13.45 – 14.30 **Lightning Panel Poster Session** – Maximizing resource recovery, Session 1

- *Effect of age and pre-treatment of sludges on methane yields during anaerobic digestion of pit latrine sludge: A case study of sludges from peri-urban areas of Zimbabwe* - Kurazhi Bangira, Department of Irrigation and Water Engineering, Chinhoyi University of Technology, Chinhoyi, Zimbabwe

- *From latrine pits to field as organic fertilizer: Action research results of BRAC in reuse of FS* - Sharmin Farhat Ubaid, BRAC, Dhaka, Bangladesh

- *Drying characteristics of FS using a scale lab medium infrared dryer ‘LaDePa’* - Santiago Septien Stringel, Pollution research Group, University of KwaZulu-Natal, Durban, South Africa

- *Occurrence of helminth eggs in on-site sanitation systems in eThekwini municipality, South Africa* - Nicola Rodda, School of Life Sciences, University of KwaZulu-Natal (Westville Campus), Westville, South Africa

- *Inactivation of four salmonella strains in faeces composting with black soldier fly larvae* - Jenna Senecal, Swedish University of Agricultural Sciences, Uppsala, Sweden

- *Treatment of vermibed effluent from the biofil toilet technology by subsurface infiltration* - Peter Owusu-Antwi, SMART Sanitation, KNUST, UNESCO-IHE, Kumasi, Ghana
Effect of Age And Pre-treatment of Sludges on Methane Yields During Anaerobic Digestion of Pit latrine Sludge: A Case Study Of Sludges From Peri-urban Areas Of Zimbabwe

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Theme: Maximising resource recovery

Keywords: biogas; pre-treatments; age of pit latrine sludge;

Anaerobic digestion consists of several interdependent, complex sequential and parallel biochemical reactions, during which the products from one group of microorganisms serve as the substrates for the next, resulting in transformation of organic matter mainly into a mixture of methane and carbon dioxide. Methane generation by anaerobic digestion is a biochemical reaction that requires certain chemical composition of the feedstock and maintenance of specific environmental conditions. Traditionally, relatively fresh feedstock has been used in biogas digesters. While pit latrine sludge has potential as feedstock, some researchers have however postulated that by the time of pit emptying, the sludge from the bottom levels of the pit would have been partially degraded hence there is a high probability of low methane yields. Further to this, it is unclear what effect diet has on the quality of latrine sludge and hence methane production. In addition, the disposal of the digested sludge after biogas generation also presents environmental challenges as it may still produce odour, and may still be high in biochemical oxygen demand (BOD) or pathogens such as Escherichia coli and ascaris which the anaerobic digestion process may fail to effectively eliminate.

The present study is investigating these aspects by exploring the physico-chemical and biological properties of sludge; and assessing the biogas production potentials of sludge taken from different depth levels of pit latrines. Different pre-treatments are also explored as enhancements for optimum biogas production. The effect of diet on the quality of sludge for methane production is explored by investigating physico-chemical characteristics of sludge sampled from communities with different socio-economic characteristics.

Samples from various peri-urban settlements in Harare and Chinhoyi are assessed for their physico-chemical composition before, during and after digestion, based on the following parameters: moisture content (MC), Total Solids (TS) and Volatile Solids (VS) contents, volatile fatty acids (VFA), pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Total Kjeldahl Nitrogen (TKN), NH₄⁺, Total Phosphorus (TP) according to APHA Standard Methods. The elemental composition (CNS) of the pit latrine sludge is determined by dynamic flash combustion and the C:N and C:P ratios estimated. Laboratory
based reactors constructed at pilot scale were used to assess methane (CH\textsubscript{4}) production per unit weight under different digestion conditions. Gas composition and quality were analysed using a gas analyser. At each stage of digestion the chemical and microbiological composition of the sludge were assessed.

Statistical analyses of the data were performed to establish the significance of relationships among the variables for the pit latrine sludge compositions as the digestion progresses. Initial results show that sludges of different ages, site specific variables and geographical location may have different methane yield potentials, although studies are still ongoing.

This paper contributes to the conference’s endeavour to understand the science of sludge in pit latrines, that is, it seeks to contribute to the discussion about whether issues of context, sludge age, and etc have any bearing on potential quality or quantity of by-products of sludge.
From Latrine Pits to field as organic fertilizer: Action research results of BRAC in reuse of Faecal Sludge

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Background
BRAC WASH II, with financing from DGIS and BMGF, aims for a sustained change—a measurable leap—in personal/family hygiene, sanitation and water safety in Bangladesh, and is targeting, among other things, more than 30 million people with sanitation interventions and over 60 million people with hygiene interventions. However, concentrating on the provision and usage of latrines alone is insufficient. Environmentally safe collection, transport, treatment, and final disposal or productive reuse of treated human waste, all need to be in place for a guaranteed sustained service of the technical installation at household level. The sophistication level of these services will differ between contexts. This paper has focused the use of faecal sludge from twin-pit latrine as organic fertilizer in production of rice.

Method
The research was carried out between 2013-2013. The study was done on the digested faecal sludge. The objective of the study was to check the aptitude of it as organic fertilizer. Fully digested excreta from the pit has collected and dried for 2 months for the safe removal of pathogen. Before the trial the nutrient content and microbiological analysis has been done in the laboratory which has been complied with WHO and national fertilizer standards. Then a trial plan has prepared for rice production following the conventional practice. A popular local breed of rice has chosen. And based on it the dose of fertilizer (both chemical and organic) has finalized. Four different doses of fertilizer have developed to check the efficacy of this as organic fertilizer. The Doses are:

<table>
<thead>
<tr>
<th></th>
<th>T0</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0=Control (Standard Faecal Sludge)</td>
<td>T0</td>
<td>T1</td>
<td>T3</td>
</tr>
<tr>
<td>T1=Standard Chemical Fertilizer</td>
<td></td>
<td>T2</td>
<td>T4</td>
</tr>
<tr>
<td>T2=3/4 of Standard Chemical Fertilizer + Standard Faecal Sludge</td>
<td>T3</td>
<td>T0</td>
<td>T2</td>
</tr>
<tr>
<td>T3=½ of Standard Chemical Fertilizer + Standard Faecal Sludge</td>
<td>T1</td>
<td>T3</td>
<td>T4</td>
</tr>
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</table>

Results
Trial has revealed that the sludge has the capacity to act as organic fertilizer. Even a combination of conventional chemical fertilizer and digested faecal sludge can act better and capable of reducing the use of chemical fertilizer. Comparison between treatment T1 and T4 explains that application of faecal sludge with organic fertilizer can increase the
production of rice by 300 kg per hectare. At a time treatment $T_2$ revealed that application of chemical fertilizer can be reduced $\frac{1}{4}$ of the current practice without facing any loss in the yield by adding faecal sludge in the field. As Bangladesh agricultural soil is depleted with organic matter (Akter et al, 2012), this can be great solution for reduction of chemical fertilizer use and enhancement of organic matter in the soil.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Duration (days)</th>
<th>Tillers per hill</th>
<th>Plant height (cm)</th>
<th>Spikelet/panicle</th>
<th>Yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_0$</td>
<td>142</td>
<td>9</td>
<td>93</td>
<td>132</td>
<td>5790</td>
</tr>
<tr>
<td>$T_1$</td>
<td>148</td>
<td>14</td>
<td>104</td>
<td>162</td>
<td>9082</td>
</tr>
<tr>
<td>$T_2$</td>
<td>146</td>
<td>13</td>
<td>100</td>
<td>159</td>
<td>9108</td>
</tr>
<tr>
<td>$T_3$</td>
<td>145</td>
<td>12</td>
<td>103</td>
<td>167</td>
<td>8287</td>
</tr>
</tbody>
</table>

**Conclusions**

The usage of twin-pit latrines, where appropriate, is recommended in the Bangladeshi Draft National Water Supply and Sanitation Strategy. The twin pit latrine model is not only cost effective and durable but can also lead to the safe disposal of human waste and its productive reuse if properly managed. The laboratory results showed that it can be pathogen free after 60 days of sun drying in Bangladesh and comply with national fertiliser standards after addition of rice husk and saw dust. There is a big opportunity to develop business model on faecal sludge based organic fertiliser as it is already a conventional practice in agriculture. Faecal waste is rich in major nutrient elements and has a beneficial effect on soil fertility. As redundant use of chemical fertilizer reduces the organic content of soil, this fertilizer can play a good roll to increase the organic matter. BRAC has applied for an organic fertilizer permit with Bangladeshi Agricultural Research Council, and awaits its answer within the coming 12 months.

**Reference**


Ubaid SF, Dey D, Kabir B Making profit from faecal Sludge, Working paper, WASH Conference 2014, Brisbane, Australia
Drying Characteristics of Faecal Sludge using a Scale Lab Medium Infrared Dryer ‘LaDePa’

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Theme: Technology innovation

Keywords: Faecal sludge; Infrared heating; Drying; Pasteurisation

In Durban and its agglomeration, over 600 000 Ventilated Improved (VIP) latrines has been installed from 1999, after the commitment of the South African government to provide adequate sanitation to every citizen. The eThekwini municipality has set up the ‘Latrine Dehydration and Pasteurization’ (LaDePa) prototype machine in the Tongaat waste water treatment plant to process the faecal sludge collected from VIP latrines at the end of their usage cycle. The sludge drying, which is performed mainly by means of infrared radiation, leads to pathogen-free pellets, which are planned to be used as soil improver or fertilizer. The dried pellets could be also potentially used as a bio-fuel.

This study focuses on the understanding of the phenomena occurring during the faecal sludge drying in the LaDePa machine and on its optimization, by using a lab scale prototype located in the Pollution Research Group laboratory, at the University of KwaZulu-Natal, Durban, South Africa. The feedstock used for the experiments is faecal sludge sampled in VIP latrines in the peri-urban zones in Durban agglomeration. The products obtained after processing in the lab scale LaDePa are characterized through several tests, including: analysis of the moisture, volatile matter and ash content; analysis of the pathogen content through Ascaris egg account; analysis of the content in nitrogen N, phosphorous P, potassium K and other micronutrients; calorific value measurement.

The effect of several parameters on the drying and pasteurization of feacal sludge were studied in the lab scale LaDePa, such as: the heating intensity, residence time, air flow rate and pellet size. It was found that the optimal drying and pasteurization conditions were obtained at intermediate heating intensities (about 160°C) for the lowest pellet diameter tested (8 mm), after 20 minutes of residence time. Under these conditions, the target of moisture content lower than 20% was achieved. At high heating intensities, the solid can be exposed to temperatures higher than 240°C, which can cause an undesirable thermal degradation of the material and damage its structure. At low heating intensities (T < 100°C) or for higher pellet diameters (10 - 14 mm), the drying of the pellets was not satisfactory. The air flow rate has shown to have a positive effect on faecal sludge drying results by enhancing moisture removal. Otherwise, measurements of temperature at the core and at the surface of the pellets during drying shows that this transformation is not isothermal under the explored conditions. Concerning the chemical and physical properties, the nutrient composition and calorific value of the pellets increases as drying proceeds.
As a conclusion, feacal sludge processing in LaDePa at the optimum operating conditions leads to a product free of pathogens and concentrated in nutriments, which makes the product suitable for agricultural purposes. Drying is also an interesting pretreatment for the potential use of the dried pellets as a biofuel.
Occurrence of Helminth Eggs in On-site Sanitation Systems in eThekwini Municipality, South Africa

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Keywords: Ascaris; helminth eggs; on-site sanitation systems

Introduction
The premise of all sanitation systems is the separation of people from their faecal waste and thereby breaking the chain of faecal-oral infection with bacteria, viruses, protozoan parasites and helminth worms. In developed urban centres this usually means flush toilets and waterborne sanitation. However, in developing countries, and particularly in informal, peri-urban and rural settlements, a mixture of formal and informal on-site sanitation solutions exist alongside open defaecation. In eThekwini Municipality (Durban), South Africa, a number of on-site sanitation systems exist outside the sewered network. These include ventilated improved pit latrines, urine diversion dehydrating toilets, pour-flush toilets and community ablution blocks based on any one of these. All of these sanitation systems require emptying when full. Viable infectious organisms remaining in the faecal sludges pose a health risk to toilet emptiers and to the households which may be contaminated during emptying. Of the possible classes of health-related organisms which may occur in on-site sanitation, the most resistant to inactivation are the eggs of geohelminth worms, especially Ascaris lumbricoides. This species is found at high prevalence along the eastern coast of South Africa (Appleton et al., 1999), in rural and in slum areas (Appleton et al., 1999, 2008). This study characterised the occurrence of helminth eggs in faecal sludge from on-site sanitation systems in the eThekwini area, at different levels within the pits or vaults associated with toilets. In addition, pellets produced from VIP sludge processed through a latrine dehydration pasteurization (LaDePa) plant were described. This is a sludge processing technology developed by eThekwini Municipality and consultants to handle faecal sludge from emptied VIP pits.

Materials and methods
Faecal sludge samples (ca. 20 g wet mass) from wet ventilated improved pit latrine (VIP) pits, dry VIP pits, communal ablations blocks (CAB) served by a pit latrine, urine diversion dehydrating toilets (UDDT), pour-flush toilets and pellets formed by processing VIP sludge through a LaDePa plant were analysed for helminth eggs (including those of Ascaris spp., Trichuris trichiura and Taenia spp.), using the method described by Moodley et al. (2008) and modified by Pebsworth et al. (2012). Results were expressed as egg counts per g dry mass in each of the sample layers. Counts of potentially viable and non-viable eggs of Ascaris, Trichuris trichiura and Taenia were recorded.

Results
Space constraints prevent results per layer in each on-site sanitation system being displayed here. These will be presented in the full paper. Figure 1.1 shows the mean viable egg count in each of the systems sampled, and in pellets from the LaDePa plant. Mean Ascaris and T. trichiura eggs counts were above 10 per g dry mass in several cases, and occasionally above 100 per g dry mass. If the WHO (2006) guidelines for faecal waste used in agriculture (<1 helminth egg per g total solids) is used as an indicator of “safe” levels of helminth eggs for handling faecal sludge, then it is clear that sludges from all the systems exceeded safe levels. By contrast, egg counts in LaDePa pellets indicate that these are safe for handling and for use in agriculture.
CONCLUSIONS

The following conclusions are drawn from all the data to be presented, not only those shown in Figure 1.1.

- Faecal sludge from all the on-site sanitation systems sampled showed viable helminth eggs ranging roughly 10-100 eggs/g dry mass for each species examined, demonstrating a significant health hazard to workers emptying toilets and handling raw sludge.

- As a generalisation, helminth egg numbers increased with increasing depth in the sludge. An anomaly was observed for dry VIP pits which showed higher counts of helminth with depth in the back, relatively inactive area of the pit than in the front, active area of the pit. This contrasts with UD toilets, which showed higher helminth egg counts throughout the sludge profile in the active vault.

- The relatively high counts of helminth eggs recovered from on-site sanitation systems shows that the provision of toilets and water is not sufficient to break the transmission of helminth infections in these communities. Additional interventions such as health education and deworming programmes are indicated.

- Sludge pellers produced by the LaDePa process showed viable helminth egg counts consistently <1 egg/g dry mass. Egg distribution in terms of both counts and species were remarkably consistent across samples. The LaDePa pellets are thus safe to handle, and this process shows promise as a sustainable solution to the treatment and disposal of sludge excavated from on-site sanitation systems.

References


