Optimization of the Sampling and Laboratory Methods for Faecal Sludge

The implementation of anaerobic digestion and other treatment technologies on faecal sludge requires reliable methods to understand its characteristics and the treatment mechanisms. The PURR Project is addressing the current lack of standardized sampling and laboratory methods for faecal sludge. M. Bassan[1,3], V.A. Nguyen[2], Ch. Holliger[3], L. Strande[1]

Introduction

It is estimated that 2.5 billion people in low- and middle-income countries rely on onsite sanitation technologies. The majority of faecal sludge (FS) from these systems is directly discharged into the environment or used in agriculture without any treatment. The high pathogenic, organic and nutrient load in FS has a severe impact on public and environmental health. To alleviate this situation, the development of appropriate treatment technologies is required.

Several wastewater treatment technologies are being adapted and tested for the treatment of FS. Anaerobic digestion is commonly used for the treatment of wastewater sludge and seems promising for large scale FS treatment. Prior to reliable implementation, however, there is the need to better understand the variability, biodegradability and potential inhibitory compounds of FS. This involves assessing the effect of sampling methodologies on the variability of characterization results to allow for the efficient design of technologies. Also, laboratory experiments are required to understand fundamental treatment mechanisms.

Magalie Bassan

Photo 1: Core sample being taken from a septic tank.

PURR (Partnership for Urban Resource Recovery Project) is evaluating the potential of the anaerobic digestion of FS. Standard methods for sampling and laboratory analyses are being developed, and experiments are being conducted to better optimize the design and operation of anaerobic treatment of FS. It is expected that the results will be directly transferable and contribute to optimizing FS management technologies.

Evaluating reliable sampling methods

Standardized methods for sampling FS do not exist. This has likely contributed to the high variability that has been observed in previously conducted characterization studies. It also reduces the comparability of results, limits the understanding of the FS that will be delivered to treatment facilities, and prevents the optimized design of treatment plants. To address this, reliable sampling and characterization methods have to be determined. A field study was conducted in Hanoi in collaboration with FAQ – Faecal Sludge Quantification and Characterization (See pp. 12–13). FS samples were collected from households and evaluated, using the following five sampling methods:

1. A vertical profile sample taken directly from septic tanks with a core sampling device (See Photo 1);
2. A vertical profile sample taken directly from the access port at the top of vacuum trucks immediately following the collection of FS from septic tanks (See Photo 2);
3. Grab samples taken while the truck discharges the FS immediately following the valve opening (i.e., beginning of the discharge) (See Photo 3);
4. Grab samples taken at the mid-point of discharge;
5. A composite of grab samples taken at the beginning, middle and end of the discharge.

Each of these methods has advantages and limitations. Method 1 provides results on the FS in the septic tank, but, due to collection methods, this is not necessarily what will be transported to the FS treatment plant for treatment. Method 2 provides results on the actual FS collected in the truck that will be delivered for treatment, but opening the access port requires time and labour, and truck operators are not necessarily willing to do this. Methods 3 to 5 are hypothetically easy to do at discharge sites, and are also representative of the FS that would be discharged at the treatment facility. However, as there are not legal discharge sites in many countries, this method can also be complicated as truck operators will not necessarily allow samples to be collected during illegal discharges. Methods 3 and 4 are the easiest to implement, but it is not certain how representative they would be of the entire truck contents due to settling during transport. Method 5 would be more representative of the entire truck contents, but both methods 4 and 5 rely on the somewhat qualitative decision of determining the "mid-point" of discharge. This is more reliable when trucks have volume gauges.

Magalie Bassan

Photo 2: Sampling from the access port at the top of a truck.

Evaluating potential for anaerobic digestion of faecal sludge

The rates of anaerobic digestion and the performance of biological treatment technologies depend on how readily the organic matter in FS is degraded. In Hanoi, the majority of households empty their septic tanks on average every seven to eight years, and it is not known how stabilized the FS is in general. The characterization study being conducted in Hanoi with FAQ is addressing this. In addition to the standard parameters commonly analysed to assess solid and organic content, proteins, carbohydrates, lipids and fibers are also being analysed. The results will provide information on the biodegradability of the organic matter and, therefore, the potential for biological treatment, such as anaerobic digestion. Concentrations of volatile fatty acids, sulfates, and heavy metals are also being analysed, as they inhibit anaerobic digestion. Preliminary results indicate that the FS in Hanoi still has readily degradable organic matter in it and can be a good substrate for anaerobic digesters.

Magalie Bassan

Photo 3: Grab samples being collected at a discharge site.

Development of synthetic sludge for controlled laboratory experimentation

Due to the highly variable nature of FS, once reliable sampling methods are developed and the characteristics fully understood, there is still the need to develop methods to conduct controlled laboratory experimentation to understand the fundamental mechanisms of anaerobic digestion. With wastewater, research is commonly conducted with recipes of synthetic sludge to assess the effects of controlled treatment parameters and avoid the complication that arises from the variability of wastewater. Some researchers have developed recipes that represent the physical properties and solid content of FS and that mimic the soluble organic matter (Sung Ryong et al., 1986; Radford et al., 2013). However, recipes have not yet been developed to research the degradation mechanisms active in the biological treatment of FS. PURR is developing a synthetic recipe with the following objectives:

- To represent the FS characteristics that influence its biodegradation, including the main biological, physical and chemical characteristics,
- To represent the attachment sites for microorganisms on solid particles,
- To use components that are easily available, that can be controlled, and safe to use,
- To be easily reproducible, and rapidly prepared with simple equipment and material,
- To be adjustable to the characteristics of different FS.

Several compounds, such as hay flour and walnut, are mixed with tap water to represent the heterogeneous solids and recalcitrant and easily biodegradable organic matter, based on the analysed characteristics. The concentrations of total nitrogen and phosphorous are adjusted with ammonium carbonate and sodium phosphate. Other components, such as clay, can also be added to adjust the surrogate characteristics, and increase the content of non-biodegradable suspended particles. By varying the quantities of water and of each of the compounds, various characteristics can be represented, as shown in Table 1.

Parameter	Hay flour	Walnut
pH	6.6	7.4
TS (g/L)	18.4	19.3
TVS (g/L) (%TS)	16.4 (89 %)	18.4 (95 %)
TSS (g/L)	14.2	18.0
VSS (g/L)	13.4	17.8
COD (g/L)	12.5	33.5
SCOD (g/L)	3.2	1.6

Table 1: Recipe characteristics for synthetic FS prepared with tap water (to reach 1L volume) and 19g hay flour (second column), and 18.5g crushed walnuts (third column).

Conclusion

Further tests will be conducted to assess the representativeness of the synthetic sludge in terms of biodegradability during anaerobic digestion. These outputs will provide important solutions to test treatment and resource recovery technologies. PURR will use them to assess the feasibility of anaerobic digestion of FS in Vietnam and these results are expected to be useful for FS research in general. Guidelines will also be developed for sampling and characterization methods and on the use of synthetic surrogates in laboratory experiments to facilitate future research, as well as for the accurate design of treatment plants.

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[2] Radford, J.T., Fenner, R.A. (2013): Characterization and fluidization of synthetic pit latrine sludge. Journal of Water Sanitation and Hygiene for Development *3 (3)*, 375–382.

[1] Eawag/Sandec, Switzerland

[2] Insitute for Environmental Science and Engineering, Hanoi University of Civil Engineering

[3] Laboratory for Environmental Biotechnology, Ecole Polytechnique Fédérale de Lausanne

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Contact: magalie.bassan@eawag.ch, linda.strande@eawag.ch