Faecal sludge to fuel: revenue to improve sanitation services

Cities in sub-Saharan Africa grapple with the management of faecal sludge from on-site sanitation technologies. There is a lack of funding for sanitation services, resulting in the dumping of faecal sludge directly in the urban environment. Revenues generated from using dried faecal sludge as a combustible fuel in industries could provide an incentive to improve faecal sludge collection, transport and treatment services. *By Moritz Gold and Linda Strande*

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Fig. 1: Sanitation needs for most urban residents in sub-Saharan Africa are met by on-site sanitation technologies such as pit latrines and septic tanks.

In Switzerland, 97 per cent of households are connected to a sewer conveying domestic wastewater to a centralized treatment plant. But disposal systems of this kind require large amounts of water and energy as well as skilled operation and continuous maintenance. In Switzerland, the total costs of sanitation are CHF 1.69 billion per year, or CHF 232 per person [1]. Such infrastructure is not feasible in low-income countries, and a billion people worldwide lacking access to sanitation have to defecate in the open. Another 2.7 billion people use on-site sanitation technologies such as pit latrines or septic tanks, which are not connected to a sewer [2]. These kinds of facilities are more affordable than sewer-based systems and can provide sustainable sanitation if they are well managed [3]. This includes collection, transport, treatment and safe end-use or disposal of faecal sludge, the waste accumulating in on-site sanitation technologies, once they become full (Fig. 2) [4].

Market demand for faecal sludge treatment products

Because appropriate management is too expensive for all the different stakeholders along the service chain, with households bearing the largest share of the costs, the current reality in most cities of sub-Saharan Africa is that faecal sludge is dumped directly in the urban environment [3]. In the Faecal Management Enterprises (FaME) Project, Eawag collaborated with local partners to develop innovative approaches to improve sanitation services in sub-Saharan Africa. In particular, we have identified markets and demands for end-products from faecal sludge treatment. In Dakar (Senegal), Kampala (Uganda) and Accra (Ghana), we investigated whether – in terms of energy potential and technical feasibility – dried faecal sludge could be used as an industrial solid fuel.

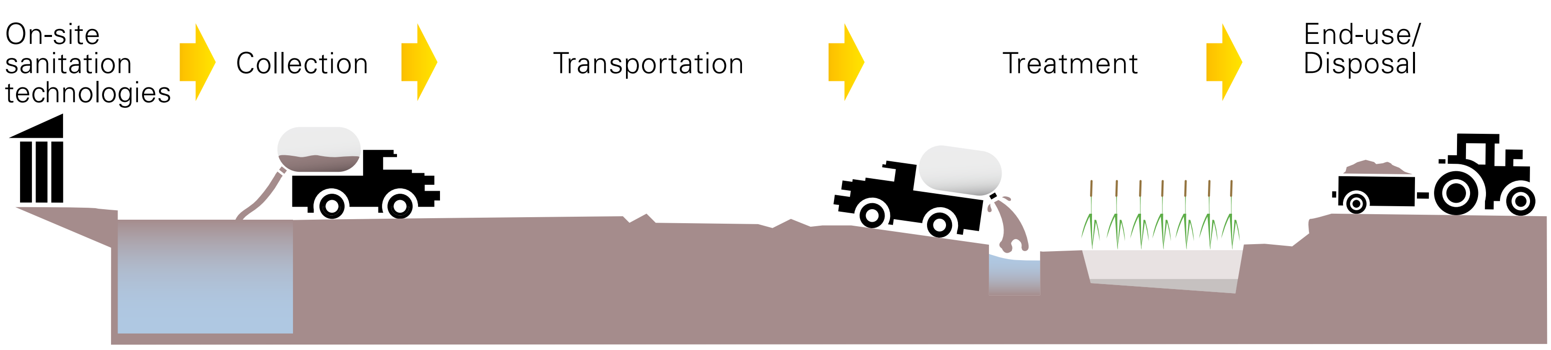

Fig. 2: From collection to end-use or disposal, sustainable sanitation requires a functional faecal sludge management service chain [5].

In the three cities, FaME research identified markets for faecal sludge treatment end-products – dried faecal sludge as a solid fuel, as a source of organic matter to produce protein for animal feed, as a source of biogas and as a component in building materials. Although farmers throughout the world have used faecal sludge in agriculture, the current usage in Dakar, Kampala and Accra is very minimal. The other end-products are not currently used, but showed strong potential for generating increased revenues. The market potential, however, depends on local factors, such as faecal sludge characteristics, existing markets, local industry requirements, legal regulations, subsidies and locally available materials [6].

Industries such as cement and brick companies have high and expensive energy requirements and are pervasive in cities of sub-Saharan Africa. The lack of energy generation capacity creates the need for alternative fuels such as waste oil and coffee husks. Industries in the three cities rely on a variety of fuel sources which could potentially be substituted or supplemented with dried faecal sludge. The companies surveyed in Dakar and Accra mainly use electricity or liquid fuels (diesel, heating oil or kerosene) for energy. In Kampala, many companies use solid fuels, indicating the market potential for combustion of dried faecal sludge. 45 per cent of the respondents expressed an interest in immediately switching to this type of fuel if it met their process requirements [6].

Dried faecal sludge is a viable fuel

In the US and Europe, sludge from wastewater treatment is already used as an alternative solid fuel. The question of how this experience can be transferred to faecal sludge and the context of sub-Saharan Africa was addressed in the technical feasibility component of the FaME project. In contrast to wastewater sludge, the calorific value of faecal sludge was not previously known. Therefore the energy potential of faecal sludge was analysed based on samples collected from pit latrines, septic tanks, anaerobic ponds and drying beds. The average calorific value was 17.3 megajoules per kilogram of dry solids; in this respect, faecal sludge is comparable to wastewater sludge and can compete with local biofuels such as coffee husks, rice husks and sawdust (Fig. 3). The three cities produced similar results. The calorific value was found to be reduced by anaerobic treatment [7].

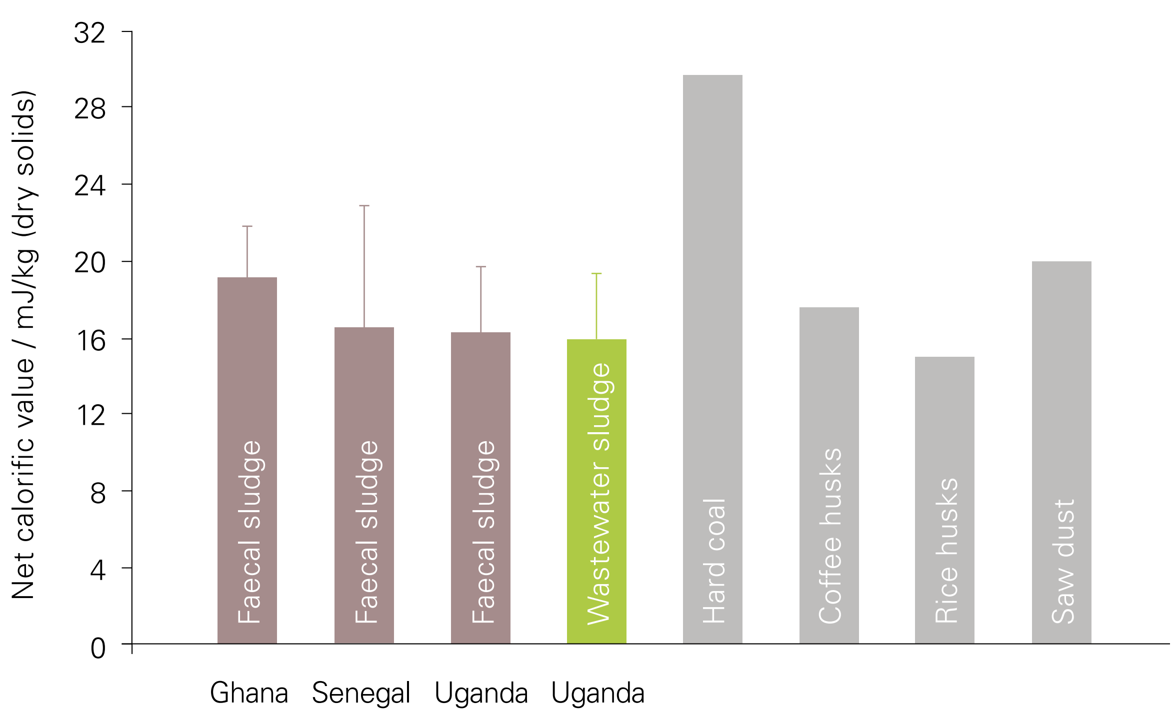

Fig. 3: Average net calorific value of raw faecal sludge and wastewater sludge compared to hard coal and biofuels [7].

If faecal sludge is to be used as a solid fuel, efficient and cost-effective drying methods are required. While research has shown that a net benefit from combustion can be obtained at 27 per cent dryness [7], the companies surveyed indicated a demand for fuels with 90 per cent dryness. At an experimental facility in Dakar, we therefore evaluated how faecal sludge drying can be increased with drying beds (Fig. 4). First results indicate that storage in actively ventilated greenhouses is an effective method. But in the arid climate of Dakar, this in itself did not significantly improve the drying rate, even though it provided protection against rain. Daily turning of faecal sludge did, however, significantly increase drying rates, with over 90 per cent dryness achieved in 20 per cent less time (Fig. 5).

The average calorific value of faecal sludge dried at the experimental facility in Dakar was 12 megajoules per kilogram of dry solids. This was lower than the overall average (Fig. 3), most probably on account of the high content of ash (42 per cent) which does not contribute to the calorific value. High ash contents are therefore generally not desirable. In Dakar, the ash content is a result of the disposal of solid household wastes and the sandiness of local soil. In addition, sand from the sand filter layer of the drying beds sticking to faecal sludge removed from the beds accounted for 6 per cent of the ash content [8]. The ash content of faecal sludge could be reduced by screens and grit chambers at the inflow of treatment plants.

End-use of inadequately treated faecal sludge can pose risks to public health. In Dakar, for example, dried faecal sludge contained still pathogenic germs and eggs of parasites. The content exceeded the values recommended in the WHO guidelines for safe use of wastewater and excreta in agriculture [9]. However, an additional benefit of use of faecal sludge for a combustion fuel is that human health exposure pathways are greatly reduced.

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Fig. 4: Pilot-scale drying beds were used to investigate innovations to increase drying of faecal sludge.

Successful application of fuel in pilot kilns

Dried faecal sludge has never been used as a solid fuel in industries. As part of the FaME project, therefore pilot-scale kilns were constructed in Dakar and Kampala to demonstrate the technical feasibility of using faecal sludge as a solid fuel for industrial purposes (Fig. 6). In Dakar, the results indicated that this fuel has the potential to provide sufficient heat to contribute to a waste oil regeneration process. With the combustion of 5 kilograms of dried faecal sludge, temperatures between 174 and 261°C were achieved, and with an increased fuel load they exceeded 500°C. The Hofmann kiln in Kampala, which was operated at 800°C, produced bricks comparable in quality to those made using other biomass fuels [10]. Both pilot facilities thus met the demands of local industrial partners.

A financial flow model was implemented to evaluate the potential revenue generation from

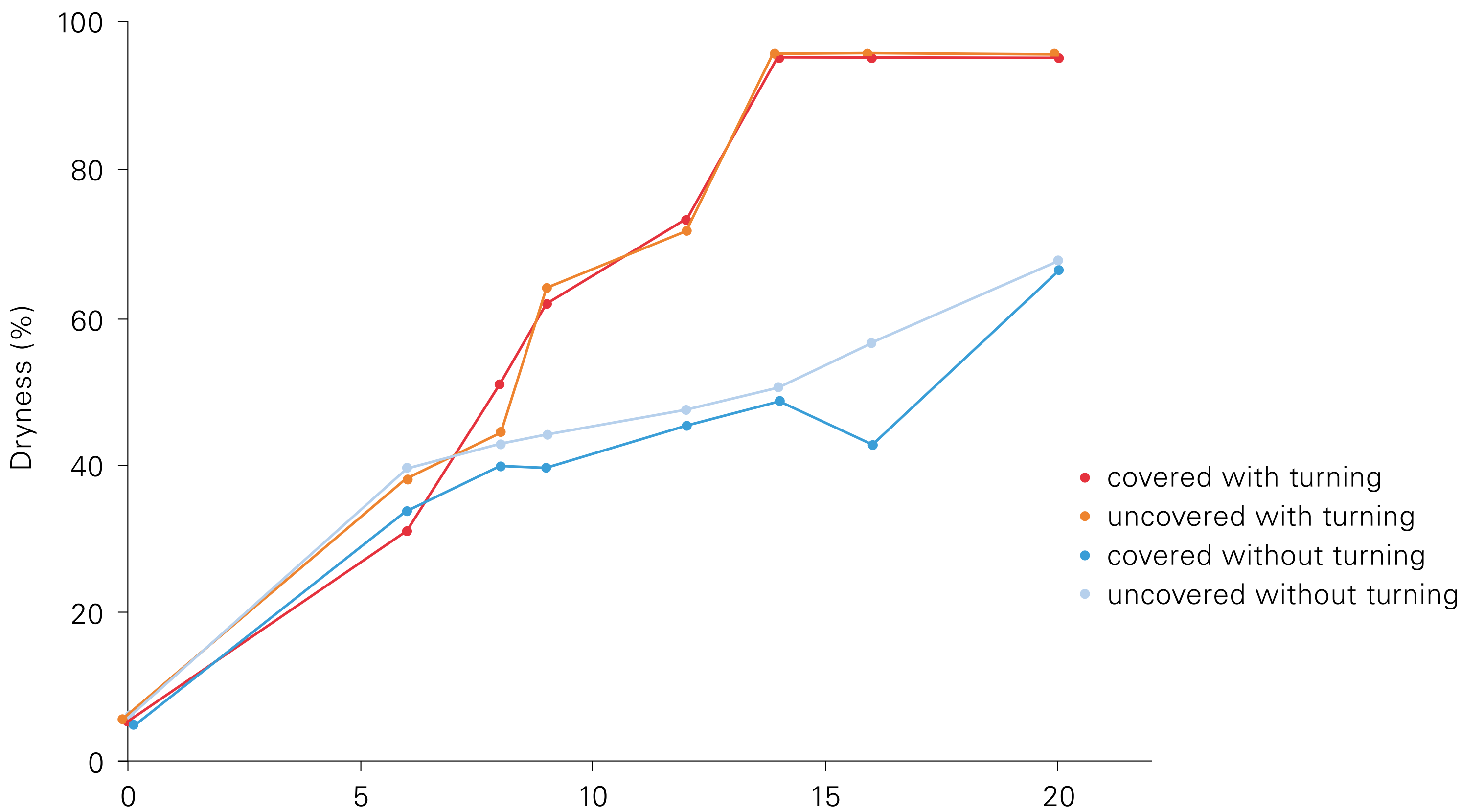

Fig. 5: Faecal sludge dryness over time with and without daily turning. The drying beds were loaded with 100 kg of thickened sludge per m^2 and year [8].

faecal sludge treatment products, and potential costs and benefits throughout the service chain. It was shown that, based on current commercial prices, the production of combustible fuels could generate revenues 2–35 times higher than the sale of faecal sludge as a soil conditioner [10]. The wide variation is due to the conditions prevailing in the different local markets studied. The additional revenue could provide an incentive for public or private operators to build up an effective faecal sludge management system, with treatment costs being at least partly offset. The revenues could also be used to reduce collection and transport fees for households reducing discharge fees at treatment plants.

Tapping this revenue potential requires increasing and improving faecal sludge collection and transport services as well as developing treatment systems to scale up faecal sludge fuel production. The generated revenue could fund improvements throughout the service chain, reduce dumping of faecal sludge in the environment, and increase public and environmental health. The FaME project has demonstrated that this is both technically and financially viable. With the new SEEK project (Sludge to Energy Enterprises in Kampala), Eawag and its partners are now continuing their research on faecal sludge to energy. The aim is to study co-processing of faecal sludge and other urban organic waste streams to produce fuel pellets and with these electricity through gasification. Updates on current research can be found on the Sandec website (www.sandec.ch).

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Fig. 6: Pilot-scale kilns fuelled by dried faecal sludge were used for brick production in Kampala (left) and waste oil regeneration in Dakar (right) [10].

>> Further information on the FaME project
>> Interview in «Water21»
>> Faecal Sludge Management book

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