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ENSURING AVAILABILITY AND SUSTAINABLE MANAGEMENT
OF WATER AND SANITATION FOR ALL

Development of low-cost decentralised faecal sludge treatment system for resource recovery

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Uganda has a largest population using onsite sanitation facilities. In Kampala Capital city over 90% use onsite sanitation. The situation is even worse where some towns have no sewer line and no faecal sludge disposal sites. The Ministry of Water and environment has clustered some towns within a radius of <35km to have a common dumping site. With the current few wastewater treatment plants in the country, this intervention would require more 36 faecal sludge plants to be constructed across the country. The current conventional plants seem very costly and at times underutilised because very few serious entrepreneurs would move all the distance to a safe disposal site. As a result there is illegal dumping in bushes. Water For People has developed sustainable sanitation business model right from capture structures through emptying with gulpers, transport with tricycles, pick-ups to low cost decentralised faecal sludge treatment (DEFAST) and Reuse of faecal sludge (FS) as briquettes, feeds, Vermicompost/ compost, Biochar.

Introduction

About 2.7 billion people in the world use onsite sanitation (OSS) facilities and its management has traditionally not received much attention of engineers and municipal authorities *(Strande et al., 2014)*. Most developing countries don't have specific plants for adequately treating faecal sludge (FS) (S*obieray et al., 2013).*

In urban areas of Asia, Africa and Latin America, the excreta disposal situation is dramatic: every day, worldover, thousands of tons of sludges from on-site sanitation (OSS) installations, undergo unsafe disposal (*Ingallinella et al., 2002).*

Uganda and Kampala city in particular, has about 90% of the dwellers relying on OSS (*Semiyaga et al.,2012*). In the urban slums especially, the most common facilities are pit latrines both lined and unlined and when they are filled up, the obvious solution is to abandon them to build new ones. This practice is now close to impossible since land is no longer available given the high population growth rates.

BORDA, a German NGO have created a package anaerobic baffled reactor, but these are likely to be beyond the financial reach of the average entrepreneur and a lower cost, entry point, treatment package is required. Based on DEWATS concept and in collaboration with a local plastic tank manufacturer, NWSC and Kampala Capital City Authority, a low cost, simplified, version of the DEWATS has been created using mainly rota mould plastic tanks. With Funding from the Water Research Commission, the DEFAST was designed, and constructed by Water For People's SaniHub project in Lubaga Division Kampala, and its operational performance been monitored since May 2014 at a loading rate of 500l/d. The pilot plant has six major units i.e. the inlet unit which has a screen to remove non-biodegradable solids, the biodigester/dewatering tank, two anaerobic baffled reactor tanks (ABR), two anaerobic filters (AF), a planted gravel filter (PGF) and a polishing/holding pond. Other units are composting with Tiger worms and Black soldier flies, modified unplanted drying bed and a separate briquette making facility.

Over the monitoring period, we have several times recorded over 80% removal efficiency for chemical pollutants like BOD_5 and COD whereas biological pollutants like E-coli in effluent has always been above

90% meeting the national discharge standards. For reuse products like Vermicompost, Biochar and at times biosolids we have recorded zero helminths and ascaris eggs. It's upon this basis that a full scale design as in figure1 is being implemented in two districts to handle at least 15m^3 of faecal sludge per day.

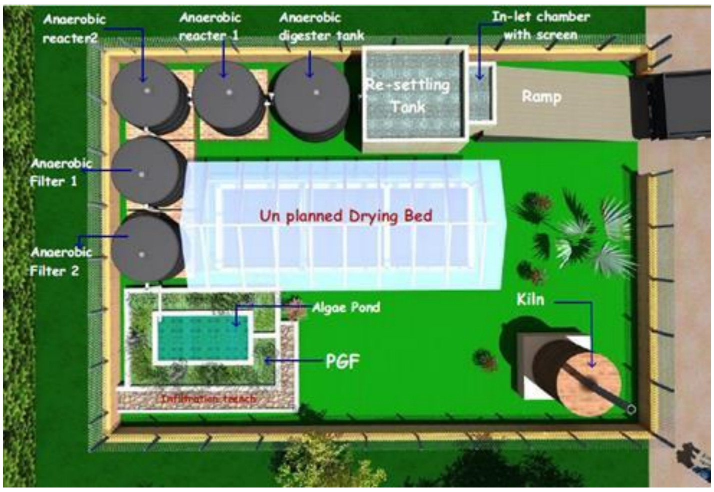

Figure 1. Aerial view of DEFAST with all units

Objective

The main of objective is to develop and field test a low cost faecal sludge management system for benefication and advice on possibility of scaling up.

Methodology

The study involved characterisation of raw faecal sludge from onsite sanitation systems, sizing/ designing, constructing and monitoring plant and finally assessing the performance and advising on possibilities of scaling up.

Characterising the raw faecal sludge

This was rapidly done to ascertain what to expect in the faecal sludge in terms of physical, chemical and biological parameters. The purpose was to help in initial sizing of the plant though detailed characterisation was being conducted by partners in Makerere University (School of Agricultural/ Biosystems Engineering) that together with raw sludge properties at the pilot informed on the full scale design.

Samples were collected from 15 filling pit latrines and 5 septic tanks in Lubaga division. The pit latrine and septic tank sludge ratio was derived from the fact that over over 70% of people in Kampala use pit latrines *(Okumu 2004).* All samples were picked from a depth of 1m (photo1) using a locally manufactured devise that is suited to collect samples from any required depth.

These were mixed together in a bucket to form a homogeneous sample which was taken to the laboratory and analysed for PH, Total Solids, Total Volatile Solids, Total Nitrogen, Total Phosphorus, Biological Oxygen Demand, and Chemical Oxygen Demand according to *APHA , AWWA, WEF (1998)* (standard methods for the examination of water and wastewater.

Designing and monitoring plant performance

From the sludge characterisation and based on the DEWATS layout, the DEFAST was designed to have six units of inlet with screen for non- biodegradable solids, the dewatering unit, anaerobic baffled reactors, anaerobic filters, planted gravel filter and drying bed (figure 2).

Photograph 1. Picking a faecal sludge sample from septic tank

Source: Field photograph in Kampala

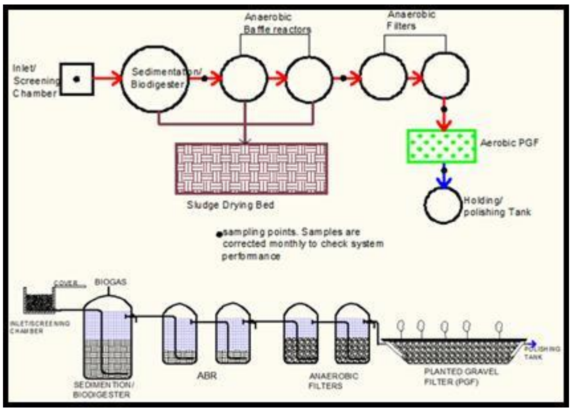

Figure 2.The schematic layout and section through the Pilot plant

On a monthly basis, samples were picked from the sampling nodes as shown in figure2 and analysed for BOD_5, COD, TSS, faecal coliforms, pH, Nitrates and phosphates. All analysis was done according to the standard methods of examination for wastewater **(APHA/AWWA/WEF, 2005).**

Furthermore, separate reuse experiments were set up for vermicomposting faecal sludge, carbonising to briquettes and biochar and black soldier fly (BSF) breeding to produce feeds, photo2. Vermicomposting involved introduction of worms on faecal sludge at a stocking density of 1.5kg/m^2 and how to harvest both compost and worms. Briquettes involved appropriate carbonisation means, blending, extruding and analysing the energy content, whereas char was analysed for NPK content. With BSF, emphasis was put on establishing a colony in Uganda, while utilising natural conditions to optimise mating and egg laying.

https://www.dropbox.com/s/0aa5ms1rci11y2w/WRC%20REUSE%20DELIVERABLE%20FINAL.pdf?dl=0

Photograph 2. Showing some of the reuse products

Source: Field photo

Results and discussions

Characteristics of raw sludge received at pilot plant

A total of seven parameters were used for monitoring plant performance as shown in table 1. For this particular discussion a summary has been made for influent characteristics COD, BOD_5, TSS and Faecal coliforms removal efficiency as shown in figures 3, 4, 5 and 6 respectively.

Table 2. Influent FS characteristics

Parameter	Range	Average	Standard deviation
pH	6.84-9.1	7.75	0.6047
COD (mg/l)	1134-45500	23657.82	10746.08
BOD_5 (mg/l)	2001-29591	16561.84	8467.83
TSS (mg/l)	7455-82688	31779.8	27938.08
TN (mg/l)	755.1-2734	1844.33	702.47
TP (mg/l)	176-1181	685.81	343.97
FC (CFU/100ml)	2110-60x10^7	9933489	20867418
pH	6.84-9.1	7.75	0.6047

Sludge in developing countries is known for its variability in properties due to difference in capture and disposal mechanisms. Properties range from physical, chemical and biological. High variations also impact on design of treatment systems to ensure uniform load onto the plant especially when biological systems are preferred. The variations in chemical and biological properties have been showed in table1. And a good example is BOD range, since sampling was done from inlet tank, the sample captured is not representative of general sludge treated and a reason for variations depending on source of sludge, retention time in pit and pit location.

COD and BOD_5 removal efficiency

There was a general reduction in COD and BOD5 across the units and sampling period. There was anomaly in trend recorded in the month of September which was attributed to high loading of the plant with septic sludge expected to have undergone bio digestion already. However, generally performance was over 90% and 70% for COD and BOD5 respectively as shown in (figures 3 and 4) for all other months. It's important to note that however, the high efficiency recorded, effluent didn't meet national discharge standards of 100mg/l COD and 50mg/l BOD, (Kajura, 1999) respectively. This was attributed to high pollutant load in influent and some operational challenges which have been catered for in the new design being scaled up and we expect higher performance.

Removal of TSS

For TSS removal the efficiency was higher compared to chemical pollutants, over 93% removal was recorded throughout the monitoring period, (figure 5). Though in some months we failed to meet the national discharge standards of 100mg/l. The highest percentage removal was attributed to efficiency in dewatering tank, entrapment/ interference in filter media and sufficient retention time that allowed for settlement.

Efficiency removal of biological pollutants

The key indicator here was faecal coliforms and generally the effluent met the national discharge standards of 10,000 counts/ 100ml despite the high concentration in influent. This is clearly demonstrated in (figure 6) with efficiency removal being over 96% and at times 100%.

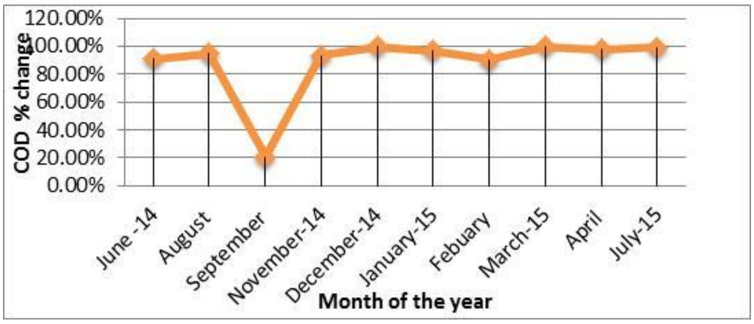

Figure 3.Plant efficiency removal for COD

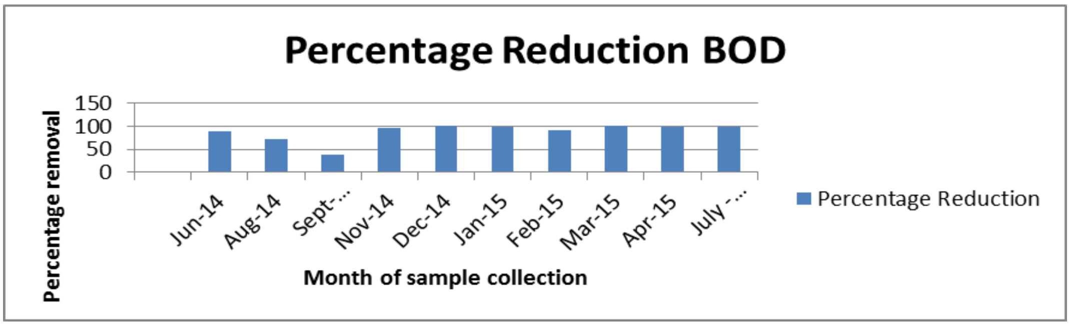

Figure 4. BOD removal efficiency over the monitoring period

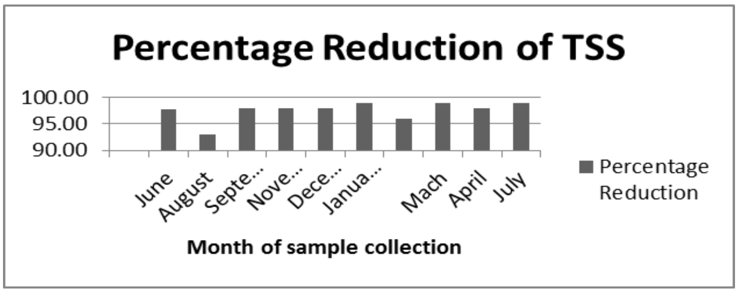

Figure 5.TSS removal efficiency across the monitoring period

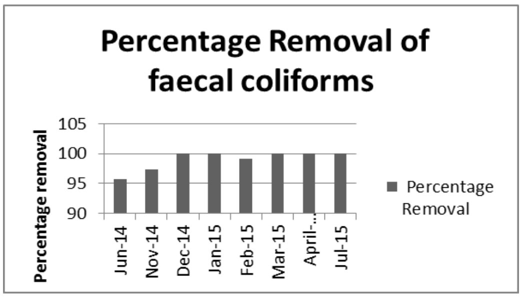

Figure 6. WEDC – Plant performance in removal of faecal coliforms

Lessons learnt

- Using low cost materials like plastic tanks can greatly reduce the cost and time needed to establish similar plant using other materials like concrete. Companies dealing in plastics should start manufacturing special tanks/ systems to minimise need for modifications of water tanks.
- Well planned Decentralised FS management creates more entrepreneur opportunities around emptying, treatment and reuse hence profit driven sanitation services.
- With decentralised faecal sludge treatment, private sector can be fully involved in faecal sludge management given the opportunities hence reducing the burden on governments.

Conclusion

Despite the operational challenges like variability of influent properties, the general plant performance has been impressive and as a result full scale plants have are being constructed to boost the sanitation as a business program in areas that originally had no faecal sludge disposal options. The full scale plants will be limited to 15m^3 per day and main focus will be put on briquette making, co-compost, feeds and using effluent water for irrigation in dry season.

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