

# Faecal Sludge to Fuel: A Financial Incentive to Improve Sanitation Services

FaME research has shown that dried faecal sludge can be used as an industrial combustible fuel. The revenue earned from its sale as fuel has the potential to be a game changer in terms of improving faecal sludge management services in Sub-Saharan Africa. Moritz Gold<sup>1</sup>, Ashley Murray Muspratt<sup>2</sup>, Charles B. Niwagaba<sup>3</sup>, Seydou Niang<sup>4</sup>, Papa Samba Diop<sup>5</sup>, Linda Strande<sup>1</sup>

## Introduction

In Sub-Saharan Africa, the sanitation needs of the majority of the urban population are met by onsite sanitation technologies. In order for these technologies to provide a sustainable sanitation solution, the FS that accumulates has to be collected and adequately managed. Currently, poor quality or non-existent collection, transport and treatment services lead to the discharge of untreated FS into the urban environment, causing serious environmental and public health problems. One reason for this is because the present sanitation service chain is financially unsustainable, with households in poor urban areas bearing the largest share of the costs. The goal of the SPLASH funded research project Faecal Management Enterprises (FaME) is to demonstrate how innovative solutions for resource recovery from FS could enhance and increase FS management services, improving public and environmental health in urban areas of Sub-Saharan Africa.

## Dried faecal sludge as an alternative fuel

Industries in urban and peri-urban areas, such as cement and brick companies, have high and expensive energy requirements. As energy demand rises and the reserves of the lowest cost fuels are depleted, fuel prices

rise, increasing the importance of alternative fuels. In the US and Europe, sludge from wastewater treatment is already used as an alternative fuel and transferring this knowledge to FS is one of FaME's main objectives. FaME research conducted in Kampala, Uganda; Kumasi and Accra, Ghana; and Dakar, Senegal; has demonstrated that dried FS has a calorific value competitive with alternative fuels already in use [1]. And the FaME market demand study identified that there is great market demand for alternative solid fuel products, especially in Kampala, where a variety of alternative solid fuels are in use [2].

## FS drying research

Because of its low solids content, FS must be dried to be efficiently used as a fuel, requiring the development of cost-effective drying methods. While research has shown that a net benefit from combustion can be obtained at 27% dryness [1], industries interviewed stated that their fuel has to be at 90% dryness. FaME set up a pilot-scale research facility in Dakar (See Photo 1) to research how to increase FS drying rates and reduce the required footprint of land required for drying beds [3]. This included greenhouses and experimenting with daily turning of the sludge. Preliminary results indicate that greenhouses can be effective if

they are actively ventilated, although in Dakar, they did not significantly improve the drying rate other than by providing rain protection. Yet, it is thought that further research will be able to adapt this technology and determine the optimal modes of operating greenhouses for FS drying. The daily turning of FS, however, significantly impacted drying rates in Dakar (See Figure 1). This reduced the drying time to achieve 90% dryness on average by around 25%, which corresponds to a reduction of the required land area by 25% and/or increased capacity.

## Dried faecal sludge characteristics for energy recovery

The calorific value of dried FS in Dakar was 12 MJ/kg TS [3] and this is lower than other FaME calorific value results [1]. This might be due to the high 42% ash content in the FS, which probably stems from Dakar's sandy soils and the local onsite sanitation technologies. Sand from the drying beds, for instance, is responsible for ~6% of the ash content. High ash content does not add to calorific value and is not desirable, depending on the fuel application. Installing screens and grit chambers at the inflow of the faecal sludge treatment plant could reduce the ash content, thereby increasing the calorific value.

Viable helminth eggs were quantified as an indicator of the hygienic quality of the FS and samples exceeded the values recommended by the WHO guidelines for agriculture use (WHO, 2006). However, a benefit of FS combustion is that risk exposure pathways would be greatly reduced. Ultimate and proximate analysis of dried FS samples collected in Dakar, Kampala, Accra and Mombasa to predict emissions from combustion and provide scientific data for informed decision making are ongoing.

## Pilot kiln studies

Pilot-scale kilns (See Photo 2) were built in Dakar and Kampala to demonstrate the technical feasibility of using dried FS as a fuel to industry stakeholders. In Dakar, results indicated that FS fuel has the potential to

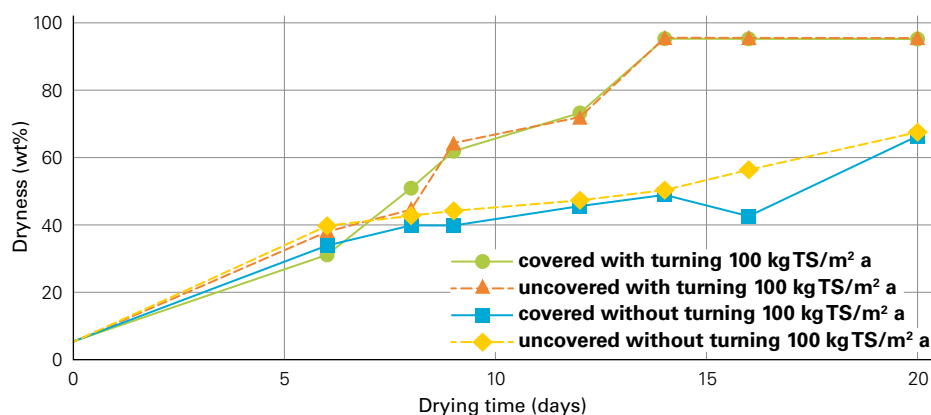


Figure 1: FS dryness over time from drying beds operated with and without greenhouses and with and without daily turning (Seck et al., submitted).

provide heat for a waste oil regeneration process, while in Kampala, a Hofmann kiln was used to test if the brick products produced were comparable in quality to those made from burning biomass fuels.

Temperatures between 174 and 261 °C were achieved in Dakar by burning 5 kg dried FS, and it exceeded 500 °C with an increased fuel load. FS pellets, briquettes and cakes were used. Except for the briquettes, the smoke and odour produced were minimal. In Kampala, temperatures between 150 and 1015 °C were achieved and tests showed that the brick strength was similar to products currently made by industry. Although many bricks were blackened by smoke and the kiln had irregular temperature distribution, these preliminary results are very promising and further optimization of kiln design and operation is ongoing [4].

### Financial research

FaME developed a financial flow model to evaluate the financial viability of FS treatment end products, and their associated economic costs and benefits. Results show that FS as a combustible fuel could produce revenues 2 to 35 times higher than selling it as soil conditioner for agriculture [4]. This additional revenue could partially or fully offset the treatment costs and/or be transferred to other stakeholders along the FS management service chain. This revenue stream could also lead to improvements in FS collection and transport services.

### Conclusion

FaME has demonstrated the technical viability of using FS as a combustible fuel in in-



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Photo 2: Pilot-scale kiln for brick production in Kampala (left) and for waste oil regeneration in Dakar (right).

dustrial kilns. Depending on the local market, this enduse can provide high revenues and hence increase FS management services. Tapping this revenue potential would require increasing and improving FS collection and transport services, which would lessen the environmental and public health impact of FS, as well as developing treatment systems to scale up FS fuel production.

Co-processing FS with other waste streams could also increase capacities for resource recovery and the overall efficiency of the treatment and end use process. The upcoming SEEK (Sludge to Energy Enterprises, Kampala) Project will pilot innovative pelletizing and gasification technologies with the goal of developing off the shelf applications for urban waste management and resource recovery.

- [1] Muspratt, A.M., Nakato, T., Niwagaba, C.B., Dione, H., Kang, J., Stupin, L., Regulinski, J., Mbéguéré, M., Strande, L. (2014): Fuel potential of faecal sludge: Calorific value results from Uganda, Ghana and Senegal. *Journal of Water, Sanitation and Hygiene for Development*, 4(2), 223–230. ([http://www.eawag.ch/forschung/sandec/publikationen/ewm/index\\_EN](http://www.eawag.ch/forschung/sandec/publikationen/ewm/index_EN))
- [2] Diener, S., Semiyaga, S., Niwagaba, C.B., Murray Muspratt, A., Gning, J.B., Mbéguéré, M., Ennine, J.E., Zurbrügg, C., Strande, L. (2014): A value proposition: Resource recovery from faecal sludge – Can it be the driver for improved sanitation? *Resources, Conservation & Recycling*, 2014, 88 (1), 32–38. ([http://www.eawag.ch/forschung/sandec/publikationen/ewm/index\\_EN](http://www.eawag.ch/forschung/sandec/publikationen/ewm/index_EN))
- [3] Seck, A., Gold, M., Niang, S., Mbéguéré, M., Strande, L. (submitted): Technology development of unplanted drying beds for resource recovery from faecal sludge: fuel production for Sub-Saharan Africa.
- [4] Gold M., Niang S., Niwagaba C.B., Eder G., Murray Muspratt A., Diop P.S., Strande L. (2014): Results from FaME (Faecal Management Enterprises) – Can dried faecal sludge fuel the sanitation service chain? (37th WEDC International Conference, Hanoi, Vietnam, 2014)



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Photo 1: FaME pilot-scale drying bed research facility in Dakar, Senegal.

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