Financing Sanitation: Resource Recovery from Faecal Sludge in Sub-Saharan Africa

Revenues related to resource recovery from faecal sludge treatment products could provide a financial incentive to enhance faecal sludge management services.

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Abstract

Without a developed sewer system, the majority of the urban population in Sub-Saharan Africa remains dependent on onsite sanitation technologies. Rapid population growth is increasing pressure on these already very inefficient systems, resulting in a large amount of faecal sludge being dumped untreated into the environment. Without sufficient capacities of faecal sludge collection, transport and treatment, faecal sludge is seriously threatening public and environmental health. The lack of financial incentives is often seen as one of the main reasons for malfunctioning faecal sludge management. Providing incentives and cash-flow to be re-invested in order to enhance the service chain, requires to understand how value can be created from faecal sludge treatment products. In cities such as Accra, Dakar and Kampala, investigations through financial modelling showed that financially sustainable production of faecal sludge treatment products is possible under certain conditions. Modelling results are thereby intended to support strategic decisions in urban sanitation planning.

Background

In many fast growing cities throughout Sub-Saharan Africa, population growth is increasing pressure on sanitation services. While onsite sanitation technologies are most commonly used to meet sanitation needs of the urban population, inefficient faecal sludge management services result in large amounts of faecal sludge being dumped untreated into the urban environment. Poor collection and transport services are working in an uncontrolled manner, often too expensive for poor households, which are left with no option but to abandon their onsite sanitation facility as in Figure 1, or employ manual faecal sludge collector, which frequently results in dumping of the the collected faecal sludge into the immediate environment (Günther et al., 2011). But even where onsite sanitation technologies are accessible

Key findings:

- Identified inefficiencies along the poorly working faecal sludge management service chain could be overcome by providing incentives and cash-flow from selling dried faecal sludge as a solid fuel to industries.
- It is presumed that the financially sustainable production of faecal sludge treatment products is possible under the conditions that treatment capacities are created or increased, households are financially supported and mechanical collection and transport businesses receive assistance, also implementing innovative ways of increasing the accessibility of onsite sanitation facilities in dense urban settlements.
- Kampala's current faecal sludge treatment capacity holds a revenue potential of an estimated USD 54,000 per year, if dried faecal sludge was sold at an industrial pick-up price of USD 15 per tonne. Meanwhile, if a faecal sludge treatment plant was realised in Accra, it could annually generate around USD 781,000 at current levels of supply, selling the product to a plastic factory that expressed interest at approximately USD 85 per tonne. In Dakar, project-internal research conducted in 2012, indicated that the volumes discharged at the faecal sludge treatment plants could produce revenues of around USD 90,000 annually if sold for about USD 59 per tonne. Industrial revenues have hereby shown to be about 2 to 17 times higher than revenues from selling dried faecal sludge to farmers for agricultural use.
- Industries will only be interested in using dried faecal sludge in their production process, if supply could be guaranteed at an improved level of quantity and quality

Figure 1: Abandoned toilet in an informal settlement in Kampala.

Figure 2: Faecal sludge discharge at the Bugolobi waste water treatment plant in Kampala.

and households can afford mechanical collection and transport, there is often only insufficient treatment capacity available, Figure 2 hereby showing how faecal sludge is inappropriately dumped at the waste water treatment plant in Kampala. The lack of appropriate collection, transport and treatment is posing a serious threat to public and environmental health (Blackett et al., 2014).

Accra is presenting itself in an especially dark light without any faecal sludge treatment capacity available (Ackon, 2013). Currently, collected but untreated faecal sludge is dumped at a central discharge point into the sea. A high dependency on expensive public toilets (GSS, 2013) is forcing over 10% of the population (Harris, 2013) to resort to open defaecation, further polluting the immediate environment. In Kampala on the other hand, the construction of the first faecal sludge treatment plant can be observed in Figure 3. An enlargement of at least half of its current capacity, would though be required to meet the estimated volumes of faecal sludge that could currently be delivered. In Dakar, once realised, rehabilitation of the existing faecal sludge treatment plants could enable treatment of capacities that exceed the estimated volumes of collected faecal sludge.

Faecal sludge collection and transport services are furthermore limited by low accessibility of dense urban settlements and inefficient mechanical emptying technologies, unable to collect all of the material settled in the onsite sanitation technology (Chowdhry and Koné, 2012).

A lack of financial incentives is often seen as one of the main reasons for the malfunction of faecal sludge management (Steiner et al., 2003).

While cities seem to struggle with the amount of faecal sludge required to be collected, delivered and treated to secure a safe living environment, rising prices for combustibles are forcing industries to search for fuels available at sufficient quantity and quality.

The FaME Project

With respect to the above mentioned circumstances, a project consortium joined forces to launch the Faecal Management Enterprises (FaME) project. This project aims to develop solutions for scalable end-use oriented faecal sludge management, that provide a financial drive in order to enhance service along every step of the value chain. The focus was hereby laid on the Sub-Saharan African cities of Accra (Ghana), Dakar (Senegal) and Kampala (Uganda).

The FaME market demand study showed that untapped markets exist for faecal sludge treatment products (Diener et al, 2014). Energy producing options showed the highest market potential. The FaME calorific value study indicated that dried faecal sludge has a calorific value competitive to other solid biomass fuels, which was demonstrated for two industrial applications (Murray Muspratt et al. 2014).

Figure 3: Drying beds in construction at the new faecal sludge treatment plant in Kampala.

The financial viability of end-use of dried faecal sludge was then assessed together with the broader economic costs and benefits of this process, showing the financial potential of this untapped market. End-use as soil conditioner or as solid fuel, were hereby chosen as two innovative ways of resource recovery that responded well to the market demand for treatment products.

Throughout the entire project, the research findings were disseminated to decision makers and other stakeholders, including the aim to raise interest of industrial users, as in progress in Figure 4.

Financial Flow Modelling Approach

As part of the FaME project a consortium led by hydrophil GmbH aimed to develop a tool that can be used to evaluate the financial viability of end-use oriented faecal sludge management with respect to the broader economic costs and benefits. Therefore an end-use oriented financial flow model was developed, adapted and implemented for the three cities of Dakar, Accra and Kampala.

The financial viability of faecal sludge products was analysed, based on a generic stepwise approach set out in Figure 5:

Figure 4: Raising interest of industrial users for alternative biomass fuels in Kampala.

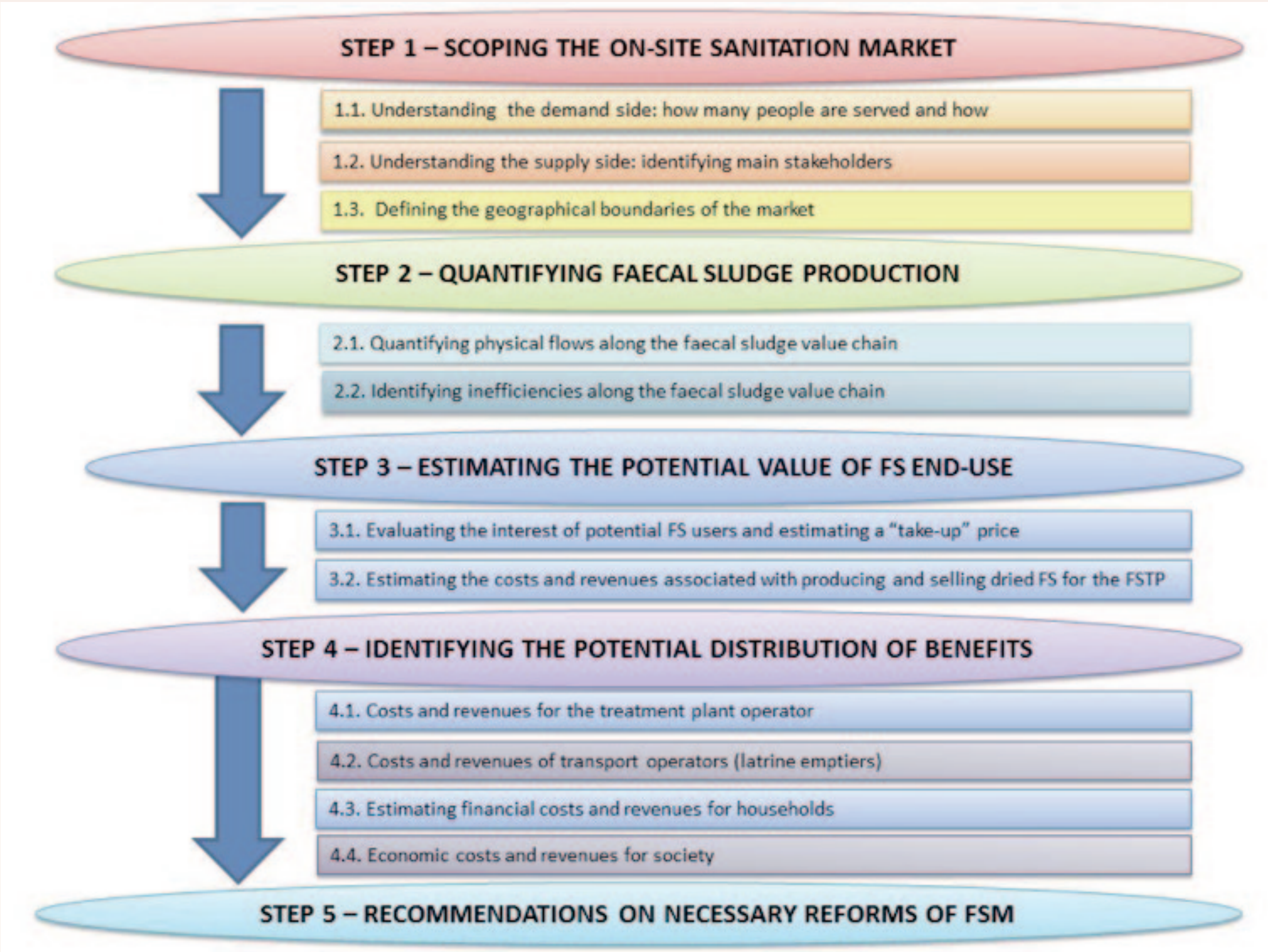

Figure 5: Approach to evaluating the potential value of faecal sludge end-use (Bäuerl et al., 2014a).

The analysis was hereby conducted with data from an in-depth literature research, referring to scientific articles and surveys, as well as reports from local and national institutions, official authorities' development plans or project-internal pieces of work. As reliable data or sufficient information was not always available and finances are perceived as a sensitive issue, semi-structured interviews with key stakeholders were conducted additionally. These represent a sensitive method of investigation, allowing to receive more detailed information and better understanding the prevailing circumstances (Davis Case, 1990). Local FaME project partners hereby helped to identify the most important key stakeholders.

The expert team then included the received data into an excel-based financial flow model, hereby basing their decisions and estimations on their long-term experience within the field of sanitation and economics, as well as benchmarks of other countries or projects.

Based on the collected data, the analysis was then conducted in the following steps:

1. Establishing the frame under economic and financial assumptions, including a reasonable pick-up price for the product;
2. Quantifying the amount of faecal sludge that is produced onsite and then carried along the service chain to reach the designated faecal sludge treatment plant and hence would be available for valorisation through end-use;
3. Estimation on the potential revenue from valorisation of faecal sludge end-products for different scenarios, including a "business as usual" scenario;
4. Identifying the potential distribution of these revenues among the stakeholders to see whether the establishment of a financially sustainable service chain is feasible;

As no complete or reliable data on costs of faecal sludge treatment could be collected in the investigated cities, a full viability calculation for this section of the value chain could not be performed. A sensitivity analysis was therefore conducted for different volume-scenarios. Based on the results, recommendations which could help to increase financial flows from end-use were then formulated.

Specific guidance on how to use the developed financial flow model is presented in Annex 1 of the project report, available for download under: http://www.tremolet.com/publications/report-financial-viability-faecal-sludge-end-use-dakar-kampala-and-accra

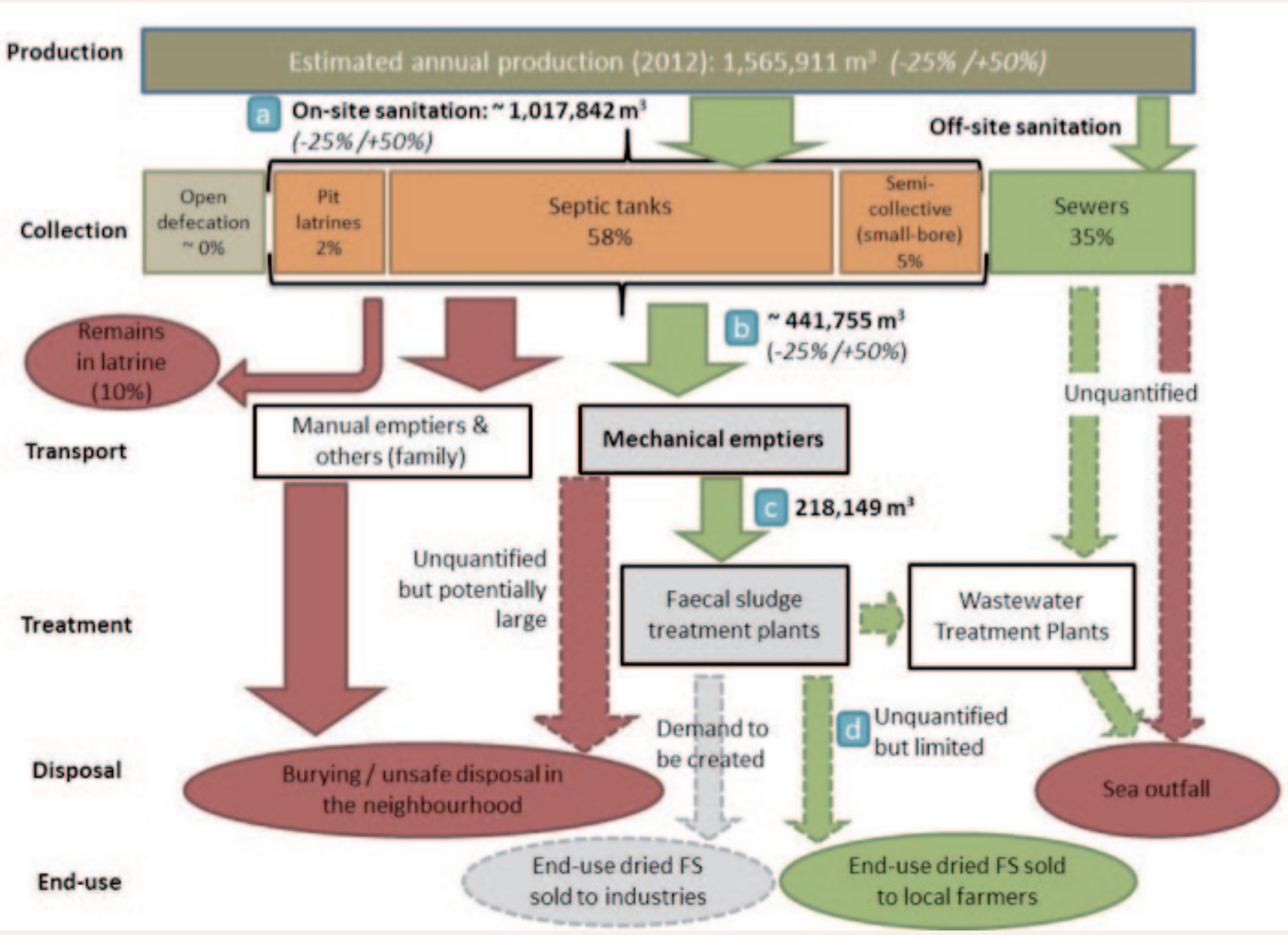

Figure 6: Flow of faecal sludge (in m³/a) along the faecal sludge management service chain in Dakar, Senegal (Bäuerl et al., 2013b)

Results from the Analysis

As a representative example of the results, Figure 6 shows the volumes of faecal sludge along the faecal sludge management service chain of the most certain scenario used as a reference in Dakar.

The analysis of volumes and cash-flow along the faecal sludge management value chain, revealed the following inefficiencies that avert a potentially viable system:

- Unavailability of sanitation technologies. In Accra, up to 40% of the population are still dependent on expensive public toilet services (GSS, 2008), while almost 11% still have no access to sanitation facilities (Harris, 2013). Therefore people have to resort to open defaecation, which makes the produced volumes unavailable for end-use.
- Inaccessible onsite sanitation technologies. A large amount of onsite sanitation facilities remain inaccessible for mechanical emptying. Hence households have to abandon their facilities, once they fill up or employ a manual scavenger who would then presumably dump the matter into the immediate environment (Günther et al., 2011).
- Inefficient faecal sludge collection. Poor organisation of expensive mechanical collection services averts the efficient collection of faecal sludge throughout the city. Furthermore emptying technologies used are not advanced enough to empty the settled material at the bottom of the pit, causing many facilities to fill up faster and requiring more frequent emptying.
- Insufficient treatment capacities. In Accra no treatment capacity is currently available, while Kampala and Dakar are only providing treatment for a part of the faecal sludge volume that could actually be collected and delivered.

Potential revenues

At present it was not possible to identify immediate industrial interest for faecal sludge product in any of the three cities. This is most likely due to the fact that the supply of dried faecal sludge could not be guaranteed at the level of quantity and quality required by the industries. Hence companies are not willing to make initial investments for the adjustment of their combustion process.

Still, based on estimated industrial pick-up prices, financial modelling indicated the potential of different revenue scenarios. The preliminary price quote was hereby set at half of the price of the fuel in relation to their calorific value, to imitate a realistic market scenario and make the process more attractive for industrial users.

At current levels of 1,455m³/d being delivered to the dumping site in Accra (Anum, 2013), an annual revenue of USD 781,000 was calculated, assuming that a tonne of dried faecal sludge could be sold for USD 85. The content of total solids was set at 22 g/l, based on field test conducted for the project in Kumasi and the statistical distribution of sanitation facilities in the city (GSS, 2008). Given that the planned faecal sludge treatment plant is realised with a capacity of 626,000 m³/a (Kabe, 2013), revenues could rise by half.

Sales of current faecal sludge volumes of 697 m³/d delivered to the faecal sludge treatment plants in Dakar could generate around USD 90,000 annually, if sold to industrial users for USD 59 per tonne and given an amount of 7 g/l of total solids, which was indicated by a project-internal study at the Cambérène faecal sludge treatment plant in Dakar. The industrial use would hereby allow to generate revenues 17 times higher than if sold to farmers as soil conditioner for around USD 4 per tonne (Diener et al., 2014). If the old and inefficiently operating faecal sludge treatment plants were successfully rehabilitated to reach a capacity of 1,360 m³/d, revenues around USD 176,000 could be generated.

Fully established, the treatment capacity in Kampala allows to treat 125,200 m³ annually, selling at a price of USD 15 to industries or USD 8 to farmers (Diener et al., 2014) thereby creating revenues of USD 54,000 or 29,000 respectively. These calculations further refer to an amount of 29 g/l of total solids (KSP, 2008). These revenues could be about four times higher if all faecal sludge produced was effectively collected and delivered to a faecal sludge treatment plant of sufficient capacity, given an estimated overall mechanical collection of 212,000 m³/a (Matuvo, 2013).

Mentioned revenues could significantly offset operational costs of the faecal sludge treatment plants and outweigh government subsidies or household fees. The revenue could also be reinvested to increase the efficiency of faecal sludge management, resulting in an overall improvement of environmental and public health.

Required Measures

Following measures have been identified to have the biggest potential in increasing the faecal sludge valorisation potential:

Create and increase treatment capacity

The lack of a functional faecal sludge treatment plant in Accra, as well as current treatment capacities in Dakar and Kampala, do not seem to allow producing enough dried faecal sludge to raise the interest of big industries like clay or cement factories. Accra is planning to build a large faecal sludge treatment plant that could treat estimated future amounts of faecal sludge collected, while Kampala is aiming to increase its current treatment capacity to 40% of what is produced, through another small faecal sludge treatment plant. In Dakar rehabilitation of the

Figure 7: Delivery of mechanically emptied faecal sludge in Dakar, Senegal (picture credits to Sophie Trémolet)

faecal sludge treatment plants should increase capacities to 96% of faecal sludge that is currently discharged at the faecal sludge treatment plants, as can be observed in Figure 7. In all cases the production of more dried faecal sludge through the introduction of larger and more efficiently working treatment plants, would be required to attract big businesses. Clay and cement factories have hereby shown to provide a fuel demand that could have a significant financial impact on the process. If a long-term supply of dried faecal sludge at sufficient quality and quantity could be assured through proper operation and maintenance, it is likely that the cities hold the capacities to meet the fuel-demand of larger businesses. Of course, onsite conditions would have to be assessed individually and the combination of several smaller industries could also present a solution.

Support mechanical emptiers businesses

Mechanical collection and transport services are inefficient in various ways. Improving the overall performance of these systems would require support on all levels in order to increase the amount of faecal sludge that is actually collected and reaches the designated site.

Heavy traffic and high distance-related costs to the faecal sludge treatment plants pressure many collectors to dump closer elsewhere. These costs could be reduced through enhancing logistics e.g. through truck routing, zoning the city for different operators or establishing centralised bidding systems through mobile phones. Transport costs could furthermore be reduced if technologies were implemented that allow to empty the solidified matter on the bottom of the systems, avoiding to add dilution water. Such technologies would also substantially increase the biomass portion and hence the energy content per trip, which in turn would raise the cash value of the load if it were hypothetically paid by the treatment plant.

Besides improving logistics, lowering discharge fees or outright payment for faecal sludge at treatment plants could incentivise more emptiers to deliver the collected faecal sludge to the facility. Paying trucks for the delivery of faecal sludge would most likely efficiently close the gap between collection and treatment, but it seems difficult as a quality-dependent check and payment system would have to be established.

Increase accessibility of dense urban settlements

Dense informal settlements being home to a major proportion of the population served by onsite systems, it is essential to make these systems accessible for mechanical emptying at a price that poor households can afford. Preventing uncontrolled manual emptying and the abandonment of sanitation facilities is not only essential to make the volumes available for valorisation through end-use but also to secure a safe living environment. Innovative emptying technologies such as VacuTugs or Gulpers (visible in the centre of Figure 8) should therefore be supported as they would allow collecting faecal sludge from dense settlements. The implementation of innovative emptying technologies, as well as the establishment of small profitable businesses behind it (Sudgen, 2013) would through require even more support from local authorities and NGOs.

Financially supporting households

Employing a mechanical emptier poses a major financial burden to many poor households. Under certain modelling assumptions, it is shown that a poor household in Dakar would annually have to spend between 1.5% and 4.5% of their income (dependent on the number of required emptyings per year) (Mbeguere et al., 2011). In Accra the annual emptying costs for poor households amount to about 0.7% of their annual income, while extremely poor households would have to spend about 1% (Wassel et al., 2005). In Kampala a poor tenant's monthly household income of about USD 39 equals the costs of one mechanical emptying service (Günter et al., 2011).

Additionally, in places such as Dakar where inadequate septic tank designs and high water tables lead to a higher frequency of required emptying, financial support should be given to poor households to build improved systems. Again, this could increase the concentration of total solids within the collected faecal sludge. Micro-loans pose a potential financing solution, based on the assumption that savings would be created by reducing the required emptying trips. In Accra and Kampala increasing the amount of private toilets could also increase the concentration of total solids within the collected faecal sludge.

Financing the Reforms

Funds to improve faecal sludge collection, transport and treatment, cannot initially be provided through revenues of selling dried faecal sludge to industries, but referring to the fact that the enhancement of the sanitation system could (partly) offset the costs of inadequate sanitation

Figure 8: Delivering faecal sludge that has been emptied with a Gulper

for society, initial investments could be financed through public money or cross-subsidies from other services. Only once a reliable industrial demand for faecal sludge has been established, could the costs be carried by the revenues themselves. Another option would be to provide dried faecal sludge for free during an initial testing phase, giving industries the chance to realize the benefits without bearing extra-costs. However, further research should be conducted to increase the energy content of dried faecal sludge and allow to produce faecal sludge in any form that would be demanded by users. Interesting research is also provided by the question of how faecal sludge could be co-processes with other waste streams in order to increase fuel quantities.

Acknowledgement

The FaME project was conducted by an international consortium of researchers, consultants and practitioners. hydrophil GmbH herewith wants to express special thanks to their project partners the Swiss Federal Institute of Aquatic Science and Technology, Zurich (eawag), Waste Enterprisers Limited, the National Sanitation Utility of Senegal (ONAS), the University of Makerere, Uganda and the Cheikh Diop University, Senegal for their great cooperation. The project was funded through SPLASH, the European Union Water Initiative Research Area Network (EUWI ERA-net). For more information please visit www.sandec.ch/fame.

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