where the content of septic tanks are added in. If this overfilling is observed, the sludge discharge pipe has to be opened and instead of water the digester will discharge bottom sludge. This is the oldest material in the digester and is to a large extent stabilized.

- The sludge displacement tank will have a volume of $12m^3$ with separated overflow chambers $3x4m^3$ in the case that vacuum transport is missing out. The extra capacity allows a minimum of three days without vacuum transport.
- The sludge proceeds to the final treatment/drying by vacuum tuck. The truck can either take material from the sludge discharge chamber (where in the dry season it has thickened) or through the 8" sludge discharge pipe from the bottom of the digester or a mix of the two.
- The gas produced will be in the range of 15-20 m^3 per day. This could be sufficient for 13 households or an institution which is cooking for 70 people. The value of the gas is, if calculated below the price of charcoal 5000 ZMK per day per family connected.
- A mode on how people should be accounted for the use of gas will have to be identified.
- The responsibility for the operation of the enterprise as well as the financial flows is a matter of further discussion.
- The sludge discharged will be in the range of 3–4 tons per day. If dried to a TS of 35 %, it is in the range of 1ton. For this pilot project is not likely that the sludge can be dried to a reasonable level on the premises provided near the KWT.

Digester

The technical drawing indicates the digester with its peripheral structures only. In its final design it will show all details precisely elaborated. The drawing contains all information which is required for the construction of the digester. For further information see attachment 5.

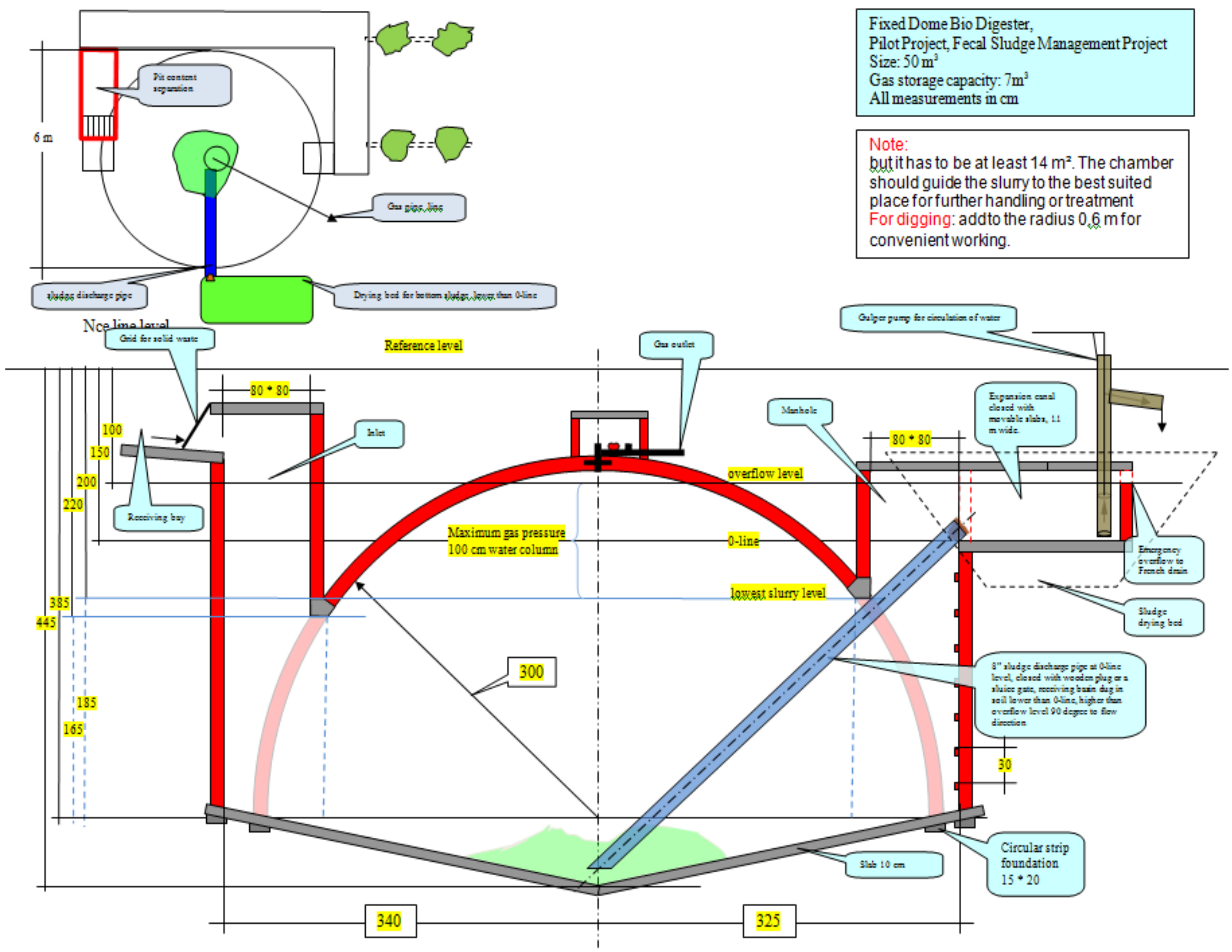

Figure 9: Technical drawing for 50m³digester solution for transfer station

The anaerobic digestion process removes carbon components in the range 10%–40% of the total solids entering the digester. The sludge will slowly build up in the digester. Water will separate out and flow through the digester transporting in the first year of operation only traces of the organic matter. Only when 50m^3 of the digester are filled with the remaining sludge well digested material will be discharged. This material has the characteristic that water runs out easily.

Below the combined material cost for the primary treatment are listed. The most expensive factor is the amount of cement. The prices for the different material can still change but the values correspond as far as possible to the current market prices.

Table 2: Material cost for trial primary treatment facility

Item	Unit	Amount	Unit Price in ZMK	Material Cost in ZMK
Total sand	ton	9	85.000	85.009 ZMK
Total agregate	ton	4,8	85.000	85.005 ZMK

Total cement digester	bag	73	68.000	
Total cement + sludge bed	bag	91,5		6.220.935 ZMK
Bricks	piece	3232	300	969.676 ZMK
Mesh wire	role	2,00	900.000	
Total				**7.360.624 ZMK**
				$1.472

Furthermore costs of approximately **4.500US$** for labor, supervision and administration will be incurred.

Sludge Drying Beds

For the sludge drying beds a principle sketch is provided. The bed receives only sludge from the transmitter station, discharged from the sludge discharge pipe. This has the advantage that it is well pretreated, stabilized, free of non-degradable material and free of smell. It does not attract flies and is relatively uniform. The actual sludge drying space is a permeable brick layer, loosely laid in sand, without mortar. The beds are completely flat. Below the brick layer there is a layer of rough sand, in the middle of each drying bed there is a perforated pipe which can pick up water when the underground is saturated. The pipe is slightly slanted, guiding the filtered water below ground outside the bed into a plantation of a few bananas. When overflow will be drained on it, the sludge will fill the gaps but allow the water to drain down to the barrier layer (clay or plastic fabric) and finally discharge through perforated pipe into the banana plantation. The drying beds measure 5m by 7m inside with an operation access alley of 3m in between each drying bed. That way enough space is provided for easy dig out of the dried material and pile up beside the drying beds for composting (without additional structure material) and final transport to a platform where it is bagged. The vacuum truck has a volume of $5m^3$. With the drying bed area of $35m^2$ the thickness of the fresh sludge layer should be 15cm. After drying the sludge layer thickness will decrease to approximately 5 cm. The pilot layout of the secondary treatment contains seven drying beds from which 2 are in the KWT compound and 5 in a separate location.

Gas use

For the gas use a campaign has to identify the households in the vicinity which could use the gas. The easiest and also most effective way of using the gas is by cooking. This replaces charcoal which has a relevant importance for Zambia. The gas network is laid as HDPE pipe to houses and restaurants. Intermediate shut off valves have to allow for sections of the gas piping system to be pressure tested for eventual leakages. Below roads the pipe needs protection against heavy traffic. As the gas contains moisture (condensation water) several water traps have to be incorporated in the network. Within the houses the piping system is changed to ½” galvanized steel pipe.

For a start the number of houses connected should be limited to three. Only if it is realized that the gas is more than enough, the number of houses connected can be increased. For average households the number can be around 15 to 20.

It has to be emphasized that community gas use in biogas technology has its own challenges. Even though WASAZA gains slowly more and more experience in this (Kariba, Ndola 10 families are sharing the gas, similar distributions are under construction or planned for Solwezi and Livingstone (2 locations)), the challenge of uneven gas use remains. One option could be to install prepaid gas meters for each household. But this has its own challenges.

The cooking gas replacing charcoal can be accounted as a value of 3000 ZKW per family per day. If and how this is recovered and taken as a revolving fund for the maintenance of the system is a matter for further discussion.

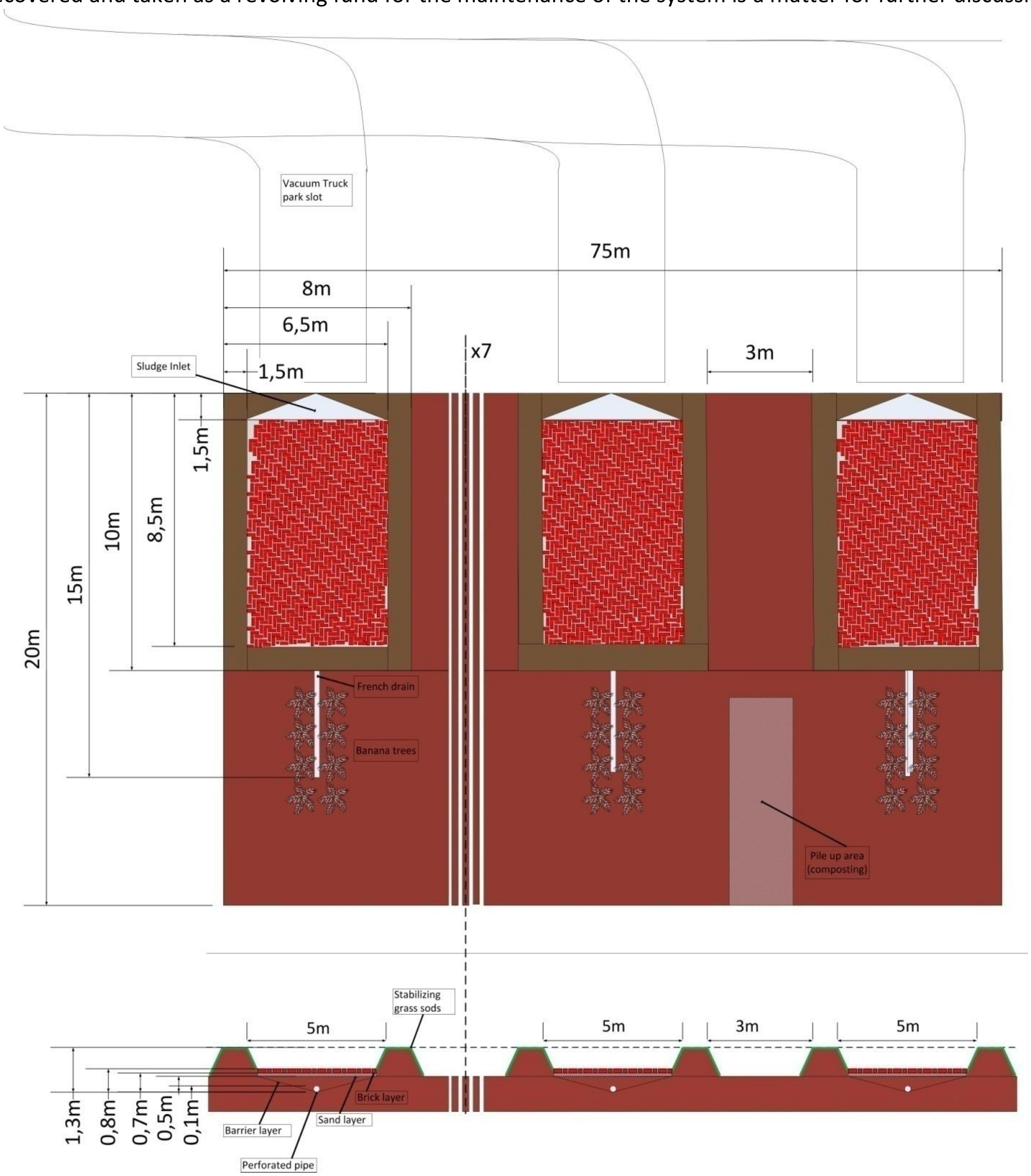

Figure 10: Layout of drying bed (secondary treatment)

The bricks will absorb moisture from the sludge and allow easy removal of the dried material without mixing up with sand. The outer frame of the drying bed could be concrete and brickwork or also just moulded by soil with the respective angle of 45 degree and stabilized with grass sods. Like this even the surrounding of the drying bed would remove moisture from the sludge. This is particular possible as the stabilized sludge is suited to be used as a fertilizer as it is.

As there are different technical options there will also be different cost related to that. One bed of 35m² would cost **650US$** only for the filter sand and the bricks. Just dug out in soil without pipe, bricks and filtration sand, one bed would cost about **500US$** just for labour. The grass sods for the edges can be taken out of the drying bed itself.

OPEN QUESTIONS AND STATE OF IMPLEMENTATION

This document has to be understood as a tool for further discussion. All stakeholders should read it carefully and provide feedback to WASAZA

Important decisions to be made are:

- Where will be the pilot test station? The location was in the meantime decided.
- What will be the arrangement in terms of station operation?
- Will the WASAZA recommendations be implemented as suggested?
- Who should use the gas?
- How to maximize the revenue from the gas use?
- How to minimize the running cost?
- Are the assumptions on filling material in the digester realistic?
- Up to what detail will the pilot operation be monitored?
- What additional technical measures have to be in place to monitor the project.

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