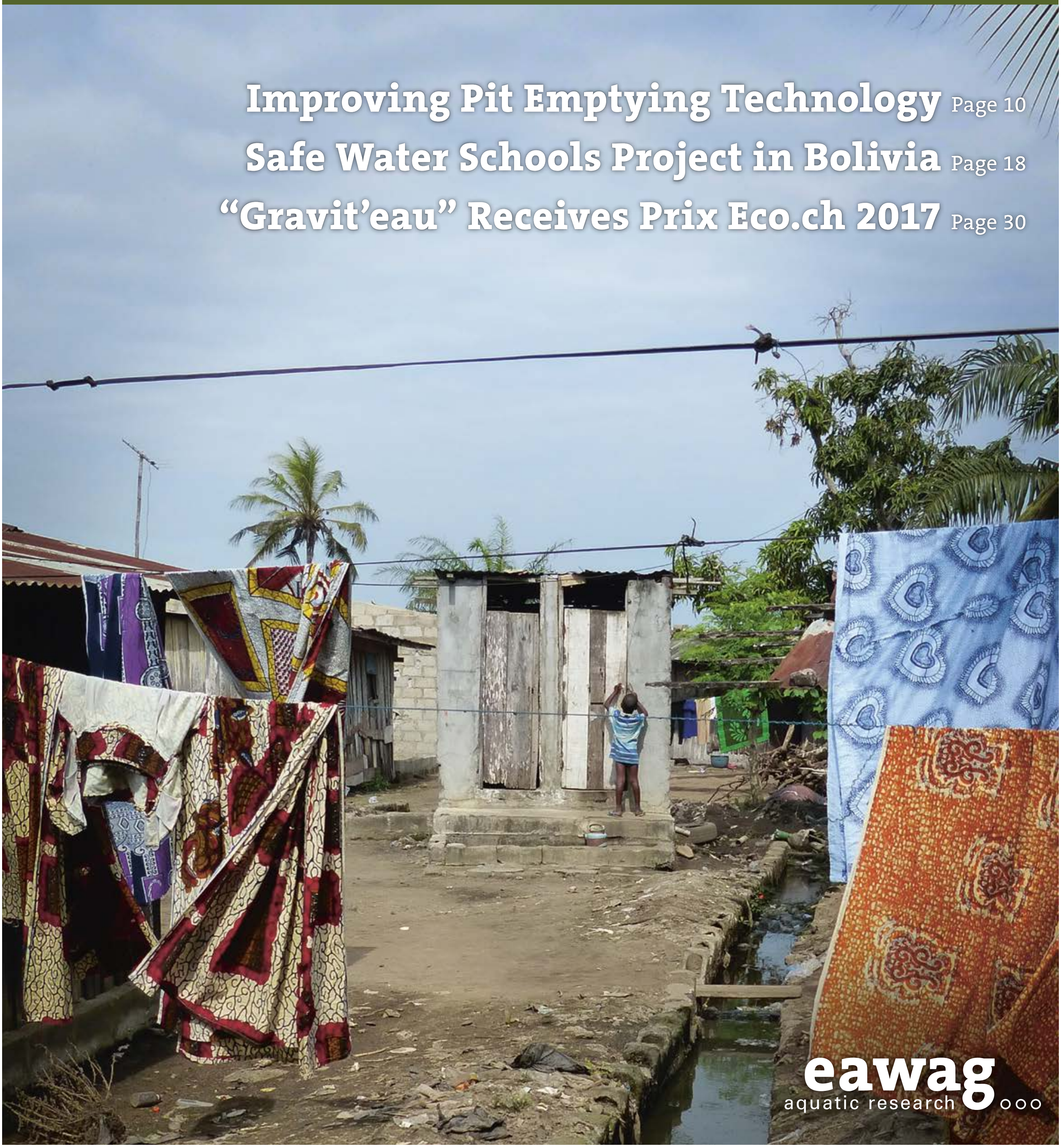
No. 18
07/17

Sandec: Department of Sanitation, Water and Solid Waste for Development

sandec news



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Sandec
Sanitation, Water and Solid Waste for Development

Publisher: Eawag, 8600 Dübendorf, Switzerland, Phone: +41 (0)58 765 52 86
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Publication: Sandec News is published once a year and is free of charge. It is available as a printed copy or it can be downloaded as a pdf file from our homepage, at www.sandec.ch.

Cover: Low-income neighbourhood in the city of Grand-Bassam, Côte d'Ivoire (Photo: Philippe Reymond)

Layout and figures: Lydia Zweifel, Eawag

Photos: All photos are from Sandec if not mentioned otherwise.

Printer: Mattenbach AG, Winterthur, Switzerland

Circulation: 3 500 copies printed on original recycled paper

New subscribers: Please contact caterina.dallatorre@eawag.ch

ISSN 1420-5572

Eawag: Swiss Federal Institute of Aquatic Science and Technology

Meeting Future Education Needs For WASH

“Our MOOCs are powerful educational tools, reaching thousands of students and practitioners in Africa, Asia and Latin America.”

Ten years ago, we began working on the first edition of the Compendium for Sanitation Systems and Technologies and finished just in time for the 2008 International Year of Sanitation. We saw a need for this document as there were few publications that acknowledged and gave equal space to all technologies on the development spectrum – especially the non-sewered options.

Sandec’s Compendium became an instant success and is now in its 2nd (English) edition. Since 2008, it has been translated into six languages and the Arabic version has just recently been published. 2017 will be another “Compendium Year” for us, with two new related publications being developed:

(1) The new **Compendium of Drinking Water Systems and Technologies,** with Dr Maryna Peters (FHNW) as the main author, provides a well-structured overview of relevant drinking water technologies from source to consumer with a focus on low-income country contexts. This Compendium for the drinking water sector targets engineers, planners and practitioners in low- and middle-income countries and promises to be a blockbuster publication, just like its older cousin.

(2) The **Compendium of Sanitation Systems and Technologies for Emergencies** will be published in early 2018 and pulls together a huge range of information on sanitation for emergencies. This Compendium is jointly produced with the German WASH Network and BORDA, Germany and is specifically meant for humanitarian WASH practitioners in the field. It will feature many cross-cutting topics and emergency specific technologies.

During the last three years, our MOOC series “Sanitation, Water and Solid Waste for Development” has reached more than 42 000 participants in 176 countries. With about half of the participants coming from low- and middle-income countries, our MOOCs are proving to be a powerful educational tool, reaching thousands of students and practitioners in Africa, Asia and Latin America. This year, we are expanding our education and training programme by piloting a new format: the Certificate of Open Studies (COS). COS combines the strengths of the MOOCs with onsite teaching and overcomes some of the major barriers faced by eLearning in low- and middle-income countries: limitations of digital access, the lack of formally recognised certificates and limited face-to-face interaction with lecturers.

Sandec will continue to expand its outreach with a new course being developed with the International Committee of the Red Cross (ICRC) on Public Health Engineering in Humanitarian Contexts, which is projected to launch in October of this year.

For more details on any of the projects featured in this edition, please do not hesitate to contact the authors. We hope you enjoy this issue of Sandec News.

Christoph Lüthi
Director Sandec

Which Biowaste Treatment Technology for Limbe Market in Blantyre?

The decision support tool "SOWATT" was used to evaluate biowaste treatment options for the largest produce market in Blantyre, Malawi. Seven technology options were evaluated and the results showed that vermicomposting is the most promising technology to use in this context. Imanol Zabaleta[1], Wrixon Mpanang'ombe[2], Elizabeth Tilley[2], Christian Zurbrügg[1]

Introduction

Blantyre is Malawi's second largest city and is around 300 kilometres south of the capital, Lilongwe. It has around 1 million people and Blantyre hosts one of the biggest markets in the country, Limbe Market. The market is divided into sections according to the goods being sold and every section has a Chairperson elected by the vendors. Although owned and operated by the Blantyre City Council (BCC), much authority lies with the Chairpersons. Sandec's SOWATT (Selecting Organic Waste Treatment Technology) approach [1] was applied to the vegetables, fruits, fish, butchery and paper and cardboard sections of the produce market. A second fruit section and the wood and sugarcane sections across the street were also included.

The waste generation and characterisation study done prior to the SOWATT analysis revealed that the market generates approximately 1.1 tons of waste daily, and 90 % is biowaste. Of this, 70 % is wet vegetable waste, i.e. onion leaves, leafy greens, banana peels and tomatoes, and 30 % is dry vegetable waste (15 %) and paper and cardboard waste (15 %) [2]. The waste is transported to the Mzedi city dumpsite, which is unfenced, not compacted, and past its design life.

SOWATT decision support tool

The SOWATT tool, based on "Multi Attribute Value Theory", helps to structure decision making concerning biowaste treatment technologies [3]. Six technologies are considered in the tool: windrow composting, in-vessel composting, vermicomposting, anaerobic digestion (AD), black soldier fly processing (BSF) and slow pyrolysis (SP). In the case of Limbe Market, wet-biomass-briquetting (WBB) was also analysed as it is a common biowaste treatment technology used in Blantyre, Malawi.

The achievement levels of the technologies were scored using the following objectives: technical reliability, economic sustainability, social acceptance, environmental pollution, and community health protection. The long term operational sustainability of the technologies depends on these objectives. Next, the stakeholders weighed the objectives according to their level of importance through a multi-stakeholder participatory process: the treatment technologies were not presented to avoid possible biases. The weights given to each objective and the achievement levels were combined to assign a score to each technology, and the scores were used to make comparisons and for decision making.

Stakeholders and priorities

Four stakeholder groups were consulted: 1) Blantyre City Council (4 interviewees), 2) NGOs supporting biowaste management (4 interviewees), 3) Limbe Market Chairpersons (3 interviewees) and 4) Limbe Market vendors (16 interviewees). Results showed that BCC stakeholders and NGOs prioritised environmental aspects, then social aspects, while Limbe Market Chairpersons favoured economic sustainability. Not surprisingly, the vendors prioritised hygiene and community health, since they are most affected when waste is not properly managed (Figure 1).

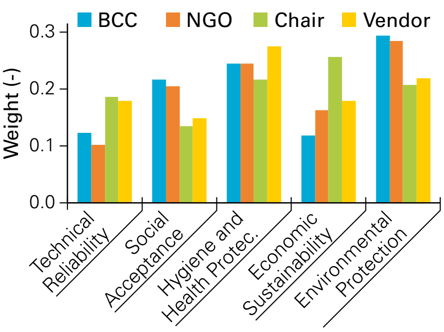

Figure 1: The weight of the objectives given by the stakeholder clusters.

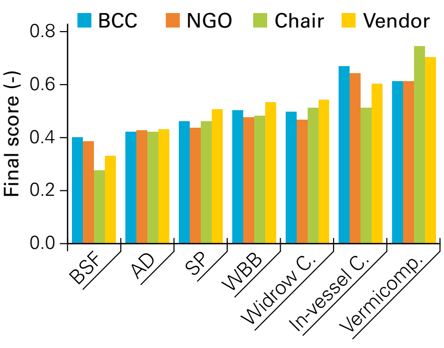

Figure 2: Final scores of each technology by each stakeholder cluster.

Scores

Vermicomposting obtained the highest overall score (Figure 2), while in-vessel composting ranked second. The scores among the stakeholder groups were quite consistent. However, BCC and NGOs scored in-vessel composting higher than vermicomposting.

Conclusion

Evaluating organic waste treatment options acted as a catalyst for the stakeholders to think about and discuss the challenges and opportunities of biowaste management. Some stakeholders, however, found SOWATT's weighting exercise to be too complicated. And the tool requires doing performance and cost estimates for all alternatives; yet, evidence is lacking for the more innovative treatment technologies. Nonetheless, the SOWATT method resulted in a structured overview of the pros and cons of the different technologies and led to a full analysis of the different stakeholder perspectives. These results should serve as a valuable evidence base for planning and raising funds for a full-scale biowaste treatment facility at Limbe Market.

[1] Zabaleta, I., Scholten, L., and Zurbrügg, Ch. (2015): Selecting Appropriate Organic Waste Treatment Options in the Philippines. Sandec News No. 16, 4–5.

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[3] Sandec News No. 16, 4–5. ibid.

[1] Eawag/Sandec, Switzerland

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We would like to thank Lisa Scholten for her help with the Multi Attribute Value Theory.

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Greenhouse Gas Emissions from Black Soldier Fly Biowaste Treatment

Black soldier fly larvae turn organic waste into insect protein, which can substitute for fishmeal in animal feed. What is its carbon footprint? At the *FORWARD* treatment facility, the direct methane and nitrous oxide emissions were assessed and compared with composting. A. Mertenat[1], A. Fadhila[2], T. Kusumawardhani[2], S. Diener[1], B. Dortmans[3], B. Verstappen[3], Ch. Zurbrügg[1]


Adeline Mertenat

Photo 1: Gas sampling from a BSF larvero.

Introduction

Organic waste contributes significantly to greenhouse gas (GHG) emissions when it decomposes anaerobically at disposal sites. Reducing GHG emissions by providing alternatives to landfill disposal and treating biowaste is of key interest to waste managers. Among technology options, composting remains the best documented method to treat biowaste [1], but it releases large amounts of methane (CH_4) and nitrous oxide (N_2O) into the atmosphere [2]. How do other options compare to composting in terms of direct GHG emissions?

Our research on biowaste treatment by black soldier flies (BSF) shows great promise. BSF larvae grow by feeding on biowaste, reducing the amount of waste by 80 %. After two weeks, they can be harvested, processed and used as a substitute for fishmeal in conventional animal feed. BSF offer a good waste management solution and the larvae can help alleviate the global demand for animal feed. Nevertheless, a knowledge gap remains on how this technology performs in regard to GHG emissions.

Methodology

Using the BSF treatment facility of the *FORWARD* project in Sidoarjo, Indonesia, we measured the direct CH_4 and N_2O emissions during the BSF conversion process. Gas samples were extracted daily from three treatment boxes (40 x 60 x 15 cm) with larvae. Each box, called *larveros*, contains 10 000 larvae. They received 15 kg of household kitchen waste over three feeding events: days one, five and eight. For the sampling, the three larveros were covered daily by a box equipped with a valve, which was hermetically sealed, while a small battery driven fan in the closed larvero ensured the complete mixing of the gas. After 90 minutes, the gas was extracted through the valve using a syringe and injected in vials pre-filled with argon (Ar), providing a pure gas sample. All vials were transported to Switzerland, where they were analysed using a gas chromatograph.

Emissions of CH_4 and N_2O

The results in Figure 1 show the variation of CH_4 and N_2O emissions from the larveros during the 13 day treatment period. The CH_4 concentrations were low on average, similar to the concentrations found in ambient air samples (1.2 ppm), indicating that the larvae moved and aerated the waste, and hindered anaerobic conditions. N_2O production and larvae weight increased proportionally after the feeding events on days five and eight. However, it remains to be verified whether this was due to the metabolic process or bacterial activity.

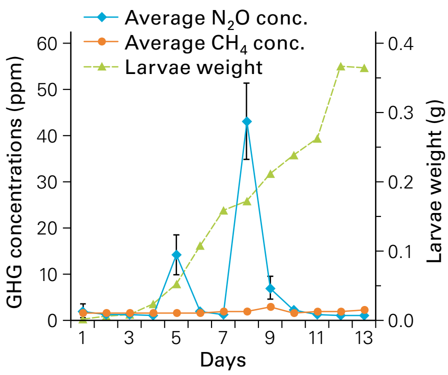

Figure 1: Daily average direct CH_4 and N_2O emission concentrations and larvae weight in larveros observed after a 90 minute closure time. Waste feeding events on days 1, 5 and 8.

The results also show an average total CH_4 production of 0.4 g and a total N_2O production of 8.6 g per ton of household kitchen waste treated. Following the IPCC 2013 100a method, this corresponds to a direct emission of 2.3 kg $CO_{2\text{-eq}}$ per ton of organic household waste. This is 47 times less GHG emissions than what composting produces [3].

Conclusion

Based on the measurements of the direct GHG emissions at the BSF treatment facility and a comparative literature review of composting data, we conclude that BSF treatment seems to be a promising alternative to composting as it produces very low direct GHG emissions. Further experiments should be done, however, that use a flow chamber for sampling, as our results show that the closed box affects larvae behaviour.

An overall evaluation of BSF waste treatment emissions also entails doing a full assessment of indirect emissions. This requires doing a Life Cycle Analysis, which was also done at the BSF treatment facility. This data is still being reviewed and a manuscript about the direct and indirect emission results is being finalised for scientific publication.

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[1] Eawag/Sandec, Switzerland

[2] Project *FORWARD* Associates, Indonesia

[3] Eawag/Sandec, *FORWARD*, Indonesia

We would like to thank Serge Robert and Matthias Brennwald from Eawag, as well as Martin Schroth from ETH, for their assistance in lab measurements, the *FORWARD* project team for their help in Indonesia, and the SPROUT project funded by ECO-INNOVERA for financial support.

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Black Soldier Fly Biowaste Treatment – A Step-by-Step Guide

This new Sandec publication describes the material, equipment and working steps required to set up a biowaste treatment facility with black soldier fly larvae. It offers a "cookbook" approach to the topic, which is based on lessons learned in Indonesia and Sweden. Stefan Diener[1], Bram Dortmans[2], Bart Verstappen[2], Christian Zurbrügg[1]

Background

Biowaste conversion by insect larvae using Black Soldier Fly (BSF) *Hermetia illucens* has received much attention in the past decade. Its popularity lies in the promising opportunity of using the harvested larvae as protein for animal feed, i.e. a valuable alternative to conventional feed. Although academic publications on BSF are on the increase, knowledge of the very practical day-to-day working steps of operating a BSF facility is not very widespread. Filling this gap is the main objective of the recently published 'Black Soldier Fly Biowaste Processing – A Step-by-Step Guide', which is available for free on Sandec's website and on demand as a hard copy.

The guide presents the operating steps that are minimally required for a BSF facility treating 10 to 20 tons of organic waste per week. It also provides an equipment and material list with pictures, as well as task-scheduling and data monitoring templates. The content is based on the experience gained over the past years from the operation of the one ton/day waste treatment facility of the *FORWARD* project in Indonesia and an experimental facility at the Swedish Agricultural University SLU in Uppsala, Sweden.

Processing Units

The document is structured according to the five main processing units of a BSF processing facility (Figure 1). "Waste sourcing", although crucial, is not discussed in great detail. The guide also does not cover the financial aspects of such a facility as this would depend on local market conditions, the scale of the facility and potential waste processing and/or product sales revenue (e.g. whole larvae, protein meal, larval oil and waste residue).

BSF rearing unit

To ensure that a defined amount of waste is regularly treated, the rearing unit has to daily provide a definite number of five-day-old-larvae (5-DOL). Each rearing step, therefore, has to be carefully controlled and monitored. For instance, controlling the number of prepupae for pupation is important to accurately estimate the number of emerging flies, as well as the number of egg packages and hatching larvae.

Waste receiving and pre-processing unit

The waste should be purely organic and biodegradable. Larvae are quite tolerant when it comes to feeding substrates and many organic materials are, thus, suitable when offered at a given moisture and particle size. The waste may have to be pre-processed to reduce particle size, dewatered if it has high water content, and/or different organic waste types blended to achieve a suitable balanced diet and moisture (70–80 %) for the larvae. The guide lists various substrates that lead to satisfactory growth and biomass conversion.

BSF waste treatment unit

A given amount of 5-DOL are transferred daily from the BSF rearing unit to a BSF treatment unit (called the "larvero"). Here, the 5-DOL are added to a certain amount of waste.

The rule of thumb used is: 10 000 5-DOL in one larvero of 40 x 60 x 15 cm to treat 15 kg of waste over a 12 day period (Photo 1).


Sirajuddin Kurniawan

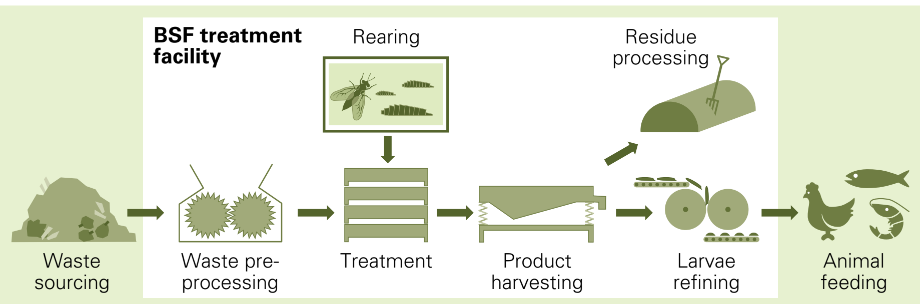
Photo 1: Feeding a stack of larveros with organic waste.

Product harvesting and product refining units

Shortly before turning into prepupae, the larvae are harvested. Both products, larvae and residue, can be processed depending on market demand. This is called product refining. Typically, a first step is to process the larvae into a storable product if direct live sales are not an option. Some refinement steps that have been tested are freezing, drying and pelletising. Additionally, separating the larvae oil from larvae protein can create feed ingredients. Refining the residue can also involve composting. Or, it can be added to an anaerobic digester for biogas production.

Outlook

This guide is published as an open source document to achieve the widest possible dissemination. The aim is for BSF treatment to receive the attention it deserves. In this spirit of sharing, feedback is welcomed from practitioners so that continuous improvements to the document can be made.



Stefan Diener

Figure 1: The different units of a BSF treatment system.

[1] Eawag/Sandec, Switzerland
[2] Eawag/Sandec, *FORWARD*, Indonesia

We would like to acknowledge all those who helped to develop, document and discuss the practical aspects of BSF rearing and waste treatment by larvae. Particular thanks go to Cecilia Lalander and Björn Vinnerås of the Swedish Agricultural University SLU (Sweden), Longyu Zheng and Jibin Zhang of the Huazhong Agricultural University (China), Michael Wu of JM Green (China), and all partners of the *FORWARD* project.

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An Improved Slow Pyrolysis Reactor in Dar es Salaam, Tanzania

Research on producing char from biowaste, using an improved vertical small scale slow pyrolysis reactor, shows very promising results with regard to char quality and energy balance. The results showed that feedstock with moisture content higher than 20 % limits the performance. Imanol Zabaleta[1], Benjamin Pfyffer[2], Hassan Mtoro Rajabu[3], Christian Zurbrügg[1]

Introduction

Finding affordable, reliable and sustainable cooking fuel for urban households in low- and middle-income settings is a challenge. At the same time, solid waste management services are often inadequate, and the municipal solid waste – consisting mainly of biodegradable waste – severely impacts the environment. Producing char from biowaste can contribute towards energy needs, as well as provide an appropriate solution for biowaste management. In collaboration with the University of Dar es Salaam, a slow pyrolysis reactor was built in 2015 and has been iteratively improved in the course of this project.

Experiment	MC (%)	N° of barrels	Energy ratio	Char yield (%)	FC yield (%)
A	6.0	1.0	6.0	32.0	27.0
B	10.0	1.0	4.6	31.3	26.0
C	40.0	1.0	0.5	15.0	13.0
D	10.0	2.0	7.0	35.3	30.3

Table 1: Average energy ratios, char yields and fixed-carbon yields of experiments with different MC using sawdust.

Reactor system

The vertical slow pyrolysis reactor system comprises a furnace, two oil-barrels stacked on top of each other, and a chimney (Figure 1). Seven metal pipes, which are welded together and sealed at one end, are filled with waste, then closed with metal lids and inserted into each barrel. Heat from the furnace fuelled by LPG (HHV = 50 MJ / kg) carbonises the waste in the pipes of the bottom barrel, and pyrolysis gas exits the pipe lids and burns, generating additional heat. Excess heat from the bottom barrel heats the upper barrel, drying the feedstock within it. The supply of secondary air is controlled by shutters in the furnace and chimney. This allows the oxygen supply to the furnace and the draft through the reactor to be controlled to better manage heat loss.

The waste is converted to char in the reactor. The aim is that the reactor should be energy efficient and generate high quality char with good burning properties. Its energy efficiency is determined by the energy ratio (ratio of the energy in the generated char to the energy consumed in the furnace), which should be higher than one.

Study variables

Several different biowaste feedstocks were tested, such as sawdust, briquetted sawdust and coffee husks. Experiments were conducted in triplicate with different moisture contents (MC) (6 %, 10 %, 20 % and 40 %) and different particle sizes (PS) (sawdust < 0.5 cm and sawdust briquettes of 3x6 cm and 6x6 cm) to assess their influence on energy ratio, char production and char quality. These experiments were conducted only with the bottom barrel and the assessments were based on: the higher heating values (HHV), char yield, moisture content (MC), volatile solids (VS), fixed carbon (FC) and ash content. The results, i.e. energy performance, were compared to experiments with the two barrel system, which used sawdust as feedstock.

Results

All carbonised feedstock types showed very similar and satisfactory high heating values (30.9 ± 0.7 MJ / kg), char yields (30–32 %), proximate analysis (MC: 1.9 ± 1.2 %; VS: 12.1 ± 1.7 %; FC: 82.1 ± 1.3 %) and ash content (5.9 ± 2.9 %). As expected, feedstocks with lower MC achieved higher energy ratios and higher char yields (Table 1). Energy ratios were < 1 when the MC was higher than approximately 20 %. Results also showed that the density of the feedstock, i.e. the mass of feedstock per pipe volume, influences the energy ratio more than PS. In experiments using small PS (sawdust), only 20 kg_{db} (dry basis) could be filled, and the resulting average energy ratio was 3.6. Comparatively, in larger PS experiments with sawdust briquettes, 60 kg_{db} could be filled into one barrel, resulting in an average energy ratio of 5.9. The LPG is used more efficiently by the two barrel system, and results in higher energy ratios, char yields and fixed-carbon yields (B versus D in Table 1).

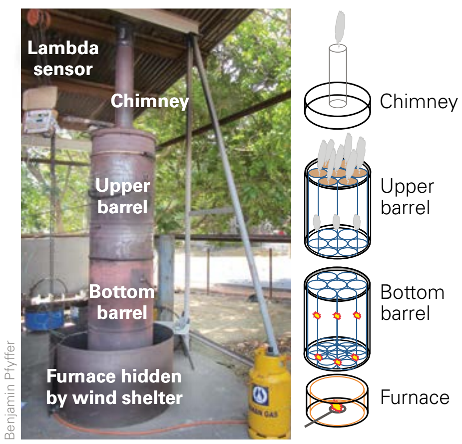

Figure 1: Scheme of vertical experimental slow pyrolysis reactor.

Conclusion

Further research is underway to test the drying capacity of the upper barrel as well as to develop a furnace fuelled by char briquettes. This could limit the need for and costs of external fuel and might allow the process to function on self-produced fuel. Lowering capital investment costs (now 950 USD) and improving the overall financial sustainability of this biowaste treatment method are other research objectives.

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Dewatering Characterisation of Synthetic Faecal Sludge Project

Dewatering faecal sludge is a crucial step in its treatment. Synthetic faecal sludge was developed for controlled studies of the characteristics impacting dewatering performance. Results indicate that sludge strength and urine concentration both impact dewaterability. Barbara Jeanne Ward[1], Eberhard Morgenroth[1,2], Linda Strande[1]

Introduction

Inefficient dewatering is a major barrier to the implementation of effective faecal sludge (FS) management. Improvements in dewatering technologies can reduce land area requirements for drying beds and produce safer, higher-quality treatment products for resource recovery. Prior to the development of improved FS dewatering methods, a fundamental understanding of what parameters impact dewatering must be developed. Because FS is highly heterogeneous, it has been difficult to perform controlled analyses of the factors that determine dewatering behaviour. To address this, synthetic FS was developed for controlled experiments.

Methodology

Six types of synthetic FS were prepared by combining synthetic faeces [1] with deionized (DI) water and varying concentrations of synthetic urine [2] to simulate low-strength FS (4 wt % synthetic faeces) and high-strength (25 wt %) FS. Both low- and high-strength FS were made at three urine concentrations to simulate urine diverting (no urine), pour-flush (7 % v/v urine/DI water), and waterless toilets (100 % v/v urine/DI water). FS was analysed for total solids (TS), total volatile solids (TVS), chemical oxygen demand (COD), ammoniacal nitrogen (NH_4-N), pH, electrical conductivity (EC) with standard methods [3], dewatering rate by capillary suction time (CST), and dewaterability (% TS in cake) by centrifugation.

Results

Results show that the chemical characteristics of synthetic FS are generally comparable to literature values. Synthetic FS had higher TVS than FS from literature. This can be attributed to the fact that synthetic FS did not undergo digestion, while FS from literature likely experienced degradation during storage in containment. pH values for all synthetic FS samples were lower than literature values, due to the low pH (5.5) of the deionized water. Future experiments will be designed to evaluate changes in parameters of sludge decomposition that effect dewatering.

High-strength sludge had reduced dewatering rates, as illustrated in Figure 1a, and had an increased CST compared to low-strength sludge (even when normalised for TS). High-strength sludge achieved the highest TS in the dewatered sludge cake, but low-strength sludge had the greatest overall increase in TS following dewatering (Figure 1b). These results are in line with findings from empirical FS dewatering studies [4, 5], which report better dewatering performance for less concentrated septic tank sludge compared to high-strength public toilet FS. Urine concentration had no discernible impact on the absolute dewatering rate, but did impact normalised CST and dewaterability. High urine concentrations increased TS before and after dewatering, but decreased the efficiency of centrifuge dewatering for both low- and high-strength synthetic sludge (Figure 1b).

Conclusions

Synthetic FS is useful for evaluating the fundamental dewatering behaviour of FS. Our results indicate that sludge strength and urine concentration impact dewaterability. Future experiments will validate these results with FS and degradation.

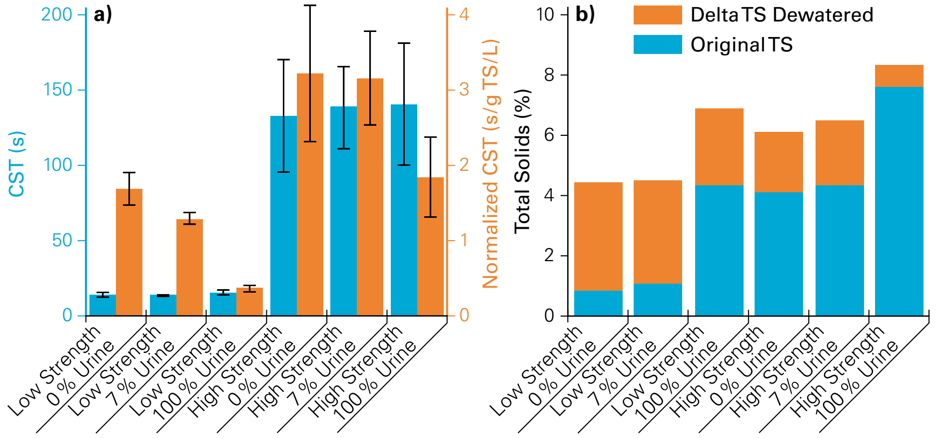

Figure 1: a) CST results for low-strength and high-strength synthetic sludge made with different urine concentrations; b) Comparison of TS in synthetic sludge before and after centrifuge dewatering.

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A Pilot-Scale Faecal Sludge Research Facility in Dar es Salaam, Tanzania

This article presents an update about the on-going faecal sludge dewatering innovations and pyrolysis research in Dar es Salaam, Tanzania. The aim of this research is to support comprehensive and affordable faecal sludge management. Nienke Andriessen[1], Richard Kimwaga[2], Linda Strande[1]

Anonymous

Photo 1: The research team.

Introduction

Existing faecal sludge (FS) treatment technologies are land intensive, and acquiring land in urban areas where space is limited is difficult and expensive. It is, therefore, relevant to develop lower-cost and less space intensive treatment technologies. At the same time, resource recovery can also generate value from FS and could alleviate some of the treatment costs. Sandec and the University of Dar es Salaam (UDSM) in Tanzania are doing collaborative applied research on improved dewatering and resource recovery of FS (Photo 1).

The pilot-scale facility

In 2015, a pilot-scale FS treatment facility was constructed at UDSM. The treatment chain consists of a sludge discharging inlet with a bar screen, two parallel settling-thickening tanks (each with a volume of 18.5 m^3) which are operated alternately, a mixing tank (total volume 7 m^3), and six unplanted drying beds (each 1.5 m x 1.5 m, hydraulic loading rate 45 cm). Master's students of UDSM and École Polytechnique Fédérale de Lausanne (EPFL) are analysing dewatering mechanisms and the solid and liquid streams from the treatment facility.

Experiments

The following details the research at UDSM:

- Because dewatering is one of the biggest challenges to the implementation of FS treatment worldwide, Sandec's research focuses on how using conditioners could improve the flocculation of sludge particles. One student is researching the use of two locally producible conditioners, chitosan and *Moringa oleifera*, on the drying beds and exploring optimal dosages. Dosing is hard to determine due to the variability of sludge. Preliminary results indicate that chitosan could be suitable for certain types of sludge, but more tests are required to determine the proper dosing.
- Geotubes are engineered textile bags that allow liquids to permeate from the inside to the outside, while retaining solids inside. These are already used as a dewatering technology in wastewater treatment, and a student is assessing their potential as an inexpensive and low-tech solution for onsite FS dewatering. The sludge would be delivered to transfer stations, i.e. safe disposal points in neighbourhoods, by manual emptiers, where it would be collected by a larger truck to be transported to a central treatment facility. The outcome of this research could lead to more sludge being transported out of high-density areas without having to transport the water.
- The leachate from the drying beds is currently flowing directly to the waste stabilisation ponds that treat the wastewater from the university. It is unclear how this affects the treatment capacity of the ponds, or whether it could be discharged into the sewer network. This is important to consider particularly when scaling up treatment. One student is characterising the leachate and modelling its effects on the waste stabilisation ponds and sewer. In the future, the leachate from the geotubes will also be characterised and incorporated into the model.
- One way of using the solid fraction of the sludge from the drying beds and geotubes for resource recovery is by pyrolysis. Sandec research has shown that although pyrolysed FS has potential as a solid fuel, its high ash content reduces its calorific value and, thus, the quality of the char. To improve the quality of the produced char, a student is researching how different sludge drying technologies and containment types affect the sand and ash content in FS.
- To optimise the design of treatment technologies, it is important to know how much and what type of sludge is actually arriving at the treatment facility. No validated methods exist currently to do this. For this reason, one student is testing methods for quantifying and characterising sludge.

Figure 1 depicts how these experiments fit together into a comprehensive research program, the goal of which is to reduce the footprint and costs of adequate faecal sludge treatment. It is based on previous Sandec work [1], and four UDSM students are currently completing their Master theses. Stay tuned for their final results in the next issue of Sandec News!

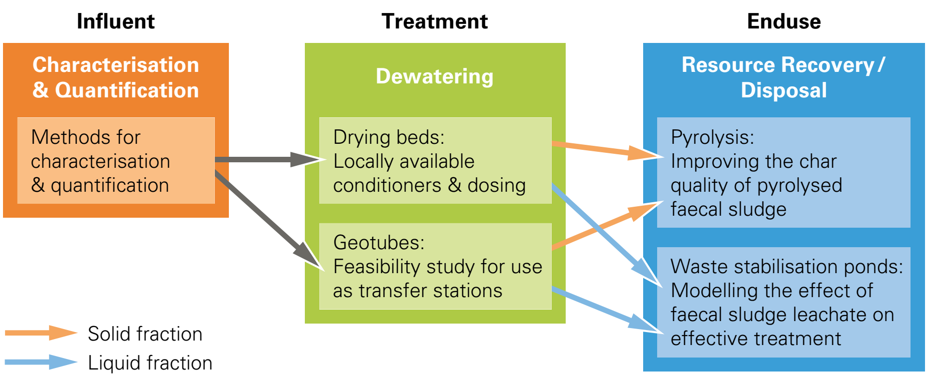

Figure 1: The interconnectedness and collaboration of the research at UDSM.

[1] Sandec News No. 17, 2016.

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Keeping the Trash Out: Improvements in Pit Emptying Technology

Removing the vast quantities of trash from pit latrines is time consuming and dirty work that raises prices to consumers because of the extra work involved. Researchers at North Carolina State University have developed a technology that reduces this burden and tested it in Malawi. Elizabeth Tilley[1], Tate Rogers[2], Francis de los Reyes[3]

Introduction

In recent years, much emphasis has been placed on not just building toilets, but on using them, both consistently and correctly [1]. Unfortunately, there is much evidence that points to the other, more popular uses of toilets: grain storage, animal housing and garbage bins [2]. Given the lack of solid waste collection in most urban settlements, residents often use their pit latrines as a convenient way to dispose of solid waste. In many ways, this is an easy solution that protects the local environment and makes use of an existing resource. The challenge, of course, comes when it is time to empty the pit.

Elizabeth Tilley

Photo 1: Sludge-soaked trash that has been fished out of a pit.

The struggle with trash

Although sucking faecal sludge out of pits can be challenging, it can be done with the right mechanical pump. What makes pit-emptying difficult are the conditions around, between, and inside the pits: poor, steep roads limit the size and type of vehicles that can reach the household; small holes for defecation and low roofs make bulky equipment hard to manipulate; and trash, such as plastic bags, diapers, rocks and bottles, quickly clog, if not destroy hoses and pumps, leaving the operator with a repair bill and the customer with a full pit.

Because of the risk to their equipment, most emptiers will first take the time to "fish" out the garbage with a hooked, steel rod. Fishing is time consuming and messy, and someone has to haul the sludge-soaked trash away (Photo 1). Extra time is also necessary, meaning that the cost often increases accordingly. Fishing is not a guaranteed method: the self-made tools are best suited for rags and bags, but do not work for bottles or other hard objects, which require other methods and more time, resulting in even higher prices for the service.

Flex-X

Of course, keeping trash out of the pit would be the easiest solution, but city-wide solid waste management strategies and behaviour change take time to implement. In the meantime, there is a need to empty thousands of pits with significant levels of trash. One possible solution was developed at North Carolina State University: the Flex-X, which actively excludes the trash during desludging.

The Flex-X is a modular attachment that can be fitted onto the hose of any conventional vacuum truck. It consists of two parts: a shaftless, flexible screw that rotates inside a flexible vacuum hose, and a power/control unit. The screw inside the hose rotates in a reverse manner to push material away, thus preventing the trash from entering the hose. At the same time, the free-flowing sludge is sucked up through the centre of the screw by the existing vacuum system. External power for the screw rotation comes from a generator, while the vacuum to lift out the sludge is provided by the vacuum truck, as in normal operations. The vacuum tank fills with sludge while the trash remains in the pit.

This has several advantages: no clogging, no extra time needed to fish, and no contact with the sludge-covered trash. If the user insists on having the trash removed, it can be done at an additional cost after the emptying has been completed. Because the sludge has been removed, the trash is not "swimming" in faecal material, and can be more easily taken out using long rods with hooks, or modified trash collection tools [3].

Results

Extensive lab-testing (at NC State) and field testing (in Hyderabad, India) were carried out before bringing the Flex-X to Malawi in December 2016 to test it under different operating conditions. Harold Chirwa and his experienced pit emptying team were enlisted to test the equipment and determine its ease of use from the perspective of operators (Photo 2). The Flex-X was connected to the vacuum tanker used by Mr. Chirwa's

Elizabeth Tilley

Photo 2: The pit-emptying and research team examine the equipment before testing.

team and tested on six pits. It showed promising results as the equipment demonstrated its ability to reject large pieces of trash, while removing sludge from every pit tested. The compact size and flexibility of the hose made it easy to access the pits and for operating inside the superstructure. Some areas for improvement were also identified: (1) preventing small, stringy trash from causing blockages inside the hose and (2) making a rigid end piece for the hose similar to current equipment that allows the operator to remove "slugs" of waste in more viscous pits.

Based on this data, the Flex-X was improved and tested again on another six pits in February 2017. The modifications proved successful as only one blockage was observed during testing and the rigid end made manoeuvring within the pit easier on the operator. This testing also showed that as the sludge became more viscous, the flow rates with the Flex-X dropped in comparison to the existing vacuum equipment. Final modifications are currently underway to improve the trash rejection efficiency and to increase the flow rates through the system with more viscous sludge. These modifications will be tested in Malawi and other African countries beginning in July 2017.

Conclusion

The Flex-X does not solve the pit-emptying challenges of inaccessible toilets or slabs. It does, however, represent a significant time saving to the operator who can then pass the savings onto the customer, by being able to service more pits in a day. More importantly, keeping the trash in the pits means that the operators (during fishing) do not come into contact with the highly pathogenic waste. Future work will quantify the time savings and health risk reductions associated with using the Flex-X. Even still, this equipment is not meant to replace much needed solid waste collection and disposal options, two often over-looked elements of effective faecal sludge management that will, hopefully, put the Flex-X out of a job one day soon.

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Acknowledgements: The technical support of Walt Beckwith is acknowledged.

Funding: The development of the Flex-X and other pit emptying technologies is supported by a grant to North Carolina State University from the Bill & Melinda Gates Foundation.

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Small Towns: Research on Solutions for the Sanitation (Planning) Gap

Sandec is conducting cross-sectional applied research on small town sanitation planning in Nepal, Malawi and Bolivia. This is providing insight into various aspects of sustainable sanitation planning, and is helping to define the tools and steps needed for City Sanitation Plans. C. Lüthi[1], P. Reymond[1], S. Renggli[1], E. Reynaert[1], M. Klinger[1], A. Sherpa[2], M. Sherpa[2], W. Mtika[3]

Introduction

Small and medium-sized towns, here considered as towns with less than 100 000 inhabitants, carry the brunt of urbanisation; most future urban growth is expected to occur in these towns [1]. Sanitation coverage in small towns will, thus, be key to the achievement of the Sustainable Development Goals (SDGs). Although the challenges are similar to big cities, small towns suffer from a weaker institutional base, lack economies of scale and fewer funding opportunities are available. In many countries, the high level of centralisation of the State hinders access to national budget transfers, or the existing decentralisation processes has delegated responsibilities to municipalities, but without the necessary financial transfers. These limitations are most apparent in the delivery of basic services, such as water, sanitation and solid waste management.

Eva Reynaert

Photo 1: Peri-urban areas of Cochabamba, Bolivia.

Research on small town sanitation services

With the aim to provide tools and solutions to facilitate sanitation planning and service delivery in these contexts, Sandec is conducting field research in Nepal, Malawi and Bolivia. The three projects are testing, adapting and validating sanitation planning tools, and providing insight into appropriate sanitation systems and service delivery mechanisms, while supporting local stakeholders in planning. The objective is to develop state-of-the-art guidance for small town urban environmental sanitation planning and programming.

Tikapur, Nepal

An important bottleneck to realistic infrastructure and basic services planning in Nepal's rapidly growing small- and medium-sized towns is the lack of reliable and up-to-date data. Within the framework of the *"Small Towns Water Supply and Sanitation Sector Project"* in Tikapur Municipality (estimated population: 65 000), the need was identified for simplified, contextualised planning tools which: (i) are easy to utilise and (ii) add value to an integrated planning approach, i.e. covers the entire sanitation value chain from toilet to re-use options. The first step was validating the assessment of the current situation and service delivery options. This included analysing technical, institutional, regulatory and socio-economic aspects (Figure 1). A situational analysis was conducted (the cornerstone of any successful planning), which consisted of a structured household survey with 400 households, three focus group discussions and the production of a Geographical Information System (GIS) database, featuring toilet coverage, storm water drainage and water provision. These assessments formed the basis for prioritising what needs improvement and what needs to be newly developed in terms of basic urban sanitation services and infrastructure.

A Shit Flow Diagram (SFD) was also developed for Tikapur, Nepal, a powerful tool to communicate and visualise how excreta physically flows through a city or town, which clearly differentiates between safe (green) and unsafe (red) disposal (Figure 1). SFDs are helpful advocacy and assessment tools because they are easily understood by non-experts and decision-makers.

One of the main challenges in Tikapur is the total absence of formalised faecal sludge management (emptying, conveyance and treatment). Like many other small towns in Nepal, there is high toilet coverage, due to successful campaigns against open defecation in the past decade. However, the faecal sludge is commonly not emptied or is directly disposed of into the environment, resulting in unhygienic urban environmental conditions. Tikapur's SFD shows that only 30 % of the sludge is currently safely managed.

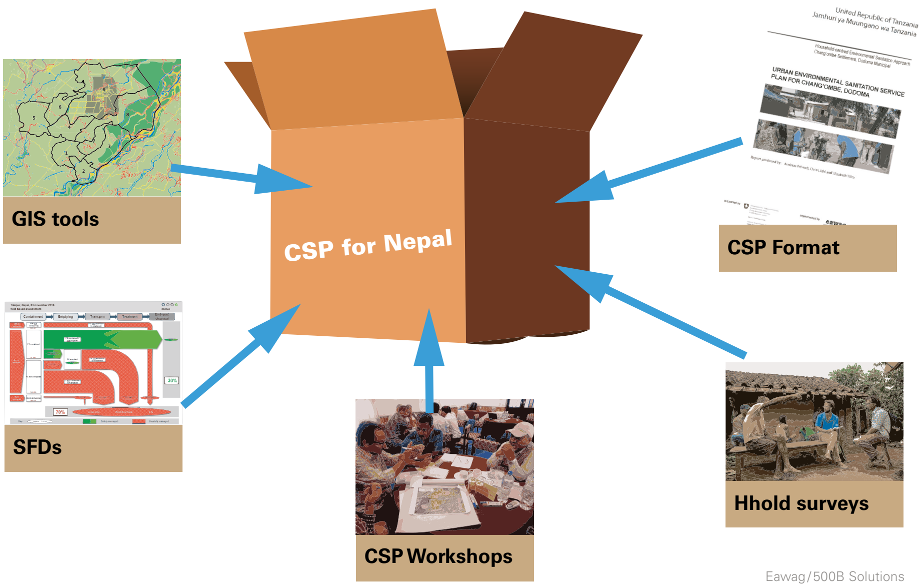
Luchenza, Malawi

In Malawi, Sandec's Community-Led Urban Environmental Sanitation (CLUES) planning approach is being validated in the small town of Luchenza (approximately 20 000 inhabitants) in partnership with the University of Malawi, The Polytechnic. The project was launched with a sanitation planning workshop in Luchenza that had more than 50 participants from the Municipality, the community and the private sector. A second, re-

gional workshop was held in May 2017 at which various stakeholders, such as vacuum truck operators, municipal officials and NGO representatives from different areas of the country, came to talk about sanitation service delivery solutions for urban contexts.
Through community mobilisation, household surveys and water quality testing, an action plan for water, sanitation and hygiene (WASH) service delivery improvements in the town is being developed. As services and funds are very limited, the priority is to develop recommendations that can be executed within the community. Because data on municipal WASH services in Malawi is scarce, the project is creating a database for the town and methodologies that the Municipality can use as a baseline for work and as a metric against which future progress can be measured.

Arbieto, Valle Alto de Cochabamba, Bolivia

The peri-urban area of the city of Cochabamba (Photo 1) has recently experienced strong population growth due to rapid development, attracting migrants from all over the country. In 2014, an international NGO built 500 single-vault urine-diverting dry toilets (UDDTs) in seven peri-urban neighbourhoods and a composting facility for the faeces. Due to poor planning, however, the NGO abandoned the project before a collection service for the faeces and urine was implemented. Two main questions were asked: (i) which sanitation systems and services are appropriate for peri-urban areas that cannot be connected to the main sewer network, and (ii) under which conditions is a large-scale UDDT-based system with collection and treatment service feasible and sustainable?
An evaluation of the present situation was conducted based on a household survey, which collected information about the current use of the UDDTs and people's perceptions of the water and sanitation situation, and through direct observations of the toilets. The assessment showed that since their construction, the number of UDDT users has constantly decreased. At present, only a third of the population uses them; many residents have turned their UDDTs into pit latrines.
Different service scenarios were investigated to determine if implementing a collection service and starting the faeces composting plant is financially feasible. The two main scenarios considered were: (i) collecting and treating only the faeces or (ii) collecting all solid waste (including the faeces) and treating the faeces and organic waste at the composting plant. The collection would be handled by either door-to-door collection or through collection points. In general, services that collect all solid waste have larger numbers of customers and, thus, more potential revenue to run a system. Collection points also decrease service costs, by reducing transport times and facilitating access.
This case study provided good insight into the feasibility and replicability of single-vault UDDT-based sanitation systems in peri-urban areas. It showed, however, that these are not financially sustainable in the short term and require long-term government and/or third party assistance. The systems that currently operate relatively successfully in Bolivia, for instance, receive permanent financial support.



Eawag/500B Solutions

Figure 1: City Sanitation Planning Toolbox validated in Tikapur.

The way forward

This research project is testing and validating the toolbox needed to produce City Sanitation Plans (CSPs), i.e. realistic and implementable sanitation solutions for small towns. Diagnostic tools were applied and validated in Tikapur, while work on participatory planning of bottom-up action took place in Malawi and service options for a specific sanitation system in Bolivia were analysed. We believe the tools applied in Tikapur, could be useful and add significant value for similar planning processes in other small towns looking to improve their urban environments. The project has already attracted the attention of stakeholders at the national level in Nepal and several tools used during the project will be applied in other small towns to further develop the CSPs.
The research findings will assist small towns worldwide in the development of plans to improve their urban sanitation environments. Hundreds of cities around the world, especially in India, are undertaking city sanitation planning exercises, with mixed results, as they are often not properly prepared to do this work and/or receive weak initial assessments. CSPs provide an approach to address environmental sanitation challenges from a systems perspective and facilitate selection of the best alternatives for a given context. Through the development of sound CSPs, this project will provide a proper framework for small towns to solve their sanitation problems, implement sanitation systems and strengthen the work done on the local level to achieve the SDGs.

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All outputs of this research can be found at www.sandec.ch/sesp.

Funding: SDC WESSP Programme.

Project partners: Helvetas, AGUATUYA, 500B Solutions, Asian Development Bank and University of Malawi.

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Small-Scale Sanitation in South Asia: 4S Progress and Challenges

The Bill & Melinda Gates Foundation-funded research project "Small-Scale Sanitation Scaling-up (4S)" in South Asia was launched in January 2016 and ends early 2018. This article looks back at 15 months of data collection and is an analysis of challenges and preliminary insights. Lukas Ulrich[1], Rohit Chandragiri[1], Marius Klinger[1]

Background

In 1992, the Indian Ministry of Environment and Forests stated: 'For a country like India, conventional [wastewater] treatment plants are costly. In fact, these are beyond the financial means of many small towns' [1]. In 2004, the same ministry issued a notification which required on-site sewage treatment plants (STPs) to be built for new, large construction projects (including residential, institutional or commercial projects). This triggered the installation of thousands of privately-owned, small STPs in Indian cities and the development of an important market with hundreds of companies that design, build and service a wide range of treatment technologies.

The benefits of small-scale (often called decentralised) sanitation systems that prioritise local water re-use, cost-effectiveness and stage-wise implementation have long been recognised. As a result, these systems are increasingly considered all over the world in both rural and neighbourhood-level urban planning. It is noteworthy that in India most small STPs are not an outcome of concerted urban infrastructure planning, but of innovative national and, partly, state-level policies aimed at protecting the environment and bridging the gap in (waste)water infrastructure.

While the number of small-scale sanitation systems in South Asia is growing, the list of reports on failed or poorly performing installations is also increasing. Efficient institutional frameworks are needed to monitor the systems' design, establishment and long-term operation and maintenance (O&M). A sound understanding of how small-scale sanitation can be systematically and effectively planned, implemented and managed at a scale that optimises their role in urban sanitation service delivery is lacking. The 4S project aims to assess the current status of small-scale sanitation (serving 10 to 1 000 households) in South Asia and generate evidence-based policy recommendations for sustainable scaling-up.

Allie Davis

Photo 1: Primary treatment component of a community treatment plant in Tamil Nadu.

Methodology

The project has five main components:

1. A desk-based landscape study. This has compiled available information on small-scale systems in South Asia, private sector actors, related policies and findings from previous research.
2. A basic assessment of a large number of existing installations. The aim is to understand the performance of existing systems and the factors that influence sustainability, such as design, O&M, management, and socio-cultural as well as financial aspects. More than 300 units (30 in Nepal, 10 in Pakistan and the rest in India), treating between 5 and 700 m^3/day, have been inspected (Photo 1) and interviews conducted with stakeholders, i.e. managers, operators and beneficiaries (Photo 2).
3. A detailed performance assessment of selected systems. To gain a substantiated understanding of treatment performance and make comparisons with relevant standards, a sampling campaign is being carried out in more than 40 units (including five in Nepal). A representative range of treatment capacities, technologies and applications is being covered. Composite sampling of inlets and outlets over 24 h (complemented with grab samples every 6 h) is being done three times at each site (Photo 3), and key water quality parameters are being analysed.
4. An institutional and governance analysis. This is identifying the elements of an enabling environment required for the successful management of small-scale sanitation systems. A social network analysis (SNA) is looking at stakeholders, their influence, interests and relationships, to understand the current frameworks and potential gaps. Interviews are being conducted with stakeholders, who deal with policy development, monitoring and enforcement. The SNA is focusing on four cities in Karnataka and Tamil Nadu (Bangalore, Mysore, Chennai and Coimbatore).
5. A financial analysis. This is delineating economies of scale and financial flows

between system stakeholders. The life-cycle costs of seven main treatment technologies at six relevant scales between 40 and 700 m^3/day are being collected, mainly from private sector actors. Identifying the financial reasons for underperforming STPs will aid the development of improved financial and management mechanisms.

Progress and challenges

The landscape study has compiled a list of 9200 small-scale systems in India and 260 private players implementing and servicing them. It has also collated the relevant national and state-level policies and previous research.

The project team has developed a set of questionnaires and checklists for the basic assessment and field work started in April 2016. Contacting system owners, organising interviews and obtaining access to systems has been a major bottleneck, especially in India where small STPs are mostly privately owned and operated. The team dealt with such challenges as outdated or lack of information and contact details, and little interest, trust and availability on the part of interview partners. Unannounced visits and visits made through personal contacts and design and O&M companies worked better than trying to make arrangements through phone calls and emails. The 4S team was finally able to do 8–10 basic assessment site visits per week and after 15 months, more than 280 systems have been studied.

Getting information from the interviewees, especially managers, was often difficult; inquiries about costs, for instance, regularly went unanswered. The interviewers were repeatedly trained and questionnaires and processes for data collection monitoring and prompt data validation were often revised to ensure good data quality.

Rohan Sunny

Photo 2: Residents interviewed during the evaluation of a treatment system in Tamil Nadu.

The sampling campaign is in progress since August 2016. Findings from the basic assessment, distances to laboratories as well as local conditions, for example, accessibility of sampling points, determined the site selection.

Preliminary insights

In India, sanitation is a state responsibility; states even have the freedom to tighten the limits of national policies and standards. This has led to big regional differences in how small STPs are enforced and regulated. Karnataka, Tamil Nadu, Maharashtra and the National Capital Region are among the leaders with the biggest numbers of STPs, most of which are conventional activated sludge processes, sequencing batch reactors (SBR) and moving-bed biofilm reactors (MBBR). State pollution control boards (PCBs) face the challenge of monitoring the implementation and performance of all the systems. Unified and comprehensive national- or state-level databases of systems are lacking, however, and while the number of STPs continues to increase, the staffing capacity of PCBs has not [2]. Current mechanisms to enforce and monitor the design and operation of installations are inefficient and fairly easy to circumvent [3].

Interviews with private sector actors show that capital costs and space are the main factors typically considered in technology selection. Once built, STPs are frequently managed by stakeholders, who were not involved in the design phase, and who often must deal with under-designed systems that are costly to operate [3]. Operators come and go, making training difficult, and unskilled labour is often hired to save costs. O&M is also often outsourced to professional service providers or the engineers who designed the systems.

Many experts from engineering firms, civil society organisations, and PCBs agree that a large percentage of systems are poorly performing or non-functional. Water scarcity is a reality in South Asian cities; yet, low water tariffs still do not incentivise efficient reuse. Well-designed and maintained STPs produce high-quality treated water, but typically there is limited capacity to use all of it on-site. Often, water is discharged, sometimes untreated. Planning beyond the installation level is needed to identify the most economical size and location of treatment plants. Despite these issues, good examples of well-performing installations are also found across all types of technologies.

Shreyas Kumar

Photo 3: Field team at work for the 24 h sampling of a treatment system in Bangalore, Karnataka.

Conclusion

Although the data collection has been more time-consuming than planned, a wide variety of systems have been assessed, and in order to complete all the objectives, the project received an extension until March 2018. As the field work ends, data processing and analysis has started, and a cause-effect framework is being developed to understand the conditions that determine the performance of installations. Analysis will highlight the bottlenecks hindering small STPs from sustainably contributing to water conservation and pollution abatement. Technical, financial and management recommendations will be devised for different stakeholders. A regional dissemination event will take place in India to mark the end of 4S. Stay tuned to Sandec's website and social media for announcements of project publications and events.

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Partners: BORDA, Germany, IIT Madras, India, CDD Society, India, ENPHO, Nepal and NMBU, Norway

This project is funded by the Bill & Melinda Gates Foundation.

Project website: www.sandec.ch/4S

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Pre-selecting Sanitation Technology Options in Arba Minch, Ethiopia

Identifying appropriate, sustainable sanitation technologies is a complex multi-criteria decision-making problem. This systematic procedure has been developed to determine sets of sanitation technology options as input when structured sanitation planning frameworks are used. Dorothee Spuhler[1], Maria Rath[2]

Introduction

A sanitation system is a set of technologies, which in combination manage sanitation products, such as excreta and wastewater, from the point of generation to final reuse or disposal [1, 2]. A sustainable sanitation system provides appropriate technologies that protect human health and the environment, conserve natural resources, and is financially viable, socially acceptable, and institutionally appropriate [3]. Identifying an appropriate and sustainable sanitation system is a complex multi-criteria decision-making problem that involves many technology options and multiple criteria [4]. This is particularly challenging to do in informal or low-income urban areas of low-income countries, which is where most population growth worldwide is currently taking place.

Structured decision-making frameworks, such as CLUES or Sanitation 21, can help address such complex situations. They combine environmental engineering with multi-criteria decision analysis (MCDA) to evaluate trade-offs and to balance opposing stakeholder preferences. These approaches, however, focus on the selection and implementation steps and assume that the options to choose from are already given. Yet, decisions are only as good as the options presented and as novel technologies emerge, it becomes increasingly difficult to pre-select a good set of technology and system options to consider in planning processes. This systematic and transparent screening method has been developed as a means to determine technology options appropriate for contexts in which frameworks, such as CLUES or Sanitation 21, are being applied.

Approach

This approach was developed in the GRASP project (Generation and Assessment of Sanitation Systems for Strategic Planning [5]), and is based on previous work at Eawag on sanitation technologies and systems [1, 2, 3]. It involves three steps (Figure 1):

(i) identification of all potential sanitation technologies and corresponding system configurations;
(ii) identification of a set of screening criteria derived from the overarching objective of sustainable sanitation (based on the minimal requirement of being appropriate); and
(iii) evaluation of the appropriateness of the technology options in a given case.

The aim is to reduce the large number of technology options and corresponding system configurations to a smaller set, which is both locally appropriate and still covering a broad range of possibilities (i.e. on- and off-site, conventional and novel technologies, etc.). This set can then be further evaluated (e.g. by MCDA) to identify trade-offs and to weigh different stakeholder preferences (Figure 1).

The procedure acts as a first screening phase. It streamlines the process and enhances the transparency and accountability of initial planning phases. It can also work with uncertain information, which is common at initial planning phases, i.e. information about novel technologies or of newly developing urban areas.

Definitions and methods

A potential sanitation technology option (TechOp) is defined as any process, infrastructure, or service designed to contain, transform, or transport sanitation products. A sanitation system (SanSys) is defined as having (i) at least one source and one sink; and (ii) a number of TechOps in which every occurring sanitation product is either transformed, transferred or ends up in a sink. Figure 2 illustrates the structural concept of sanitation systems.

Screening criteria are used to evaluate the appropriateness of the TechOps in a given application case (AppCase). In order not to anticipate any decisions, only criteria, which can be exogenously defined and which do not involve trade-offs or depend on stakeholder preferences, are used (e.g. water or temperature requirements). Each criterion is defined by an attribute for the TechOp and one for the AppCase, which are compared in terms of their compatibility. To evaluate the attributes, we used probabilistic func-

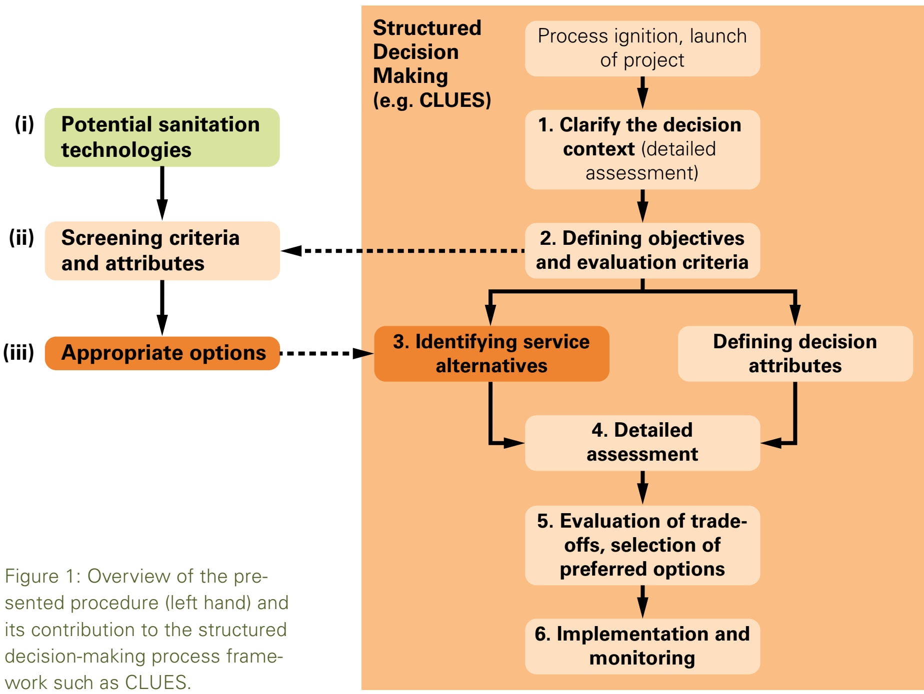

Figure 1: Overview of the presented procedure (left hand) and its contribution to the structured decision-making process framework such as CLUES.

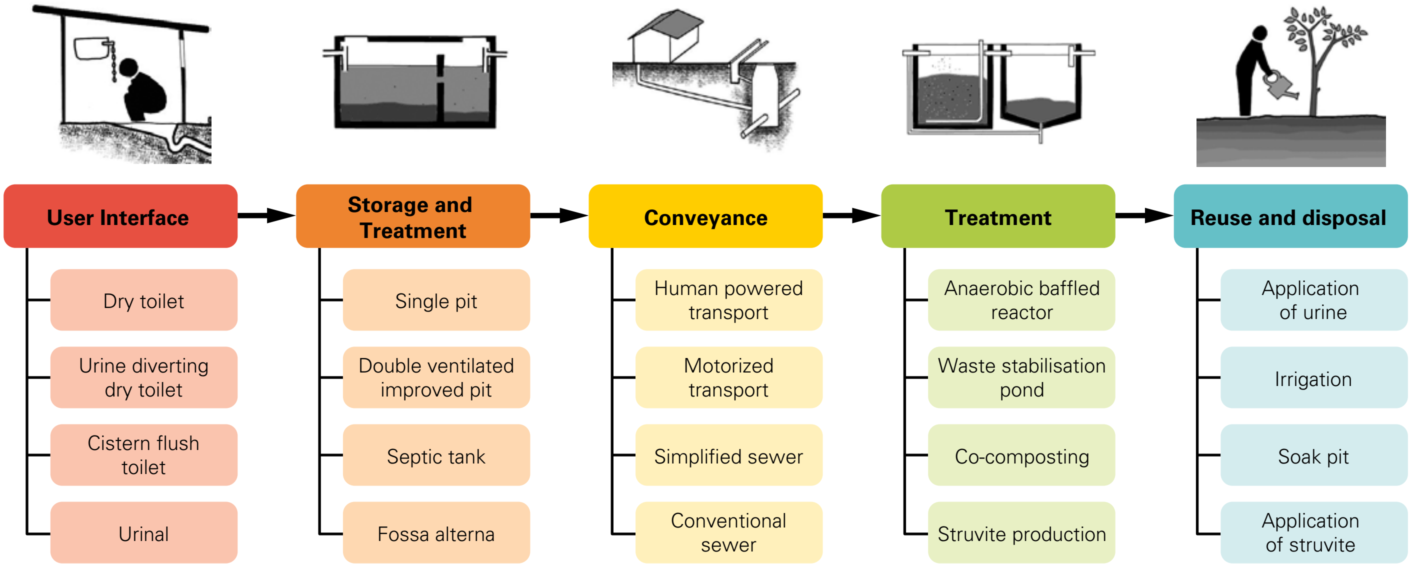

Figure 2: Examples of technology options along the sanitation chain. (Icons: [6])

tions because of the uncertain nature of the available information. For example, the performance of a special type of composting toilet at a certain temperature could be described by a function which shows a maximum of 100 % performance at around 20 °C and then decreases in efficiency as temperatures increase. The temperature in a given case could be presented as a normal distribution with minimum, maximum and mean annual values. By overlapping these two functions, a score between 0 (no compatibility at all) and 100 % (full compatibility) can be obtained.

Woze and Mehal Ketema Neighbourhoods in Arba Minch

The method was tested in two neighbourhoods of Arba Minch (a small town in Ethiopia) in collaboration with the Department of Water Supply and Environmental Engineering at the University of Arba Minch. As the list of all potential TechOps is very long (e.g. [2]), the procedure was only tested for a smaller set representative of a broad range of conventional and novel technologies (Figure 2). The screening criteria and attributes were identified in a workshop with local stakeholders and included legal, physical, technical, environmental, demographic, and to some extent socio-cultural aspects.

The results indicate that TechOps with low resource requirements (e.g. water, energy, or frequency of maintenance) scored higher. Examples include dehydration vaults, simplified sewers, human-powered transport, or co-composting. Technologies relying on pits for infiltration or storage (e.g. dry pit latrine or soak pit) have a lower flooding tolerance (e.g. drying bed), and rank lower in both neighbourhoods. The ranking varied between the two neighbourhoods, showcasing the model's sensitivity to different case conditions. Mehal Ketema is at the centre of the town and has a comparatively high population density, lower area availability, and higher water availability and consumption due to hotels and institutions. Woze is at the town outskirts, with mainly single floor residential buildings. Consequently, cistern flush toilets received a score 0 in Woze, while they had a relatively good score in Mehal Ketema (0.84).

A rapid sensitivity-check indicated that the number and nature of attributes highly influences the final outcome. It was found, for instance, that the more attributes used, the more similar are the scores, making it difficult to differentiate among them. Also, some attributes might strongly impact the results, and some involve trade-offs and, thus, should be evaluated based on stakeholder preferences at later planning stages. Therefore, it is important to select screening attributes with the local stakeholders who have a good understanding of the procedure, and to reduce the set of attributes to only the most relevant.

Conclusion

Our procedure can reduce the large number of available technology options to a small, and yet appropriate, set of options in a systematic way. It streamlines the planning process, enhances transparency, and contributes to the implementation of appropriate and eventually more sustainable sanitation options. This method also has the potential to overcome several gaps in current sanitation planning practices. It explicitly looks at the entire sanitation chain in the local context; it can systematically consider a broad range of technology options, including novel and conventional technologies; and it can work with uncertain information, the kind of information that is very prevalent in initial planning phases, i.e. information of newly developing urban areas or about novel technologies.

As this approach is generic, it can also be applied to other types of systems (e.g. solid waste) or application cases. However, its application requires a good understanding of sanitation technologies and is complex and time consuming. The procedure is being further developed to overcome these issues.

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The Safe Water Schools Project in Tiquipaya: Successes and Challenges

Although the Safe Water Schools project in Tiquipaya, Bolivia, conducted in 46 public schools, ended with promising results, challenges remain. A post-project evaluation confirmed the importance of the involvement of local authorities to the success of such projects. Fabian Suter[1], Regula Meierhofer[1]

Introduction

In the last three decades, Bolivia has made significant progress in increasing access to drinking water coverage. The percentage of people in rural areas with access to water from pipes onto premises or other improved sources increased from 40 % to 76 %. And the percentage of people practicing open defecation in rural areas decreased from 72 % to 46 % [1]. The national government is committed to the human right to water approach and has increased its water sector investments [2]. Yet, the water, sanitation and hygiene (WASH) conditions remain unsatisfactory in many schools in the Tiquipaya municipality where the Safe Water Schools project took place. The local authorities, the local NGO Fundación SODIS, Eawag-Sandec and Antenna Technology Foundation started this WASH in schools project in 2012 in 46 public schools.

Methodology

First, a literature review of WASH in schools was done. A Safe Water School Training Manual was written and the project's structure developed as a result. The project had four pillars: 1) education of students, teachers and staff, 2) installation and maintenance of infrastructure, 3) monitoring and evaluation, and 4) awareness raising in the surrounding community [3]. The training manual was translated into Spanish and adapted to the local context by Fundación SODIS [4].

Safe Water School committees at each school, consisting of one to two teachers and five to twenty students, were key to the project. Students were selected from different grades to avoid knowledge loss at the end of the school year, and trained weekly on the application, organisation and monitoring of WASH practices in schools. The committees received equipment and training on how to treat water with Solar water disinfection (SODIS) and self-produced chlorine, and on conducting microbiological water quality tests. Hygiene training focused on hand washing and soap production. The local authorities contributed greatly by constructing and renovating school toilets at selected schools. The project team collected baseline and evaluation data by interviewing the heads of the schools and students, and by doing structured observations at each school. 17 months after the project's end, a post-project evaluation was done in 40 of the 46 schools; six were logistically not accessible or closed due to a lack of students.

Results

The post-project evaluation showed positive results. The students' WASH knowledge and skills had improved and the WASH equipment and infrastructure properly maintained. At least one water treatment method could be observed in 34 schools. 28 schools applied SODIS, 24 used chlorine and five schools boiled their drinking water. Most students could correctly demonstrate at least one water treatment method and the correct application of hand washing with soap increased from 14 % at baseline to 72 %.

The water quality measurements, however, showed that international and Bolivian water quality standards were not being met at all the schools. Six schools had no drinking water treatment in place and five schools, using SODIS and/or chlorine for water treatment, failed to meet these guidelines. Faecal contamination was found in four out of twenty eight SODIS-water samples and in one out of twenty four chlorinated water samples. A closer look at the Safe Water School Committees of the 40 schools showed that they focused mainly on practical water treatment, i.e. chlorine production, and did not regularly monitor WASH practices in the schools.

Conclusion

The Safe Water School project did improve WASH practices and conditions in the schools in Tiquipaya. The evaluation identified elements crucial to the sustainable implementation of WASH activities in schools: an enabling environment including support of the local authorities, integration of WASH trainings into curricula, developing context specific monitoring and educational materials, continual support for the Safe Water Committees by the heads of the schools and/or local authorities and involvement of local communities. Problems were detected and solved by documenting water quality measurements and WASH practices. Continuous dialogue among the stakeholders strengthened local ownership and triggered the interest of the authorities to invest resources into WASH at the schools.

Fundación SODIS

Photo 1: Safe Water Committee members measuring free residual chlorine in their drinking water.

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Further information about WASH in schools:
>> WASH in schools, IRC: http://www.washinschools.info/
>> WASH in schools mapping, UNICEF: http://washinschoolsmapping.com/

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Gravity-driven Membrane Water Kiosks in Three Ugandan Schools

Three gravity driven membrane water kiosks in rural Uganda treating surface water from Lake Victoria were evaluated. Results showed effective treatment of turbid water, while the systems require little maintenance and supply good quality water at low operational costs. M. Peter[1], N. McFadden[2], K. Dreyer[1], H. Ouma[3], K. Wanyama[3], C. Etenu[4], R. Meierhofer[5]

Introduction

Starting in January 2015, three gravity driven membrane (GDM) drinking water purification systems were constructed in Lugala, Busime and Bulwande Primary schools in Eastern Uganda (Photo 1). Currently, the water kiosks supply safe drinking water to 1 650 pupils for free and also sell water to the community at 1 EUR per month or 0.02 EUR per jerry can of 20 L. The water kiosks are managed and operated by the school management together with community representatives under the supervision of the Water School Uganda. The Nalwire Technical Institute provides support for technical maintenance and repairs. The Safe Water Promotion group conducted research on the water quality of the three water kiosks from November 2015–December 2016. The major objectives were to:

- evaluate the design and technical performance of the GDM systems in regard to water quality, capacity and flowrate
- develop and implement appropriate operation and maintenance procedures, and
- evaluate the business and management concept and assess overall sustainability.

GDM water kiosks

Each GDM water kiosk treats up to 6 000 L of water pumped from Lake Victoria per day. The system has two components: the intake structure at the lake shore and the treatment facility at the school. The intake structure includes an infiltration well and a low cost solar pump placed in a pump house. The treatment facility consists of the raw water tank that stores 6 000 L of untreated water, the membrane tank, containing the membrane, and a 6 000 L tank to store purified water. Rain water is collected in the same raw water tank during the rainy season.

Three ultrafiltration flat sheet membrane modules with a pore size of 20–40 nm and a total filtration area of 75 m^2 are used to filter out bacteria, protozoa and viruses. Water is filtered by gravity with hydrostatic pressure of about 100 mbar. The biofilm developing on the membrane surface over time remains porous and does not clog the membrane, allowing for low but stable water flux over years of operation [1].

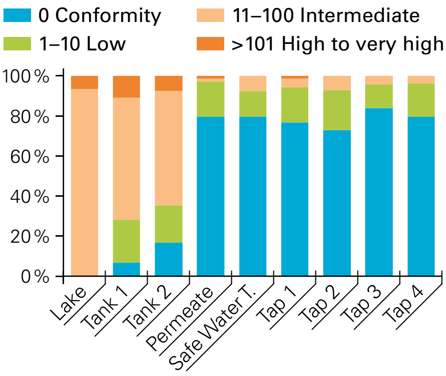

Figure 1: Samples in four *E. coli* count categories: 0, 1–10, 11–100 and >101 *E. coli*/100 ml. Source: [2]

Results

Microbial water quality

Figure 1 shows that all samples collected from the lake contained intermediate or high levels of contamination. Most samples collected after passing through the membrane and from the safe water tanks (SWT) and taps showed either 0 or 1 *Escherichia coli*/100 ml and corresponded to the low risk category. A few samples (under 8 %) contained higher numbers. These were measured during the starting phase of the system's operation and the contamination was caused by improperly tightened connections.

Flow rate and capacity

The membrane filtration flowrates were measured over several months in the three systems and varied between 0.22 m^3/h and 0.8 m^3/h. Stable flux has been observed in all systems. The measured flowrates were sufficient to cover the average daily demand for water in all schools in all weather conditions. On average, 6.5 hours of filtration were required to cover the demand.

Water sales

The schools sold 784 m^3/year of treated water in 2016 at Lugala, 223 m^3/year in Busime and 172 m^3/year in Bulwande. 868 EUR were made by water sales at the three schools, while the total expenditures were 155 EUR. This included all operational costs since the beginning of the kiosks' operation, resulting in 712 EUR profit, which is kept in an account for future maintenance needs.

Karin Dreyer

Photo 1: Water Kiosk in Lugala, Uganda.

Conclusion

Systematic water quality monitoring revealed that the GDM systems treat water to a good quality. Flowrates measured in the systems showed that stable flux values between 2–6 L/h per m^2 have been achieved in two systems despite the relatively low quality of the raw water in regard to turbidity and organic matter content. All three kiosks currently generate a profit from water sales. Although profits are accumulating, business management of the kiosks could be improved through business management and promotion activities.

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Drinking Water Safety in Mid-Western Nepal: Insights from Project Scoping

Implementing effective and sustainable strategies for drinking water safety in rural communities is a global challenge. An essential prerequisite to establishing a viable approach is to assess and understand the country context and unmet needs regarding drinking water quality. Ariane Schertenleib[1], Madan Raj Bhatta[2], Bal Mukunda Kunwar[2], Rubika Shrestha[2], Sara Marks[1]

Introduction

In the post-2015 development period, water sector professionals will be challenged by Sustainable Development Goal Target 6.1 (SDG 6.1) to deliver "universal and equitable access to safe and affordable drinking water for all", free from faecal and priority chemical contamination. In Nepal, over 90 % of rural households have access to an improved drinking water source, such as boreholes or gravity-fed piped schemes [1]. Yet, improved water schemes do not ensure water free of faecal contamination, necessitating efficient water quality monitoring strategies [2].

In remote rural settings, the collection, management and analysis of water quality information is hampered by multiple barriers, including long traveling distances and times, unreliable supply chains for sampling materials, the high cost of laboratory equipment, and unreliable or non-existent access to electricity. Rural communities in alpine regions of Nepal exemplify many of these challenges.

Through a one-year study that began in January 2017, Eawag and HELVETAS-Nepal aim to establish a risk-based water safety strategy for piped water supplies in the Mid-Western Region. The goal of the study is to demonstrate a viable approach to achieving effective water safety planning for rural communities in alpine settings.

Scoping activities

Before implementing the project the team conducted an in-depth scoping study to assess the current situation. The goal of scoping was to: understand the water sector's current activities related to drinking water quality, define the unmet needs regarding water quality monitoring within a water safety framework, identify key stakeholders in this domain, and gain knowledge about the definitions of standards, roles and responsibilities in the country.

To gather this information, the scoping visit included several activities: face-to-face meetings with governmental representatives, NGOs and local stakeholders; field visits in rural areas; and organising a national workshop. The national workshop gathered 21 attendees from government, NGO, and academia, a subset of whom contributed presentations. Emphasis was placed on group discussions and reflection to identify needs and possible ways forward. The overall goal of these discussions was to ensure that the proposed project would not repeat ongoing efforts and experiences in Nepal, meet the government's needs, and effectively fill a gap in the domain of water safety.

Results and work preparation

In Nepal, water quality surveillance is linked to many organisations and actors across public and private sectors. There are six governmental laboratories in the country (one per region and one central). Roles and responsibilities for water quality monitoring and surveillance are defined in the National Drinking Water Quality Standards, edited in 2005 by the government of Nepal [3]. Following the national workshop, the team visited the responsible branches mentioned in the Standards document for the Mid-Western region and learned that there was a lack of coordination among actors responsible for water quality surveillance.

The Government of Nepal and WHO provided WAGTECH field test kits to each regional laboratory for sampling across rural areas. Discussions and follow-up visits concluded that these kits are hardly used due to malfunction of the materials and lack of training on the operation of the kit. The WHO Water Safety Planning (WSP) approach is dominant in Nepal, but according to implementers, very few rural WSPs are audited or functioning as expected. It clearly appears that the biggest challenge for achieving water safety in the Mid-Western Region is not a lack of adequate material, but rather inadequate staff training and lack of a defined coordinated strategy.

Conclusion

This scoping phase clarified many challenges and unmet needs for achieving universal access to safe drinking water in Nepal. Field visits, meetings, and a national workshop revealed that the "ground truth" of rural water quality management often diverges from official policy recommendations. This information shaped the project's eventual implementation strategy to include targeted sanitary inspections, field laboratory units equipped with microbial and chemical testing capacity, scheme-level treatment upgrades, and centralised data management using Akvo FLOW. Scoping activities also increased awareness on the topic, with sector actors discussing together how to improve the situation and better fulfil their tasks.

Sara Marks

Photo 1: Scoping activities in Mid-Western Nepal.

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Hybrid Coagulation-ultrafiltration Process for Drinking Water Treatment

Ultrafiltration allows for compact, effective and low-cost water treatment plants to be installed in developing countries. However, membrane fouling remains an overriding obstacle. This article highlights the performance of a pilot coagulation-ultrafiltration study in Kampala. Samuel Gyebi Arhin[1,2], Noble Banadda[2], Allan Komakech[2], Sara Marks[1]

Introduction

Worldwide, the numerous challenges associated with inadequate access to safe drinking water are well-known: 1.8 billion people use water contaminated with faecal pathogens [1] and 3 900 children die daily from diseases transmitted through unsafe water [2]. In Uganda, although piped water coverage has increased over the years, treatment of piped supplies is not guaranteed, and only 5 % of the population have access to a tap on their premises [3]. Residents without access to piped water use untreated sources, which are prone to contamination with enteric pathogens (Photo 1). As a result, 29 300 children die annually in Uganda from diarrhoeal diseases [4].

Ultrafiltration (UF) is a promising technology for decentralised water treatment in developing countries; yet, a major hindrance to long-term operation of UF is membrane fouling. This leads to permeate flux losses, increased membrane cleaning routines and high operating costs. Several researchers have studied coagulation pre-treatment of feed water to overcome fouling, but no study has been done on surface water sources characterised by concentrated organic and inorganic matter content in Uganda. This study examined the performance of a UF system for drinking water treatment, using polyaluminium chloride (PACl) coagulant for fouling control.

Methods

Preliminary batch experiments, aimed at obtaining the optimum conditions for coagulation pre-treatment, were done on raw water samples taken from Lake Victoria at the Ggaba II Water Treatment Plant inlet. PACl doses ranging from 10–20 mg/L were tested under flocculation retention time (FRT) of 5–20 mins in a bench-scale in line coagulation/ultrafiltration process. The optimum PACl dose and FRT were selected based on conditions resulting in higher removal of turbidity and UV_{254}, while retaining a high hydraulic permeability.

Two sets of pilot-scale UF experiments were performed. In the first, the optimum PACl dose and FRT were used to pre-treat the feed water prior to the filtration process (system A). In the second, the feed water was filtered without PACl (system B). The efficiency of the treatment process was assessed based on the removal of turbidity, colour, UV_{254} absorbance, dissolved organic carbon (DOC), pathogen count (*Escherichia coli* and total coliforms), and fouling rate of the UF membranes.

Results

The optimum PACl dose and FRT were 20 mg/L and 14 min respectively. It was observed that PACl dose(s) and FRT(s) that formed very small flocs had lower hydraulic permeability. The study further revealed that with smaller flocs, tiny particles were able to permeate through the UF membranes leading to lower permeate quality.

In the pilot-study, less fouling was observed in system A compared to system B because coagulation pre-treatment was effective in removing natural organic matter from the feed water. As shown in Table 1, 77.8 % removal of UV_{254} absorbing organics was attained in system A whereas in system B, only 28.6 % of UV_{254} organics were removed.

Samuel Arhin

Photo 1: People fetching water from an unprotected spring in a slum in Kampala.

Aside from UV_{254}, system A also contributed to high removal of DOC.

Parameter	System A (%)	System B (%)
Turbidity	99.2 ± 0.2	98.1 ± 1.0
Colour	100.0 ± 0.0	97.5 ± 0.8
UV_{254}	77.8 ± 8.3	28.6 ± 6.9
DOC	35.3 ± 7.2	11.8 ± 3.3
E. coli [a]	> 3.3 ± 0.1	> 3.3 ± 0.1
Total coliforms [a]	> 3.8 ± 0.1	> 3.6 ± 0.1

Table 1: Percentage removal of water quality parameters in systems A and B.
[a] Log_{10} reduction.

Conclusion

The relatively high removal of turbidity, colour, UV_{254}, DOC, *E. coli* and total coliforms from the permeate of system A and the ability of the system to control membrane fouling indicate that integrating PACl coagulation with the UF process is potentially an effective and sustainable technique for producing safe drinking water in Uganda. Further long-term research, however, is needed to provide insight into the overall feasibility of implementing this hybrid system in Uganda.

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The RANAS Approach to Systematic Behaviour Change

A practical guide using the RANAS approach was recently published. Its aim is to give practitioners a tool to help them design effective behaviour change campaigns. The methodology is outlined step by step and all necessary skills and requirements are explained. Hans-Joachim Mosler[1]

Introduction

The Risks, Attitudes, Norms, Abilities, and Self-regulation (RANAS) approach to systematic behaviour change is an established method for designing and evaluating behaviour change strategies that target and change the behavioural factors of a specific behaviour in a defined population (Mosler, 2012). In the RANAS approach, it is assumed that all behaviour is based on processes in people's minds. Knowledge is activated, beliefs and emotions rise to the fore, and an intention to perform a particular behaviour emerges, eventually resulting in observable behaviour. In other words, these processes, which we term behavioural factors, determine behaviour. To change behaviour effectively, these behavioural factors have to be targeted by intervention programs.

The RANAS model integrates leading theories of behaviour change, as well as the findings of environmental and health psychology, and is based on decades of scientific research expertise. It is an easy to apply method for: measuring behavioural factors, assessing their influence on behaviour, designing tailored strategies that change behaviour and measuring their effectiveness. Although it was originally developed to change behaviour in the Water, Sanitation and Hygiene (WaSH) sector in developing countries, RANAS is applicable to a range of behaviours in various settings and populations.

The RANAS approach to systematic behaviour change involves four phases (see Figure 1). First, identify possible behavioural factors; second, measure the behavioural factors identified and determine those steering the behaviour; third, select corresponding behaviour change techniques (BCTs) and develop appropriate behaviour change strategies; and fourth, implement and evaluate the behaviour change strategies. In the following, we briefly describe these four phases.

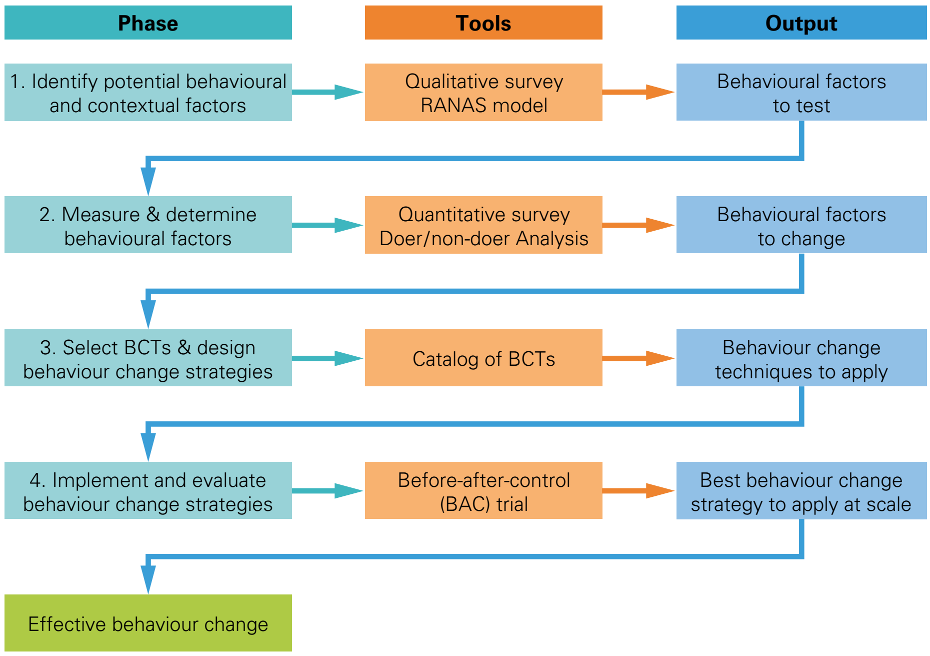

Figure 1: The four phases of the RANAS approach to systematic behaviour change.

Phase 1: Identify potential behavioural factors

The first step is to specify the exact behaviour to be changed and the specific population group to be targeted. Then, information on behavioural and contextual factors that might influence the target behaviour is collected. This can be done, for example, by conducting short qualitative interviews with various stakeholders at different levels, including the target population. Following this, the potential behavioural and contextual factors that have been identified are arranged in the RANAS model of behaviour change; this may involve adapting and extending the model. As indicated in Figure 2, behavioural factors are perceptions, thoughts, feelings, and beliefs that influence the practice of behaviour. Together, they characterise the mindset of a person in regard to that behaviour.

Behaviours are critically regulated by different behavioural factors in differing populations and contexts. To select the most effective behaviour change techniques, we recommend surveying all the potential behavioural factors and conducting a doer/non-doer analysis to specify which are most critical. These are the factors to be addressed through behaviour change techniques.

Phase 2: Measure the identified potential factors and determine those steering the behaviour

Developing a questionnaire to measure the behaviour and the potential behavioural factors and a protocol to conduct observations of the target behaviour is the next step. Template tools have been designed to assist in the making of questionnaires and observation protocols. When developing them, it is important to take local conditions into account.

A doer/non-doer analysis is conducted to identify the specific behavioural factors steering the target behaviour. The responses of people who perform the behaviour (doers) are compared to the responses of those who do not (non-doers). A large difference in these responses will show which behavioural factors critically steer the behaviour in question. These are the factors that should be addressed through behaviour change techniques (BCTs) to change the behaviour.

Phase 3: Select corresponding BCTs and develop appropriate behaviour change strategies

After determining the appropriate BCTs (see Figure 2), a behaviour change strategy is developed. This is done by reviewing a catalogue of BCTs, which lists the BCTs that have been shown to change specific behavioural factors based on evidence from environmental and health psychology. Upon selecting the appropriate BCTs, they next have to be adapted to the local context and combined with suitable communication channels, i.e. modes of delivery. Together, the BCTs and the communication channels form a behaviour change strategy.

Phase 4: Implement and evaluate the behaviour change strategies

To verify and optimise the efficacy of behaviour change strategies, they are evaluated with a before/after control trial. Through the use of a questionnaire and observations, behaviour and behavioural factors are measured both before and after implementing the strategies. A control group also has to be evaluated to control for intervention-independent changes in behaviour.

The differences in behaviour scores and in the behavioural factor scores before and after implanting the strategies are calculated and compared to those of the control group. It has been shown that behaviour change strategies are effective when the before-after differences in behaviour and behavioural factors are larger for the population that received the strategies than for the control group. The strategies can also always be refined if needed. Otherwise, if they have worked, they can be applied directly at larger scales or in other, similar areas, backed up by the evidence that they are effective at changing behaviour.

Figure 3: Countries in which RANAS projects were conducted.

Conclusion

Although the RANAS approach is time-intensive, and requires several months to apply, doing it is worth the effort. It results in behaviour change strategies which: (1) are tailored to the local population, (2) have been proven to effectively change behaviour under local conditions, and (3) provide an evidence base for further interventions (Mosler, 2012). The RANAS method has been shown to effectively change behaviour and, at the same time, provides evidence useful to attract support from local governments and donors for future projects.

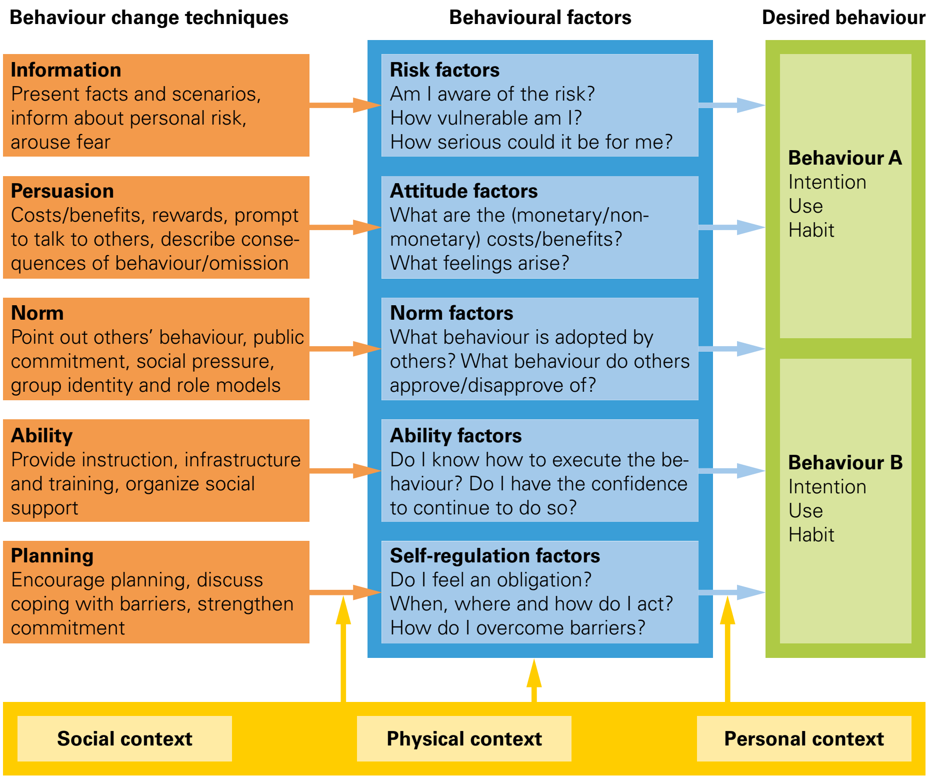

Figure 2: The RANAS Model of behaviour change.

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The practical guide: http://www.eawag.ch/en/department/ess/empirical-focus/environmental-and-health-psychology-ehpsy/

Publications: Mosler, H.-J. (2012): A systematic approach to behavior change interventions for the water and sanitation sector in developing countries: a conceptual model, a review, and a guideline. International Journal of Environmental Health Research *22 (5)*, 431–449.

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Drivers of Ebola Prevention Behaviours: Research in Guineau-Bissau

This study aimed to identify the behavioural drivers influencing compliance with Ebola prevention instructions in Guinea-Bissau. The results can help to design efficient behaviour change interventions and to address the behavioural barriers in the population. Anna E. Gamma[1], Hans-Joachim Mosler[1]

Sidi Mohamed Jaquite

Photo 1: Ebola information session of the local partner NADEL.

Introduction

The last outbreak of the Ebola virus disease from 2013 to 2016 in West Africa was with 28 646 confirmed cases and 11 323 deaths the largest and most complex Ebola outbreak in history [1]. The most severely affected countries were Guinea-Conakry, Liberia, and Sierra Leone.

Ebola is a severe illness in humans with high case fatality rates if untreated [2]. Wild animals, such as bats and monkeys, can transmit the virus to people; it then spreads through human-to-human transmission via direct contact with the body fluids of infected people [3].

Guinea-Bissau remained at high risk throughout the regional epidemic due to its proximity to Guinea-Conakry. Cross-border market activities, burial ceremonies and poor water, sanitation, and hygiene conditions in many communities [4] were among the main factors contributing to Guinea-Bissau's high Ebola-related vulnerability. To be prepared for the eventuality that Ebola would affect the country, the government of Guinea-Bissau opened new field hospitals and arranged a procedure to evacuate suspected cases to health centres. It also focused on strengthening community engagement, including through dialogue with traditional and religious leaders, and linking these community structures with the national response mechanism.

As an Ebola vaccine was still in the testing phase, prevention behaviours played a crucial role. Underlying psychosocial factors, which are elements in the mindset of a person, such as knowledge and beliefs, are key aspects of these behaviours and ought thus to be taken into account. A person suffering from Ebola needs to be treated and isolated in a health centre. To facilitate this, the Health Ministry launched the National Ebola hotline to enable rapid communication of suspected cases of Ebola. One objective of this study was to determine the intention of the population in Guinea-Bissau to use the hotline to report suspected cases of Ebola.

If a person might be suffering from Ebola in the household, a very important behaviour is to not touch this individual, due to the high risk of infection via direct contact with their body fluids. However, not touching someone who might be suffering from Ebola could be seen as disloyal and selfish by others. The second objective of this study was, therefore, to reveal the psychosocial factors of the intention not to touch someone who might be suffering from Ebola. The project was conducted in close collaboration with UNICEF Guinea-Bissau, the Ministry of Health of Guinea-Bissau and the local partner NGO Nadel.

Methods

The data collection took place in July and August 2015 in the whole country. Villages were randomly selected in all regions. The sample sizes in the different regions were determined relative to their respective population size. A team of 26 national and local health sector employees carried out structured face-to-face interviews with 1 369 respondents. The questionnaire aimed to assess the psychosocial factors of the RANAS (risks, attitudes, norms, abilities, and self-regulation) model [5], the intention to follow the prevention instructions, and contextual factors (socio-demographic characteristics, wealth, having access to a mobile phone, etc.).

Results

The contextual factors did not explain much of the intention to follow the two prevention instructions (reporting a suspected case to the Ebola hotline and not touching someone who

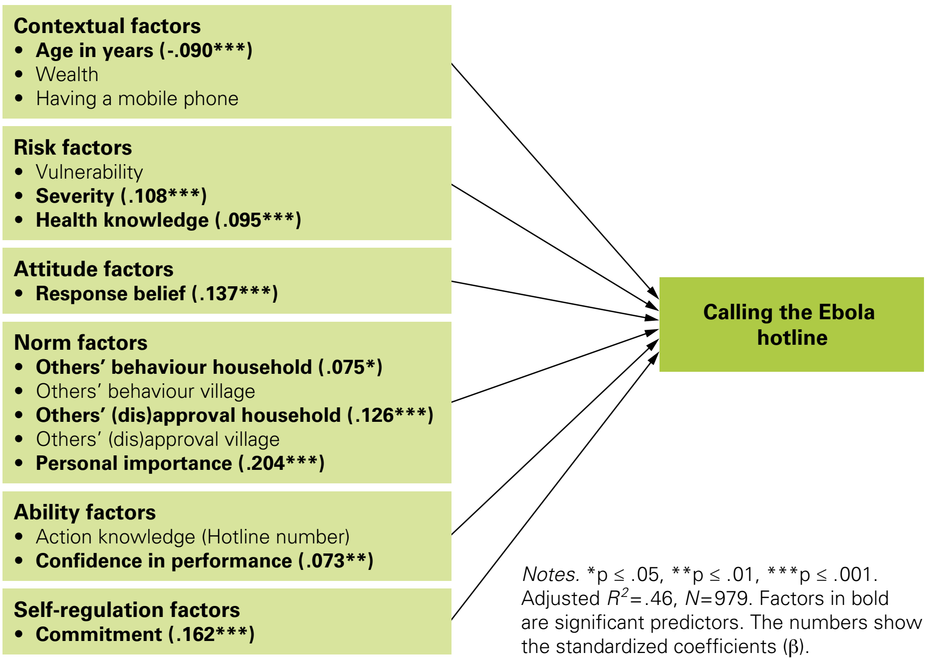

Figure 1: Regression analysis with the included factors explaining the intention to call the Ebola hotline.

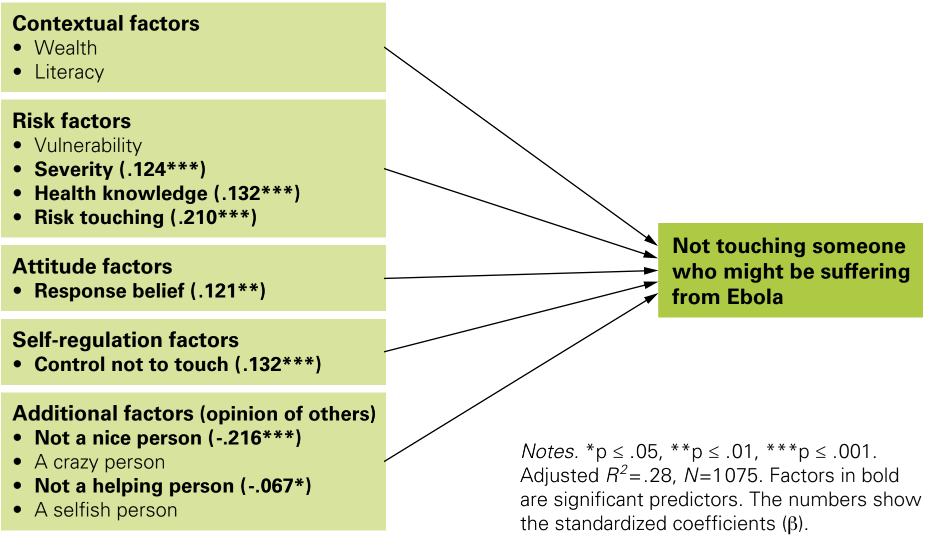

Figure 2: Regression analysis with the included factors explaining the intention not to touch someone who might be suffering from Ebola.

might be suffering from Ebola). Only age in years was found to be a significant predictor for the intention to call the Ebola hotline; younger people were more likely to use a service like the Ebola hotline than older people.
It was discovered that the most important predictors for the intention to call the Ebola hotline (Figure 1) were the following: believing that calling the Ebola hotline will help the infected person (Response belief), perceiving that important members from the household approve of calling the Ebola hotline (Others' (dis)approval household), that the respondents think calling the Ebola hotline is something they should do (Personal importance) and the belief that it is important to call the Ebola hotline and to report a suspected case (Commitment).
The most important predictors for the intention not to touch someone who might be suffering from Ebola (Figure 2) were: health knowledge, risk perception and the confidence to be able not to touch a possibly infected person (Control not to touch and Confidence in performance). This behavioural intention was difficult to measure, as it should not be performed. In order to avoid talking about this behaviour for a long time, we asked only a few questions about it.
Reasons for still touching someone even if he or she show symptoms of Ebola include the fear that others would think the respondent is a bad person if he or she did not touch a suspected Ebola case and that others would think the respondent does not want to help a sick person. This is a critical barrier to proper prevention behaviour in an actual outbreak of Ebola or of other highly contagious diseases and would need to be taken into account when designing an Ebola preparedness campaign.

Conclusion

During the Ebola outbreak, health workers had to address disbeliefs about the disease and strong cultural traditions that contributed to the spread of the virus (e.g. going to traditional healers, being in close contact with dead bodies before the burial ceremony, etc.). Communication is a key activity during an emergency response [6], but the content of messages should go beyond simple health information (Photo 1). Many health promotion activities, for instance, focus on disseminating knowledge about the risks associated with WASH-behaviours and about awareness raising, but this does not necessarily on their own lead to the desired behaviour. The findings of this study demonstrate that health knowledge was a predictor of Ebola prevention behaviours, but the norm factors, especially others' (dis)approval, response belief, and commitment, emerged as more relevant to predicting behavioural intention to follow Ebola prevention instructions. Behaviour change programs should use evidence to target the right psychosocial factors and to maximise their effects on prevention behaviours, especially in emergency contexts. For example, to increase the intention to call the Ebola hotline, a radio spot could serve as a communication channel, where different kinds of people (others' behaviour) and a local opinion leader (others' approval) could pledge their intention to call the Ebola hotline (commitment) if there is a suspected Ebola case in their household. They would say that they believe that this service has to be used to help the affected person and to protect other family members and members of their community (response belief).
The RANAS model focuses on changes that can be achieved by individuals [7]. Changes on other levels, such as the institutional, political, or systemic, are needed as well to control an outbreak of a contagious disease like Ebola. A situation such as what occurred in West Africa during the last outbreak of Ebola highlights the need for adequate public health infrastructure, public health resources, and concomitantly, culturally appropriate risk communication and health promotion. Factors, such as different languages, dialects, clear illustrations for illiterate people and whether there is a strong tradition of oral communication and traditional beliefs, also have to be considered in the communication [8].

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[2] Ebola virus disease [http://www.who.int/mediacentre/factsheets/fs103/en/]
[3] Ebola Virus Disease Consolidated Preparedness Checklist [http://apps.who.int/iris/bitstream/10665/137096/1/WHO_EVD_Preparedness_14_eng.pdf?ua=1]
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[1] Eawag/ESS, Switzerland

This project was funded by UNICEF Guinea-Bissau and the EU.

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Website: http://www.eawag.ch/en/department/ess/empirical-focus/environmental-and-health-psychology-ehpsy/

Contact: anna.gamma@eawag.ch

Expanding Sanitation Business Models with Information Technology

Innovation in the sanitation sector is moving beyond creating new toilet designs and novel treatment approaches to disrupting how actual sanitation services are provided. This article explores how three sanitation service providers have adopted and applied various technologies. Caroline Saul[1], Heiko Gebauer[1], Grégoire Virard[1]

Business model innovation

Companies are embracing information and communication technologies and the Internet of Things (IoT) to offer a higher level of service to their customers at affordable prices (Figure 1). They are leveraging technologies for customer acquisition and management, logistics and payments. Their aim is to improve their overall operations through new technology.

Firm overview

Container based sanitation (CBS) refers to a sanitation system in which excreta is stored in a vessel at the point of use (usually at the household). The excreta are transported to a treatment site with pushcarts and motorised vehicles, where it is safely handled and treated. CBS organisations use the excreta to recover nutrients or energy [1]. Maintaining customer relationships and managing and monitoring the movement and contents of containers full of human waste are crucial for these organisations.

x-runner Venture is a CBS service provider in Lima, Peru, and works in communities that tend to have electricity, but no networked water or sanitation services. x-runner customers pay a monthly fee to rent plastic, urine diverting dry toilets (UDDTs), which store the urine and faeces separately. The faeces land in a biodegradable bag in the back section of the toilet and are collected and treated through composting.

LooWatt is a UK-based organisation that has 100 toilets in Antananarivo, Madagascar. Their system differs notably from other CBS service providers because their toilets seal the users' excreta in a bioplastic casing after each use and customers purchase rolls of bioplastic "refills". The filled plastic casings are stored in the bucket, which is weighed, collected, and exchanged weekly. The excreta are then treated via anaerobic digestion and pasteurisation.

Over 100 households in Nivasha, Kenya, rent Blue Box UDDT toilets from Sanivation and the waste containers are collected twice a week. Pathogens in the faecal matter are deactivated via solar heating and the treated waste is used as a binder and mixed with char dust and agricultural waste to make cooking briquettes. Many clients like the service because the toilets are inside their homes and are more convenient than public latrines.

LooWatt

Photo 1: A LooWatt employee scanning a QR code.

Logistics

IoT is being used in novel ways, i.e. Bluetooth controlled bidets [2] and toilets that provide in-situ health analysis [3], as well as for logistics. By applying tags to their inventory, for instance, organisations can track their performance and improve their service quality.

LooWatt's refills, buckets and toilets are outfitted with "Quick Response" or QR codes, which are like barcodes [4]. These can be scanned with basic smartphones, and are used in manufacturing, inventory management, logistics and retail. Each customer has a personal QR code associated with their customer number and each collector also has a personal QR Code. At every collection point, the collectors scan the QR codes on the buckets and weigh them. The buckets are re-scanned and re-weighed at the treatment site (Photo 1). LooWatt uses this technology to track whose waste was collected, how long it took, the quantity and if all of it reached the treatment site.

x-runner has Near Field Communication (NFC) tags on about half of their buckets. NFC tags can send and receive data wirelessly to some electronic devices, including some smartphones [5]. The buckets are scanned using an Open Data Kit (ODK) based smartphone application when the bags of waste are removed and placed on the collection truck. The collectors can thereby make sure that the users have paid for the service and also note if there are problems with the conditions of the buckets. If a bucket is repeatedly smelly or has liquid in it, they can retrain the household on proper toilet usage.

Customer management

Successfully providing CBS services requires managing customers cost-efficiently. Although the three systems below are different, they all facilitate data collection and management, which are necessary for reporting and decision-making.

x-runner enters potential customers' information into an application called Formyoula from the moment a customer first voices interest in having a toilet installed, creating their customer profile. This app works offline, which is important in areas with spotty cellphone coverage, and is synced daily with Salesforce, a customer relationship management (CRM) system. Once a profile is created, the sales team can visit the customer and have a contract signed. This database also stores service history and other behavioural data.

Sanivation's bespoke CRM system provides a structure to keep track of customer data, such as household size and wealth, payment history, amount of excreta generated, their referral history and account manager. Most of the operations' data collection, e.g. bucket weight and condition, is done by hand with pen and paper and keyed later into the system. A rollout of an ODK based data collection system, however, is in the works.

LooWatt uses a web-platform to house their database. It stores all the QR scans and payment histories, aggregates cash and mobile money payments, and allows managers to see if customers still have credit to access refills and services. Customers can request technical services, additional refills or on-demand collection using a free SMS system that is connected to the web-platform.

Payments

By using electronic tools to collect fees, organisations reduce the effort needed to do revenue collection. Although door-to-door money collection fosters direct customer interaction, there are many problems associated with it, i.e. it is time and labour intensive, customers are often not at home, do not have cash or make only partial payments. Collectors are also at risk when they have large sums of money or when needing to deal with money while also handling waste.

Sanivation encourages its customers to pay using M-Pesa, Kenya's leading mobile money platform. When customers send money, the platform automatically generates a receipt. M-Pesa is also used to send targeted text messages about promotions and payment reminders. Since many of Sanivation's customers are elderly and not avid users of technology, Sanivation has to train many of them on how to use the system. M-Pesa shops are, however, mostly in the town centre; people living far from the centre have less access to their services.

x-runner collaborates with a national bank for payment collection. Once a month, customers pay at local pharmacies or shops. They give their customer number and payment to the clerks who enter the data into the banking system.

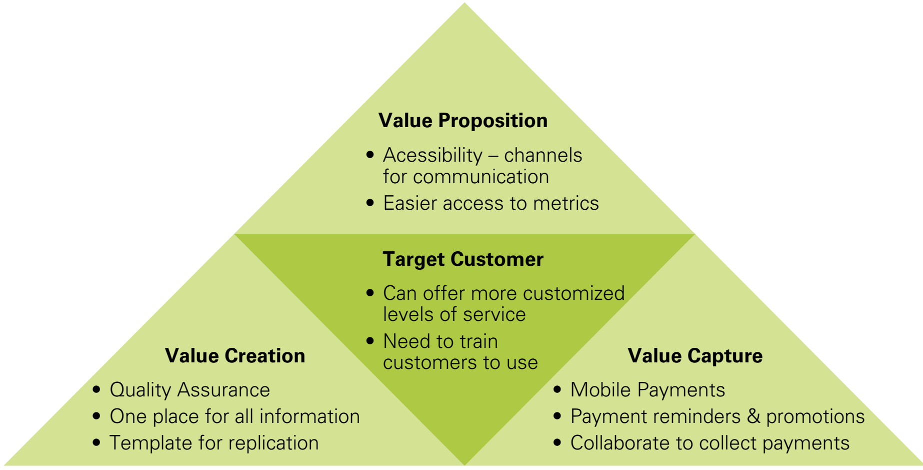

Figure 1: The role of information technology on CBS service providers' business models.

Tool development

Although the recordkeeping of these three organisations started with a mishmash of spreadsheets and paper, they later followed different strategies to develop more sophisticated systems that address their specific needs. x-runner and LooWatt worked with international developers to build their software systems, receiving external grants to fund the process. They both worked with the developers over Skype for half a year to design the process flows; then, the developers visited to tweak the software and train people. Sanivation's CRM system was built by a Kenyan developer over three months and financed from internal funds.

Developing these systems led each organisation to better understand the possibilities offered by technology and its limitations. For example, limited network coverage means that the apps have to work offline. Therefore, they use quite a bit of memory, which can be a problem depending on the cellphones being used. Some system components also had to be specially designed for people with limited literacy.

Looking forward

Each organisation is anticipating the next version of their software systems. And they draw inspiration from other basic service providers, which are also applying new tech developments, such as household solar pay-as-you-go businesses.

LooWatt notes that their app is not needed to manage day-to-day operations since they have just 100 toilets. Scaling up, however, will require a good understanding of the behaviour of their customers, which is easier when customer data is digital. The app and web-platform also standardises the system's quality assurance and creates a template for replication and future franchising opportunities.

Sanivation's toilet service representatives carry a GPS tracker and download their daily service path, which is overlaid on a map of their customers. This helps them check that all households have been served. As the company grows, this could be taken a step further, with the use of route optimising software. This would require, however, the development of better maps of roads and pathways.

CBS service providers are innovating to craft IT systems that fit their unique needs, contexts and growth plans. As described above, these systems have been able to unlock new potential in their business models. These organisations are also exchanging experiences to foster further development and potential future collaborations.

[1] Sandec News No. 17, 2016.
[2] http://www.lixil.co.jp/lineup/toiletroom/satis/smartphone/
[3] https://www.wired.com/insights/2014/04/toilet-role-internet-things/
[4] qrode.com
[5] www.nfc-forum.org/what-is-nfc/

[1] Eawag/Environmental Social Sciences, Switzerland

Acknowledgements:
The authors would like to thank Armel Segretain, Natalia Benavides, and Benjamin Kramer for being interviewed for this article.

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Shaping the Future of eLearning in the WASH-Sector

Education in the WASH sector is at an inflection point. How will it be organised in the coming decades? While MOOCs are established as a low-cost option, reaching hundreds of thousands of students and practitioners, new, hybrid formats are being developed and tested at Sandec. Fabian Suter[1], Christoph Lüthi[1]

Introduction

Massive Open Online Courses (MOOCs) emerged in 2012 when Silicon Valley entrepreneurs and universities, such as Princeton, Stanford and Berkeley, teamed up to make higher education accessible to everyone with an Internet connection. By 2016, more than 700 universities are producing MOOCs that reach 58 million students worldwide [1]. In low- and middle-income countries, MOOCs are rapidly meeting the largely unmet need for educational opportunities among learners of all ages. Major barriers to further dissemination, however, are the lack of tailored content in local languages and the limitation of digital access [2].

While research about the role of MOOCs in education in low- and middle-income countries is still an emerging field, there is ongoing debate about whether MOOCs will contribute to the democratisation of education, or exacerbate the digital divide [3,4]. What is clear is that enrolment numbers continue to grow immensely. A crucial question remains, whether universities and training institutes in Africa, Asia and Latin America will embed MOOCs into their curricula. Will they position themselves as high quality content producers and host their content on regional platforms? The recent trends are promising. The first regional platforms, such as Miríada X, the first regional MOOC provider for Latin America, and the Indian platform Swayam have been launched successfully [5]. EPFL (Ecole Polytechnique Fédérale de Lausanne) started MOOCs Afrique to support MOOC production in Africa, and innovative institutes, such as Kepler in Kigali, Rwanda, have started to offer complete curricula, combining online digital media with tailor-made on-campus education [6].

The MOOC series "Sanitation, Water and Solid Waste for Development"

In 2014, Eawag/Sandec and EPFL jointly developed the open-access MOOC series "Sanitation, Water and Solid Waste for Development". To date, the series' four courses have reached a global audience of 41 000 active learners and there have been around 6 000 course completers (Figure 1). Over 50 % of the participants are students and practitioners from low- and middle-income countries.

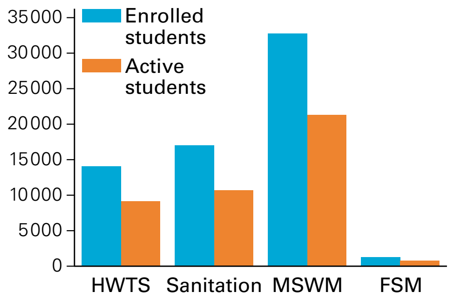

Figure 1: Enrolled and active students of the MOOC series "Sanitation, Water and Solid Waste for Development".

The way forward

While the online MOOC format is well suited to reach thousands of learners, it cannot adequately replace more tailor-made education providing in-depth knowledge and skills. Sandec is, therefore, exploring promising combinations of learning formats and will implement three approaches in the near future:

- Blended learning: The first approach is to support universities and training centres by assisting them in developing a blend of online and onsite learning curricula. Any institution interested in using its MOOCs and other learning materials should contact Sandec.
- Education and training packages: These packages combine MOOC content with additional educational materials produced for specific contexts and target groups. The first one is currently being produced with the Bandung Institute of Technology for the solid waste management sector in Indonesia.
- Certificate of Open Studies (COS): COS merges distance and onsite learning by combining the MOOC series with an onsite exam and a written project at a local university. Students have to pay to enrol and will receive 10 ECTS-credits issued by EPFL. Within the next two years, an initial pilot will jointly be implemented at three partner universities. A merit-based system will award selected students with a sponsorship that covers the COS fee.

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[5] https://miriadax.net, https://swayam.gov.in
[6] https://moocs-afrique.epfl.ch/fr/, http://www.kepler.org/

Figure 2: The MOOC-series "Sanitation, Water and Solid Waste for Development".

[1] Eawag/Sandec, Switzerland

Website: MOOC-series "Sanitation, Water and Solid Waste for Development": www.eawag.ch/mooc

Events: World Water Week Event "Reaching millions – Future capacity development for the sanitation sector".
Date: Monday 28 August 2017, 14:00–15:30.

Contact: fabian.suter@eawag.ch

The Faecal Sludge Management Book Soon in French!

Thanks to support from the Agence Française de Développement (AFD), the Association Internationale des Maires Francophones (AIMF), the Syndicat Interdépartemental pour l'Assainissement de l'Agglomération Parisienne (SIAAP) and the Agence de l'Eau Seine-Normandie (AESN), and through the coordination of our French partner SIA-Conseil, the Faecal Sludge Management (FSM) book will be published in French in late 2017. The "gestion des boues de vidange" is a major challenge in the francophone world, and will remain so for decades to come. From Senegal, Burundi, Madagascar to Haiti, most of the urban population is not connected to a sewer network, but rely on pit latrines and septic tanks.

The FSM book provides technical, organisational and planning guidance on how to set up a proper faecal sludge management system at city level. This edition will fill the lack of reference tools in French on this topic, and will complete the French language educational resources of Sandec, i.e. the MOOCs "Planning & Design of Sanitation Systems and Technologies" and "Introduction to Faecal Sludge Management" (respectively dubbed and subtitled in French) and the Compendium of Sanitation Systems and Technologies in French. It will be free to download on the Sandec website.

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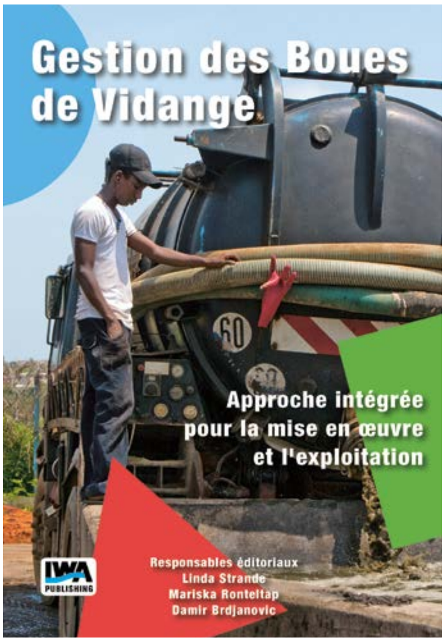

Sandec/Eawag

Gestion des Boues de Vidange. (Faecal Sludge Management: Systems Approach for Implementation and Operation)

Water Supply and Treatment Group Launches New Fact Sheet Series

As a means to assist people working in the field and to be used as teaching and training tools, the Water Supply and Treatment Group is producing a series of Fact Sheets on technical topics. The aim is to make complex, technical matters understandable to the layperson.

The first Fact Sheet was produced to assist people with little or no knowledge of solar power on how to safely set up a photovoltaic array with batteries in the field. It presents all the information one needs to know, such as the different kinds of electric current (AC and DC), the basic components of a field solar supply system and how to calculate your power needs. The Fact Sheet also goes through different setup options, provides field tips and illustrates the setup step by step in pictures.

It can be downloaded for free at: https://goo.gl/NDJQ2r.

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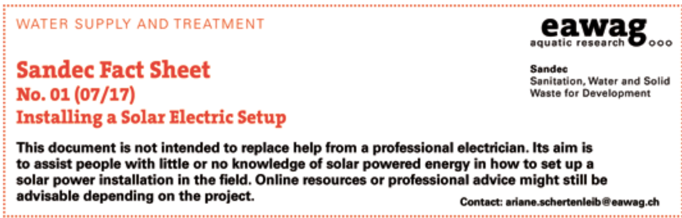


WATER SUPPLY AND TREATMENT

eawag aquatic research

Sandec
Sanitation, Water and Solid Waste for Development

Sandec Fact Sheet
No. 01 (07/17)
Installing a Solar Electric Setup

This document is not intended to replace help from a professional electrician. Its aim is to assist people with little or no knowledge of solar powered energy in how to set up a solar power installation in the field. Online resources or professional advice might still be advisable depending on the project.

Contact: ariane.schertenleib@eawag.ch

Number 1: Installing a Solar Electric Setup.

Sara Marks

Batteries and Incubator.

Launch of "Introduction to Faecal Sludge Management" Workshop

The Management of Excreta, Wastewater and Sludge group successfully launched the *Introduction to Faecal Sludge Management* workshop last November in Dar es Salaam, Tanzania. It was developed with the Centre for Affordable Water and Sanitation Technology for practitioners in developing countries who are or will be designing, planning, promoting or managing FSM systems. All workshop materials are available free at: www.sandec.ch/fsm_tools. This includes a trainers' manual, which explains how each lesson should be taught. To date, the workshop has been taught in Canada, Tanzania, South Africa, USA, Vietnam and Malawi. It is available in a two or a three day format.

Karolina Zareba

The workshop launch in Dar es Salaam, in collaboration with CAWST and BORDA.

Eawag/FHNW Project "Gravit'eau" Awarded prix eco.ch

"Gravit'eau", a joint Eawag and FHNW School of Life Sciences project, was awarded prix eco.ch 2017, the Swiss Prize for Sustainable Development. "Gravit'eau" is setting up water kiosks in Uganda where water is purified using gravity-driven membrane filtration. The kiosks are robust, need very little maintenance and cheap to operate. The technology removes bacteria, viruses and protozoa from turbid water and can be deployed in remote rural areas in developing countries or city slums.

eco.ch

Maryna Peter and Regula Meierhofer receive the eco.ch prize from Violette Ruppanner.

Forthcoming Event

Sandec/Eawag Presenting Seminar at the SIWI 2017 World Water Week
28 August 2017, 14:00 – 15:30, Stockholm City Conference Center, Room: FH 202

SIWI WORLD WATER WEEK
www.worldwaterweek.org

Sandec/Eawag and partners are presenting the seminar "Reaching Millions: Future capacity development for the sanitation sector" at World Water Week. This seminar reflects the need for capacity development in the WASH sector that is not being met by traditional educational institutions. New learning products have been developed, i.e. Massive Open Online Courses (MOOCs), to meet this need.

State-of-the-art online educational tools (massive, blended, and small private formats) will be presented and the potential and limitations of reaching sanitation and water professionals through eLearning will be discussed. Experts from Sandec/Eawag, Water & Sanitation for the Urban Poor, IHE and IWA will be present and available to answer questions.

The World Water Week is organised by the Stockholm International Water Institute (SIWI) and takes place in Stockholm, Sweden. It has been the annual focal point for the globe's water issues since 1991.

For more information, please contact Fabian Suter: fabian.suter@eawag.ch

The Sandec Team

Phillipe Reymond

From left to right
In front: Imanol Zabaleta
Front row: Phillipe Reymond, Petra Kohler, Jasmine Segginger, Adeline Mertenat, Audinisa Fadhila, Christian Riu Lohri, Sara Marks, Ariane Scherteinleib, Elizabeth Tilley, Christoph Lüthi
Back row: Samuel Renggli, Christian Zurbügg, Linda Strande, Joëlle Batschauer, Maryna Peter, Regula Meierhofer, Guillaume Clair, Paul Donahue, Marius Klinger, Hildemar Mendez Guillen, Nienke Andriessen, Barbara Jeanne Ward, Hans Mosler, Caroline Saul, Fabian Suter, Dorothee Spuhler, Stefan Diener, Caterina Dalla Torre, Lukas Ulrich
Missing in photo: Rohit Chandragiri

New Faces

Nienke Andriessen started working with the Management of Excreta, Wastewater and Sludge group in October 2016. As a project officer, she is conducting research on faecal sludge dewatering and resource recovery in Tanzania. She has a MSc in Environmental Technology from Wageningen University in the Netherlands, and has previously worked on faecal sludge management with SNV Netherlands Development Organisation in Nepal and Bangladesh.

Marius Klinger, MSc in Environmental Sciences and Engineering from École Polytechnique Fédérale de Lausanne, joined Sandec's Strategic Environmental Planning (SESP) group in January 2017. He is part of the management unit of the 4S project in South Asia and is more specifically coordinating and monitoring the project's data collection. In 2016, he did his civil service in SESP and worked on the first City Sanitation Plan in Nepal for the small town of Tikapur.

Guillaume Clair, MSc in Water Engineering from Nice Sophia Antipolis University, joined Sandec's Water Supply and Treatment group in March 2017. His work focuses on monitoring drinking water quality in Burkina Faso and arsenic uptake in irrigated vegetables. In 2014, he was an intern with Sandec's Management of Excreta, Wastewater and Sludge group's FaME project in Dakar and during the past two years he worked on a WASH program in Kenya and on a micropollutants research project in Switzerland.

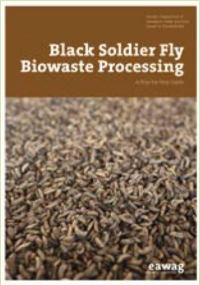
Miriam Englund, MSc in Energy and Environmental Engineering and Management, will join Sandec's Management of Excreta, Wastewater and Sludge (MEWS) group in August 2017. She will coordinate a workbook on engineering design examples for faecal sludge technologies on a city-wide scale, based on existing research and on the field experience of sector professionals. She worked previously as an intern in the MEWS group's Sludge to Energy Enterprises in Kampala project.

On the Bookshelf

Apart from the publications cited in the previous articles, we would like to recommend the following new books and key readings in the areas of our research, including some of our own new publications.

Municipal Solid Waste Management

Black Soldier Fly Biowaste Processing – A Step by Step Guide



This book deals with how to convert urban organic municipal waste from households, commercial activities, and institutions, using the Black Soldier Fly, the larvae of which can be used as a source of protein for animal feed. It explains the materials, equipment and working steps required to develop and operate a Black Soldier Fly larvae waste processing facility.
By Sandec/Eawag, 2017, 100 pages.
ISBN: 9783906484662.
It can be downloaded for free at:
https://goo.gl/zo34Tn.

Management of Excreta, Wastewater and Sludge

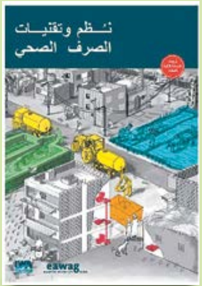
Faecal Sludge Management: Sanitation for all – a visual insight

Based on reportages from Mexico, Tanzania, Indonesia, India and Nicaragua, this picture book pays a beautiful tribute to the people and activities around faecal sludge management, from the toilet to enduse.
By BORDA and CDD Society, 2nd Edition 2017, 48 pages. ISBN: 9783000557026.
It can be downloaded for free at:
https://goo.gl/6z6zKc.

Novel plant species for faecal sludge drying beds: Survival, biomass response and forage quality
This article looks at the ability of forage plant species, not previously used in the treatment of faecal sludge, to grow in planted drying beds. All species used in these trials improved with growth in faecal sludge drying bed conditions.
By Gueye, A., et al., Ecological Engineering, 2016, *94*, pp. 617–621.
It is available as a pdf download at:
https://goo.gl/7yRX49.

Strategic Environmental Sanitation Planning

New Compendium Editions: Arabic and Russian



The Compendium in Arabic language was launched in Amman in March and the Russian language edition will be published in autumn 2017. The translations were coordinated respectively by our partners Benaa, in Egypt, and Oxfam GB, in Tajikistan. These new editions open two huge new geographical areas for knowledge dissemination about non-conventional sanitation and sanitation system thinking.
By Sandec/Eawag, 2017, 179 pages.
ISBN: 9783906484648.
Downloads are free at:
www.sandec.ch/compendium.

On the YouTube Channel

We would like to recommend these new videos produced by Sandec/Eawag that deal with issues in our areas of research.

Improving Onsite Sanitation in Low-income Communities in Lusaka, Zambia

This documentary highlights the work of WSUP to improve sanitation in low-income communities in Lusaka by working closely with the utility, micro-enterprises, residents and community-based organisations.
Produced by: Sandec/Eawag and WSUP.
Filmed by: Sven Torfinn.
Edited by: Paul Donahue. 2016, 7:47.
It can be seen at: https://goo.gl/qKPfR5.

Research and Local Knowledge: Water Safety Planning

This video is about the partnership work of Sandec's Water Supply and Treatment Group and Helvetas Swiss Intercooperation with local communities in the mountainous region of Mid-Western Nepal to improve access to safe drinking water and promote water safety planning.
Produced by: Sandec/Eawag.
Filmed and edited by: Arnt Diener. 2016, 5:07.
It can be seen at: https://goo.gl/n2N62B.

Biowaste – Moving FORWARD

This documentary details the importance of biowaste management in cities of low- and middle-income countries, based on the case of the FORWARD project in Indonesia. It shows different biowaste treatment options including conversion by Black Soldier Flies.
Produced by: Sandec/Eawag. Filmed by: Christian Riu Lohri and Sirajuddin Kurniawan.
Edited by Christian Riu Lohri. 2017, 11:55.
It can be seen at: https://goo.gl/D4w8nM.

Genderised WASH in Public Health Care Facilities – An Indian Case Study

This video is about a SNIS funded research project to monitor WASH infrastructure in public health care facilities in India and Uganda, especially looking at the context of maternal health and menstrual hygiene.
Produced by: Sandec/Eawag.
Filmed and edited by: Paul Donahue. 2017, 8:50.
It can be seen at: https://goo.gl/yCFi8t.