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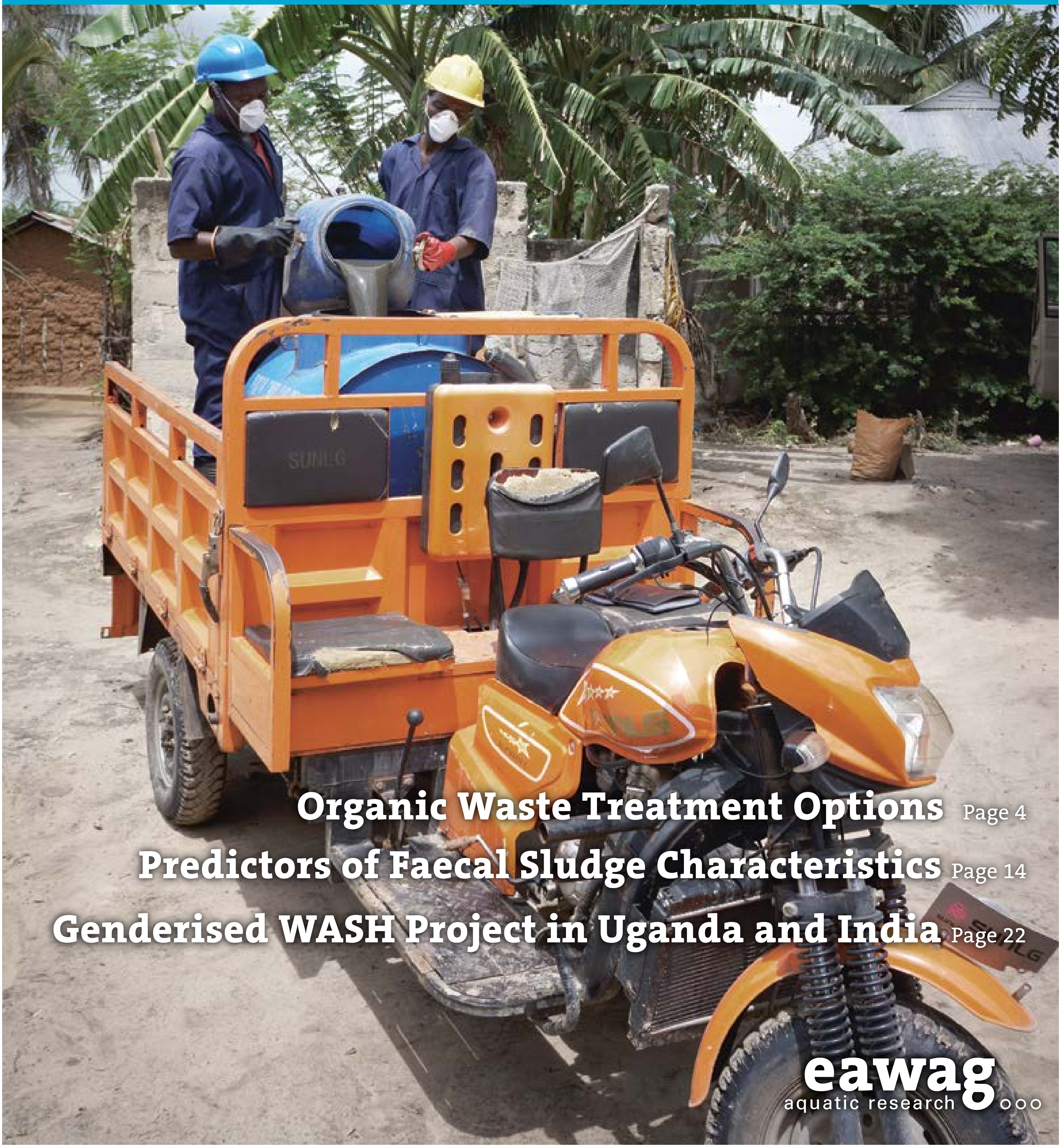

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Municipal Solid Waste Management

Excreta and Wastewater Management

Strategic Environmental Sanitation Planning

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In Brief

Sandec
Water and Sanitation in Developing Countries

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Many Small Cities – An Opportunity for Water and Sanitation Services

"An increasing number of small cities with high growth rates are already a reality and the trend continues. Instigating sustainable solutions for such circumstances is a challenge but also a rewarding task for research."

Worldwide, more than half of the population now live in urban areas, and in low- and middle-income countries urban growth is even more pronounced. Most of the urban population lives in small cities and towns and these are expected to double in both number and size within 15 years. So, why is this relevant for water, sanitation and waste services? Towns and small cities often show a mix of rural and urban characteristics, and when looking at water, sanitation and waste services, the increasing density of settlement calls for organised and regulated service provision replacing individual solutions. Typically, infrastructure investments, as well as skills and capacities in small towns, cannot keep pace with growth and demand for services. Furthermore, such settlements are often not in the focus of policymakers and donors who tend to either support rural programmes or infrastructure programmes for large cities. When small towns receive support, these are often 'one size fits all' blueprint solutions, without consideration of the specific individual contexts. Research has an important role to play here, by identifying promising or innovative approaches to service delivery, understanding the factors of success and evaluating appropriate management arrangements. Capitalizing on such results can help to foster replication and upgrading in the many towns worldwide.

Sandec has already been pursuing this focus with the ESRISS project that dealt with the sanitation planning gap in Nile Delta villages, which cannot be connected to large centralised treatment plants. This project came to an end in early 2015 and we are now taking the next step with the further development of the community led urban environmental sanitation (CLUES) planning approach – adapting the planning steps to typical small town settings.

Also relevant for towns and small cities is the ongoing research on organic waste treatment, sludge management and multiple water use services, especially concerning decentralised solutions. With the publication of the faecal sludge management book and the faecal sludge conference FSM3 in early 2015 in Vietnam, we are now finally seeing a significant increase of interest in our work by municipalities and researchers. We are proud to have been at the forefront of this development and it is thanks to Martin Strauss, Doulaye Kone and Linda Strande that we have been able to come so far. We are pleased to announce that Linda has been granted tenure at Eawag – a clear appreciation of her scientific achievements around sludge management.

As usual, this edition of the Sandec newsletter puts a spotlight on some selected Sandec projects and you are most welcome to contact the authors if you require more detailed information. In line with the new Eawag Internet profile, Sandec has also renewed its web presence. As before, all research publications and reports are available online, free of charge. If you have difficulties in finding what you are looking for, do not hesitate to ask for help by email. We shall gladly assist you.

Besides our research activities, we remain committed to capacity development with tailored courses and workshops, as well as to further developing our Massive Open Online Courses (MOOCs) in partnership with EPFL and Coursera. Our MOOC on "Planning & Design of Sanitation Systems and Technologies" was held in October 2014 with more than 5 000 registered students and our "Household Water Treatment and Safe Storage" MOOC was updated and shown for the second time in June 2015. The next MOOC on "Municipal Solid Waste Management" will be launched in early 2016.

Given Sandec's mandate to hire young professionals, provide them with an entry point into the sector and develop their skills and experience to further their careers, we have a regular turnover of staff. Eawag has asked me to contribute to its work at the directorial level and I have accepted this challenge. After 11 years as the Director of Sandec, I shall, therefore, be handing over the department leadership to Christoph Lüthi on 1 August 2015, but will remain strongly embedded inside Sandec with my ongoing research in the solid waste management field. I thank you all for the support and recognition you have given to Sandec and hope that this will remain, and that you will offer your best support to Christoph and Sandec in the future.

Chris Zurbrügg
Director Sandec

Selecting Appropriate Organic Waste Treatment Options in the Philippines

The first test of the SOWATT decision support tool showed that black soldier fly and slow pyrolysis are the most promising organic waste treatment technologies for San Fernando City. Local stakeholders considered environmental and social criteria more important than economic criteria. Imanol Zabaleta[1], Lisa Scholten[2], Christian Zurbrügg[1]

Introduction

Organic solid waste (biowaste) is the main fraction of the total generated municipal waste in low income countries [1]. Consequently, there is growing interest in municipalities to find appropriate management solutions for organic waste. Although there have been many attempts to construct and operate biowaste treatment technologies, these have largely failed because structured assessments and analyses that take local determinants into consideration were normally not done.

Waste related decisions are complex as they deal with many influencing factors and alternatives. In order to assist organic waste management decision making, Sandec developed the SOWATT manual (Selecting Organic Waste Treatment Technologies), which describes a structured decision making process based on the "Multi Attribute Value Theory". The approach was tested in San Fernando City, province of La Union, in the Philippines.

SOWATT, a decision support tool

Because there are different organic waste management technologies that exist, making decisions about which would work best is difficult. SOWATT provides a systematic structural approach that considers both technology and local characteristics to compare available treatment options. Five technologies are included in the SOWATT manual: windrow composting, in-vessel composting, anaerobic digestion, slow pyrolysis, and black soldier fly processing (BSF).

The technologies are assessed against an array of criteria, called objectives, which are arranged in an objective hierarchy. The first two columns of Table 1 show the objective hierarchy used for SOWATT; the objectives are grouped as higher-level objectives (HLO) and lower-level objectives (LLO). The third column presents the attributes, which are the variables identified to measure, either qualitatively or quantitatively, the extent of fulfilment of each objective. SOWATT makes use of the objective hierarchy as a default for all case studies. We, however, suggest validating the objective hierarchy with local stakeholders and, if required, adapting it accordingly.

HLO	LLO	Attributes	Composting windrow	In vessel composting	Anaerobic digestion	BSF	Slow pyrolysis
High technical reliability	–	Downtime days per year	10	30	10	10	30
High Social acceptance	**High job creation**	Workers/ton of waste treated per day	2.5–5.0	1.5	1.25–2.5	2.5–5.0	3.75–7.5
	High working safety	Level of potential hazards (1–10)	4	3	7	4	9
	Low smell impact	Hours per week of smell 20 m from the plant (hrs/week)	168	0	0	168	56
	High trust in technology	% of past experiences which are still working	0 %	50 %	33 %	No data	25 %
High environmental protection	**Low environmental pollution**	Emission of CO_2 equiv. (CO_2 eq./ton of waste treated)	325–390	23–33	170–690	200–300	1 600–2 700
		Risk level for Leachate (1–5)	5	1	4	2	0
	High resource recovery	Nitrogen recovered in product (% of input N)	25–91	62.5–91.0	90–100	43	0–10
		Phosphorus recovered in product (% of input P)	62–99	85–99	95–100	67	100
		Energy output (kWh/ton of waste treated)	0	0	600–900	0	2 000–3 000
High hygiene and community health protection	**Low residue generation**	Percentage of residue over original wet waste (%)	0	0	If no market for digestate: 1 000 L/t	If no market for residues: 350–400 kg	0
	High treatment capacity	% of generated waste treatable by the technology	38 %	38 %	20 %	20 %	55 %
High economic sustainability	–	Income expenditure ratio (IER)	0	0	0.003	3.77	2.44

Table 1: Performance table for San Fernando City.

The manual explains how to conduct a stakeholder analysis to identify the most relevant stakeholders. In addition, the Swing and the Reverse Swing methods are introduced. The first is used to assign weights to the objectives, whereas the second is used as a consistency check [2], [3]. The manual also describes how to estimate the performance of each technology for each objective. The estimations of performances are based on a literature review and should be adjusted accordingly whenever local data is available. Other performances are based on past experience, i.e., field data. Finally, the manual explains the additive model method that combines the weights given to the objectives by local stakeholders with the performances to obtain a single aggregated score for each technology [2].

San Fernando City, a case study

San Fernando is the capital city of La Union Province and has approximately 115 000 inhabitants and a growth rate of 2.27 %. The city has an area of 10 699 ha and is divided into 59 barangays (districts). It already has an existing solid waste management plan (2014–2023) and there is a well-functioning recycling sector and a sanitary landfill that was built in 1998. Waste assessment and characterisation studies were done, and showed that the total generated waste in San Fernando amounts to 45 475 kg/day, out of which 39 % consists of biodegradable organic waste. Household waste amounts to 69 % of the total generated waste [4].

The stakeholder analysis in San Fernando City identified five different key stakeholder groups: the municipal "Environment and Natural Resources Office" (CENRO); the municipal "General Service Office" (GSO), which is in charge of the waste collection and the landfill; a local NGO called Solid Waste Management Association of the Philippines (SWAPP); the informal recycling sector; and the inhabitants, represented by the Pollution Control Officers (PCO) designated for environmental issues within the district councils. For our study, 12 PCOs were interviewed, one from each of the 12 model districts (those with the best environmental performance). Furthermore, two representatives from each of the other four stakeholder groups were interviewed.

During the interviews, weights were obtained for every HLO and LLO. Averaged weights given to the HLO show that *high social acceptance* was considered most important, followed by *high environmental protection, high hygiene protection, high economic sustainability* and finally *high technical reliability* (Figure 1). The informal sector was the only stakeholder group that regarded *high economic sustainability* as the most important objective; the others did not believe this to be highly relevant. Not surprisingly, the governmental agency CENRO and the PCOs, both responsible for environmental issues, scored *high environmental protection* as the most important HLO.

As for the weights given to LLOs, *high working safety* was considered the most important among the LLOs of *high social acceptance*. The stakeholders working with waste on a daily basis especially regarded *high working safety* as a high priority. *High job creation* ranked last, which suggests that economic prosperity is not a major preference for the interviewed stakeholders. Finally, regarding the LLO of *high environmental protection, low pollution* weighted stronger than *high resource recovery*, showing the overall awareness and importance given to avoiding pollution, while resource recovery is given less priority.

Focus group discussions and interviews were used to estimate the performances of the five technologies for each objective. These results are summarized in Table 1.

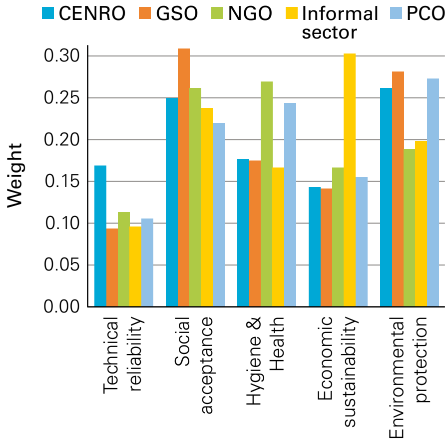

Figure 1: Weights given by the 5 stakeholder clusters to the HLO.

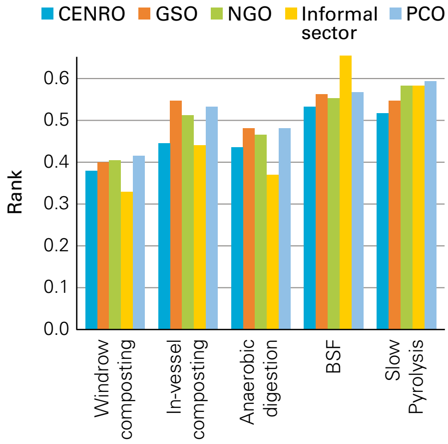

Figure 2: Final scores of each technology by each stakeholder cluster.

Final Assessment for San Fernando

Figure 2 shows the final scores that were obtained after applying the additive model. BSF and slow pyrolysis scored the highest in San Fernando City. BSF is the first choice of three stakeholder clusters (CENRO, GSO and the informal recycling sector), while pyrolysis is preferred by the NGO and PCOs. Both technologies should be financially profitable, whereas revenues from compost or biogas from anaerobic digestion are not foreseen to be sufficient to cover operational costs.

Conclusion

The main weakness of SOWATT lies in the limited available evidence concerning the performances of the technologies. Some technologies are still in the early development phase, and for them, there is little implementation evidence. Over time we hope to obtain more reliable information on how they perform, and to further test SOWATT to identify where improvements and simplifications can be made, especially in its structured approach for doing assessments and analyses.

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[4] SWAPP (2013): Ten Year Integrated Waste Management Plan 2014–2023. City of San Fernando, La Union Province.

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Improving the Energy Efficiency of the HTC Process and Reactor

In order to improve the energy efficiency of the experimental hydrothermal carbonization reactor for developing countries, different experiments were carried out at Sandec. The results of these experiments allowed for a better understanding of the process parameters and energy aspects of the reactor. Manuel Rohr[1], Imanol Zabaleta[1], Christian Zurbrügg[1]

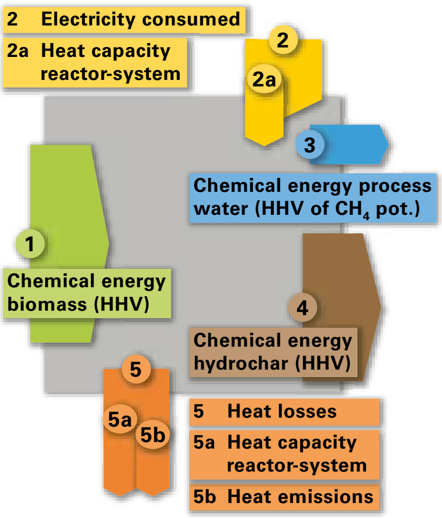

Figure 1: Simplified energy flow diagram for experiment TS25_1T170. Energy flows arranged to the right/top are inputs related/unrelated to mass flow, flows arranged from the left/bottom are outputs related/unrelated.

Introduction

Hydrothermal carbonization (HTC) is a thermochemical process which converts biomass into a coal-like product (hydrochar) that can be used as fuel. This requires applying high temperatures (160–250 °C) to biomass in suspension with water under saturated pressure for several hours (0.5–15 hrs). Although HTC might pose higher risks and costs than other pyrolysing methods (e.g., slow pyrolysis), it is considered a promising technology due to its capacity to treat and hygienise wet organic wastes, which are commonly found in developing countries. The goals of this project were: to optimise the reaction parameters (loading rate (TS), residence time and maximum temperature) of a 22 litre batch reactor in order to achieve a high energy ratio; to assess the impact of insulation; and to suggest further research issues.

Methods

The experiments were carried out in a reactor built at Sandec [1]. The design of the experimental set up was based on results from previous research. For instance, Dea Marchetti had found that higher TS are preferred [2] and this was taken into account. Energy flow diagrams from previous experiments were sketched (similar to Figure 1) to identify the most influential energy flows: the chemical energy of materials (1, 3, and 4), heat loss during carbonization (5a) and the heating up and cooling down of the reactor and of the feedstock (2a, 5b).

Nine experiments were carried out at different TS (20 & 25 %), and for different time periods above 160 °C (2–10 hrs). The maximum temperatures of 160–190 °C were targeted. An artificial biowaste, consisting of maize, rice, potato, cabbage and banana peel, was used as feedstock with a HHV of 17.8 MJ/kg. In addition, six experiments were conducted to determine the heat emission differences between insulated and non-insulated reactors. For these experiments, the reactor was filled only with water.

Results

The experiment with the highest energy ratio, TS25_1T170, (energy content of hydrochar/energy consumed for the reaction) resulted in 1.7 (48.6 MJ/29.2 MJ) being the HHV of hydrochar 21.7 MJ/kg_{db}, similar to that of brown coal. This experiment was carried out without insulation or heat recovery and with the following parameters: TS=25 %, T=170 °C, t=3 hrs. with max. p=16.2 bar(g). Other experiments with the same TS, however, showed higher HHV (up to 23.4 MJ/kg_{db}), but lower energy ratios (1.5).

The process parameter with the biggest impact on energy was the TS. Experiments with TS=25 % generally showed better energy ratios than those with TS=20 %; 1.7 and 1.3 were, respectively, the highest achieved ratios. The colour and texture of the hydrochar differed depending on where it was in the reactor, and three different layers could be distinguished. Approximately 80 %, 15 % and 5 % of the total mass of dried hydrochar was contained in the top, middle and lower layers. The HHV changed from 20.4–24.4 MJ/kg_{db} in the top layer to roughly 17.9 MJ/kg_{db} in the lower layer, showing a decreasing carbonization level in the reactor, most likely caused by uneven heat distribution. As for the insulation experiments, it was observed that approximately 40 % of the heat emissions (See 5b in Figure 1) could be avoided. 4.9 MJ or 17 % of the consumed energy for the experiment TS25_1T170 could be retained.

Further research

The following measures are being considered to improve energy efficiency. Opening the reactor and making use of the still hot gases and hydrochar would preheat the next incoming materials up to almost 100 °C. In addition, the internal heat of the reactor would be largely retained. How this would affect the characteristics of the hydrochar, however, is unclear. Alternatively, a heat exchanger could be installed around the reactor to recover waste-heat when it is cooling down. The total available heat after the supported reaction time is 12.9 MJ (44 % of the consumed energy) for the experiment TS25_1T170. Generating biogas from the process water could also provide additional energy. Based on its total organic carbon, an additional 15.1 MJ (52 % of the consumed energy) could be generated in theory for the experiment TS25_1T170.

Conclusion

It was proven that varying the process parameters can lead to a constant energy ratio higher than one, mainly by increasing the TS of the feedstock and, consequently, the energy contained in the hydrochar. If measures are taken to reduce the energy losses, such as using insulation, the energy ratio could be further increased.

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Urban Organic Waste Treatment – Evaluation of Systems in Kampala

Organic waste is the largest fraction of waste generated in many low income countries and the present management of this waste causes numerous problems. This article uses lifecycle analysis to identify the most suitable technologies for treating organic waste, using Kampala, Uganda, as a case study. Allan J. Komakech[1, 2], Björn Vinnerås[3], Chris Zurbrügg[2]

Introduction

In Kampala, Uganda, about 28 000 tons of waste are collected and delivered to landfills every month. According to Kampala Capital City Authority records, this represents approximately 40 % of the city's waste. The remaining uncollected waste is normally burnt and/or dumped in unauthorised sites, causing health and environmental problems. The organic fraction of domestic waste can provide an opportunity to improve livelihoods and incomes through fertiliser and energy production. This study employed environmental systems analysis to identify the most environmentally efficient technologies for treating organic waste.

Methodology

The research was multifaceted and comprised of: a literature review of waste hierarchy practices suitable for Sub-Saharan African cities, using Kampala as a case study; physical and chemical characterisation of the municipal waste collected and delivered to Kampala's landfill over a year, including both dry and wet seasons [1]; location mapping of animal farms in Kampala and the establishment of animal feeding and waste management practices on the farms [2]; treatment of Kampala's organic waste by means of the vermicomposting (VC) method [3]; and using lifecycle analysis to identify the best waste treatment method for organic waste: anaerobic digestion (AD), compost, VC or fly larvae compost (FLC) waste treatment technologies [4]. The impact categories assessed were: energy use, global warming and eutrophication potentials.

Photo 1: Worm biomass for vermicomposting.

Results

Generally, the results showed that re-use and waste prevention/waste hierarchy methods are the most feasible for waste management in Kampala. 92.1 % of the waste is organic in nature, containing an average moisture content of 71.1 %, 1.65 % nitrogen, 0.28 % phosphorus, 2.38 % potassium and a gross energy content of 17 MJ/kg. The other major waste streams were plastics 4.8 %, paper 1.3 %, glass 0.6 %, textiles and leather 0.5 %, metals 0.1 % and others 0.6 % [1].

Kampala has 1 300 animal farms, containing approximately 200 sheep, 3 000 goats, 3 900 cattle, 9 000 pigs and 250 000 poultry. Most are located on the city's periphery; the most popular animal feeds are peelings and pasture. 60 % of the animal manure is discarded and 32 % is used as fertiliser [2].

A 60.3 % material degradation was achieved in the VC process, while the feed-to-biomass conversion rate was 3.6 % on a dry matter basis (See Photo 1). The conversion rate could be increased by increasing the frequency of worm harvesting. In addition, VC was found to be a viable manure management method for small-scale urban animal agriculture. The return of investment was calculated to be 280 % for treating the manure of a 450 kg cow.

Among the different organic waste treatment technologies, AD performed the best in terms of the impact categories [4]. AD's good performance is due to its energy production ability and reduced ammonia volatilization. The environmental impacts of the different treatment technologies were determined on the assumption that all their parts (subsystems) functioned well, e.g., for AD the generator producing electricity from biogas was assumed to be efficient. However, if this were not the case, the environmental impact calculated for the different waste treatment technologies would increase, and the technology identified as best performing could prove to be the worst performing.

Conclusion

The best technology would be robust and reliable over a long period of time. Although the VC and FLC systems did not perform as well as the AD system, their products, worms and pupae, are good replacements for fish as sources of animal protein. Yet, their environmental impact is uncertain as the effect of fish on the lake ecosystem was not considered. However, their performance would probably improve if this was looked at, and their product sales could generate significant income, enhancing their sustainability. The VC and FLC systems also pose a significantly lower risk of large greenhouse gas emissions than the AD system.

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Details of this study can be found at <http://pub.epsilon.slu.se/11558/1/komakech_a_141002.pdf>

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Increasing Treatment Plant Capacity by Conditioning Faecal Sludge

Locating land for faecal sludge treatment in urban areas is a challenge. Research in Dakar, Senegal, identified that applying conditioners made from locally available resources on faecal sludge can reduce the footprint of drying beds from 6–60 %, depending on treatment goals. M. Gold[1], P. Dayer[1,3], G. Clair[1], Ch. Faye[4], A. Seck[4], S. Niang[4], E. Morgenroth[2,3], L. Strande[1]

Guillaume Clair

Photo 1: Settling experiments with faecal sludge in Dakar, Senegal.

Introduction

In many low- and middle income countries, treatment plants for faecal sludge (FS) do not exist. This means that the majority of FS produced is being discharged untreated into the environment. Dewatering is a key treatment step, as FS typically consists of > 90 % water. Settling-thickening tanks and drying beds are the most commonly employed technologies for the settling and dewatering of FS, but their application in urban areas is limited due to their large land area requirements. This problem is exacerbating because urban areas are the fastest growing worldwide, hence, treatment technologies need to be optimised in order to meet current and future demands.

Conditioners

Commercial conditioners, such as polyelectrolytes and hydrolysed metals, are commonly used to increase the efficiency of settling and dewatering in the treatment of wastewater sludge. However, commercially available conditioners are expensive and would require importation in low-income countries, frequent reasons why treatment plants often fail [1]. In addition, FS has highly variable characteristics that can affect settling and dewatering performance. This suggests that experiences from the treatment of wastewater sludge are not directly transferable. The objective of this study was to identify conditioners that work well, which could be produced with locally available resources, and, therefore, reduce the land requirements for treatment plants in urban areas.

Methods

Based on literature, five conditioners that could be produced locally were identified: *Moringa oleifera* seeds, press cake, *Jatropha curcas* seeds, *Calotropis procera* leaves and chitosan. The treatment performance of locally available conditioners was compared to commercially available wastewater conditioners as a control. FS was collected from vacuum trucks and conditioned with different dosages in a jar-test device and compared with unconditioned FS. In laboratory experiments, the total suspended solids (TSS) in the supernatant, following 60 minutes settling in Imhoff cones, and the Specific Resistance to Filtration (SRF), were respectively used as metrics for settling and dewatering performance (Photo 1). Following laboratory experiments, settling and dewatering columns were designed to replicate treatment in settling thickening tanks and drying beds [2].

Results

Conditioning FS significantly improved settling and dewatering, and the results showed that the locally available conditioners were comparable to commercial conditioners. TSS in the supernatant and SRF were reduced by at least 80 % compared to unconditioned FS. Chitosan was ranked as the best conditioner investigated in this study, while *J. curcas* seeds and *C. procera leaves* were ruled out due to poor treatment performance.

Reducing the land area required depends on the specific dewatering treatment goals. For example, conditioning FS for use as soil conditioner with chitosan or commercial conditioners could increase dewatering times by 60 %, and 6–20 % for use as solid fuel. These benefits, however, need to be balanced with increased treatment costs. An assessment of the fish industry in Dakar indicated that currently enough shrimp waste could be obtained to produce chitosan for FS treatment. Yet, the operating costs at the treatment plant would increase by around 15–30 % for locally produced chitosan and 35–50 % for imported chitosan, compared to 20–80 % for polymers [2].

Conclusion

The results of this study demonstrate that locally available conditioners can be as effective in increasing treatment performance as commercial products. However, FS conditioning is not a silver bullet as reductions in the required treatment land area also need to be carefully balanced with the increase in treatment costs. In addition, the FS used in this study was mainly collected from septic tanks, and FS from other sources could show different results. Therefore, ongoing research at Sandec is investigating the dewatering properties of different FS types in Japan, Uganda, Vietnam and Switzerland to further optimise the design of FS dewatering technologies.

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Portable Urine Diversion Toilet for Disaster Relief and Emergencies

Securing sanitation was one of the greatest concerns after the Great East Japan Earthquake that took place in 2011. A portable, foldable and simplified urine diversion toilet that did not need to use water or electricity was developed and delivered to the region. Hidenori Harada[1], Hirohide Kobayashi[2], Ayako Fujieda[2], Taketoshi Kusakabe[2], Yoshihisa Shimizu[2]

Introduction

On 11 March 2011, the Great East Japan Earthquake took place with a magnitude of 9.0 on the Richter scale, causing a gigantic tsunami and massive damage to the coastal area of East Japan. The number of people dead or missing was nearly 20 000 and approximately 300 000 of the houses were destroyed. Securing sanitation (i.e., proper excreta management) was one of the greatest concerns after the disaster. In spite of the great efforts of the municipalities, many people could not access proper sanitation and this resulted in, for example, defecation on newspaper. It was endangering human dignity, increasing health risks, and also deteriorating the environment. There was strong motivation to urgently develop a sanitation system that could tackle the situation.

Sanitation after the disaster

More than 2.2 million houses lost connection to a water supply system at the peak [1], resulting in the malfunction of water flush toilets in many evacuation centres. Furthermore, 120 wastewater treatment plants and 946 km of sewer networks were damaged [2]. Municipalities attempted to bring in huge numbers of conventional portable toilet units, the type commonly found at construction sites, but the units were bulky and heavy, and required vacuum trucks to remove deposited excreta. A few weeks after the earthquake, about 40 % of the evacuation centres still had inadequate toilet facilities [3].

Hidenori Harada

Photo 1: Portable urine-diversion toilet made from plastic cardboard.

Development of the toilet

No water, no electricity, proper portability, and good comfort were the essential sanitation crisis factors to be addressed after the earthquake. Containment and treatment of faeces was a greater priority than handling urine, which has a lower biological risk. Thus, the authors decided to develop a simplified toilet based on a urine-diversion approach.

Photo 1 shows the toilet that was developed. Faeces are contained separately from urine, and simply treated by adding a mixture of lime and dry media, such as carbonised rice husks or dry soil. Lime and carbonised rice husks are locally available in the region. Urine may be discharged without treatment in such an emergency because of its relatively low health risk. Since it was made from plastic-cardboard and ready-to-assemble, it could easily be stocked and transported. The toilet could stand alone, and also be mounted on an ordinary toilet bowl by removing a back panel. Users store the collected faecal mixture temporarily in a bucket, which would be collected by municipalities after public waste collection service is restored.

Firstly, 54 units of this toilet were provided to three cities in the region, and then more were distributed to private and public locations inside/outside the region based on request. The toilet units were positively evaluated in terms of ease of stocking and delivery, and ability to work without water. As the emergent needs for portable toilets gradually disappeared, many were kept in preparation for potential afterquakes. The authors have proposed stocking them at public buildings, i.e., evacuation places after disasters, and some municipalities have expressed interested in this.

Conclusion

A unique portable urine diversion toilet unit was developed and distributed to the disaster-affected areas. This is a promising option for sanitation in disaster and/or emergency situations. Fundamentally, preparedness for disasters is important. Together with the stocking of portable toilets, developing permanent-type disaster-response toilets for public places would be advantageous to increase society's readiness. The authors have undertaken research in this area.

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Production of Pellets and Electricity from Faecal Sludge

Resource recovery from faecal sludge treatment endproducts could help offset faecal sludge treatment costs. In Kampala, Uganda, the SEEK (Sludge to Energy Enterprises) Project is evaluating faecal sludge pellets that can be used as a solid fuel and to produce electricity. Moritz Gold[1], Charles Niwagaba[2], Florian Studer[3], Wim Getkate[4], Mohammed Babu[5], Linda Strande[1]

Introduction

Faecal sludge management (FSM) in low-income countries frequently fails due to a lack of financial resources [1]. However, FS treatment endproducts can generate revenue to offset FSM costs [2, 3]. In Sub-Saharan Africa, the following FS treatment endproduct markets were identified: as an industrial fuel, as a source of protein for animal feed, as a source to produce biogas, as a component in building materials, and as soil conditioner or fertilizer [3]. Currently, the only resource recovery from FS that is in use is as a soil conditioner; the other markets remain untapped even though they have higher revenue potentials [2, 4]. Reasons for this include a lack of reliable implemented technologies for resource recovery and undeveloped markets for FS treatment endproducts. The ongoing SEEK Project, and the recently completed FaME (Faecal Management Enterprises) Project, focus on developing technologies to maximise resource recovery, on identifying new endproduct markets, and on developing business models to increase the potential of resource recovery.

Co-processing

FaME identified that to scale solid fuel production from FS requires the optimisation of FS drying, the reduction of ash content and increasing the quantities of treatment products. Co processing of FS with other urban biowastes could be a way to tackle all three of these shortcomings, while simultaneously contributing to solid waste management. An assessment study was conducted to identify the most suitable waste streams for co-processing. Biowastes were evaluated with Multi Criteria Analysis and the main criteria were: availability, accessibility and physical chemical properties. Based on secondary data and stakeholder interviews, 28 different biowastes were identified and ten were shortlisted for in-depth analysis. All the waste streams that were identified are currently in use and have competing market value, except for drinking water treatment sludge and market waste. The ones identified as most suitable were: brewery waste, sawdust, coffee husks, maize cobs and market waste.

Pelletising

Cost-effective drying is key for the financial viability of solid fuel production from FS. SEEK is working with Bioburn, a Swiss engineering enterprise, that has designed an innovative pelletising machine, which is able to process wet biowastes into pellets (Photo 1). The pellets can be passively dried to 90 %, for example, in greenhouses. The pelletising machine is currently in use at the National Water and Sewerage Corporation (NWSC) Lubigi Wastewater and Faecal Sludge Treatment Plant in Kampala. Durable pellets could be produced from FS with 50–60 % dryness without a binder. The result is that space for drying beds could be reduced and/or treatment capacities increased. Additionally, pelletising increases the product's quality and bulk density, reducing transport and storage costs. At NWSC Lubigi, more than 10 000 m^2 are used for dewatering, drying and storing 400 m^3 FS per day.


Moritz Gold

Photo 1: Pellets produced from faecal sludge in Kampala, Uganda.

Gasification

In Uganda, electricity demand significantly outstrips electricity generation and only 14 % of the population nationally has access to electricity. The pellets produced are being used in gasification for electricity production. Converting FS for energy could contribute towards meeting present and future energy needs. FS has an energy potential comparable to other solid fuels, and pellets work well as a fuel due to their uniform size and dryness. The ash produced, however, reduces this energy value and due to the high temperatures during gasification could melt and form "clinker" which could clog the gasifiers. Preliminary results indicate that the high variability and the high ash content of FS remain key challenges for gasification. In Kampala, for example, ash content in dewatered FS is 30–50 % of the dry matter.

Parameter	Unit	FS Kampala	FS Dakar	Wastewater sludge	Excreta	Limits biosolids land application
Cadmium	ppm	< 2.0	< 1.8	4–10.1	0.3–0.4	< 39–10
Chromium	ppm	485	401	190–530	0.6	< 1 200–900
Copper	ppm	114	216	330–400	22–31	< 1 500–800
Mercury	ppm	< 0.9	< 0.8	2.1–5.4	0.2	< 17–8
Nickel	ppm	24	30	40–45	2.1–4.7	< 420–200
Lead	ppm	28	59	220–365	0.6–1.4	< 900–300
Zinc	ppm	646	918	1 132–4 900	132–305	< 2 800–2 500

Table 1: Heavy metal concentrations in faecal sludge compared to wastewater sludge, excreta/faeces and limits for biosolids land application in the USA [4].

Moritz Gold

Photo 2: Drying beds at NWSC Lubigi Wastewater and Faecal Sludge Treatment Plant in Kampala, Uganda.

Environmental impact

Wastewater sludge is already used as a solid fuel by industries in Europe, Japan and the US. Analytical results indicate that the elemental composition of FS is comparable to wastewater sludge (i.e., carbon, hydrogen, nitrogen, sulphur, and chlorine) [4]. This implies that the success of combusting wastewater sludge can be transferred to FS. However, the pollutants produced, which include dioxins, furans, nitrogen oxides (NO_x), nitrous oxide (N_2O), hydrogen chloride (HCl), sulphur oxides (SO_x) and heavy metals, would need to be controlled during energy recovery and ash disposal. Yet, large scale industries with existing emission control measures could be the target customers. Although FS has concentrations of heavy metals that are significantly lower than in wastewater sludge (See Table 1), they are still higher than those found in excreta. This highlights the potential of energy recovery from faeces collected from source separation toilets because of its' lower concentrations of heavy metals, ash and nitrogen.

Market development

Processing FS into fuel pellets and subsequent gasification could provide revenue to improve services throughout the FSM service chain, and also increase energy supplies. Fuel pellets and electricity have a higher market value than the use of FS as a soil conditioner. However, increased revenue needs to be balanced with the associated increased costs of production. SEEK is assessing the market environment for pellets, electricity and resource recovery technologies in Kampala, and this will be used as the baseline to develop implementation scenarios and business models. Results from the waste assessment, technology development and market assessment will also feed into a financial analysis of implementation scenarios at different scales and assist in the development of a resource recovery strategy for NWSC.

Ongoing research

Ongoing research is focusing on optimising the drying of FS and the pellets and on increasing the quality of pellets by reducing the ash content, i.e., by using geotextiles on the sand filter layer of drying beds and co-processing the FS with suitable biowastes (Photo 2). In Tanzania, pilot-scale research will be conducted to develop dewatering and drying technologies that reduce ash content. This is required to meet the needs of industries and for gasification. Research into the most suitable gasification technologies for FS is also being done. In order to provide resource recovery solutions for different markets, in addition to combustion and gasification, the potential of slow pyrolysis and the hydrothermal carbonization of FS will be investigated in Switzerland and Tanzania. Char from hydrothermal carbonization has the potential to be used as a substitute for wood-based charcoal or as a soil amendment.

Conclusion

High moisture and ash content, and emissions and heavy metals in the ash produced are challenges for energy recovery from FS. However, these challenges could be overcome with the appropriate technologies. FS resource recovery has the additional benefit of reducing pathogen transmission pathways and land requirements for treatment plants. Large-scale energy production could provide increased revenue, offsetting treatment costs, and act as an incentive to sustain FS treatment and meet market demands.

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Private Public Partnership Solutions for Faecal Sludge Management

Can faecal sludge management based on resource recovery be financially sustainable? This is theoretically feasible, but in reality still requires innovations. How can we evaluate solutions and business models for chances of success prior to implementation? Lars Schoebitz[1], Chris Zurbrügg[1], Charles Niwagaba[2], Viet-Anh Nguyen[3], Linda Strande[1]

Introduction

Inadequate urban waste management is a widespread problem, especially in rapidly growing urban environments of low- and middle-income countries. Waste streams, such as municipal solid waste, wastewater and faecal sludge, are often directly discharged into the environment with little or no treatment. The harmful effect on public and environmental health is indisputable, and viable solutions are necessary to improve this situation. Resource recovery of nutrients, water and energy from waste streams is an attractive possible solution because it could generate revenues from the sale of treatment endproducts if there is significant and consistent market demand. Private sector involvement is, therefore, considered necessary because it provides profit driven solutions to urban waste management problems. This is especially the case for faecal sludge management (FSM) for which financially viable business models offer possible solutions and incentives for the involvement of private entities.

Assessing the feasibility of waste-based business models

As part of a three-year research project in collaboration with the International Water Management Institute, the World Health Organisation, the Swiss Tropical and Public Health Institute, and the International Centre for Water Management Services, 21 business models based on resource recovery of water, nutrients and energy from waste streams were evaluated for their viability in four cities: Bangalore, India; Hanoi, Vietnam; Kampala, Uganda; and Lima, Peru <http://www.sandec.ch/rrr>. The multi-criteria assessment evaluated the following:

1. Supply, availability and characteristics of treated waste-streams
2. Market demand for the generated endproducts
3. Financial analysis and logistics of treatment processes
4. Risk assessment of environmental and health impacts
5. Assessment of required treatment technologies
6. Institutional analysis of enabling environment
7. Socio-economic analysis of product acceptance

The project results indicated that, particularly for FSM, such criteria are difficult to assess. This is due to the novelty of the technologies and of the endproducts, many of which have not yet been implemented or put to use, resulting in a lack of the financial data required to assess their economic viability.

As business opportunities and markets for faecal sludge endproducts develop, new industries and market applications are emerging and innovative technology solutions are being tested. Hence, multi-criteria assessments of business models in FSM will have to be adapted and developed to evaluate current and future developments.

Development of reliable methodologies

Prior to the design and implementation of innovative technologies for treatment and resource recovery from faecal sludge, methodologies need to be developed to make reliable estimations that meet the planning needs of highly complex urban areas. Sandec is addressing these research gaps, and based on its research results, aims at producing guidance documents to support decision-making and better planning of urban FSM.

We developed hypotheses for a method to quantify and characterize faecal sludge on a city-wide scale <www.sandec.ch/faq>, which was field-tested with 180 samples taken in Kampala, Uganda, and 80 samples in Hanoi, Vietnam. The results are currently under analysis [1]. We also developed a methodology to assess the market demand and growth potential of faecal sludge resource recovery treatment endproducts <www.sandec.ch/mda>. This was done with engineers and economists, and field tested in Kampala, Uganda. It is currently being tested in Bignona, Senegal; and Son La, Bac Ninh, and Ba Ria in Vietnam.

The goal is to develop methodologies that enable, among other objectives, the selection of the most viable treatment options to

Lars Schoebitz

Photo 1: Faecal sludge being discharged by private emptying and transport service providers at the Lubigi Wastewater and Faecal Sludge Treatment Plant in Kampala, Uganda.

Lars Schoebitz

Photo 2: Dewatered faecal sludge collected from drying beds at the Lubigi Wastewater and Faecal Sludge Treatment Plant in Kampala, Uganda.

provide design criteria and reliable estimates of influent flows. They will fill missing gaps in our analyses, and provide insights into market and business opportunities, which could trigger the development of new and innovative sanitation solutions.

Resource recovery businesses

Examples exist of successful resource recovery businesses based on isolated business models that generate profits at different steps along the sanitation service chain. However, there is currently a lack of successful examples of integrated sanitation business models that cover the entire service chain (i.e., containment, emptying, transport, treatment and resource recovery). An in-depth view of sanitation service business models is found in this edition of Sandec News (Gebauer et al.) on pp. 28–29.

Another hurdle to the implementation of resource recovery based business models is that reliable treatment technologies do not yet exist, or have not yet been transferred from other sectors, such as the wastewater sludge sector. For an example of research that addresses this gap, please refer to the article on pp. 10–11 in this edition of Sandec News (Gold et al.). It addresses technology transfer and scaling up businesses involved in pellet and electricity production from faecal sludge.

Enabling environment

For successful private sector involvement in sanitation services and FSM, businesses must produce revenues. However, ensuring public health through sanitation and FSM is also a public good. Hence, public institutions need to create an enabling environment, which provides the private sector with incentives for investments, while at the same time implementing effective enforcement measures to ensure adherence to regulations [2].

In Kampala, for example, sanitation provision is the mandate of the Kampala Capital City Authority (KCCA), while water provision and wastewater management is the mandate of the National Water and Sewerage Corporation (NWSC). The management of faecal sludge is not the direct responsibility of either of these agencies and this has resulted in the development of a significant private sector for the emptying and transportation of faecal sludge. However, the private sector has no interest in building the associated treatment infrastructure that protects public health through the treatment and safe enduse of faecal sludge. In Kampala, such treatment infrastructure exists and is managed by NWSC. Constructing treatment infrastructure requires large capital investments, which decrease short-term financial viability and, therefore, does not attract the private sector. The result is that businesses often cover only one part of the sanitation service chain, and this does not provide for adequate FSM.

There is a need for private public partnerships that contribute to the development of strategies that meet the needs of sound FSM. One hypothetical example is the implementation of a decentralised treatment infrastructure, which would enable emptying and transportation service providers to decrease fuel consumption, and drive down costs. This could be combined with privately operated collection and transport companies that manage the treatment infrastructure. In this way, revenues from collection and transport, in addition to resource recovery, could offset treatment costs. Providing a regulatory framework that supports such activities and that creates opportunities for profits would be the role of the public sector. If profits can be generated through sustainable FSM with private sector involvement, competition will evolve, which could ultimately contribute to decreasing the costs of emptying services at the household level. This would be particularly beneficial for low-income households, who currently cannot afford such services. It could also reduce the unsafe practices of informal emptying and direct dumping of faecal sludge into the environment.

Conclusion

The most important goal of any sanitation or FSM project is the protection of public and environmental health. Financially sustainable solutions cannot be implemented by the private sector alone. This requires that the public sector provide an enabling environment and a regulatory framework wherein the private sector can generate profit and achieve public health goals. Even if projects are not fully financially sustainable, they are still successful if they achieve public health goals.

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Local Factors Influence FS Characteristics: Research in Hanoi, Vietnam

Understanding faecal sludge characteristics on a citywide scale is essential to optimise the design of treatment technologies. As part of Sandec's ongoing research, a study was conducted in Hanoi to assess how the design and operation of septic tanks influence the faecal sludge. M. Bassan[1,2], A. Ferré[1,2], V. A. Nguyen[3], C. Holliger[2], L. Strande[1]

Introduction

There is growing acknowledgement of the importance of faecal sludge (FS) management worldwide. It is now accepted that on-site sanitation technologies – where FS accumulates – will remain an important component of sanitation in urban areas of low- and middle-income countries [1]. However, the development and construction of FS treatment technologies still require further research to ensure that they are appropriately designed.

FS is broadly defined as anything extracted from on-site sanitation technologies, which is not transported in sewers. It is collected from individual buildings, and unlike in sewer systems, is not homogenized during transport. Therefore, FS management on a citywide scale includes FS with highly variable characteristics [2].

Many factors influence FS characteristics, as summarized in Figure 1. These include:

- Local context: the geology, climate and customs have a large scale impact on the inflow of groundwater, excreta and other wastes in the toilets.
- User habits: the use and maintenance of on-site sanitation technologies impact the FS characteristics at the household scale. For example, office toilets receive more urine, household toilets more faeces.
- Design: the type of on-site technology, for example, dry toilets with pit latrines, or flush toilets with septic tanks, impact the dilution and degradation processes. Also, FS from septic tanks with sealed or porous bottoms will have different concentrations.
- Emptying methods: the addition of water to extract settled FS (Photo 1) and the extraction mode (manual or mechanical) impact the characteristics of the FS that reaches the treatment plant or discharge site.

To effectively manage highly variable FS, we need to understand the following:

- How can we predict or estimate FS characteristics?
- How can we design adequate and appropriate treatment technologies to manage FS on a citywide scale?

Currently, no methods exist to estimate FS characteristics over large geographic areas, other than intensive and resource demanding sampling campaigns. The result is that when FS treatment plants are built, they are not designed for actual volumes and characteristics [3]. The objective of this study was to evaluate whether the operational and design parameters of septic tanks have any correlation with FS characteristics, and if they could be predictors of FS characteristics.

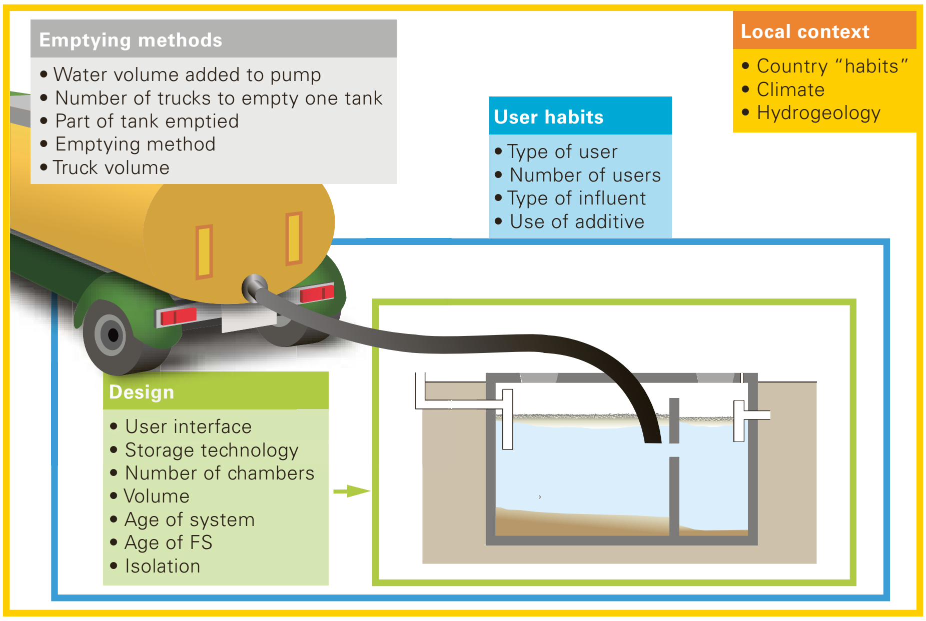


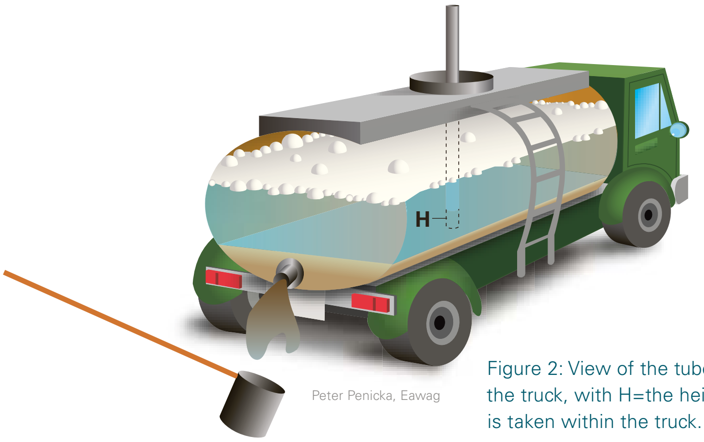
Figure 1: Different factors that can influence the characteristics of FS collected from septic tanks.

Methods

This study was conducted between September 2013 and June 2014 in Hanoi, the capital city of Vietnam. In Hanoi, most houses are equipped with flush toilets and septic tanks that have two chambers and a sealed bottom. The effluent of the septic tank is commonly collected in a combined drainage/sewer network.

59 core samples were taken from trucks that collected FS from individual households. The samples were taken with a tube sampling device, directly after the FS was pumped into the truck. As seen in Figure 2 and Photo 2, the core-samples were extracted from the access ports of the trucks. They are meant to be representative of the FS characteristics along the depth of FS in the truck. The collected FS was poured into different bottles and stored on ice for transportation to the laboratory.

To assess the influence of local factors on FS characteristics, household information was also recorded. This included: the volume of the septic tank, age of FS (i.e., the time since the tank was last emptied), the number of inhabitants, the use of additives, the number of trucks required to empty the septic tank and whether the tank was partially or fully emptied. An analysis of variance was performed on these



Peter Penicka, Eawag

Figure 2: View of the tube-like sampling device in the truck, with H=the height at which the sample is taken within the truck.

The objective is to reduce the resources required to determine FS characteristics on a large geographical scale, and to obtain reliable information. This will assist in the design of treatment technologies that are appropriate and adequate for local situations and the actual FS characteristics.

factors to assess how they influenced the solids, organic and nutrient concentrations of FS.

Results and perspectives

The results of the analyses were highly variable, despite the fact that all samples were taken within the same city, from septic tanks with similar designs, and using the same sampling method. This confirmed that the type of on-site sanitation technology influences FS characteristics, as does their design, construction and operation.

The analysis of variance revealed that the best predictors are the septic tank volume and the age of FS. These two factors very significantly correlated with the solids, nutrient and organic concentrations. The emptying methods also correlated with FS characteristics, but not as strongly. It was also difficult to obtain reliable information on the different emptying protocols used by different service providers.

Magalie Bassan

Photo 1: Adding water to facilitate extraction of settled sludge at the bottom of the tank within the truck.

The other evaluated factors did not significantly correlate with FS characteristics. Sandec is currently conducting research in other cities to confirm whether the results are consistent, and to evaluate additional factors that could provide a more complete set of predictors for FS characteristics.

Conclusion

The goal of Sandec's research in this area is to develop a reasonable and easy to implement method for estimating FS characteristics in order to design appropriate FS treatment technologies. This would be a great advantage for FS management on a citywide scale. Research is ongoing and the method developed includes:

1. Information on the coverage of existing on-site sanitation technologies in a city, including:
    a. Influential design factors (e.g., tank volume, sealed versus unsealed bottom)
    b. Influential operation factors (e.g., type of wastewater, emptying frequency)
2. An optimized sampling plan based on groups of existing technologies, design and operational factors
3. Laboratory analyses on solids, nutrient and organic concentrations for each group
4. Use of the results to extrapolate on a citywide scale, based on the determined predictors of FS characteristics

Adeline Mertenat

Photo 2: Repartition of the sampled FS into bottles for laboratory analysis.

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Reflecting on a Decade of Evolution in Urban Sanitation Planning

Sandec has been a key player in the field of sanitation planning for urban areas over the last decade. During this time, priorities have evolved from the household and neighbourhood level to citywide approaches. Sandec's research publications give evidence of this shift. This article offers insight into future priorities. Christoph Lüthi[1], Roland Schertenleib[2]

Introduction

Sanitation planning for urban areas is a rapidly evolving field of knowledge. The past decade has seen the evolution of integrated planning guidelines and frameworks that provide local authorities and utilities with integrated planning approaches. The 2003 *Urban Sanitation – A Guide to Strategic Planning* (Tayler, Parkinson, Colin 2003) was the first comprehensive sector planning document. It emphasised the need for realistic planning that is multi-stakeholder, incremental in approach, and that offers an integrated view of service provision. It was one of the first documents that refuted the pervasive master planning dogma of the time and set the scene for a new generation of flexible planning frameworks. In 2005 Eawag and the Water Supply and Sanitation Collaborative Council (WSSCC) published the *Household-Centred Environmental Sanitation* (HCES) guidelines based on the Bellagio Principles [1] that placed the household at the centre of the planning process.

CLUES

Multi-country validation of the participatory HCES approach in low-income settlements in 2006–2010 led to the adaptation of the HCES guidelines and the development of the *Community-Led Urban Environmental Sanitation* (CLUES) guidelines. Jointly published with WSSCC and UN-Habitat in 2011, they are often called 'CLTS for urban contexts'. CLUES structures urban sanitation interventions at the community level around a seven-step process, going from the "triggering of communities" to project implementation. People-centred and demand-driven, the CLUES guidelines promote the inclusion of all relevant stakeholders in the decision making process, and are especially appropriate for NGOs and organizations, trying to improve sanitation services in unserved neighbourhoods.

Compendium

As a key resource tool for participatory planning and technology selection processes, such as those outlined in HCES and CLUES, the *Compendium of Sanitation Systems and Technologies* was developed and became Sandec's flagship publication for the International Year of Sanitation in 2008. It has since become our most well-known reference manual among sanitation practitioners around the world and is used extensively for training and educational purposes.

Sanitation 21

The importance of moving beyond neighbourhood interventions and incremental service improvements to undertake realistic, city-wide sanitation planning has become widely recognized, and several countries now mandate City Sanitation Plans. The *Sanitation 21* planning framework (IWA/Eawag/GIZ 2014) draws together international best practices for city-wide sanitation and provides a five-stage framework, from building institutional commitments to preparing for implementation. This document helps to bridge institutional analysis and technical planning by bringing together service delivery arrangement decisions with management options, institutional arrangements and technology issues.

Conclusion

What are possible future directions for urban sanitation planning and programming? Firstly, providing better guidance for the management of faecal sludge for the hundreds of millions of urbanites living with on-site sanitation is a crucial step in the sanitation chain that has previously been ignored. Cities and authorities must realize that for many areas on-site sanitation is not a temporary solution, but will remain an intermediate or permanent solution for decades to come. And they will need better and simpler tools and guidance to safely manage the faecal sludge loads at the neighbourhood and city-wide level. Secondly, on the supply side, improving financial management and the accountability of service providers towards their constituencies. Planners and service providers must better match infrastructure/service costs with affordable service levels for the urban poor. Thirdly, increasing attention to the creation of the right regulatory, financial (i.e., WASH budget allocations) and institutional environment to ensure sustained demand for safe sanitation systems.

Figure 1: Timeline of publications in the field of urban sanitation planning.

[1] EAWAG, WSSCC (Editors) (2000): Summary Report of Bellagio Expert Consultation on Environmental Sanitation in the 21st Century. Dübendorf & Geneva: Swiss Federal Institute for Aquatic Science and Technology EAWAG & Water Supply and Sanitation Collaborative Council.

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MOOCs – Reaching Students and Practitioners Worldwide

In 2014, Sandec launched the MOOC series "WASH in Developing Countries". This series offers free online courses and covers all Sandec research fields: Strategic Environmental Sanitation Planning, Water Supply and Treatment, Municipal Solid Waste Management and Excreta and Wastewater Management. Fabian Suter[1], Christoph Lüthi[1]

Introduction

While distance learning has been a feature of higher education since the 1960s, online education emerged in the 21st century favoured by two main drivers – Internet penetration and students' demographics [1]. In 2008, Massive Open Online Courses (MOOCs) were introduced as courses aimed at unlimited participation and open access via the web. They combined the provision of course materials (e.g., videos and supplemental reading documents) with interactive user forums. Since then, MOOCs have witnessed an impressive growth, especially after 2011, when the three main MOOC platforms (Coursera, edX, and Udacity) started to work with top universities. The leading MOOC platform Coursera, for example, has managed to attract over 12 million learners within three years.

MOOC series "WASH in Developing Countries"

In 2014, Sandec launched the full-fledged MOOC series "WASH in Developing Countries", particularly targeting students and practitioners in low- and middle-income countries. Learners can build their capacity sequentially and obtain stepwise certification with the final objective to reach integral expertise in the field of water, sanitation and hygiene (WASH).

Sandec offers the series due to its recognition as a WHO Collaborating Centre for Sanitation and Water in Developing Countries, and it is produced in collaboration with the École Polytechnique Fédérale de Lausanne (EPFL). All the courses are in English with French subtitles and have a duration of five weeks. Each week, the participants have access to about one hour of video lectures split up into several short modules. Their knowledge is evaluated with quizzes at the end of each week and a final exam at the end of the course. The participants can interact with each other and with the lecturers via the course forum.

The first MOOC of the series was launched in April 2014 by Rick Johnston. It covered the most important water treatment methods at the household level, successful implementation strategies and how to assess the impact of Household Water Treatment and Safe Storage (HWTS). The second MOOC "Planning and Design of Sanitation Systems and Technologies" was produced by Christoph Lüthi and his team. It took place in October 2014 and deals with how to plan urban sanitation at the city and local/community level, and also teaches about different sanitation system and technology configurations.

With a total of 15 132 enrolled students, the demand for the first two courses was enormous. 1 181 students successfully completed the courses and received a Statement of Accomplishment. Both courses reached students from more than 170 countries and more than 40 % of the students participating were from low- and middle-income countries. Feedback and testimonials from the MOOC participants showed high levels of satisfaction with the course content and with the fruitful interaction that was possible with fellow learners. It was also appreciated that the workload (3 – 4 hours/week) was manageable for on-the-job learners.

Conclusion

The "Introduction to Household Water Treatment and Safe Storage" MOOC was updated by Sara Marks and took place in June 2015. Chris Zurbrügg will launch the "Municipal Solid Waste Management in Developing Countries" MOOC in February 2016. Sandec also aims at gaining further experience on how to best produce MOOC materials that can be used for more than one purpose, i.e., in other teaching and training activities, such as in lectures and courses at partner universities in Africa.

[1] Escher, G., Noukakis, D., Aebischer, P. (2014): Boosting Higher Education in Africa through Shared Massive Open Online Courses (MOOCs). Education, Learning, Training: Critical Issues for Development, International Development Policy Series No.5, Geneva: Graduate Institute Publications, Boston: Brill-Nijhoff, pp. 195 – 214.

Fabian Suter

Photo 1: Rick Johnston and Sara Marks in the MOOC EPFL studio, recording a lecture about household water treatment.

[1] Eawag/Sandec, Switzerland

Further information

MOOCs on Coursera:

- Introduction to Household Water Treatment and Safe Storage: <https://www.coursera.org/course/hwts>
- Planning and Design of Sanitation Systems and Technologies: <https://www.coursera.org/course/sanitation>

Please visit the Sandec MOOC webpage, <www.eawag.ch/mooc>, for more information about the series "WASH in Developing Countries", to have access to the video lectures on our YouTube channel and/or if you would like to receive emails about future MOOCs.

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Estimating Wastewater Quantity and Characteristics at the Village-level

The SECO-funded ESRISS project worked on the development of small-scale sanitation in Egypt's Nile Delta. It developed a tool package to estimate wastewater quantity and characteristics on a village-specific basis that does not require wastewater sampling. Ph. Reymond[1], C. Demars[2], A. Papangelou[2], M. H. Tawfik[3], K. Hassan[3], R. A. Wahaab[3], M. Moussa[4]

Introduction

Many investments in the wastewater sector are literally wasted because of the under- or over-design of treatment plants, resulting in underperformance or costly idle capacity. A major reason for this is because often design parameters are used that do not reflect the real conditions, i.e., using Code of Practices based on urban, not rural data. In the Nile Delta, the Egyptian-Swiss Research on Innovations in Sustainable Sanitation (ESRISS) Project's fieldwork showed that the wastewater in small settlements is very different than that in urban areas, and that these settlements (hamlets and villages up to 5 000 inhabitants) are very heterogeneous (which results, for example, in COD concentrations averaging from 400 to 2 500 mg/L) [1]. As a consequence, there are no one-size-fits-all options and design parameters. Instead, there is the need for a case-by-case approach and, thus, for a simple tool that allows practitioners to estimate design parameters on a site-specific basis, based on the collection of a minimal amount of first-hand data [2].

To address this need, ESRISS developed a tool package that allows practitioners to do relevant assessments of the wastewater situation and to be able to estimate the quantity and characteristics of the wastewater to be treated on a village-specific basis within three days and without wastewater sampling. This latter advantage is crucial as taking representative samples in such villages is very difficult and sometimes even impossible because they often lack accessible outlets or sewer networks. This tool package is a result of the collaboration with the Egyptian Holding Company of Water and Wastewater (HCWW) and its Affiliated Company in Beheira Governorate, taking place under the auspices of SECO's institutional support and in parallel to the World Bank-funded ISSIP project.

A tool combining MFA and field experience

The tool package consists of a user-friendly Excel-based model, and a semi-structured interview guideline for village authorities and a simplified household survey questionnaire (in English and Arabic) for the site-specific baseline data collection (Figure 1). It helps the user focus on collecting the key data in a very systematic and structured way. The tool translates the data into an estimation of future wastewater quantity and characteristics. As a result, data analysis is greatly facilitated and the user saves a lot of time, both in data collection and analysis.

The tool package was developed as follows: the material flow analysis (MFA) method was used to systematically estimate the value of the different sanitation-related flows inside small rural settlements. This led to a MFA model that was validated through its application in villages where sewage sampling was possible (i.e., villages where characteristics of both inflows and outflows were known).

Based on both the MFA model and the baseline data, the tool focuses on the key parameters which vary on a site-specific basis, in this case, the number of inhabitants, the water consumption, the type of sanitation system(s), the interaction with groundwater, the liquid manure production and discharge locations, and the greywater management practices. In a context where it is difficult to get accurate data, the tool supports the user to collect information from different sources and then to crosscheck the results. The user has to select a value for each of the six key parameters. This way, the tool pushes the user to critically assess his data and the creation of a blackbox is avoided.

The daily average and peak value for the following design parameters are computed based on the selected values: the flow volume, BOD, COD, total solids (TS), total suspended solid (TSS), total nitrogen (TN) and total phosphorus (TP). The MFA model is used to estimate the wastewater volumes, nitrogen or phosphorus, whereas BOD, COD, TS and TSS, which are much more difficult to assess within the system, are estimated based on field experience. A village factsheet is automatically produced to synthesise all key data. ESRISS has produced a

Philippe Reymond

Photo 1: Village of Kawm Abu Khalifa, Beheira Governorate.

user manual that includes a step-by-step procedure, and has made this available. [3]

Applications

This is a planning support tool for villages where a sewer network and a treatment plant are being built. Besides permitting sound estimates of the characteristics and quantities of the wastewater to be treated once a proper sewer network is built, the tool assists in comparisons of sanitation system scenarios and estimates of the nutrient contents (nitrogen and phosphorus – in the perspective of optimal wastewater and nutrient reuse). The user can, thus, estimate the impact of different measures.

The tool was first validated in four villages where sewage sampling was possible, allowing for the results of the model to be compared with real sewage characteristics. It was then applied in several settlements in collaboration with different rural sanitation programmes in Egypt.

Model estimation		Daily average		Morning peak	
Parameter	Unit	Conc.	Precision	Fact.	Conc.
Flow	m^3/day	290	20 %	1.6	460
Flow	L/min	200	20 %	1.6	0.6
COD	mg/L	1 390	30 %	1.3	1 810
BOD [1]	mg/L	710	30 %	1.2	850
TS [2]	mg/L	3 040	30 %	1.5	4 560
TSS	mg/L	410	30 %	1.4	570

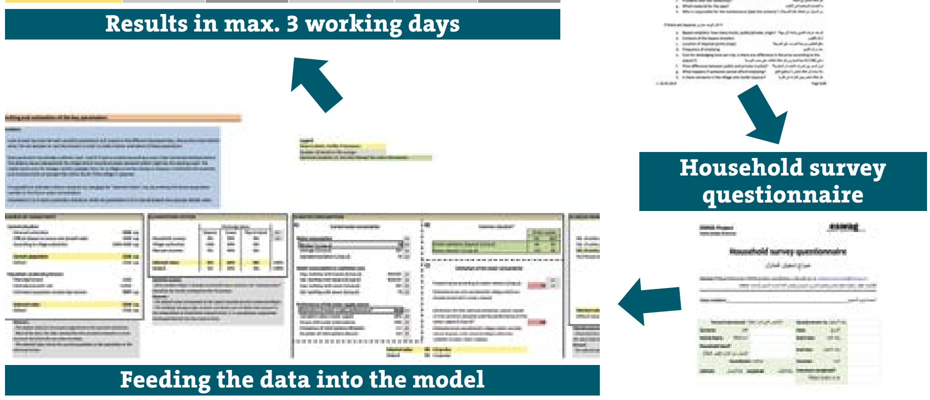

Figure 1: Synthesis of the tool package.

Several research questions could be answered with the MFA model [4]:

a. What are the flow volume and nutrient loads in sewage, respectively, septage? To what extent does the wastewater production increase when a sewer network is built?
b. What influence does liquid manure have on the loads and concentrations of nutrients and organic matter in sewage?
c. Which flow volume and nutrient loads can be isolated through the centralised management of liquid animal manure? What impact does it have on the nutrient loads in sewage, respectively, septage?
d. What are, in terms of reuse potentials and volumes to be treated, the benefits of storing blackwater and animal manure in onsite sanitation systems (e.g., biogas digesters) and of separating greywater?

For example, the study showed that the wastewater volume would increase 67 % when a sewer network is built and that the implementation of a liquid manure management unit permits an average reduction of about 20 % of COD and nitrogen loads in the sewage. The material flow analysis model and results were graphically represented with STAN software.

Adapting the tool to other contexts

The tool is open-source and available at <www.sandec.ch/esriss>. Because it can be applied to any small rural village or settlement, it opens up a large application potential worldwide. Applying the procedure in contexts outside of the Nile Delta requires first, reviewing each baseline parameter and assumption and, if necessary, to replace them with context-specific ones. For example, it cannot be assumed that water consumption patterns or the manure management practices would be identical in every context. The adapted model should then be validated in several villages where the inflows and outflows are known. The user manual describes how the model was developed and how the hypotheses were done. The Excel-based model includes computation sheets which show the model parameters and equations, thus, facilitating any adaptation.

Conclusion

The tool developed by ESRISS constitutes one small step towards an enabling environment for rural sanitation and cost-effective sanitation systems. Its use should support a sound Code of Practice, which should be part of a clear national rural sanitation strategy. In Egypt, a paradigm shift is needed to take up the sanitation challenge of the 85 % unserved rural areas, which includes about 4 700 villages and 30 000 scattered settlements. This will require constructive coordination among the concerned ministries. As a last outcome, ESRISS intends to translate its extensive experience into a policy paper, and into clear inputs to assist in the development of Egypt's new national rural sanitation strategy.

[1] Reymond, Ph., Demars, C., Papangelou, A., Hassan Tawfik, M., Abdel Wahaab, R., Moussa, M. (2014): Small-Scale Sanitation in the Nile Delta: Baseline Data and Current Practices. 2nd ed. Eawag, Switzerland-Egypt.

[2] Reymond, Ph., Abdel Wahaab, R., Moussa, M. (2012): Small-scale Sanitation in Egypt: Challenges and ways forward. Eawag, Switzerland-Egypt.

[3] Reymond, Ph., Demars, C. (2014): A Model-Based Tool to Quantify and Characterise Wastewater in Small Nile Delta Settlements: User Manual. Eawag, Switzerland-Egypt.

[4] Reymond, Ph., Papangelou, A., Demars, C., Hassan Tawfik, M., Ulrich, L., Abdel Wahaab, R. (2014): Modelling Small-Scale Sanitation in the Nile Delta: A Material Flow Analysis with Nutrient Reuse Perspective. Eawag, Switzerland-Egypt.

[1] Eawag/Sandec, Switzerland

[2] EPFL/ETHZ

[3] Holding Company for Water and Wastewater, Egypt

[4] Helwan University, Egypt

We would like to thank all of our Egyptian partners and colleagues for their support, and the Swiss State Secretariat for Economic Affairs (SECO - www.seco-cooperation.ch) for funding this project.

For more information and to download the documents & tools: <www.sandec.ch/esriss>.

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Towards Reliable Cost Estimates of Sanitation Infrastructure

Information about the costs of different sanitation technologies is essential for selecting the right options and planning adequate budgets, but is not easily available. Sandec is developing a tool that facilitates data collection and cost estimates to improve sanitation decision-making. Lukas Ulrich[1] and Christoph Lüthi[1]

Introduction

The price tag is often the predominant criterion when it comes to deciding on the sanitation technology option to put in place. Having accurate and transparent cost estimates is also important for project development and capital budgeting.

Today, engineers struggle to provide site-specific cost estimates that allow for sound technology decision-making and budget planning in sanitation programming. This applies especially to unconventional technologies that are innovative or not widely used. Estimating capital and operational infrastructure costs is not easy, especially considering all the context-specific and variable factors that determine the total costs. Such factors include design parameters, material choices, local unit prices, available implementation methods and equipment – each with their respective uncertainties. With very few exceptions, standardised designs do not exist for most sanitation technologies, and this results in a wide range of individual designs, adding to the complexity and uncertainty of cost assessments.

Sanitation costing tools

With the aim to support decision-makers in understanding the cost implications of sanitation projects, a variety of computer tools have been developed or are currently under development. Examples are:

WASHCost Share (by IRC): An online tool for the creation of lifecycle cost reports on water and sanitation services, which can be used to plan for sustainable, long-lasting services. It takes into account all related expenditures and affordability. However, the tool does not provide technology cost estimates and the user is required to enter data on capital costs [1].

CLARA Simplified Planning Tool (by CLARA Project): A country-specific Excel tool that aims to support planners in finding the best among a range of water and sanitation alternatives based on net present value (NPV) calculations. Its cost estimates rely on technology-specific assumptions, user-specified design parameters and country-specific bills of quantities (BoQ). The tool has been developed for five African countries [2].

Economics of Sanitation Initiative (ESI) Toolkit (by WSP): An online tool that facilitates a range of economic analyses like cost-benefit and market size analyses to improve sanitation decision-making. The toolkit also includes a technology cost analysis that supports estimation and comparison of the annualised total costs of different options, but capital costs need to be provided by the user [3].

Several other organisations are also working on costing tools, each with their own scope of analysis and application. While some of the tools do assist in estimating and/or comparing capital costs, none of them provide detailed sanitation technology cost analyses that are fully transparent, based on disaggregated cost data, and flexible for adaptation to any user-defined context.

Objective

Sandec's work aims to fill this gap by incorporating cost data collected from its projects and partners in recent years into a tool that allows engineers and planners to estimate context-specific investment costs of sanitation technologies based on a BoQ approach (See Box). We envision that the tool will be:

Quick and easy to use: The tool will be largely self-explanatory and can be used without training. It is Excel-based to be widely accessible and independent of the Internet. The user simply enters local unit prices (e.g., for materials and labour) and receives a realistic estimate and comparison of the costs of the available pre-defined BoQ models (design alternatives) of a technology.

Context-specific and flexible: The pre-defined technology designs collected by Sandec will be easily adaptable to local contexts, e.g., by changing materials, quantities or dimensions, or by including or removing any cost element. Engineers will be able to add new designs by entering their own BoQs. Unit costs will typically be entered in local currencies, but it will be easy to switch between currencies and to update exchange rates.

Transparent: The BoQs and all their elements will be fully accessible and straightforward, and the calculations will be easy to verify. This transparency will make the tool credible and enable practitioners to be more confident in providing cost estimates, as well as to understand any associated uncertainties.

Structured: Each BoQ will be arranged according to different categories of items (e.g., material and labour) and components (e.g., substructure and superstructure). Additionally, technologies will be organised in line with the Compendium nomenclature, adding to the tool's clarity.

As simple as possible, as complex as necessary: Although it will not be a design software for detailed engineering design, the costing tool will generate reasonably accurate estimates based on relatively detailed lists of items with moderate efforts on the part of the users. Although some uncertainty will always remain with the resulting estimates, precision can be improved by adapting the BoQs and their level of detail to local contexts.

Gradually developing and open access: The tool has a strong focus on capital costs, yet its flexible structure will allow for the stepwise inclusion of any other cost element for which data becomes available (e.g., operation and maintenance). Due to the current weak data baseline for certain technologies, the tool will first start with the on-site sanitation technologies for which good datasets exist. In an on-going process of data collation and validation, the database of technologies and different design alternatives will gradually increase, and possibly include crowd-sourced (user-generated) BoQs. The tool will be freely available from the Sandec website.

Complementary: This sanitation costing tool will have the potential to provide an added value when combined with existing cost analysis tools which do not include accurate technology cost data. Its estimates could be used as input data for other tools that provide more complete economic analyses, such as full life cycle costing, or annualised cost and NPV calculations.

Bill of Quantities (BoQ)

Component	Item (ID and Description)	Item Category	Quantity	Unit	Rate [UGX]	Amount [UGX]
Substructure	1: Cement	Material	7.00	bags (50 kg)	29 500.00	206 500.00
Substructure	8: Clay bricks	Material	1 000.00	pieces	280.00	280 000.00
Substructure	2: Plaster sand	Material	0.60	trips (ca. 3.4 m3)	100 000.00	60 000.00
Substructure	6: Lake sand	Material	0.60	trips (ca. 3.4 m3)	130 000.00	78 000.00
Substructure	9: Aggregate	Material	1.00	trips (ca. 3.4 m3)	160 000.00	160 000.00
Substructure	12: Iron bar 38 ft	Material	2.00	pieces	30 000.00	60 000.00
Substructure	11: Binding wire	Material	1.00	kg	10 000.00	10 000.00
Substructure	10: Wire Mesh 4 x 8 ft	Material	1.00	pieces	24 500.00	24 500.00
Substructure	7: Water jerrycan 20 l	Material	30.00	pieces	150.00	4 500.00
Substructure	13: Formwork timber 4x2 in, ca. 3 m	Material	1.00	pieces	7 000.00	7 000.00
Substructure	14: Formwork timber 12x1 in, ca. 3 m	Material	4.00	pieces	10 000.00	40 000.00
Substructure	5: Eucalyptus poles 4 m	Material	1.50	pieces	3 000.00	4 500.00
Substructure	3: Nails 3 in	Material	0.50	kg	5 000.00	2 500.00
Substructure	4: Nails 4 in	Material	0.50	kg	5 000.00	2 500.00
Substructure	15: Polythene (DPC/DPM)	Material	0.80	m2	3 125.00	2 500.00
Substructure	16: Vent pipe PVC	Material	3.00	m	5 000.00	15 000.00
Substructure	17: Vent pipe cover	Material	1.00	pieces	3 000.00	3 000.00
Substructure	20: Excavation	Labour	10.00	m3	8 000.00	80 000.00
Substructure	21: Mason	Labour	6.00	man days	20 000.00	120 000.00
Substructure	22: Unskilled worker	Labour	6.00	man days	7 000.00	42 000.00
				Total Amount		**1 202 500.00**

Lukas Ulrich

Figure 1: Excerpt of a sample BoQ (substructure of a Ugandan design of a lined single VIP toilet) implemented in the Excel tool. The items, their categories, units and rates are defined in a separate sheet, through which the entering of local unit prices is facilitated. In the BoQ table as shown here, the items can then be selected from a dropdown list and their quantity defined or adapted. Costs are then automatically calculated. Green cells can be modified by the user, while grey cells are automated and locked.

Bill of quantities explained

A bill of quantities (BoQ or BQ) is an itemised list of materials, components and labour required to construct, maintain or repair a specific structure. For each item, the quantities, units, rates and resulting total amounts are listed. BoQs are normally used in tendering for construction work to allow tenderers to efficiently price the work for which they are bidding [4].

BoQs are typically structured as trade bills (according to the respective trades, such as earthwork or brickwork) or as elemental bills (according to the functional parts of a building, such as walls or roofs). A BoQ is normally a schedule of work items (tasks) in a construction sequence, but for simple structures (e.g., a VIP toilet) it can also be a simple list of materials and labour required.

Methods

In order to achieve this vision, Sandec has been collecting BoQs of sanitation technologies via its network of partners and through its projects. It has also developed a tool framework which allows for easy data entry and cost estimates (See Figure 1).

Where possible, prevalent technology designs are identified based on data from the field and related design information. These are then entered in the Excel format as preassembled, exemplary design alternatives which the user can work with and adapt to his/her own needs if necessary. A validation of the pre-defined designs can then be made by comparing the calculated costs with technology cost data from the field.

The database of available technologies and designs will gradually increase and develop as part of Sandec's work, and also possibly with crowd-sourced information. The user-friendly tool framework provides an interface that will facilitate data collection and streamline BoQ development for any technology. The tool has been implemented in Excel, but it could become an online database and tool at a later stage if there is sufficient demand.

Preliminary results

The current version of the tool framework has all the required functions and provides the structure for easy entry and analysis of BoQ data. A considerable amount of data has been collected for different sanitation technologies. However, because key design information (e.g., dimensions, drawings or descriptions) is often lacking, many of these collected datasets are not useful for the development of the tool. In other cases, BoQs are too context-specific and cannot be used to develop representative design alternatives. Due to these data challenges, typical BoQ models have been generated up to now for only a small number of on-site sanitation technologies. These are now being validated and entered into the tool.

Conclusion and outlook

Discussions with practitioners have confirmed the interest and need for such a sanitation costing tool; yet, the lack of quality data is a major challenge to its implementation. Often, engineers and project managers are not willing or able to share design details. And only well-documented BoQs with respective design specifications are useful for the tool's development. An additional challenge is that some project BoQs are not representative or do not represent best practice. Not all designs can be replicated in other contexts.

Particularly in the case of more complex sanitation infrastructure (such as treatment technologies), the costs depend on a large number of design and dimension parameters which may not be known before the detailed design phase. Therefore, it is difficult to provide transparent BoQ templates for such technologies and the uncertainty of the resulting cost estimates can be high.

To overcome these challenges and improve the database, further data collection will be done by Sandec, supported by research partners and practitioners who are willing to share cost information from sanitation projects. Sandec also seeks collaborations with other organisations working on related initiatives, as well as with implementing professionals at the data source. In a final stage, the tool could be integrated into existing complementary software for economic analyses.

A beta version of the costing tool for the first technologies will be available for testing and feedback by late 2015.

[1] <http://www.ircwash.org/projects/life-cycle-costing-tools>

[2] <http://clara.boku.ac.at/index.php/planning-tool-2>

[3] <http://www.esitoolkit.org/> (at editorial deadline not fully accessible yet)

[4] <https://en.wikipedia.org/wiki/Bill_of_quantities>

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Genderised WASH in Ugandan and Indian Public Health Care Facilities

This interdisciplinary project, combining social anthropology and gender studies with sanitary engineering, is researching users' needs and WASH infrastructure in health care facilities, particularly how they deal with the special needs of women. Petra Kohler[1], Samuel Renggli[1], Victoria Abu Atukunda[2], Charles Niwagaba[3], Ramesh Sakthivel[4], Christoph Lüthi[1]

Introduction

Water, sanitation and hygiene (WASH) in health care facilities in developing countries fail to provide user friendly and gender sensitive services. It is estimated that 15 % of all patients develop an infection during their stay in a health care facility [1]. These facilities are often underperforming, due to inadequate water supply and sanitation infrastructure, putting the most vulnerable user groups, i.e., pregnant women, women in childbirth, small children, the elderly and disabled people, at risk. Also, within the realm of WASH, the area of menstrual hygiene has been identified as one of the most neglected [2]. In addition to health issues, women are confronted with gender-specific social norms, e.g., taboos, which often hinder proper hygienic habits during menstruation, affecting their health and challenging their dignity. Our research aims to provide data on the sanitary requirements of health care facilities and will address the gendered realities of intimate needs in the face of inadequate or poorly designed infrastructure.

Research interests and methodological procedure

The two-year (2014 – 2016) Genderised WASH project responds to the research question: What are the shortcomings of existing WASH facilities in public health centres and what are the needs of specific user groups with regards to WASH infrastructure concerning genderised sanitation?

The project assesses the state of the art of sanitary infrastructure in four selected public health centres in India and Uganda. Due to the sensitivity of intimate sanitary needs and hygiene practices, the methodological challenges will be addressed by applying a proven technique from the participatory rural appraisal repertoire. The specific needs and priorities of the different user groups, patients, visitors and staff members, are explored using the Gender Action Learning System (See Box). This assessment of users' needs will be supplemented by semi-structured interviews with key stakeholders and gatekeepers from the medical divisions, management and health authorities. The data will provide evidence for possible interventions that are needs-based, technically appropriate and socially acceptable.

The **Gender Action Learning System** (GALS) is a focus group discussion method, originally used for gender justice in relation to livelihood improvement [3]. It has been tested in a previous research project in different cultural contexts [4] [5] and adapted to the realm of gender and sanitation in health care facilities settings.

GALS has proven its strength in the investigation of local knowledge – the needs, concerns and priorities of local persons. It is also particularly known for its gender sensitivity because it promotes the collection of sex-disaggregated data and gender-mixed plenary discussions. Furthermore, it can capture the views of illiterate persons, as it allows for non-written contributions (drawing symbols and discussions).

Petra Kohler

Photo 1: Empty water tanks outside a selected hospital in Uganda. Rainwater is being collected during the rainy season.

Expected project outcomes

The expected research outcomes are a WASH indicators checklist for health care facilities, supplemented with a gender perspective, an assessment of the infrastructure, and practical guidance on necessary improvements concerning hardware and software. Furthermore, an intervention is planned, which will be defined in more detail after the data analysis, that will be in accord with the sanitation demands of the various user groups.

The results will be published in an academic article and in a policy brief on best practices for dealing with the sanitation needs of specific user groups. The publications will be relevant for health care managers, health authorities, and the local communities, and made accessible to relevant actors on local, regional and national levels.

Indian and Ugandan settings and situations

In each country, health care facilites in rural districts were selected that fulfilled pre-defined criteria: government hospitals with health care services for in- and outpatients, offering maternal and delivery care, with sufficient numbers of women and men to conduct the GALS, and having experts and specialists willing and available to be interviewed.

One District and one Sub-District health care facility will be investigated in both countries. All offer various health care services and face recurring challenges: underfunding, understaffing and lack of basic infrastructure. In Uganda, the lack of a reliable water supply during the dry season is a major challenge (See Photo 1), while in India the patient to sanitation facility ratio and understaffing seem to be the most pressing issues (See Photo 2). Due to the high number of patients, the recommended ratio of one toilet for 20 users is hard to meet [1].

Preliminary data on infrastructure assessment

In addition to the selection of the health care facilities, the first field trips also led to initial research outcomes. These results showed the need to add three essential dimensions to the infrastructure assessment checklist [6]:

- **Inclusion of complexity of health care facility WASH infrastructure:** Often, more than one sanitation system and many different water sources are in service in the same health care facility, varying from time of day, seasonal conditions and the composition of user groups. The currently used monitoring tools, and the Indian and Ugandan national guidelines for infrastructure requirements do not take this complexity into account.
- **Infrastructure requirements of attendants:** Attendants are the visitors of patients who fulfil the role of care-takers, as the medical staff is not able to handle basic services for all patients. Attendants provide such services as the provision of drinking water, cooking and much more. Because they stay at the health care facility for long periods and use the infrastructure, their needs should also be taken into account when planning WASH services.
- **Gender specific infrastructure indicators:** Current infrastructure in India and Uganda is centrally planned by engineers. Gender specific needs are often not incorporated in existing guidelines. Infrastructure indicators and guidelines need to encompass: (i) a place to take a bath after giving birth, including warm water; (ii) a washing and drying place for reusable menstrual hygiene products; and (iii) safe disposal of used menstrual hygiene material.

Samuel Renggli

Photo 2: Maternity Ward in Beed District Hospital in Maharashtra, India.

International efforts to improve WASH services in health care facilities

Preliminary research results of the Genderised WASH project were presented at the WHO international meeting on "Water, Sanitation and Hygiene in Health Care Facilities – Urgent Needs and Action" in Geneva in March 2015. The presentation was very welcomed, given the gaps in evidence and research in this area. An international work group led by WHO and UNICEF, consisting of experienced representatives from health authorities, donors, NGOs and academia, has started to share knowledge and work together with the goal of formulating an action plan and develop workable solutions that address the current gaps. Given the post – 2015 Sustainable Development Goals, it is even more essential to pursue common efforts towards improving WASH infrastructure in health care facilities in order to provide healthy and sound services, especially for the underserved and the most vulnerable.

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Evaluating Sustainable Ceramic Filter Production and Marketing in Nepal

In the last decade, 19 micro-entrepreneurs in Nepal were trained and supported to produce ceramic filters for water treatment at the household level. Qualitative interviews were conducted with them to assess which factors have to be present to have successfully operating businesses. Regula Meierhofer[1], Anne Bogler[1]


Regula Meierhofer

Photo 1: Potter producing ceramic water filters.

Introduction

An estimated 1.8 million people do not consume safe drinking water [1]. Household water treatment, if applied correctly and consistently, is a strategy to reduce the health risks related to the consumption of unsafe drinking water [2]. Acceptance and use trials with Household Water Treatment and Safe Storage (HWTS) products have been carried out in recent years and revealed that people have a high preference for filters due to their ease of operation [3]. Organisations such as Village Forward, Unicef / SAPPROS, IDE and Helvetas, therefore, have supported efforts to train local entrepreneurs in the production and marketing of ceramic filters in Nepal since 2005. A total of 19 entrepreneurs were trained in the past decade in producing a ceramic filter that was designed by Potters for Peace, consisting of a pot-shaped filter that fits into a receptacle. This design was modified for production in Nepal, where only the bottom, the filter disk, is made of porous material, not the whole pot. An evaluation was conducted of the 19 potters to collect qualitative information about their businesses and to identify the factors that support their success, as well as reasons for failure.

Method

Although contact with five of the ceramic filter entrepreneurs could not be established, structured qualitative interviews were conducted with 14 of them. In addition, qualitative interviews were done with the managing staff of the organisations that supported the training and establishment of the production sites. The interviews were complemented with structured observations, and the interview guide covered the different elements of a business model, as well as the enabling environment. It contained 66 questions and covered such issues as production aspects, partnerships with other organisations, customer demand, marketing conditions and marketing measures taken, external market influences, business and management skills of the potter, sales and profit margins and entrepreneurial spirit.

In most cases, the production had never been successfully established. To get a more systematic understanding of the factors that could lead to the successful and sustainable operation of a ceramic filter production business, a Qualitative Comparative Analysis (QCA) was done. Eight potters who had started filter production were questioned to identify the factors that lead to the successful marketing of ceramic filters, which is the outcome variable. This method uses truth tables to find paths that lead to the outcome, whereby a path consisting of causal combinations shows if different factors are present or absent [4].

For the QCA, the information gathered was grouped into the following categories: production (5 questions), collaboration & support (7 questions), customer availability (4 questions), external influences in the market (7 questions), business and management skills (11 questions), marketing skills and effort (6 questions), entrepreneurial spirit (16 questions) and customer interest in filters (10 questions). The answer to each question was rated either as positive (+1), without influence (0) or negative (-1) and was multiplied with an attributed weight between 1 and 3. All the ratings within a category were summed up and divided by the maximally possible score within the category to normalize the scores to a scale from -1 to 1. This score

	Sites							
	D	Pa	K	Ch	Dy	Do	Kb	S
Nr of Filters sold	*15 000*	*4 000*	*3 750*	*500*	*175*	*150*	*150*	*10*
Production (P)	0.778	0.778	0.889	0.556	0.167	0.167	0.556	0.944
Collaboration & Support (C)	0.273	0.727	0.909	0.818	0.455	0.455	0.727	0.318
Market (M) joined by logical OR	0.706	0.765	0.912	0.583	0.917	0.917	0.269	0.269
Availability of Customers	0.667	0.417	0.750	0.583	0.917	0.917	0.167	0.250
Ext. Influences Market	0.615	0.615	0.462	0.462	0.846	0.808	0.269	0.269
Interest in Filter	0.706	0.765	0.912	0.412	0.706	0.706	0.118	0.147
Potter (P) joined by logical OR	0.852	0.450	0.630	0.421	0.950	0.650	0.211	0.519
Business Mgmt & Finanical Skills	0.816	0.237	0.421	0.421	0.737	0.421	0.211	0.500
Marketing & Effort	0.400	0.450	0.200	0.250	0.950	0.650	0.150	0.400
Entrepreneurial Spirit	0.852	0.389	0.630	0.370	0.593	0.556	0.185	0.519

Table 1: Fuzzy set scores for eight categories/four factors of the different cases.

Site	Outcome Scores		Causal Combinations					
	Cont.	Term.	R*C*~M* ~P	R*~C*~M* P	~R*~C*M* P	R*C*M*~ P	R*~C*M* P	R*C*M* P
D	1.0	0	0.148	0.294	0.222	0.148	**0.706**	0.273
Pa	1.0	0	0.235	0.235	0.222	**0.550**	0.273	0.450
K	1.0	0	0.088	0.088	0.091	0.370	0.091	**0.630**
Ch	0.5	0.5	0.417	0.182	0.182	**0.556**	0.182	0.421
Dy	0.175	0.825	0.050	0.083	**0.545**	0.050	0.167	0.167
Do	0.15	0.85	0.083	0.083	**0.545**	0.167	0.167	0.167
Kb	0.15	0.85	**0.556**	0.211	0.211	0.269	0.211	0.211
S	0.01	0.99	0.318	**0.519**	0.056	0.269	0.269	0.269
Consistency for Sufficiency		Cont.	0.623	0.664	0.580	**0.811**	**0.837**	**0.870**
		Term.	**0.751**	0.636	0.742	0.528	0.482	0.477

Table 2: Membership scores of eight potters in causal combinations ("Production" (R), "Collaboration" (C), "Market" (M) and "Potter" (P)).

subsequently was converted into a value between 0 to 1 by dividing the sum of the score plus 1 by 2.

As only eight cases were available for analysis, the previously formed categories had to be condensed into the four factors "Production", "Collaboration", "Market" and "Potter". "Market" consists of the categories: availability of customers, external influences on the market and customer interest in filters, and "Potter" consists of: business management and financial skills, marketing skills and effort, and entrepreneurial spirit. The categories in the factor "Market" and in the factor "Potter" were joined by using logical OR [5].

The scores for each factor were converted into fuzzy-sets for the QCA. Four factors result in 16 causal combinations. Each potter's membership in each causal combination was calculated using logical AND. The outcome was defined as the successful continuation of ceramic filter production. The scores for continuation were calculated using the number of filters sold by each site divided by 1 000. Sites with more than 1 000 filters sold received an outcome score of 1. This was done in order to reach a score of 0.5 for one potter who was only producing filters from time to time, i.e., half in and half out of production. If a causal combination had at least one case with membership above 0.5, its consistency and coverage of sufficient conditions were calculated for each outcome [4]. Causal combinations with consistencies above the cut-off value 0.75 were analysed to find which path leads to which outcome.

Results

The qualitative evaluation of the interviews revealed that successfully establishing a production business had been a hurdle for more than half of the trained potters. Eight potters were provided with all the equipment and production resources, while 11 potters were expected to build their own kilns, after receiving training on how to do this. For some, this was too big of a challenge. Lacking equipment, such as the temperature measurement device, prevented two potters from starting production. Some potters found that their clay was unsuitable for firing at high temperatures, and had difficulty finding another source of clay. Two potters are still trying to solve this problem.

Another critical area is demand for the filters. Potters told us that the people in their area are aware of the dangers of drinking unsafe water. However, people often think that their water is safe and does not require treatment. And most of the potters lack resources for marketing and awareness raising. Table 1 shows the fuzzy set scores of the eight cases that successfully established filter production for the factors "production", "collaboration and support", "market" and "potter".

The QCA delivered results that supported the findings of the qualitative evaluation of the potters' cases and yielded more consistent causal combinations for the outcome of continuation than for termination. Production problems or low market demand can end a potter's business. If there are no production problems and there is also high demand, the path to continuation is present. This path also showed that strong collaboration and support, and the potter's expert skills, are exchangeable (See Table 2).

Critical to the further expansion of ceramic filter production in Nepal is the fact that the entire filter business depends on one potter, who helped in its development, and who also produces and supplies the filter disks required by all the potters for their businesses. His production capacity is limited and he cannot meet the demand for filter disks of all the potters.

Conclusion

The evaluation showed that smooth production with good access to all required resources, as well as a good marketing context, are essential for the successful operation of a ceramic filter business. This would include training at least one other entrepreneur in producing filter disks, which would break up the current monopoly held by one person and assure that enough discs are available for all potters. Furthermore, we believe that too many of the entrepreneurs trained in Nepal failed due to problems related to the initial start-up of production. Most of these problems could have been overcome with more coaching on how to set up production and systematic capacity building in how to implement marketing activities.

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Researching Water Quality, Consumer Preferences and Treatment Behaviour

The Water Supply and Treatment and Safe Water Promotion Groups are partnering with Helvetas Swiss Intercooperation to improve drinking water quality for homes across rural Nepal. The objective is to develop and implement a water treatment strategy through systematic field-based monitoring. S. Marks[1], A. Diener[1], M. Bhatta[2], D. Sihombing[3], R. Meierhofer[1]

Introduction

In rural Nepal, 88 % of households have access to an "improved" drinking water source [1]. Yet many of these water points cannot guarantee microbiologically safe drinking water. Water quality data is limited due to difficulties with systematic collection in remote communities, leaving program managers without the information needed to plan treatment strategies. A research team from Sandec's Water Supply and Treatment and Safe Water Promotion Groups partnered with Helvetas Swiss Intercooperation in Nepal to assess household drinking water quality, behavioural factors determining water handling practices, and market conditions for treatment products using field-robust data collection techniques.

Project background

The Helvetas Water Resource Management Project (WARM-P) aims to identify water resources and foster effective, equitable, and efficient use at the local level across five districts of Nepal (Achham, Dailekh, Kailali, Kalikot, and Jajarkot) [2]. Within the WARM-P service area there is the added goal to improve drinking water quality through a demand-led treatment and safe storage approach.

Several critical questions were identified within WARM-P: To what extent are households' drinking water supplies contaminated with faecal bacteria? How do households collect and manage their water? Are households using any existing water treatment techniques? Which behavioural factors determine the water handling and consumption practices? Which consumer preferences and behavioural factors should be addressed to create demand for safe water? What is a promising market-oriented strategy that has potential for sustainable implementation at scale?

Drinking water quality assessment

The objective of the water quality assessment was to quantify the concentration of faecal bacteria in households' drinking water supplies. Water samples were collected from 166 points of collection (household or public taps, boreholes, and traditional wells) and 512 household storage containers (Photo 1). In addition, structured observations were conducted at the intakes of piped systems to assess potential contamination sources. Samples were collected in Whirlpak bags and transported within six hours to temporary laboratory stations centrally located within villages. Samples were processed to enumerate *E.coli* concentrations using membrane filtration with compact dry plates. Plates were placed in a solar-powered incubator at $35^{\pm 2}$ °C for 24 hours before colony forming units (CFUs) were counted.

Nine out of every ten households sampled were accessing an improved source for their main drinking water supply. Most households (91 %) were using the same container for transport and storage. Nearly all storage containers (91 %) had detectable *E.coli* in excess of the WHO guideline for microbial safety of drinking water [3], with 21 % of stored water samples containing over 100 colony forming units (CFUs) per 100 mL. At the point of collection, 31 % of the samples were free of faecal contamination and about one in ten samples contained >100 CFU *E.coli*/100 mL (Figure 1).

Better water quality at the point of collection was associated with cleaner water in storage containers (Spearman's ρ (283) = 0.25, $p<0.001$). For water systems which households identified as providing water continuously (no interruptions), water quality was significantly cleaner than for systems experiencing daily interruptions (Mann-Whitney U (196) = 3380, $p<0.05$). Intake observations revealed the close proximity of animal faeces and farming, as well as missing intake protection, as potential reasons for contaminated piped water supplies.

Water treatment and hygiene behaviour

Structured interviews with households (n = 512) were conducted to assess behavioural and environmental factors determining water handling and consumption practices. Fifty percent of survey respondents had at least a primary school level of education. Only 4 % of households had adequate hand washing facilities and 41 % of respondents reported washing their hands two times daily or less. Most households (87 %) had a ventilated improved pit (VIP) latrine. Five percent of households and 19 % of children under age five had experienced

HELVETAS, Nepal

Photo 1: Water transport and storage containers.

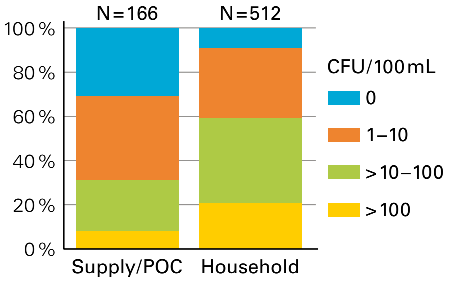

Figure 1: *E.coli* concentration levels for point of collection and household water samples.

diarrheal and acute respiratory illness, respectively, within the past three days.

Most households said that their drinking water quality was "good" (57 %) or "acceptable" (25 %) (Figure 2), and 46 % attributed no or little diarrhoea risk to drinking untreated water. Still, two-thirds of respondents stated that water treatment was "important" or "quite important" to practice. However, across the five Village Development Committees (VDCs) visited, between 53 % and 94 % of the households did not practise any form of water treatment. Knowledge of different water treatment technologies was very limited; most households (70 %) could not explain more than one treatment method.

In bivariate tests, household water treatment use was significantly and positively correlated with: having access to treatment products locally, emotional factors regarding water treatment, having sufficient knowledge of treatment methods, intention to treat, assuring the continuous practice of treatment, and believing it is important to treat water (Spearman's ρ, all $r>0.3$, $p<0.001$). In a logistic regression model of household water treatment use ($n=78$, 1 VDC only), two behavioural factors were statistically significant at the $p<0.05$ level: risk knowledge regarding consumption of untreated water ($OR=2.7$) and availability of water treatment products in the home ($OR=3.2$).

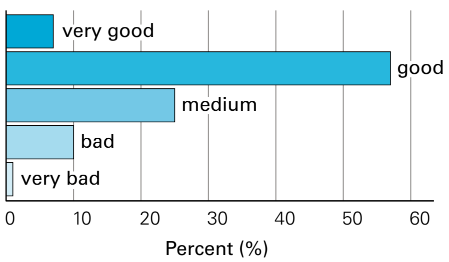

Figure 2: Households' perception of their own drinking water quality.

A reduced logistic regression model on water treatment use ($n=438$, 5 VDCs) found that risk knowledge regarding the consumption of untreated water ($OR=1.3$), knowledge of treatment methods ($OR=1.4$), and intention to use treatment products ($OR=1.8$) were each significant at the $p<0.05$ level.

Market assessment

To assess underlying consumer preferences for treatment products, health risk perceptions, and local market conditions, the research team applied an explorative approach and conducted expert interviews ($n=122$) with health practitioners, merchants, households and sector institutions. Additional data sources included structured observations ($n=201$), household survey questions ($n=512$), and local and national records.

The health sector analysis revealed a preference for short-sighted coping strategies, mirrored by most households' health risk management practises. Interviews with physicians and pharmacists suggest that patients show little to no preference for preventative measures to safeguard health, including consistent water treatment. Rather, health risk management focuses on reactive measures to treat symptoms. Acute water-borne diseases are rarely laboratory tested and their treatment is dominated by antibiotics, whereas vital rehydration is often neglected and indication of a high prevalence of viruses is largely ignored.

Findings suggest that the demand for water treatment is limited by preference rather than price and availability. Water treatment products (mainly ceramic filters and chlorine) are available at urban wholesalers, but market penetration in rural areas is still low and has not kept pace with the reach of toilet infrastructure and soap. The mean stated monthly willingness to pay for water treatment is 80 NPR*, while the revealed monthly expenses for its proxies (hand-soap and private water connection fee) suggest an ability to pay of 110 and 50 NPR, respectively. Both estimates could theoretically match the monthly cost for chlorine disinfection (~25 NPR). However, only 10 % of households state that water treatment products are a priority for household investments in the coming year ($n=201$).

Conclusion

In the coming year, the research team will work closely with Helvetas to develop and implement a strategy for promoting safe water consumption and hand washing behaviour. Several key findings regarding drinking water quality, behavioural factors, and market conditions emerged from the baseline study to directly inform this effort.

First, study results reveal that water quality deteriorated between the point of collection and storage, implying that re-contamination occurred during handling and transport. In addition, one in ten water samples taken at the point of collection had *E.coli* concentrations >100 CFU/100 mL, highlighting the inadequacy of current infrastructure-centred definitions for an "improved" water source. Potential explanations for contamination within piped networks include infiltration through broken joints or pipes or inadequate source protection.

Second, we found that households almost universally reported valuing water treatment, but few actually practised it. This could be explained by the fact that most households perceive their own water quality to be acceptable or good. An effective behaviour change campaign will target knowledge on personal risk and mitigation options, emotional factors, and the perception of personal vulnerability to highlight the importance of consuming safe water. An intervention should also support households to develop strategies for assuring access to safe water products, and improving access to hand washing infrastructure.

Finally, the market analysis revealed low demand for safer drinking water despite sufficient ability to pay for treatment products. Interviews with physicians revealed that many patients prefer a biannual antibiotics therapy to investing in preventative measures to safeguard health, such as household water treatment or frequent hand washing.

* 1 NPR = 0.01 CHF or 1 Rappen

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Business Model Innovation in the Sanitation Chain

Although sanitation as a business is becoming an increasingly popular concept, empirical evidence indicates mixed outcomes at best. Our article explores recent business model innovations, highlighting different business models and the innovations required to make sanitation businesses more financially viable. C. Saul[1], G. Virard[2], H. Gebauer[1]

Vic Hinterlang

Photo 1: Contract signing and payment for a household toilet service (SOIL, Haiti).

Introduction

Sanitation has emerged from being a neglected topic to be a key priority for donors and governments [1, 2]. As its priority has increased, the approach to sanitation has shifted to be more private sector driven. Sanitation as a business changes people's awareness from getting something for free to having to pay for something with value. By paying for sanitation, people become aware of its value and are motivated to use sanitation services more carefully. Because governments often support sanitation programs very minimally, the sanitation solutions that they offer are commonly not so attractive, and many poor (and not-so-poor) people do not want to buy or use them. Since the private sector is more suited to understanding and providing what people actually want, entrepreneurs could overcome this constraint. Private sector involvement could improve the quality of sanitation solutions.

Sanitation sector businesses

Actors in the sanitation sector range from individual entrepreneurs to public utilities. Public utilities exist mostly in urban and more developed areas. They operate sewage systems and treatment plants. The private sanitation sector consists mostly of small enterprises with low turnover and limited access to financial resources. These individual sanitation enterprises normally provide discrete sanitation services, selling sanitation or manufacturing components, or offering latrine construction and pit-emptying services. Although such activities can be profitable, these enterprises rarely invest in branding and marketing to increase their sales. They also often lack the business skills to create more value or to expand.

Business model innovation

Business models represent an organisation's underlying core logic and strategic choices for creating and capturing value [3]. The term "business" does not imply that "business models" are only useful for profit-oriented organisations. Business models (or "funding models") are also relevant for organisations trying to maximise social value [4]. They can unlock the value potential of new sanitation technologies and convert them into poverty alleviation outcomes.

Business model innovations encourage sanitation businesses to rethink their value proposition, value creation, and value capture. Value proposition can be considered by asking: what products and services should we offer and who are our target customers. Value creation is how an organisation delivers value to their customers, and represents how sanitation products and solutions are produced and sold. Value capture considers such questions as: how should we finance our sanitation business, how can we reduce our costs, and how can we generate more revenue.

Examples of business models

Our research reveals two basic types of business models: isolated and integrated. In an isolated business model, sanitation businesses focus on a single activity in the sanitation chain, such as toilet usage, collection, or treatment. iDE's sanitation program in Cambodia is an example of an isolated business model. iDE focuses on toilet usage, acting as a market facilitator to commercialise the 'Easy Latrine' through a network of latrine manufacturers and sales agents. Its value proposition focuses on easy to build, easy to buy, and easy to use pit latrines. iDE captures value through donors, who pre-finance the identification of affordable and appropriate sanitation solutions, the training and coaching of sales agents, and the training of latrine manufacturers for production and delivery. Latrine manufacturers cover their costs through sales at market prices, and the sales agents receive a sales commission from them. The value creation stems from the manufacturing, marketing and sales of pit latrines; their assembly and installation; and their financing. iDE collaborates with local micro-finance institutions that provide four to twelve month loans to customers for the latrines.

In an integrated business model, sanitation businesses cover the whole sanitation chain. Integrated sanitation businesses manufacture and sell toilets, collect human waste, treat the waste and sell the end products. A typical example is SOIL (Sustainable Organic Integrated Livelihoods) in Haiti. SOIL provides access to safe and affordable sanitation in low-income urban areas through renting out

	User Interface	Storage	Conveyance	Treatment	Use and/or Disposal
Challenges	• Matching supply and demand • Creating a desirable product • Managing sales • Durability	• Variability in pit latrine construction and content • High startup costs for container design	• Punctuality of collectors • Securing payments • Variable costs, such as fuel and maintenance	• High investment costs for equipment from suppliers and land • Ensuring pathogen destruction • Regulations do not exist	• Generating enough end product reliably to secure customers • Customer attitude
Business innovations	• Customise offerings and payment options • Iterate design to ease installation and use	• Consider handling and access in the design • Standardised, cost-effective containment options	• Using GPS for route optimisation • Centralized dispatch to reduce search costs • Optimise transport vehicles	• Consider additional waste streams • Leasing treatment equipment and/or performance-based payments leasing	• Focus on socially motivated customers • Establishing unique branding

Table 1: Example of challenges and business innovations along the sanitation chain.

household toilets for a monthly fee to households that do not have access to proper sanitation. The toilets are locally manufactured, urine diversion dry toilets and use containers to store the faeces and urine. SOIL collects the waste containers twice a week and transfers the waste to their waste treatment site, where it is composted and sanitised. After several months, it is ready to be sold as nutrient rich compost.

Most organisations with a business model that addresses the entire sanitation chain, such as SOIL, have not yet reached cost recovery, and still rely on external funding, i.e., donations, investors and grants. Organisations, such as iDE, with isolated sanitation business models are able to focus on the parts of the sanitation chain that can be profitable, but face the challenges of marketing and expansion. Table 1 summarises some of the challenges and potential business innovations we have observed along the sanitation chain.

Conclusion

Despite the business model innovations that have taken place in the field of sanitation, further innovation is necessary to make stand-alone sanitation businesses that can successfully scale. For instance, user interface developers such as iDE Cambodia, which act on a single part of the sanitation chain, have to be innovative in their market penetration strategy, and have to balance penetrating existing geographical markets with expansion into new areas. This requires developing marketing and business analysis skills because accurate data on manufacturing and sales costs and estimations of the diffusion process would have to be done in order to expand successfully.

Integrated sanitation businesses face the challenges of cost improvements and the securing of revenues. They work on reducing toilet construction costs, on the maximisation of payment rates and on incentivising the on-time payments. Furthermore, integrated businesses look into innovations that facilitate the replication of their business models in other geographical areas.

These are some of our first insights in the area of sanitation business model innovation. Our team is currently collaborating with sanitation businesses in many areas of the world to develop and implement innovative solutions that would help them succeed and assist in the scaling process.

Vic Hinterlang

Photo 2: Construction of a toilet (SOIL, Haiti).

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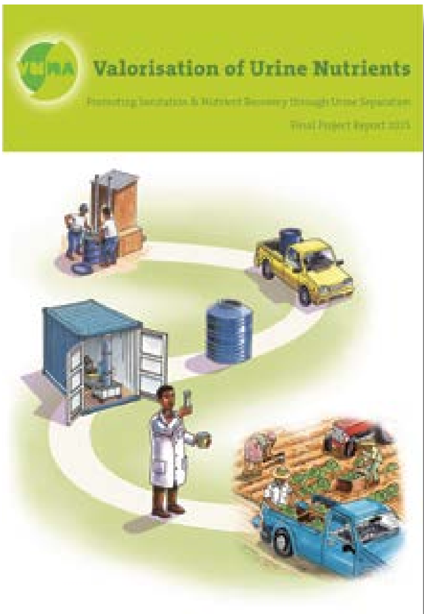
VUNA – Harvesting Nutrients from Urine – Final Report Published

Valorisation of Urine Nutrients–Promoting Sanitation & Nutrient Recovery through Urine Separation, Final Project Report 2015.



Producing a valuable fertiliser from urine has been the goal of the VUNA Project. This encompassed developing a technology to extract nutrients from urine, and establishing a system to collect the urine separately, to manage it as a resource, and to produce a safe end product. The project was presented in detail in the 2014 Sandec News (#15) and reached its term this year. To summarise the findings of VUNA, the consortium of researchers and practitioners in South Africa and Switzerland have compiled a comprehensive yet concise report, which you may download from the project's website: www.vuna.ch. As one of VUNA's achievements, the project team is happy to announce that it recently received an official authorisation from the Swiss Federal Office of Agriculture to market and distribute the urine-derived fertiliser in Switzerland. Currently, the team is planning the next steps on how to take nutrient recovery from urine to a larger scale.

Sandec Invites You to Take This Survey

Is the term "developing countries" still appropriate? Lately, we at Sandec have been thinking about our mission, as well as what we write, and how we write. Specifically, where we work and how we talk about our partner countries.

We have discussed, debated and researched, but would like to hear from you–our actual partners.

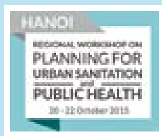
Please take a minute to fill in the short survey that can be found here: <https://www.surveymonkey.com/s/88YQX63>.
We look forward to receiving your opinions!

Lars Schoebitz

Sewer construction in Kampala, Uganda.

Forthcoming Event

Regional Workshop on Planning for Urban Sanitation and Public Health
20–22 October 2015 Hanoi, Vietnam



The regional partnership capacity building workshop on urban environmental sanitation will take place in Hanoi, Vietnam, 20–22 October 2015. Its aim is to build capacity in urban sanitation planning and public health issues among local experts and institutions in the sanitation and public health sector. The workshop is open to representatives of public, private and civil society organisations, and will cover state-of-the-art knowledge and developments in urban environmental sanitation systems, planning and technologies.

The workshop is organized in collaboration with the regional Swiss Agency for Development and Cooperation office, and will also take place in West Africa, the Middle East and Latin America in 2015 and 2016.
For more information, contact Dr Pham Duc Phuc: pdp@hsph.edu.vn.

The Sandec Team

From left to right

Front row: Paul Donahue, Katerina Brandes, Sara Marks, Alix Reichenecker, Elizabeth Tilley, Magalie Bassan, Frederik Weiss, Hidenori Harada, Petra Kohler, Samuel Renggli, Hussain Etemadi

2nd row: Maryna Peter, Chris Zurbügg, Katja Höreth, Aoife Byrne, Jasmine Segginger, Caterina Dalla Torre, Juliette Ndounla, Dorothee Spuhler, Arief Gunawan, Christoph Lüthi, Regula Meierhofer, Linda Strande, Allan John Komakech

Back row: Arnt Diener, Hans Mosler, Manuel Rohr, Annette Johnson, Fabian Suter, Imanol Zabaleta, Moritz Gold, Heiko Gebauer, Stefan Diener, Phillipe Reymond, Lukas Ulrich, Bart Verstappen, Lars Schoebitz

New Faces

Stefan Diener re-joined Sandec in May 2014 to continue his solid waste management research. Originally an Entomologist, Stefan received a PhD in Environmental Sciences from ETH. His work focuses on the valorisation of waste sources, such as the conversion of organic waste into insect protein or the use of faecal sludge as a fuel for industrial processes. At Sandec, Stefan is responsible for the black soldier fly project SPROUT and supports the Municipal Solid Waste Management Group with his expertise.

Petra Kohler, MA in Social Anthropology, specialised in the topic Gender and Sanitation with a focus on low and middle-income countries. She has conducted research on participatory approaches to sanitation planning and adapted methods for sensitive data gathering. Since October 2014 she has been working with the Strategic Environmental Sanitation Planning Group on WASH in health facilities in Uganda and India, focusing on cultural aspects of sanitation and menstrual hygiene management.

Hidenori Harada, BS in Environmental Engineering, MS and PhD in Global Environmental Studies, specialised in the topic of toilet and septic tank management in Vietnam. Currently, he is an assistant professor at Kyoto University, and since November 2014, has been a visiting professor at Sandec. He has worked on faecal sludge management, microbial exposure analysis, and river pollution analysis in low- and middle-income countries.

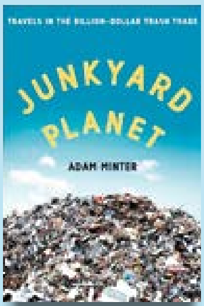
Ariane Schertenleib, MSc in Environmental Engineering, specialised in environmental chemistry and bioprocesses. She joined the Water Supply and Treatment Group in April 2015, and works on the Multiple-Use Water Services Project in Burkina Faso and Tanzania. In 2013 she did an internship at Sandec, working on fluoride removal from drinking water systems in Ethiopia. Her Master's thesis focused on the inactivation of pathogens during a urine nutrients recovery process.

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 sustainable development, municipal solid waste management, excreta and wastewater management, strategic environmental sanitation planning and water supply and treatment.

Municipal Solid Waste Management

Junkyard Planet: Travels in the Billion-Dollar Trash Trade



Growing up as the son of a scrap dealer in Minneapolis, Minter learned first-hand that one man's trash is truly another man's treasure. In his first book, the Shanghai-based journalist charts the globalisation of the recycling trade, focusing on the U.S. and China, and featuring a cast that ranges from self-made scrap-metal tycoons to late-night garbage pickers. Minter successfully resists oversimplifying the issue China currently faces – with a growing middle class demanding more raw materials for new construction, the options are living with the pollution caused by recycling or the environmental consequences of mining for raw materials. Minter takes readers through aspects of the scrap trade, one of the few business ventures possible in the developing world, and shows that this "profession for outsiders" shows no signs of slowing down. Minter concludes that the solution is in the first word in the phrase, "Reduce. Reuse. Recycle."
By Minter, A., Bloomsbury USA, 2013,
304 pages, ISBN: 9781608197910.

'Wasteaware' benchmark indicators for integrated sustainable waste management in cities

This article provides a solution to the problems of lack of data and the inconsistency of data in the field of international solid waste management. It presents a set of integrated sustainable waste management indicators that could be applied in cities both North and South that allow for analysis of a city's performance, comparison of cities and monitoring developments over time. The indicators' set is based on the report prepared for UN Habitat on the state of solid waste management in the World's cities.
By Wilson, D. C. et al., Waste Management, 2015, *35*, pp. 329–342. It is available for download at: <http://goo.gl/qy4S70>.

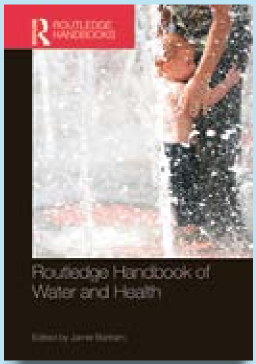
Strategic Environmental Sanitation Planning

Waterlines – An international journal of water, sanitation and waste

Until recently, the development sector including WASH (water, sanitation and hygiene) had not explored or attempted to address the challenges related to Menstrual Hygiene Management (MHM), an important issue affecting the health, dignity and privacy of millions of girls and women on a daily basis. This issue of Waterlines is dedicated to this topic and will assist the male dominated, engineering-based development sector in increasing its understanding of this important aspect.
By Practical Action Publishing, 2015, *34 (1)*, ISSN: 17563488 (Online).

Water Supply and Treatment

Routledge Handbook of Water and Health



This comprehensive handbook provides an authoritative source of information on global water and health. It addresses this interdisciplinary subject from the perspective of both developing and developed countries through assessing: hazards, exposures, interventions, implementation of interventions, distal influences, policies and their implementation, investigative tools, and historic cases. This handbook offers a complete teaching tool for field workers, advanced undergraduate students, and graduate students. Written by a team of expert authors from around the world, the book provides a thorough and balanced overview of current knowledge, issues and relevant debates, through integrating information from the environmental, health and social sciences.
By Bartram, J., Routledge, 2015,
672 pages, ISBN: 9781138910072.

On the YouTube Channel

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

Behind The Data: The People Who Make Research Happen

This short documentary highlights the work that was done in rural communities by the people who were instrumental in collecting and recording data for a sanitation-based research project. The video shows the fundamental value of each person's role in achieving the ultimate research objectives, which focused on the impact of incentives on urine-diverting dry toilet use and the effects on sanitation coverage and acceptance. The research was carried out in collaboration with the eThekwini Water and Sanitation Unit around Durban, South Africa and the University of KwaZulu-Natal.
Produced by: Sandec/Eawag. Written and narrated by Elizabeth Tilley. 2014, 5:54.
It can be seen at: <https://goo.gl/9NE1rk>.

Municipal Solid Waste Management

HTC Experiment Timelapse

This experimental video shows two Sandec researchers conducting a hydrothermal carbonization experiment, which is a thermochemical process that converts biomass into a solid coal-like product that can be used as a fuel. Sandec considers hydrothermal carbonization to be a promising technology due to its capacity to treat and hygienise wet organic waste, which is commonly found in developing countries.
Produced by: Sandec/Eawag. Filmed and edited by Paul Donahue. 2015, 3:46.
It can be seen at: <https://goo.gl/4cKcJp>.

Excreta and Wastewater Management

Innovation in Urban Sanitation: FaME and U-ACT Research in Sub-Saharan Africa

This documentary tells the story of FaME (Faecal Management Enterprises) and U-ACT, two research projects that deal with the global issues of access to clean toilets and faecal sludge management. From faecal sludge pits to treatment plants, the video highlights research into innovative solutions to increase access to sustainable sanitation services. It was filmed in Sub-Saharan Africa in Senegal and Uganda, an area of the world where the sanitation needs of the majority of the urban population are met by on-site sanitation technologies.
Produced by: Sandec/Eawag. Filmed and edited by Paul Donahue. 2014, 16:26.
It can be seen at: <https://goo.gl/GXd6ep>.