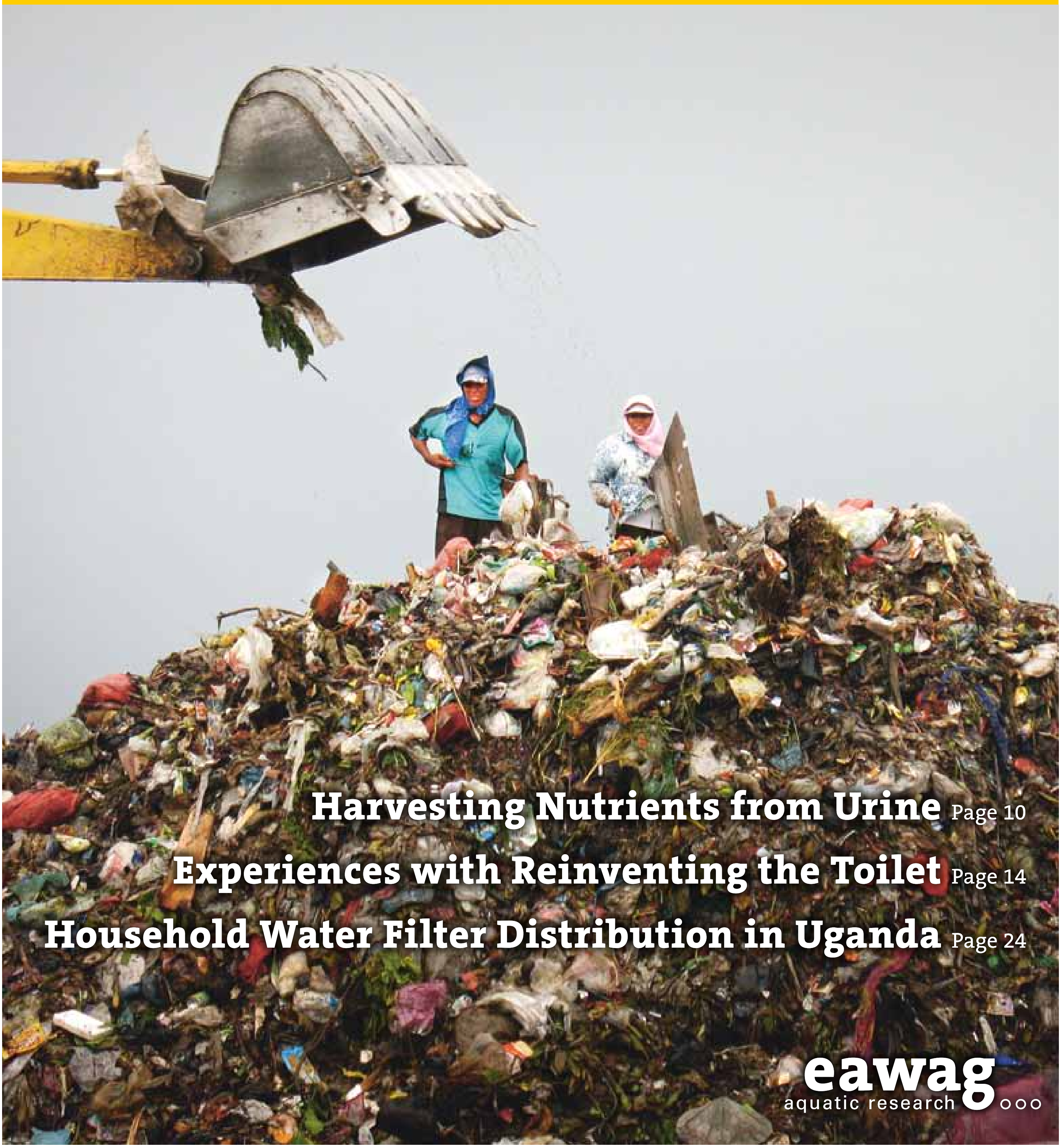
No. 15
09/14

Sandec: Department of
Water and Sanitation
in Developing Countries

sandec news



eawag
aquatic research

Table of Contents

Sandec
Water and Sanitation in Developing Countries

Publisher: Eawag, P.O. Box 611, 8600 Dübendorf, Switzerland
Phone: +41 (0)58 765 52 86, Fax: +41 (0)58 765 53 99
caterina.dallatorre@eawag.ch, www.sandec.ch

Editors: Paul Donahue and Chris Zurbrügg, Eawag

Publication: Sandec News is published once a year and is free of charge. It is available as a printed copy or it can be downloaded as a pdf file from our homepage, at www.sandec.ch.

Cover: Waste soldiers conquer a mountain of municipal solid waste at the dump side in Jabon District, Sidoarjo Regency, East Java, Republic of Indonesia (Photo: Bart Verstappen)

Layout and figures: Lydia Zweifel, Eawag

Photos: All photos are from Sandec if not mentioned otherwise

Printer: Mattenbach AG, Winterthur, Switzerland

Circulation: 3 300 copies printed on original recycled paper

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

ISSN 1420-5572

Eawag: Swiss Federal Institute of Aquatic Science and Technology

A Post-2015 Global Goal for Water

“A global water goal, taking us beyond drinking water and toilets to include water, excreta and wastewater management using a system perspective, is a future necessity.”

In the past two years, countless meetings and workshops took place to discuss, develop and build consensus around the future of the Millennium Development Goals (MDGs), which end in 2015. A 30-member Open Working Group (OWG) of the UN-General Assembly was tasked with preparing a proposal on Sustainable Development Goals (SDGs). The water and sanitation sector actively pushed for a stand-alone SDG. The recent outcome document of the 13th OWG session (July 2014) proves that their work was convincing as it includes the following goal: "Ensure availability and sustainable management of water and sanitation for all". This goal is exciting because it includes the word "management", thus setting a focus on the safe handling of excreta and water from a system perspective – rather than just counting toilets or people with taps.

The targets specified under the goal highlight social justice issues, such as equity, affordability and vulnerable groups. The goal also proposes targets in the wider sphere of water and sanitation, i.e., implementing integrated water resource management at all levels, increasing water-use efficiency across all sectors, ensuring sustainable withdrawals, and protecting/restoring water-related ecosystems. The OWG proposal finally goes beyond looking only at access, and includes such issues as reducing pollution, eliminating dumping, halving the proportion of untreated wastewater, and increasing recycling and safe reuse. These are issues where Sandec has much to contribute and can suggest a range of innovative solutions.

We have had a great "book year". The long-awaited book on *Faecal Sludge Management*, a collaboration with UNESCO-IHE and published by IWA, is finished and available for free on our website and at the IWA site. The book helps answer the question: "What do we do when the pits are full?" Another long-awaited publication is the Second Edition of the *Compendium of Sanitation Systems and Technologies*. This expanded edition, along with an eCompendium version to be launched in September, will help stakeholders in their decision making planning process. We also published the book *Anaerobic Digestion of Biowaste in Developing Countries* that includes practical information on biogas systems and case studies. All our publications, books and reports are available for free on our website. If large file sizes or slow Internet connections hinder access to our publications, just send us an email and we will do our best to find a solution for you.

In my last editorial, I promised updates on our E-learning efforts. Our first Massive Open Online Course (MOOC) on Household Drinking Water Treatment took place in April 2014. It attracted more than 8000 registered students of whom 640 rigorously followed the course, participating in the discussion forum, doing all quizzes and exercises, and passing the final exam. Around 50 % were from low- and middle-income countries. It was a great success and we are finalizing our next MOOC on "Planning & Design of Sanitation Systems and Technologies". It is free and you can register for it at the Coursera website.

Rick Johnston has left the Water Quality and Treatment Group to join the WHO-UNICEF Joint Monitoring Program in Geneva. Although sad about his departure, we are happy that he can help strengthen the bond between WHO and Sandec, a bond made evident by our appointment as a "WHO Collaborating Centre for Sanitation and Water in Developing Countries". We have been very fortunate to attract Sara Marks, previously at Johns Hopkins University, to join us as Rick's replacement. She has led the group since April 2014.

On the project level, there is much to report. As usual, this newsletter provides just a brief summary of our activities. For more details on any project, please do not hesitate to contact the authors. We continuously try to reach out more effectively and have established a Sandec Facebook page besides the LinkedIn group and many of our staff regularly Twitter. Please connect with us at any time to receive real-time updates of our work.

Chris Zurbrügg
Director Sandec

Experimental Char Production of Selected Urban Organic Solid Waste

This project in Dar es Salaam, Tanzania, explores how solid waste management could be improved by producing char from urban biowaste through slow pyrolysis. The char could be briquetted and used as an environmentally friendly substitute for wood based charcoal. Christian Riu Lohri[1], Elia Ephata[2], Adam Faraji[2], Hassan Rajabu[2], Christian Zurbrügg[1]

Introduction

Similar to many cities in developing countries, the solid waste management system in Dar es Salaam (DSM) is characterized by a low collection rate, high organic fraction, and inadequate disposal. Simultaneously, charcoal is the main cooking fuel used by more than 90 % of city households, thereby, contributing to substantial deforestation. The aim of this ongoing project is to assess the suitability of organic wastes for char production and to develop an appropriate experimental pyrolysis system.

Assessing the suitability of urban wastes for char production

Eight biowaste types prevailing in DSM were selected, including wood waste, coconut shell/husks, potato peelings, cardboard, trimmings, seaweed, bagasse from sugar cane juice vendors, and packaging grass/leaves used in markets for transportation of fruit and vegetables. A framework was developed to assess and rank their suitability for making charcoal fuel using two groups of criteria: i) availability and accessibility aspects and ii) physical-chemical properties. The former included assessments of total quantity generated, seasonal variation, competing uses, and degree of centralization. Data were obtained through literature review, interviews, observations, and measurements of volume and weight. Data for the latter were generated from lab experiments, including proximate analysis (moisture, fixed carbon, ash content) and from the physical appearance of the waste when collected (bulk density, particle size uniformity). Results showed that packaging grass, wood waste and cardboard have the highest overall potential for char production in DSM.

Experimental slow pyrolysis unit

A carbonization unit was designed to pyrolyze the identified waste in an efficient, cost-effective and safe manner. The unit shown in Figure 1 consists of an externally heated metal barrel (200 L) as pyrolysis chamber, a rotating and ejection mechanism, and a heat-retaining brick-kiln, in which the barrel is horizontally placed on guiding rails. When starting the process, the 2 cm hole in the barrel is aligned with an exhaust pipe to release the vapour produced in the initial drying stages of pyrolysis. When the whitish gases from the pyrolyzer change colour to yellow, which indicates the inflammability of the gases, the barrel will be rotated 180° using an external mechanism. By burning these gases, the external heating process is enhanced and CH_4 and CO pollution from the unit reduced. The rotation also helps to mix the material in the barrel. During the pyrolyzing process the temperatures inside the drum, brick housing and chimney are continuously measured. After completion of the process, the drum is removed for cooling and a new barrel filled with raw biowaste is loaded into the still hot brick housing (a semi-batch system) [1].

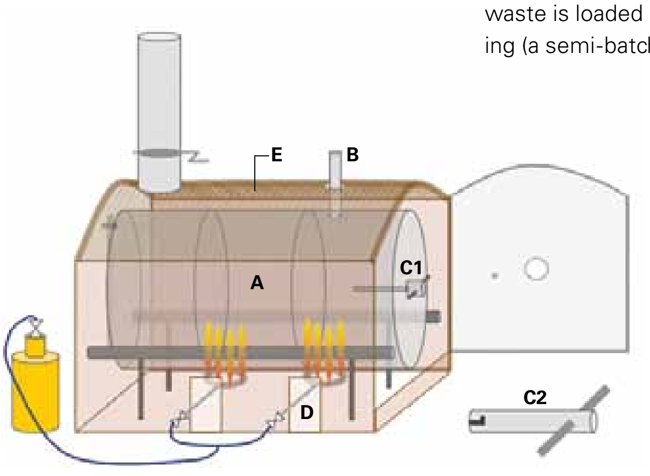


Figure 1: Scheme of pyrolysis unit. A: pyrolysis drum, B: pipe for initial pyrolysis gases, C1: rotating knob, C2: rotating and ejection handle, D: combustion chamber, E: brick kiln.

Other research components

The drying process is a pre-treatment option for wet urban biowaste types (e.g., bagasse); yet, it is also a time- and space-consuming step in the briquetting stage. To speed up the process, a hybrid solar drying system, using direct and indirect heating with forced convection, was designed and fabricated [2]. Its main elements are a solar-energy collector for air heating, a partly glazed drying chamber with several trays, and an extractor fan to suck air through the collector. Two ceramic-lined charcoal stoves can be placed underneath the collector as an alternative heating source to operate on cloudy days. The aim is to reduce the moisture content of raw waste to a level acceptable for pyrolysis and to minimize the drying time of freshly pressed briquettes.

Conclusion

Tests of different biowaste types and varying parameters are ongoing. When completed, they will permit analysis of the overall performance, including efficiencies and energy balances, which will enable the evaluation of the financial feasibilities of the two systems. Up-scaling and implementation issues will also be examined. A possible follow-up project could include emission measurements during char production and testing alternative energy sources (e.g., biogas generated from wet, mixed biowaste) as heat input for the pyrolysis process.

[1] Ephata, E. (2014): Slow pyrolysis of selected urban biowaste for char production in Dar es Salaam. MSc thesis at College of Engineering and Technology, University of Dar es Salaam *(in progress)*.
[2] Faraji, A. (2014): Experimental investigation on drying options of potential urban biowaste for char production in Dar es Salaam. MSc thesis at College of Engineering and Technology, University of Dar es Salaam *(in progress)*.

[1] Eawag/Sandec, Switzerland
[2] University of Dar es Salaam, Tanzania
Contact: christian.lohri@eawag.ch

A Decision Support Tool for Selecting Organic Waste Treatment Technologies

Sandec is instituting the Selecting Organic Waste Treatment Technologies Project in order to develop a decision support tool that will assist municipalities in their organic waste treatment decisions. The first field test takes place in 2014 in San Fernando City, La Union, Philippines. Imanol Zabaleta[1], Lisa Scholten[2], Christian Zurbrügg[1]

Introduction

Municipal organic waste (biowaste) is still clearly the main fraction of the total generated municipal waste in low income countries [1]. Because of this, there is growing interest among municipal officers to find appropriate solutions for organic waste management. Composting is the typical treatment of choice, no matter its feasibility or whether there is demand for it. Important aspects that are seldom considered before investing in and implementing treatment technologies are: the characteristics of waste feedstock (quantity and quality), the end product quality (its market demand and value), the land area required, the skills and capacity necessary for operation and maintenance, and the supply chain.

Sandec is developing the Selecting Organic Waste Treatment Technologies Project (SOWATT) to assist organic waste management decision making. This tool will be particularly appropriate for low-income countries, which normally do not have the capacity to manage the large data sets used in most existing solid waste related decision support tools. These also often focus only on environmental impact, while SOWATT will include social, legislative, organizational, and technical issues in the decision making process.

Methodology

Waste related decisions are complex as they deal with many influencing factors and alternative solutions. SOWATT is a structured decision making process based on the "Multi Attribute Value Theory". It will help in structuring complex problems and evaluating alternatives for organic waste management.

As part of the decision making process in environmental management, the first step is to develop clear objectives or a hierarchy of objectives that group lower-level objectives (e.g., "high working safety" and "low noise impact") and higher-level objectives (e.g., "high social acceptance"). Table 1 presents the objectives SOWATT considers to be essential to the decision making process regarding organic waste treatment [3, 4]. It also shows the attributes for each objective, i.e., the specific metrics for assessing how well an alternative performs in respect to an objective.

Alternatives

The alternatives are the treatment technologies that will be considered for organic waste management. In the first iteration of SOWATT, that will be tested in 2014, the following alternatives will be considered:

- Windrow and bin (in-vessel) composting (family, neighbourhood and industrial scale)
- Fixed dome and floating dome anaerobic digestion
- Black Soldier Fly processing
- Slow pyrolysis

These technologies are part of Sandec's basic research.

Evaluating alternatives

Decision making about what technology to use for organic waste management in a given context depends on: 1) evaluating the possible alternatives using the information produced by analyzing the attributes of each objective, and 2) doing a preference elicitation process with local stakeholders. The comparison and ranking of alternatives would be discussed with all stakeholders.

Conclusion

Sandec's goal in the Philippines is to validate the SOWATT approach and identify its strengths and weaknesses. The final outcome of this project will be an easy to use and practical support tool for municipal officers and practitioners that will help them make informed decisions and sustainably improve solid waste management.

Higher Level Objectives	Lower Level Objectives	Attributes and Components
High technical reliability	Low downtime of facility	Access to supply chain for maintenance Access to skills and capacity Range of acceptable waste quantity/quality Water power and fuel required Land required
High social acceptance	High workers safety Low smell and noise impact High employment opportunity High trust in technology	Risk and hazard categories Smell and noise emissions Labour intensity required Successful experiences
High hygiene and public health protection		Amount of total waste treatable by the technology
High financial sustainability	High cost recovery	Investment and operational costs Market demand and revenues
High environmental protection	Low environmental pollution High resource recovery	Emissions and reduction potential Nutrients, power or protein recovered

Table 1: Objective hierarchy and attributes.

[1] Hoornweg, D., Bhada-Tata, P. (2012): What a Waste - A Global Review of Solid Waste Management. Urban Development & Local Government Unit, World Bank, Washington, DC.

[2] Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T., Ohlson, D. (2012): Structured Decision Making - A Practical Guide to Environmental Management Choices, 1st ed. Wiley-Blackwell.

[3] Zurbrügg (2013): Assessment methods for waste management decision-support in developing countries. Ph.D. Thesis – Università degli Studi di Brescia, Facoltà de Ingegneria, Dipartamento di Ingegneria Civile, Architettura, Territorio, Ambiente e Matematica.

[4] UNEP (2012): Application of the sustainability assessment of technologies methodology: guidance manual - United Nations Environment Programme, Division of Technology, Industry and Economics, International Environmental Technology Centre, Osaka.

[1] Eawag/Sandec, Switzerland

[2] Eawag/Urban Water Management Department, Switzerland

Contact: imanol.zabaleta@eawag.ch

Optimization of the Sampling and Laboratory Methods for Faecal Sludge

The implementation of anaerobic digestion and other treatment technologies on faecal sludge requires reliable methods to understand its characteristics and the treatment mechanisms. The PURR Project is addressing the current lack of standardized sampling and laboratory methods for faecal sludge. M. Bassan[1,3], V.A. Nguyen[2], Ch. Holliger[3], L. Strande[1]

Introduction

It is estimated that 2.5 billion people in low- and middle-income countries rely on onsite sanitation technologies. The majority of faecal sludge (FS) from these systems is directly discharged into the environment or used in agriculture without any treatment. The high pathogenic, organic and nutrient load in FS has a severe impact on public and environmental health. To alleviate this situation, the development of appropriate treatment technologies is required.

Several wastewater treatment technologies are being adapted and tested for the treatment of FS. Anaerobic digestion is commonly used for the treatment of wastewater sludge and seems promising for large scale FS treatment. Prior to reliable implementation, however, there is the need to better understand the variability, biodegradability and potential inhibitory compounds of FS. This involves assessing the effect of sampling methodologies on the variability of characterization results to allow for the efficient design of technologies. Also, laboratory experiments are required to understand fundamental treatment mechanisms.


Magalie Bassan

Photo 1: Core sample being taken from a septic tank.

PURR (Partnership for Urban Resource Recovery Project) is evaluating the potential of the anaerobic digestion of FS. Standard methods for sampling and laboratory analyses are being developed, and experiments are being conducted to better optimize the design and operation of anaerobic treatment of FS. It is expected that the results will be directly transferable and contribute to optimizing FS management technologies.

Evaluating reliable sampling methods

Standardized methods for sampling FS do not exist. This has likely contributed to the high variability that has been observed in previously conducted characterization studies. It also reduces the comparability of results, limits the understanding of the FS that will be delivered to treatment facilities, and prevents the optimized design of treatment plants. To address this, reliable sampling and characterization methods have to be determined. A field study was conducted in Hanoi in collaboration with FAQ – Faecal Sludge Quantification and Characterization (See pp. 12–13). FS samples were collected from households and evaluated, using the following five sampling methods:

1. A vertical profile sample taken directly from septic tanks with a core sampling device (See Photo 1);
2. A vertical profile sample taken directly from the access port at the top of vacuum trucks immediately following the collection of FS from septic tanks (See Photo 2);
3. Grab samples taken while the truck discharges the FS immediately following the valve opening (i.e., beginning of the discharge) (See Photo 3);
4. Grab samples taken at the mid-point of discharge;
5. A composite of grab samples taken at the beginning, middle and end of the discharge.

Each of these methods has advantages and limitations. Method 1 provides results on the FS in the septic tank, but, due to collection methods, this is not necessarily what will be transported to the FS treatment plant for treatment. Method 2 provides results on the actual FS collected in the truck that will be delivered for treatment, but opening the access port requires time and labour, and truck operators are not necessarily willing to do this. Methods 3 to 5 are hypothetically easy to do at discharge sites, and are also representative of the FS that would be discharged at the treatment facility. However, as there are not legal discharge sites in many countries, this method can also be complicated as truck operators will not necessarily allow samples to be collected during illegal discharges. Methods 3 and 4 are the easiest to implement, but it is not certain how representative they would be of the entire truck contents due to settling during transport. Method 5 would be more representative of the entire truck contents, but both methods 4 and 5 rely on the somewhat qualitative decision of determining the "mid-point" of discharge. This is more reliable when trucks have volume gauges.


Magalie Bassan

Photo 2: Sampling from the access port at the top of a truck.

Evaluating potential for anaerobic digestion of faecal sludge

The rates of anaerobic digestion and the performance of biological treatment technologies depend on how readily the organic matter in FS is degraded. In Hanoi, the majority of households empty their septic tanks on average every seven to eight years, and it is not known how stabilized the FS is in general. The characterization study being conducted in Hanoi with FAQ is addressing this. In addition to the standard parameters commonly analysed to assess solid and organic content, proteins, carbohydrates, lipids and fibers are also being analysed. The results will provide information on the biodegradability of the organic matter and, therefore, the potential for biological treatment, such as anaerobic digestion. Concentrations of volatile fatty acids, sulfates, and heavy metals are also being analysed, as they inhibit anaerobic digestion. Preliminary results indicate that the FS in Hanoi still has readily degradable organic matter in it and can be a good substrate for anaerobic digesters.

Magalie Bassan

Photo 3: Grab samples being collected at a discharge site.

Development of synthetic sludge for controlled laboratory experimentation

Due to the highly variable nature of FS, once reliable sampling methods are developed and the characteristics fully understood, there is still the need to develop methods to conduct controlled laboratory experimentation to understand the fundamental mechanisms of anaerobic digestion. With wastewater, research is commonly conducted with recipes of synthetic sludge to assess the effects of controlled treatment parameters and avoid the complication that arises from the variability of wastewater. Some researchers have developed recipes that represent the physical properties and solid content of FS and that mimic the soluble organic matter (Sung Ryong et al., 1986; Radford et al., 2013). However, recipes have not yet been developed to research the degradation mechanisms active in the biological treatment of FS. PURR is developing a synthetic recipe with the following objectives:

- To represent the FS characteristics that influence its biodegradation, including the main biological, physical and chemical characteristics,
- To represent the attachment sites for microorganisms on solid particles,
- To use components that are easily available, that can be controlled, and safe to use,
- To be easily reproducible, and rapidly prepared with simple equipment and material,
- To be adjustable to the characteristics of different FS.

Several compounds, such as hay flour and walnut, are mixed with tap water to represent the heterogeneous solids and recalcitrant and easily biodegradable organic matter, based on the analysed characteristics. The concentrations of total nitrogen and phosphorous are adjusted with ammonium carbonate and sodium phosphate. Other components, such as clay, can also be added to adjust the surrogate characteristics, and increase the content of non-biodegradable suspended particles. By varying the quantities of water and of each of the compounds, various characteristics can be represented, as shown in Table 1.

Parameter	Hay flour	Walnut
pH	6.6	7.4
TS (g/L)	18.4	19.3
TVS (g/L) (%TS)	16.4 (89 %)	18.4 (95 %)
TSS (g/L)	14.2	18.0
VSS (g/L)	13.4	17.8
COD (g/L)	12.5	33.5
SCOD (g/L)	3.2	1.6

Table 1: Recipe characteristics for synthetic FS prepared with tap water (to reach 1L volume) and 19g hay flour (second column), and 18.5g crushed walnuts (third column).

Conclusion

Further tests will be conducted to assess the representativeness of the synthetic sludge in terms of biodegradability during anaerobic digestion. These outputs will provide important solutions to test treatment and resource recovery technologies. PURR will use them to assess the feasibility of anaerobic digestion of FS in Vietnam and these results are expected to be useful for FS research in general. Guidelines will also be developed for sampling and characterization methods and on the use of synthetic surrogates in laboratory experiments to facilitate future research, as well as for the accurate design of treatment plants.

[1] Sung Ryong, H., Hur, J.M., Son, B.S. Lee, J.H. (1986): A mathematical model for the anaerobic digestion process applied to a mixture of night soil and septic tank sludge. Water Science and Technology, *18 (7-8)*, 239–248.

[2] Radford, J.T., Fenner, R.A. (2013): Characterization and fluidization of synthetic pit latrine sludge. Journal of Water Sanitation and Hygiene for Development *3 (3)*, 375–382.

[1] Eawag/Sandec, Switzerland

[2] Insitute for Environmental Science and Engineering, Hanoi University of Civil Engineering

[3] Laboratory for Environmental Biotechnology, Ecole Polytechnique Fédérale de Lausanne

The PURR-Partnership for Urban Resource Recovery Project is funded by SECO and Eawag (http://www.eawag.ch/forschung/sandec/gruppen/EWM/projects_ewm/purr/index_EN).

Contact: magalie.bassan@eawag.ch, linda.strande@eawag.ch

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

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

Introduction

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

Dried faecal sludge as an alternative fuel

Industries in urban and peri-urban areas, such as cement and brick companies, have high and expensive energy requirements. As energy demand rises and the reserves of the lowest cost fuels are depleted, fuel prices rise, increasing the importance of alternative fuels. In the US and Europe, sludge from wastewater treatment is already used as an alternative fuel and transferring this knowledge to FS is one of FaME's main objectives. FaME research conducted in Kampala, Uganda; Kumasi and Accra, Ghana; and Dakar, Senegal; has demonstrated that dried FS has a calorific value competitive with alternative fuels already in use [1]. And the FaME market demand study identified that there is great market demand for alternative solid fuel products, especially in Kampala, where a variety of alternative solid fuels are in use [2].

FS drying research

Because of its low solids content, FS must be dried to be efficiently used as a fuel, requiring the development of cost-effective drying methods. While research has shown that a net benefit from combustion can be obtained at 27 % dryness [1], industries interviewed stated that their fuel has to be at 90 % dryness. FaME set up a pilot-scale research facility in Dakar (See Photo 1) to research how to increase FS drying rates and reduce the required footprint of land required for drying beds [3]. This included greenhouses and experimenting with daily turning of the sludge. Preliminary results indicate that greenhouses can be effective if they are actively ventilated, although in Dakar, they did not significantly improve the drying rate other than by providing rain protection. Yet, it is thought that further research will be able to adapt this technology and determine the optimal modes of operating greenhouses for FS drying. The daily turning of FS, however, significantly impacted drying rates in Dakar (See Figure 1). This reduced the drying time to achieve 90 % dryness on average by around 25 %, which corresponds to a reduction of the required land area by 25 % and/or increased capacity.

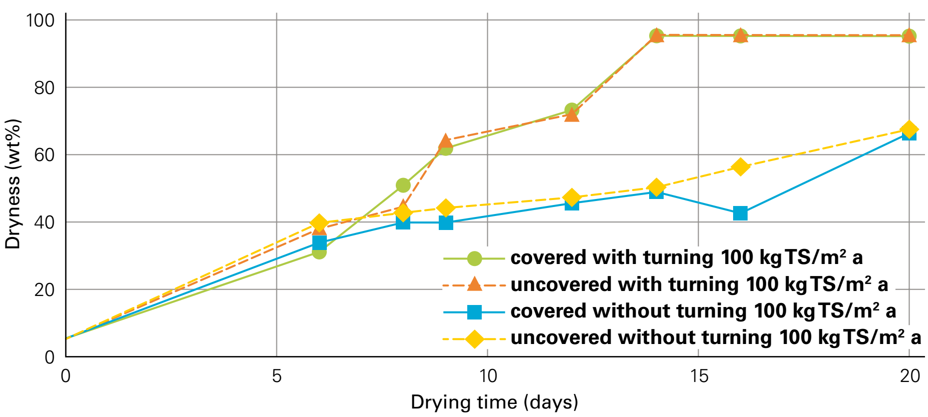


Figure 1: FS dryness over time from drying beds operated with and without greenhouses and with and without daily turning (Seck et al., submitted).

Dried faecal sludge characteristics for energy recovery

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

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

Pilot kiln studies

Pilot-scale kilns (See Photo 2) were built in Dakar and Kampala to demonstrate the technical feasibility of using dried FS as a fuel to industry stakeholders. In Dakar, results indicated that FS fuel has the potential to provide heat for a waste oil regeneration process, while in Kampala, a Hofmann kiln was used to test if the brick products produced were comparable in quality to those made from burning biomass fuels.

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

Moritz Gold

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

Financial research

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

Conclusion

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

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

Linda Strande

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

[1] Muspratt, A.M., Nakato, T., Niwagaba, C.B., Dione, H., Kang, J., Stupin, L., Regulinski, J., Mbéguéré, M., Strande, L. (2014): Fuel potential of faecal sludge: Calorific value results from Uganda, Ghana and Senegal. Journal of Water, Sanitation and Hygiene for Development, *4(2)*, 223–230. (http://www.eawag.ch/forschung/sandec/publikationen/ewm/index_EN)

[2] Diener, S., Semiyaga, S., Niwagaba, C.B., Murray Muspratt, A., Gning, J.B., Mbéguére, M., Ennine, J.E., Zurbrügg, C., Strande, L. (2014): A value proposition: Resource recovery from faecal sludge – Can it be the driver for improved sanitation? Resources, Conservation & Recycling, 2014, *88 (1)*, 32–38. (http://www.eawag.ch/forschung/sandec/publikationen/ewm/index_EN)

[3] Seck, A., Gold, M., Niang, S., Mbéguéré, M., Strande, L. (submitted): Technology development of unplanted drying beds for resource recovery from faecal sludge: fuel production for Sub-Saharan Africa.

[4] Gold M., Niang S., Niwagaba C.B., Eder G., Murray Muspratt A., Diop P.S., Strande L. (2014): Results from FaME (Faecal Management Enterprises) – Can dried faecal sludge fuel the sanitation service chain? (37th WEDC International Conference, Hanoi, Vietnam, 2014)

[1] Eawag/Sandec, Switzerland

[2] Waste Enterprisers Ltd, Ghana

[3] Makerere University, Uganda

[4] Université Cheikh Anta Diop, Sénégal

[5] Office National de l`Assainissement du Sénégal (ONAS)

FaME was funded by a grant from the SPLASH EU Water Initiative (www.splash-era.net). Further information about FaME can be found at www.sandec.ch/fame.

Contact: moritz.gold@eawag.ch or
linda.strande@eawag.ch

VUNA: Harvesting Nutrients from Urine for Agriculture

VUNA is a trans-disciplinary project that is developing a system to collect source-separated urine and process it into fertiliser. Collection logistics, treatment technologies, and social and economic assessments of nutrient recovery are some of the activities worked on by the VUNA team. Bastian Etter[1], Teddy Gounden[2], Kai M. Udert[1]

Introduction

Urine contains most of the excreted nutrients that can be recovered as fertiliser. By characterizing urine and its nutrients as having value, VUNA is promoting hygiene and sanitation, the production of locally available fertiliser, and reducing the environmental pollution caused by uncontrolled nutrient discharge into the environment [1]. Although urine separation has been an Eawag research topic for almost two decades, it was the sanitation programme launched by the eThekwini Municipality in South Africa, which encompasses the extended Durban Metropolitan area, that triggered the first large-scale field study. In 2003, the eThekwini Municipality chose urine-diverting dehydration toilets (UDDTs) to provide households in peri-urban areas with sanitation because high costs and low water availability prohibited the installation of conventional sewer-based wastewater management. In 2010, nearly 80 000 UDDTs were installed in peri-urban eThekwini, which quickly prompted the need for adequate urine treatment.

Eawag, together with eThekwini Water and Sanitation (EWS), the University of KwaZulu-Natal (UKZN), and the Swiss Federal Institute of Technology in Zurich (ETHZ), initiated the VUNA Research Project ("vuna" means "harvest" in isiZulu) to investigate the aspects of a sanitation system based on urine separation, i.e., collection schemes process technology and socio-economic boundaries (See Figure 1). Researchers from the Swiss Federal Institute of Technology in Lausanne (EPFL) and Eawag's Environmental Social Sciences Department eventually joined the team, broadening the Project's focus to include the development of business models and agricultural studies. All VUNA activities have been described in brochures that can be downloaded at www.vuna.ch.

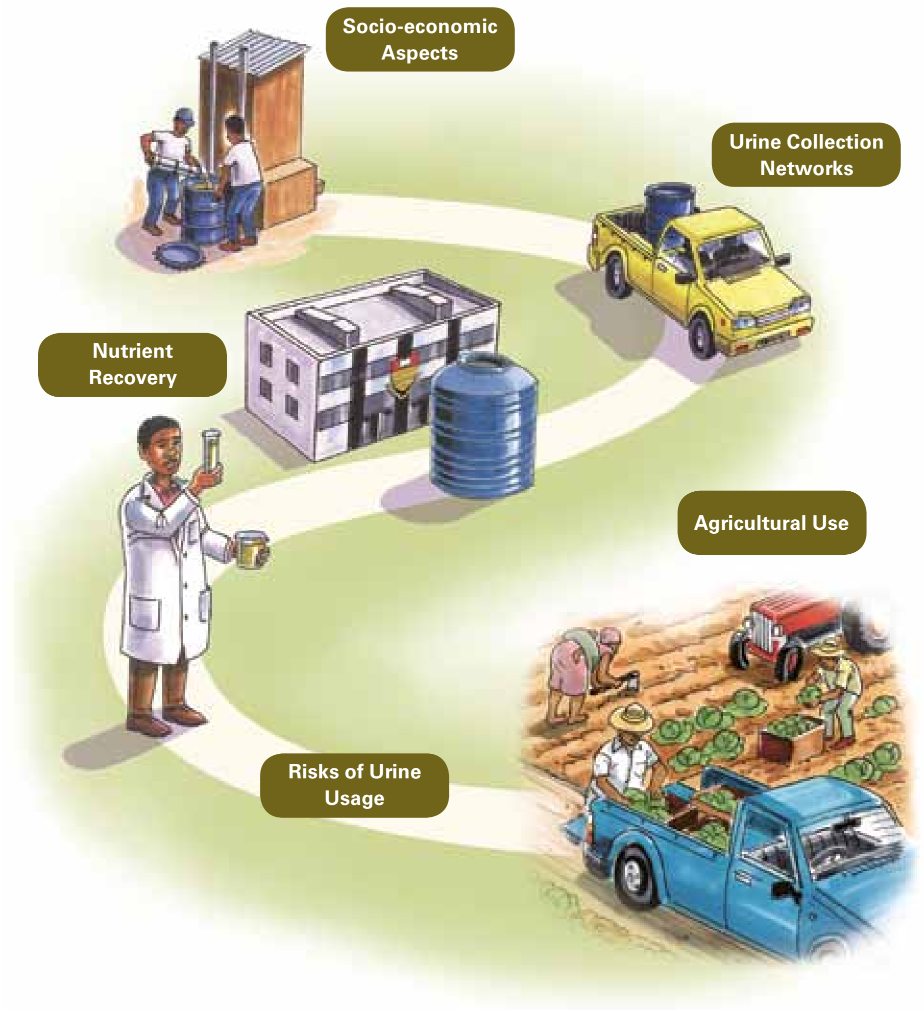


Figure 1: VUNA's research activities cover nutrient recovery from urine collection to the final fertiliser product.

Managing collection networks

In order to test and optimise urine collection schemes, selected UDDTs in eThekwini were fitted with 20-litre jerry cans. In the first set of trials, municipality workers picked up the jerry cans and transported the urine in tanker trucks to the central collection site. This led to the development of computer models that were used to fine-tune the collection process. Another field test was structured around toilet owners receiving financial compensation when they dropped off their full jerry cans at a collection tank located in their neighbourhood. The collected urine was then trucked to the central treatment site.

Both field trials and computer models helped to identify and optimise critical elements of a urine collection network, such as tank sizes, collection distance, and collection frequency. In current trials, the Municipality is further exploring how to adapt the urine collection to each neighbourhood's characteristics [2].

Treating collected urine

VUNA researchers have investigated several processes for urine treatment, including complete nutrient recovery by nitrification/distillation, struvite precipitation and electrolysis [3]. The Project team has set up two nitrification/distillation plants. The first in Eawag's main building in Switzerland converts the urine collected from Eawag's em-

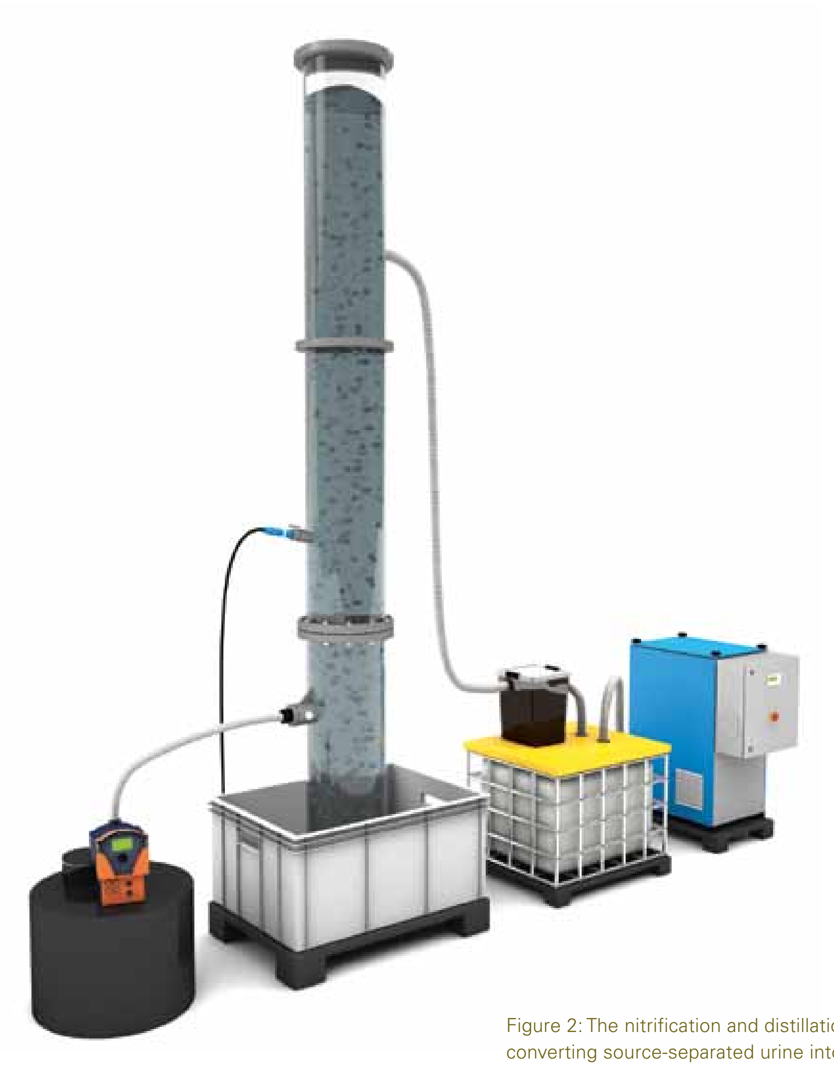


Figure 2: The nitrification and distillation process converting source-separated urine into distilled water and fertiliser.

ployees in urine-diverting toilets into fertiliser, and the second is at a field trial site in eThekwini (See Figure 2). Nitrification and distillation is a two-step process, which first stabilises the nitrogen in urine in a biological process (nitrification), and then evaporates the liquid (distillation) in order to obtain a concentrated nutrient solution. Distilled water is issued from the process as a side product.

Struvite precipitation was tested in the field in eThekwini. This process is simple in operation, but recovers mainly phosphorus (90 %) and a small fraction of nitrogen (less than 5 %). Magnesium is used as precipitant and the produced struvite is recovered from the liquid via filtration. In further trials, Eawag researchers also investigated electrochemical treatment of urine. Because urine electrolysis cells are small in size and might fit into individual toilets, this could enable on-site treatment. However, this research is still at an initial stage and further efforts are required to bring the technology to real applications.

The studies on hygienisation and the removal of trace organic substances show that nitrification inactivates certain bacteria and degrades pharmaceutical residues to a large extent. The distillation step after nitrification ensures that all remaining pathogens are killed. Any remaining pharmaceuticals can be removed with granulated activated carbon, if necessary, due to regulatory requirements. In agricultural tests, the urine-derived fertilisers performed equally or even better than conventional synthetic fertilisers.

Evaluating acceptance

Previous studies have shown that the initial acceptance of UDDTs in eThekwini was low. Increasing their acceptance by giving urine a value is one of the VUNA Project goals. To this end, an education programme on UDDTs is being developed to foster an understanding of the benefits of sanitation in general and of UDDTs in particular, and changes in perception and behaviour are being assessed by questionnaire-based surveys [2]. Preliminary results and experiences gathered from the urine collection teams indicate that people started using their toilets more frequently when they realised that their urine was collected to produce fertiliser. Although urine is not traditionally used as a fertiliser for agriculture in eThekwini, toilet users did not disapprove of eating crops fertilised with urine-derived products.

Business models have been developed for the VUNA processes, from urine collection to the final fertiliser product. The business models give an integrated overview of the most viable options for a sanitation system based on urine source-separation in eThekwini.

Conclusion

EWS presently plans to scale up both urine collection and treatment processes to serve a larger part of the population. Before collection can be taken to full scale, however, another set of trials are planned to determine the exact modalities. Similarly, although the treatment processes have proven to be functional, further research is necessary to make them more robust and user-friendly. The VUNA team is currently in contact with industrial partners that could supply the required number of urine treatment reactors necessary for future research.

[1] Etter, B., Gounden, T., Udert, K.M. (2014): VUNA – Scaling Up Nutrient Recovery from Urine. International Conference on Technologies for Development. 4–6 June, EPFL, Lausanne, Switzerland.

[2] Joseph, H., Gebauer, H., Friedrich, E., Buckley, C.A. (2014): Institutionalised collection for rural on-site sanitation. WISA Biennial Conference and Exhibition, 25–28 May, Mbombela, South Africa.

[3] Udert, K.M., Buckley, C.A., Wächter, M., McArdell, C.S., Kohn, T., Strande, L., Zöllig, H., Hug, A., Oberson, A., Etter, B. (2014): Technologies for the treatment of source-separated urine in the South African municipality eThekwini. WISA Biennial Conference and Exhibition, 25–28 May, Mbombela, South Africa.

[1] Eawag/Process Engineering, Switzerland

[2] eThekwini Water and Sanitation, Durban, South Africa

The authors would like to thank the entire Project team for their dedication to the Project.

The VUNA Project is funded by the Bill & Melinda Gates Foundation.

Project website: www.vuna.ch

Contact: vuna@eawag.ch

FAQ: Faecal Sludge Quantification and Characterization – Kampala

Through the collaboration between Sandec, Makerere University and the Private Emptier Association Uganda (PEAU), a new methodology for quantifying and characterizing faecal sludge on a city-wide scale that was developed by Sandec is being field tested in Kampala, Uganda. Lars Schoebitz[1], Charles Niwagaba[2], Okello Francis[2], Fabian Bischoff[1], Linda Strande[1]

Introduction

Quantifying and characterizing faecal sludge (FS) at a city-wide scale in low- and middle-income countries is essential for planning and designing appropriate FS treatment facilities. Yet, reliable data and accepted methodologies for representative characterisation and quantification do not exist. FS characteristics are highly variable and are influenced by a wide range of existing technologies (e.g., lined VIP latrines, unlined pit latrines, septic tanks) in use at the household level, mixed greywater and blackwater systems, cistern toilets and pour-flush systems, as well as by the number of users per system, average desludging intervals and physical factors (e.g., soil, permeability, water table). Existing characterization studies also focus on the household level, whereas significant amounts of FS are generated at public toilets, commercial entities, restaurants and hotels.

Lars Schoebitz

Photo 1: Sampling of faecal sludge at the influent of Bugolobi WWTP, Kampala.

In terms of quantification, a wide range of methods exist that base their assessments on different factors, resulting in widely variable values. These include: FS accumulation rates in onsite systems due to anaerobic digestion processes, FS production based on actual and hypothetical desludging intervals, and the FS collection rates of service emptying providers. The first two require data about the population and the distribution of onsite sanitation technologies, while the third requires data provided by the service providers.

Objective

The objective of FAQ is to develop an affordable and simple methodology that can be used to quantify and characterize FS on a city-wide scale, and fill the present knowledge gap. It is based on the spatial distribution of demographic data and on the hypothesis that this data can be used as predictors of FS characteristics. For example, income could have a correlation to FS characteristics due to such indirect factors as the type of onsite sanitation technology used, users' diets, number of users and desludging intervals. FAQ is currently being field tested in Kampala, Uganda. Tests are also being done in Hanoi, Vietnam in collaboration with PURR - Partnership for Urban Resource Recovery Project (See pp. 6–7).

Methods

Taking enough samples for statistically viable results to characterize FS at a city-wide scale would be very resource and time intensive. Therefore, the FAQ method was developed to provide a representative sampling scheme. The first step is a stakeholder analysis that identifies the key players involved in FS management to ensure that background data for the development of the characterization sampling plan and sufficient numbers for quantification are gathered.

The second step is to collect information about the context of the city. Secondary data collection and interviews are done to gather the following information:

1. Definition of city boundaries;
2. Identification of onsite sanitation technologies within the city's boundaries;
3. Identification of FS producers;
4. Identification of service emptying providers;
5. Identification of FS discharge points.

This data can be obtained through various sources, i.e., a national census, sanitation master plans, urban development plans and stakeholder interviews. The data needs to be carefully analyzed in terms of how old it is, its validity, and the validness of future projections. Doing a sensitivity analysis can help to ascertain the influence of these factors.

FAQ Implementation in Kampala

FS in Kampala is collected by either the PEAU or the Kampala Capital City Authority (KCCA) and transported to the Bugolobi wastewater treatment plant (WWTP). Vacuum trucks, ranging in size from 1.8 to 10 m^3, are used to empty septic tanks and lined pit latrines in accessible areas. Inaccessible areas, where unlined pits are the common onsite sanitation technology, are emptied manually. To gain an understanding of how much FS is collected in Kampala and from what locations, the FAQ method's first step was to implement a two week long truck counting study. Each truck driver entering and discharging FS at Bugolobi received a questionnaire with eight questions regarding such factors as the kind of onsite sanitation technology that was emptied and where it was located.

The results indicated that approximately 114 trucks discharge FS per day at Bugolobi, delivering an average volume of 577 m^3 FS. Although both weeks had similar results, they are not necessarily reflective of how much FS is delivered over the entire year as this is also influenced by conditions, such as the rainy and dry seasons.

The results of the questionnaire, which comprise Figure 1, indicate that almost no unlined pits were emptied during the study, while there was an almost equal distribution between septic tanks and lined VIP latrines. A result that was unexpected was that only half of the delivered FS came from single and multiple households, as shown in Figure 2. This confirmed that a lot of the FS that accumulates in unlined pit latrines in Kampala remains uncollected. This is significant because 37 % of the urban households utilize unlined pit latrines (KSMP, 2004). The amount of FS that was collected from industrial and commercial sources was unexpectedly high, as was the amount from schools and public toilets. This information was very valuable for the development of the sampling plan for the characterization study.

Based on the truck counting results and secondary data, a sampling plan was developed for onsite sanitation technologies in different income categories and the percentage of FS emptied from households, public toilets, schools, restaurants, hotels and commercial areas. This study did not collect samples from unlined pit latrines because vacuum trucks rarely empty these systems due to cost and their potential to collapse. In addition, the future use of unlined pits in urban areas of Kampala is not advocated for environmental protection reasons.

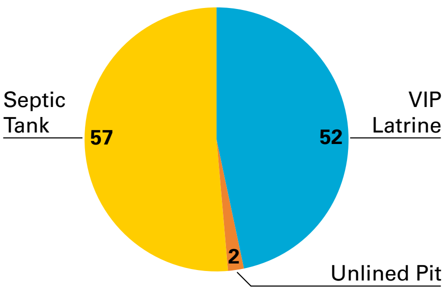


Figure 1: Average number of types of onsite technologies for faecal sludge delivered to Bugolobi.

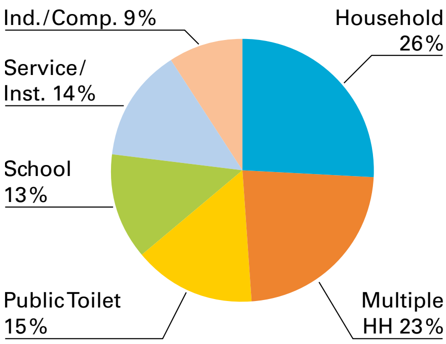


Figure 2: Percentage of faecal sludge from different sources delivered to Bugolobi.

Characterization and quantification

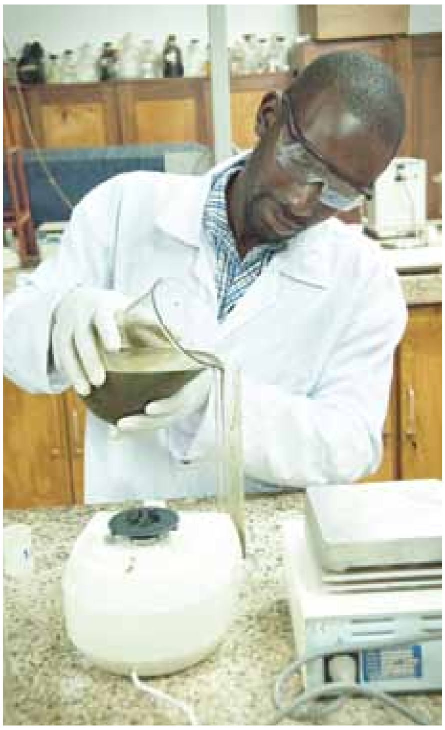
For the characterization and quantification study, a more comprehensive questionnaire was used that included information from household interviews. Data was collected about 18 parameters at the household level (e.g., number of users, greywater entering the system, desludging intervals, and use of bio-additives). The research team rode along with the truck driver during each individual emptying event to ensure the validity of the responses.

FS samples were also directly collected during the discharging process at Bugolobi (See Photo 1) and analysed at Makerere University (See Photo 2). 185 samples were collected over 22 weeks by a team of three people and were analysed for TS/VS, TSS/VSS, COD, TN, NH_4, NO_3, TP, and PO_4. Data analysis will evaluate the correlations between the FS characteristics and the household data. For example, more stabilized sludge has a lower TS/VS ratio, and usually correlates to a low number of users and longer desludging intervals.

The quantification of FS in Kampala will be based on the projection of the number of users of onsite sanitation for 2013, and this projection is based on an evaluation of 10 000 households [1]. The existing figures will be compared with the results of the truck counting study. By comparing the amount of FS that is collected with the distribution and accumulation at onsite sanitation facilities, it will be possible to estimate the quantity of sludge produced that is not collected and/or delivered to Bugolobi.

Conclusion

The implementation of the FAQ method in Kampala and Hanoi is on-going and final results of the characterization and quantification study will be presented in future publications. Several important lessons, however, have already been learned. For instance, conducting this study, especially the sampling, required the confidence and trust of the truck drivers, and this was developed due to the strong partnership established with PEAU. Also, weather and traffic conditions, i.e., heavy rain and traffic congestion, significantly impact sampling procedures and have to be taken into account. Lastly, the logistics of the sampling process were continually optimized throughout the study.



Lars Schoebitz

Photo 2: Faecel sludge analysis at the laboratories of Makerere University, Kampala.

[1] National Water and Sewerage Corporation (NWSC), Sanitation strategy and master plan for Kampala city. Vol. 2. Main report. Beller Consult-Germany, Mott MacDonald-UK and M&E Associates of Uganda for NWSC, Kampala, Uganda, 2004.

[1] Eawag/Sandec, Switzerland

[2] Department of Civil & Environmental Engineering, School of Engineering College of Engineering, Design, Art & Technology (CEDAT) Makerere University

Funding for FAQ was provided by the Swiss Development Cooperation (SDC) as part of the "Resource, Recovery & Reuse – From Research to Implementation" Project and Water and Sustainable Sanitation (WASSA).

Website: www.sandec.ch/faq

Contact: lars.schoebitz@eawag.ch

Re-inventing the Toilet – Can it Be Done and Work in Real Conditions?

We continue to pursue further challenges after successfully finishing the second phase of the Bill and Melinda Gates Foundation's "Re-invent the Toilet Challenge". The stakes are higher as we go from the lab and investigate the technology's robustness in the real conditions faced by Africa and Asia's urban poor. Christoph Lüthi[1] and Ulrike Messmer[1]

Introduction

The Blue Diversion Toilet developed by Eawag and EOOS* features an attractive grid-free, dry diversion toilet (separately diverting undiluted faeces, urine, and wash/flush water) that provides water for flushing, comfortable personal hygiene and for hand washing. The toilet is a next generation model of the urine diverting dehydrating toilet (UDDT). It was amended with a flush function (for the front part), a wash basin for hand washing, and a shower head for personal hygiene (for anal cleansing and menstrual hygiene). Furthermore, EOOS developed an attractive design language, allowing for easy and cheap industrialization by rotational moulding (See Photo 1).

Since the toilet will not be connected to piped water or a sewer, on-site treatment and re-use of water is key. The toilet features an on-site water recovery technology based on a gravity-driven ultrafiltration (UF) unit originally developed at Eawag for producing drinking water from polluted river water (Peter-Varbanets et al., 2009). We included aeration, thus, designing a new type of membrane bioreactor (MBR) that produces hygienically safe water (by ultrafiltration) at low energy consumption (filtration is entirely gravity-driven) and without maintenance (in the low-loaded filter, grazing by higher organisms keeps the filter open). This reactor type is attractive for on-site implementations. To prevent regrowth, the treated water is chlorinated by electrolysis in a commercially available electrolysis module modified for higher energy efficiency. The toilet's total continuous power consumption is 2 We/p, but the target of 1.5 We/p (15 We/toilet) is within reach. This small amount of electrical power is generated by a solar panel on the roof of the toilet superstructure, combined with a small battery.

The household-scale toilet is connected to a community-scale treatment plant where resources from the urine and faeces are recovered and fertilizer is produced. We developed a business model and a business case for urban slums in order to provide an economically, ecologically and socially sustainable sanitation service for these critical areas.

After almost three years of applied research work, the development of the Blue Diversion Toilet (i.e., the toilet as such and the water recovery technology) has now almost reached the prototype or "Technology Readiness Level (TRL) 7" stage. Reaching TRL 7 means that the toilet should be functional in a relevant environment, i.e., an informal urban settlement. Conducting "reality checks" of its functionality in low-income urban settings was part of the planning from the early stages of technology development, particularly, to ensure that the new technology set-up met users' needs, is robust and low maintenance. The key parameters analysed in the field tests included:

- User evaluation of the technology and service concept.
- Willingness to pay for the service.
- Potential barriers to renting the toilet.

First Field Test in Kampala, Uganda

Sandec's role was to manage the field testing. A purpose-built toilet superstructure was set up on private property to house the working model of the fully functional toilet during the test phase in Kampala, Uganda. Over 400 people used the first working model during the two month period in 2013. During this time, two Christian, then two Muslim families, shared the toilet over one month to simulate "real life" toilet usage. All family members were interviewed several times to assess their opinions on the user experience.

This two month field test provided information on how to improve the toilet's functionality and identified aspects that required rethinking and redesigning. The "real world" experience also allowed behavioural scientists from Eawag's Environmental Social Sciences Department to conduct a full-scale social acceptance survey with 1 500 interviews that provided empirical evidence on what people liked and disliked about the toi-

Photo 1: The different parts and functions of the Blue Diversion Toilet.

© Eawag/EOOS

Photo 2: A first toilet prototype is moved to the Mukuru informal settlement in Nairobi (March 2014).

let. The feedback and critical issues gathered during the working model test phase can be summarised in three points:

- Improve functionality of the faeces lid to better conceal previous users' 'business'.
- Reduce size (height) of water wall to ensure that it fits into existing toilet superstructures.
- Rethink the foot pump as it is considered too strenuous for children and the elderly to use.

Following the experience and feedback gathered during the Uganda field test and thanks to additional 'acceleration funds' from the Gates Foundation, the engineering company Tribecraft assisted us with re-engineering parts of the toilet. Tribecraft brought its solid expertise in mechanical and electrical engineering and transformed the first functioning working model into a re-engineered robust prototype that is close to industrialization. The hydraulics of the toilet were totally re-engineered, resulting in a smaller and more user-friendly interface that is almost one third smaller than the first working model. The simplified hydraulics led to a massive reduction of small parts, making it possible to reach the target production costs. Furthermore, the prototype is equipped with data loggers, allowing for more reliable (and anonymous) information on overall water use (e.g., flushing, hand washing and use of the shower for personal hygiene) during the first phase of piloting at scale.

Second Field Test in Nairobi, Kenya

The second field test was conducted mid-April to the end of May 2014 in Nairobi's second largest informal settlement in Mukuru, next to Nairobi's industrial area. Thanks to Sanergy (a local social enterprise), which negotiated the test site and ensured regular collection of the separated waste streams generated in the toilet, we were able to test the first prototype Blue Diversion Toilet (See Photo 2) with a family of seven. It was successfully retrofitted into an existing Sanergy superstructure, which was a major goal of the field test. Furthermore, investigations were done about its social acceptability, issues such as theft and vandalism, and its robustness on a day-to-day basis in real slum conditions.

Results of the second field test showed that social acceptability was high, that theft and vandalism were not important issues, and that operating in slum conditions would be very challenging. The evaluation given by the interviewees was largely positive. People liked the look of the toilet (100 %), thought it was easy to use (95 %) and would recommend it to friends and family (94 %). The recycled water was hygienically safe during the entire field test. The electrolysis was able to provide sufficient chlorine to prevent regrowth and proved effective at clearing up the water's colour. The new hydraulic system was leak-proof, and water for hand washing and the hand shower was available during the entire test period. However, this field test revealed the need for the following improvements:

- The hydraulic system needed additional simplification to further reduce the number of components.
- The electronics and software required further development to make them more robust and less vulnerable to failures.
- Future design work should focus on maintenance and servicing. The collaboration with Sanergy led to important insights into how to run a reliable collection system and its challenges.
- The squatting pan should be adapted for muddy and water logged areas, e.g., by expanding its range with a sitting module or an in-between sit-squat module to prevent mud from clogging the mechanism.

Both field tests in East Africa provided crucial reality checks and ensured that the Blue Diversion Toilet was developed in close cooperation with local stakeholders from academia (Makerere University), civil society (Sanergy) and the target populations in Kampala and Nairobi. The March 2014 Re-invent the Toilet Fair in Delhi attracted more than 700 participants; this was a milestone for the Eawag/EOOS team and introduced the toilet to potential funders, implementers and manufacturers from all over the world. There is growing commercial interest among potential industrial partners, especially in India and Kenya.

Presently, we are actively searching for funding and industry partners to complete the re-engineering and full industrialisation of the Blue Diversion Toilet.

* This interdisciplinary research project involves four Eawag Departments (Urban Water Management, Process Engineering, Sandec and Environmental Social Sciences) and the Vienna-based design office EOOS.

Acknowledgements

We would like to express our sincere thanks for the valuable support received from our local partners in Uganda and Kenya: The School of Engineering College at Makerere University in Uganda, and Sanergy based in Nairobi, Kenya.

[1] Eawag/Sandec, Switzerland
Contact: christoph.luethi@eawag.ch

Small-Scale Sanitation in Egypt: Towards a Data Baseline for Action

The SECO-funded ESRISS Project is working on the sound development of small-scale sanitation for settlements in Egypt's Nile Delta. This article summarizes its published report [1], which makes a strong data set available, as well as recommendations for planners and designers. P. Reymond[1], C. Demars[2], A. Papangelou[2], M.H. Tawfik[3], R.A.Wahaab[4], M. Moussa[5]

Colin Demars

Photo 1: A household survey in Beheira Governorate.

The development of sound sanitation strategies for settlements under 5 000 inhabitants in the Nile Delta has been limited due to the lack of baseline data and of design parameters characterising rural wastewater [2, 3]. To address this need, the ESRISS Project produced a data baseline under the auspices of SECO's institutional support to the Egyptian Holding Company of Water and Wastewater (HCWW). The objectives were to: (i) gather all information available and reference it in one report; (ii) provide data based on analyses of sewage, septage and animal manure samples; (iii) describe current sanitation practices in Nile Delta villages, including household-level behaviours and pit emptying activities; (iv) analyse the factors influencing wastewater quantities and characteristics; (v) describe the existing water and nutrient reuse practices; (vi) quantify the sanitation-related financial flows; and (vii) develop a model to quantify and characterise wastewater at the village level, without sampling. This required extensive field work that included: semi-structured interviews with key sanitation stakeholders (village authorities, emptying service providers, farmers, and sewer operators), household surveys, and sampling campaigns with portable lab equipment (See Photos 1 and 2). The field work was carried out in partnership with HCWW and the Affiliated Company in the Beheira Governorate (BWADC).

Heterogeneity of small settlements

Our fieldwork showed that the small settlements in the Nile Delta (ezbas and villages) are very heterogeneous and that this heterogeneity requires that sanitation options be selected and designed on a case by case basis (See Photo 3). Determining the design parameters and most cost-effective sanitation options required assessing the following factors for each settlement: density and shape, proximity to drains or canals, the groundwater table, the quality of the water supply and the number of animals per household. Statistics regarding the population number and the water consumption of the settlements were found to be unreliable and had to be determined first-hand.

The skills, capacities and willingness to participate in sanitation planning differed significantly from village to village. Our work found that involving key village sanitation stakeholders in the planning process from the start should be encouraged. In addition, sanitation management schemes should be discussed and validated before selecting the final technical options.

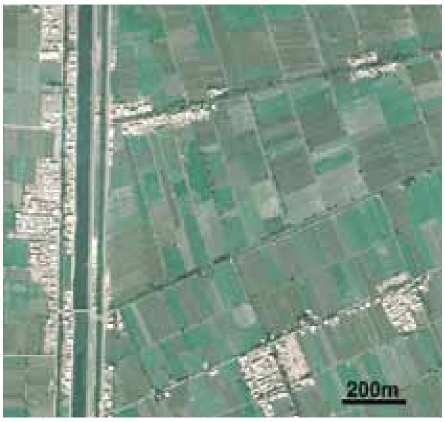
Unequal costs of water and sanitation services

Our research indicated that drinking water and sanitation costs vary from settlement to settlement. Villagers with traditional pits pay very high emptying costs that can be 20 times higher than the price paid by households connected to governmental sewer networks. The latter pay an insignificant amount for wastewater services, reflecting the high inequality between served and unserved areas.

Many communities decided to fund the construction of basic "informal" sewer systems to eliminate the burden of pits (high emptying frequency, high costs, and high potential of contaminating the water available for consumption). While our data showed that this investment is quickly offset, the lack of technical expertise often turned these construction initiatives into future problems (See

Colin Demars

Photo 2: Septage sampling.



adapted from Google Earth

Photo 3: Heterogeneous small settlements in Beheira Governorate.

Photo 4). Investments in proper "shallow sewer" systems should be encouraged. If the initial investment is too high to be paid all at once, leasing mechanisms could be instituted to make the monthly payments less than pit emptying costs.

ESRISS promoted HCWW's decision taken in 2012 under the auspices of the Ministry of Water and Sanitation Utilities to provide technical support to communities willing to pay for sewer systems. This HCWW program was cancelled, however, after the last regime change in summer 2013.

Regarding the price of drinking water, results showed that villagers pay significantly more than the official tariff. Research showed, however, that the rate in the water bills did not match the actual water consumption. Water readings and bills should be regularly cross-checked, and compared with the rate charged by the Affiliated Companies. On the positive side, our findings indicate that people are actually ready to pay more than the official tariff.

Septage management

Our work found that most pit emptying is mechanically done by trucks, which transport and discharge the septage in the nearest drains. Although the Village Councils usually own one truck, most are privately owned. It is, thus, mainly an informal private business. ESRISS recommends building proper septage disposal points, including primary treatment facilities, as a cost-effective way to reduce the contamination loads in water bodies. Private service providers could pay a small fee to discharge at the facilities to cover the O&M costs.

Farmers' interest in organic fertilisers

Our research indicated that Egyptian farmers have a strong interest in organic fertilisers, i.e., sludge, manure and compost. Because of this, the selection of sanitation systems should be geared towards those that best conserve nutrients and produce good quality fertiliser material. Small scale systems are particularly apt as the sludge in small settlements is not contaminated by industrial activities and the product can be reused on-site by the villagers. ESRISS recommends that good quality compost be produced at the farm level, and advocates techniques that insure the production of well stabilised sludge.

Unrealistic laws and regulations

Existing laws and regulations were found to be not well suited to the needs of small settlements. Often, stringent regulations "kill" simple but robust solutions and induce complex and costly options that do not work in the long term. The regulations' main limiting factor is the COD value (80 mg/L), which is significantly lower than the European Union standard (125 mg/L). The presently promoted dissolved oxygen level (>4 mg/L) is also a major limiting factor as it forces the implementation of a costly aerobic treatment step. ESRISS recommends the work being done in Jordan and Morocco because both have instituted much more pragmatic standards (250 mg/L COD in Morocco and 300 mg/L COD for biological treatment in Jordan). Morocco is presently employing an incremental approach to implement these standards, and this same approach could be very effectively applied to Egyptian rural areas.

Lukas Ulrich

Photo 4: Villager unclogging a sewer pipe.

Conclusion

ESRISS's present objective is to financially analyse the sanitation supply chain and finalise a simplified tool that practitioners can use to assess the quantities and characteristics of the wastewater to be treated at the village level in the Nile Delta. Useful tools for preliminary sanitation assessments have been developed, such as semi-structured interview guidelines and a household survey questionnaire (both in English and Arabic). ESRISS recommends that a similar data baseline be created for the Upper Egypt region, where the situation is different than in the Nile Delta. Combining the research results of these two regions would provide a strong basis towards the development of national policies and guidelines.

[1] Reymond, Ph., Demars, C., Papangelou, A., Hassan Tawfik, M., Abdel Wahaab, R., and Moussa, M. (2013): Small-Scale Sanitation in the Nile Delta: Baseline Data and Current Practices. Eawag, Switzerland-Egypt.

[2] Reymond, Ph., Abdel Wahaab, R., and Moussa, M. (2012): Small-scale Sanitation in Egypt – 10 Points to Move Forward. Research for Policy Brief. Eawag, Switzerland-Egypt

[3] Reymond, Ph. (2012): Small-scale Sanitation in Egypt: Challenges and ways forward. Eawag, Switzerland-Egypt.

[1] Eawag/Sandec, Switzerland

[2] EPFL / ETHZ

[3] ESRISS Project Assistant

[4] Holding Company for Water and Wastewater, Egypt

[5] 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.

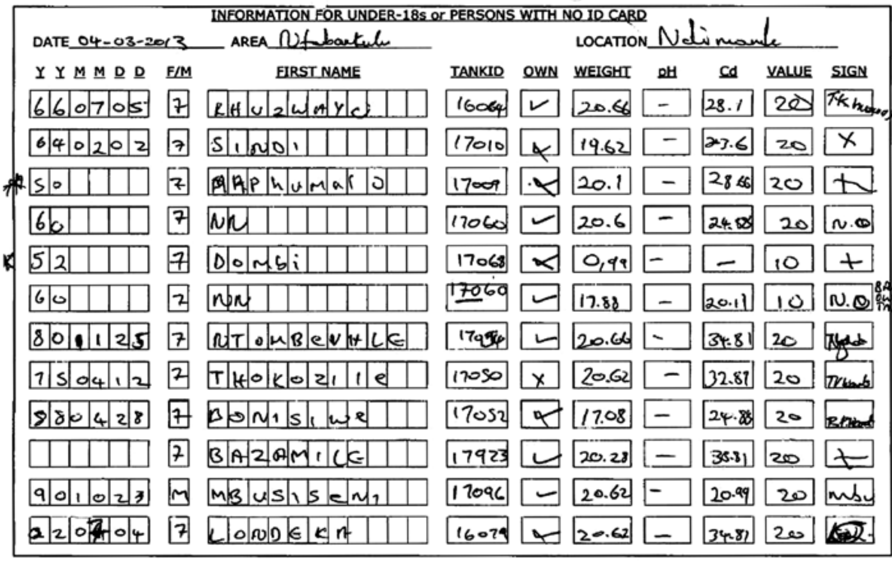
For more information and download of the documents & tools: www.sandec.ch/esriss

Contact: philippe.reymond@eawag.ch, based in Cairo

Data Collection Made Easier?: Choosing Between Mobile Phones and Paper

Collecting field data is essential for Sandec's research; yet, paper-based data can be difficult to collect and manage. Mobile phones offer advantages, but are not always the best option. This article looks at the ways mobile phones can help with water and sanitation-related data collection in low-income countries. Elizabeth Tilley[1,2] and Isabel Günther[2]

Typically, field data have been collected by enumerators wielding clipboards and pens; toilets were counted, residents were interviewed, and all the numbers and comments were carefully recorded on well-designed tables and forms. Yet, this method can be problematic because pages are easy to lose; messy hand-writing is sometimes impossible to read; rain and mud can destroy many days of carefully written notes; transferring the data to a digital format induces another source of error; and carrying huge stacks of multi-page questionnaires can be back-breaking work. The rise of mobile phone ownership and the concomitant growth of associated networks and services have made it possible, and logistically and financially compelling, to consider using mobile phones to collect field-data in low-income countries.



INFORMATION FOR UNDER-18s or PERSONS WITH NO ID CARD

DATE 04-03-2013 AREA [illegible] LOCATION [illegible]

Y Y M M D D	F/M	FIRST NAME	TANKID	OWN	WEIGHT	pH	Cd	VALUE	SIGN
660705	F	KHUZWAYO	16064	✓	20.66	–	28.1	20	[illegible]
640202	F	SINDI	17010	✓	19.62	–	27.6	20	X
50	F	MAPHUMALO	17009	✓	20.1	–	28.66	20	[illegible]
66	F	NN	17060	✓	20.6	–	24.58	20	N.O
52	F	DOMBI	17068	✓	0,99	–	–	10	+
60	F	NN	17060	✓	17.88	–	20.11	10	N.O BROUGHT OWN TANK.
80[illegible]125	F	NTOMBENHLE	[illegible]	✓	20.66	–	34.81	20	[illegible]
750412	F	THOKOZILE	17050	X	20.62	–	32.81	20	[illegible]
580428	F	BONISIWE	17052	✓	17.08	–	24.88	20	[illegible]
	F	BAZAMILE	17923	✓	20.28	–	35.31	20	[illegible]
901023	M	MBUSISENI	17096	✓	20.62	–	20.99	20	[illegible]
220[illegible]04	F	LONDEKA	16079	✓	20.62	–	34.81	20	[illegible]

Elizabeth Tilley

Photo 1: Data collection sheets used in the field are not always easy to read.

There are a variety of platforms that can be used to program the user-interface on a mobile phone and/or monitor the data as they are sent. A list of 10 resources is included at the end of this article. Generally, a survey, or template for data entry, is designed and uploaded to the phones; the same survey can be uploaded to as many phones as required and/or a specialized survey can be sent to each enumerator. The accompanying software allows the researcher to monitor the results, make changes to the interface, and communicate with the fieldworkers.

Over the last few years we have conducted extensive sanitation-related data collection in eThekwini Municipality, South Africa, using both traditional paper methods and mobile phones. Based on these experiences, we are able to evaluate the relative merits of paper and mobile phone based data collection. In the following sections, we compare the two methods in terms of Data Quality, Data Monitoring, Data Transfer, Cost, and Ethics and Corruption.

Data Quality

One of the biggest challenges associated with paper-based data collection is quality: in terms of visual quality (the clarity of writing), completeness (not missing questions), and data type (writing "yes" when the question requires a number). Intensive training and practice is required with the enumerators when issuing a paper-based survey, so that they learn beforehand to skilfully skip over questions that do not apply and ensure that extra information is obtained when a key question is answered (See Photo 1).

Although complicated logic, question and section skips, as well as data quality checks, can be programmed into the mobile phone interface, this does not negate the need for enumerator training, though it may be less than that required for paper-based data collection. Furthermore, programming logic on mobile phones does not prevent mistakes and indeed programmers (us) have made several. Yet, the difference between programming and enumerator mistakes is that the former are systematic and can be quickly noticed in the data, such as if a question is consistently skipped. Enumerator mistakes, however, may take months to detect and, by then, it may be too late, or too difficult to fix them.

Data Monitoring

Depending on the type of data collection, paper-based data are usually returned to the researcher at the end of the day, so that they can be reviewed and controlled. This can involve extensive transport, annoying logistics and, for the researcher reviewing the work, many sleepless nights. Data collected via mobile phones are nearly instantly transferred over the cellular network, so that a researcher, sitting at a computer, can monitor the data in semi-real time (See Photo 2). The benefit here is that by using sorting and analysis tools, a researcher can quickly flag poorly programmed logic, and bad or missing answers. Enumerators can be instantly contacted (after all, they are carrying a mobile phone) and asked to re-do the question or survey before they get too far away from the location.

Data Transfer

Transferring paper-based data requires physical movement, either by person or vehicle, or both. When distances are far, data transfer may be infrequent, which may, therefore, reduce the frequency of data monitoring. Transferring data from mobile phones to a central collection point (the researcher) is done across a cellular network. Additionally, mobile phones can be used by enumerators in remote or distant areas, permitting them to not have to return to a city or central collection point to physically transfer the data. Researchers have more liberty to employ local staff because of their knowledge of the area and the staff does not have to waste time and money travelling back and forth from the research areas. Unfortunately, the advantages of mobile phones only apply if and when there is a functioning, consistent mobile network, and the phones must have sufficient credit. The service providers that we used did not offer good coverage throughout the areas in which we worked; careful attention must be paid to find the best networks available in the research area.


Elizabeth Tilley

Photo 2: Nomvula finishes entering the data and sends it to be reviewed.

Ethics and Corruption

Although some phones and data were used for personal activities, especially taking photos, the issue of "abuse" was not a concern because enumerators took exceptional care of their phones. Emerging applications allow for multiple data types (e.g., finger prints, GPS coordinates, phone numbers, etc.) to be linked perfectly across surveys. This quest for a perfect panel data set (e.g., information about a family collected before and after they have built a toilet), raises some serious questions about anonymity, data storage and the concept of "informed consent", i.e., whether or not interviewees fully understand what they have committed themselves to. All types of data collection require careful storage and use; however, the ability to collect greater quantities of more detailed data with mobile phones will require that researchers review and re-evaluate their current protocols and vigilance concerning data storage and data access.

Costs

The two most expensive parts of any data collection program, depending on the location, are human resources and transport costs. There could be almost no difference between the number of workers required for a digital or a paper survey, but if they can be hired from the study communities, they might not need to travel as much, which would save time and money. In studies with dispersed, difficult to access sites, such as those we have done with mobile phones, the enumerators had to come to our office only at the beginning and end of the survey period, significantly saving on transportation costs.

The set-up or programming of mobile phones does require more time initially. Yet, revisions and additional sections are (generally) free to add. Re-printing paper copies (photocopying, binding, etc.), however, can drastically increase the costs of paper-based programs.

Although mobile phones are a large investment, prices in big cities are rapidly dropping and used or old phones can generally be obtained cheaply. Data packages are required for each phone, however, and depending on the data type (e.g., photos), this can become expensive. This has to be considered against other factors, such as buying additional cameras so that enumerators can take photos.

Paper-based data collection requires more management staff and, most significantly, time and staff to manually enter and clean the data, i.e., check for mistakes. Data entry can be a significant expense, as well as an additional source of errors. Furthermore, it can be a lengthy process that can prevent the publication of timely results. An advantage of mobile phones is that most software available for use with them allow the data to be directly exported in spreadsheet formats, such as Microsoft Excel, or Comma Separated Value formats. The data can be immediately analysed and checked for accuracy.

Conclusion

The choice between paper and mobile phone-based data collection methods is not clear-cut. Our general conclusion, based on extensive experience using both, is that paper-based data collection is better for small sample sizes and short-term, geographically contained research programs, as well as when it is important to frequently check results. Paper-based data collection is necessary where there are weak or unstable cellular networks.

Mobile phone-based data collection is generally more flexible and scalable. It is, therefore, best suited for long-term research that covers a large region and where constant contact with the data-collectors is not possible. Furthermore, complicated questionnaires with different logic-based skips and modules are more efficiently and reliably completed with mobile phones, although they do not eliminate mistakes by enumerators and programmers. It is generally not worth the programming and set-up fees to use mobile phones for a small group of interviews in a relatively small area.

With both types of data collection, it is always essential to keep in mind that the quality of the data will depend on the amount of time spent on design, training and piloting, as well as on the clarity of the research questions. If you do not clearly know what you are looking for, not even the best phones will help.

The following is a list of programming and data collection management platforms for mobile phones. We do not have experience with all of them, and, therefore, cannot comment on their quality or availability of services. Mobenzi Researcher (mobenzi.com); Cortex Software (cortextsoftware.com); Formhub (http://formhub.org); Frontline SMS (frontlinesms.com); iFormBuilder (iformbuilder.com); Jana (jana.com); Text to Change (texttochange.org); Viewworld (viewworld.net); dooblo (dooblo.net); Magpi (datadyne.org).

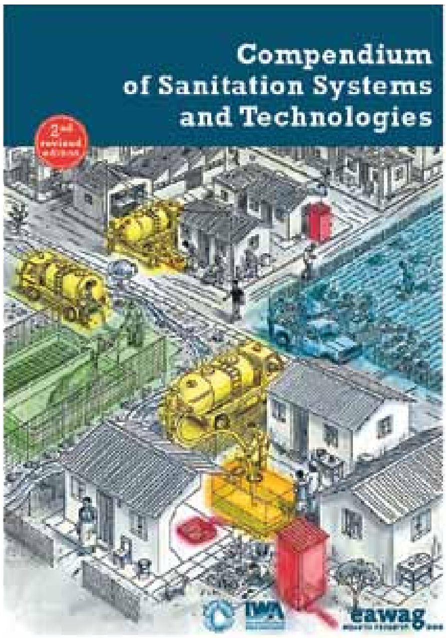
[1] Eawag/Sandec, Switzerland
[2] Centre for Development and Cooperation, ETH Zürich
Contact: elizabeth.tilley@eawag.ch, isabel.guenther@nadel.ethz.ch

2nd Edition of the Compendium of Sanitation Systems and Technologies

A second, revised edition of the Compendium of Sanitation Systems and Technologies has been recently published by Eawag, WSSCC and the International Water Association. It features updated content, a number of new additions, and will also be available in French. Lukas Ulrich[1] and Christoph Lüthi[1]

Introduction

The Compendium of Sanitation Systems and Technologies was first published in 2008, the International Year of Sanitation. Since then, it has become a well-known reference manual for sanitation practitioners across all continents.



The Compendium – a "Bestseller"

The following have resulted in the widespread distribution of the Compendium:

- An English PDF version is available on the Eawag website (where it has been downloaded more than 8000 times) and on other popular sector websites, such as the WSSCC, SuSanA and SSWM online libraries.
- The Compendium has been translated into French, Spanish, Vietnamese and Nepali. The Nepali Compendium is an adapted version, featuring a contextualized selection of sanitation technologies and country-specific drawings. It was co-published with the Department of Water Supply and Sewerage of the Ministry of Urban Development of the Nepalese Government.
- More than 6000 print copies of the different language editions have been distributed worldwide.
- Electronic online versions of the Compendium are available in English on the Akvopedia Sanitation Portal [1] and Spanish by Alianza por el Agua [2]. Based on the content of the Second Edition, an interactive eCompendium will go online in September 2014 (See box below).
- The Compendium has been used as training material in university courses and sanitation trainings, e.g., training of trainers in Peru, Nicaragua, and Ecuador.
- It has been used as a tool for the selection of sanitation options in participatory planning processes, e.g., in CLUES (Community-Led Urban Environmental Sanitation Planning) projects in Nepal, India, Kenya, Uganda and Ethiopia.

The Compendium's popularity lies in its structured and concise form. It presents a large amount of information on a wide range of proven and tested sanitation systems and technologies, and is available for free.

What's New in the Second Edition?

The structure of the Compendium is the same in the Second Edition. Like the First Edition, it is divided into two parts: Part 1 contains nine sanitation system templates and Part 2 provides two-page technology information sheets on 54 proven and tested sanitation technologies.

New features of the Second Edition include:

- Simplified how-to-use instructions.
- An overview of other important sector development tools that could be used in conjunction with the Compendium.
- An additional sanitation system (biogas system).
- Five new technology information sheets (Pre-Treatment, Settler, Imhoff Tank, Tertiary Filtration and Disinfection, and Biogas Combustion).
- Revised contents based on peer-review by international sanitation specialists and key new findings and developments in the sector over the last six years.
- Updated references and further reading recommendations.
- Improved and refined schematic technology illustrations.
- A section on design considerations for each technology.
- A more elaborate presentation of input and output products that clarifies the compatibility between technologies and streamlines system configuration.
- A double-page spread presentation of the technology factsheets, giving an overview at a glance.
- A section about promising emerging sanitation technologies.
- A revised glossary.

[1] http://akvopedia.org/wiki/Sanitation_Portal
[2] http://www.alianzaporelagua.org/Compendio/

[1] Eawag/Sandec, Switzerland

Further Information

Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph. and Zurbrügg, C., 2014. Compendium of Sanitation Systems and Technologies. 2nd Revised Edition. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland.

176 pages, available in English and soon in French

ISBN: 978-3-906484-57-0

Orders and free download:
www.sandec.ch/compendium

The Online Compendium of Sanitation Systems and Technologies

This new, interactive online tool will be presented at the World Water Week taking place September 2014 in Stockholm. Thereafter, it will be accessible for free at:
www.ecompendium.sswm.info

Contact: lukas.ulrich@eawag.ch and christoph.luethi@eawag.ch

Evaluating the "Safir" Gravity-driven Membrane Filter in Bolivia

Bolivian families recently participated in field tests of the "Safir", a new generation household water filter, to help optimize its design and functionality. Tests were done at two locations and the results will be used to prepare the filter design for mass production. Selina Derksen[1], Valentin Graf[1], Maryna Peter-Varbanets[1]

Introduction

The "Safir" filter (See Photo 1) was designed by Eawag in collaboration with the Zürich University of the Arts, and was initially modified after field evaluation tests in Kenya. It is an ultrafiltration membrane module with a pore size of 20–40 nm that is placed into the raw water container. A mesh on top of the container reduces the spilling of water and protects the membrane from damage. The water passes through the membrane by gravity and is collected in the pure water tank. The filter does not require any cleaning, pressure or power; maintenance is limited to occasional flushing of the sediments that accumulate in the raw water container. The low-maintenance is possible due to the formation of the pervious biofilm on the membrane surface, which helps to sustain the stable flux of about 4–10 L/h per $1m^2$ of membrane. Each filter lasts between 5–8 years.

Field evaluation in Bolivia

The goal was to involve users in the filter's design optimization process and test its functionality. Locally available ceramic candle filters were used for comparison. Handling and design were evaluated through structured interviews, workshops and video recorded observations, while functionality was evaluated through measuring water flow, frequency of use and water quality parameters. Two field sites were selected: Encanto Pampa, a peri-urban community, and San Benito, a rural community. 11 families at each site, that consumed untreated water from a river or from unprotected shallow wells, participated in the study. Each family started with either the Safir or the ceramic filter and then used the other one for at least one month.

Selina Derksen

Photo 1: Safir filter in Bolivia.

Filter functionality

Microbial water quality. *Escherichia coli* counts were measured in the water storage tank, at different sampling points within the filter, and in the drinking cup. The log removal values (LRV) calculated between the storage tank and the tap showed ~ 2-log removal for both filters in San Benito. Although less than 10 % of all samples from both filters showed 1 or more *E.coli* in 100 ml sample of permeate, about 30 % of all samples taken from the tap and 30–50 % of all samples tested in the cup had *E.coli.* This showed that contamination occurred either at the tap or after it.

Water flow. The Safir's flow rate was generally higher than the ceramic filter. An approximate 1.2–1.5 L/h flow rate was observed at 12 cm at both field sites, while the ceramic filter's flow rate at this pressure was lower than 0.5 L/h. In San Benito, highly turbid water led to clogging of the ceramic filter.

Filter use. Both filters were used regularly at the two sites. The Safir was filled 6.1 times per week on average, while the ceramic filter was filled 5.2 times a week. However, the volume filled in the filter was relatively low: 3.6 L/fill in the Safir and 3.9 L/fill in the ceramic filter.

Filter handling and maintenance

Everyday handling and maintenance were evaluated. The criteria of the former were: handling ease of filling with water; use of lid; handling and location of tap; height and stability of the stand; risk of damage to the filter from improper use, such as opening the membrane tank; the handles and printed instructions. Major criticism of the filter concerned its lid and the stand's height. The tap was perceived as good due to regulation and high flow, but as not robust. None of the users opened the membrane tank during use, but they could do so if asked. An important recommendation was to create a better mechanism to protect the membrane from possible damage.

The maintenance criteria involved: the flushing of the accumulated sediments from the raw water tank, cleaning of the clean water tank, and tap replacement. In general, users managed to clean the filter and replace the tap by following the instructions. About half of the participants understood the concept of shaking the filter for cleaning purposes; however, some of them shook it the wrong direction which affected the cleaning efficiency. Improving the instructions and relocating the position of the handles were two recommendations. The majority perceived the filter as heavy during cleaning, but not unbearably so.

Conclusion

Functionality. The Safir is a fully functional filter. Re-contamination of the tap was observed in both the ceramic and the Safir filters and could be reduced by either introducing a post-treatment step, i.e., chlorination, or hygienic education of the users. The Safir is especially well suited to treat highly turbid water, while other technologies, including ceramic filters, fail at this.

Use. The Safir and ceramic filters were not used at full capacity. Factors, such as the actual need for water or the size of the vessel used to collect water, impacted the volume of filtered water. Therefore, the size of the clean water tank could be reduced to 10 litres or less.

Design. In general, the design was considered adequate and the families perceived the Safir as nice and easy to use. Design recommendations were collected to improve and prepare it for mass production.

[1] Eawag/Sandec, Switzerland

This project was a collaboration between the Sandec and Process Engineering Departments at Eawag and the Zürich University of the Arts. The field work was coordinated by Fundacion Sodis. The following people were involved in the project: R. Johnston, W. Pronk, R. Meierhofer, M. Krohn, F. Müller, O. Campos, M. Bräm, S. Choque, C. Rojas, E. Sanchez, H.-J. Mosler, H. Johnston.

Contact: maryna.peter@eawag.ch

Evaluating Distribution Strategies for Ceramic Filters in Kenya and Bolivia

Determining how to optimally market ceramic filters and other household water treatment and safe storage products (HWTS) is crucial to the promotion of safe water use. Trials were conducted to test four different distribution strategies to find out which works best in different local contexts. Regula Meierhofer[1], Carina Flückiger[1], Heiko Gebauer[1]

Introduction

Four project sites were chosen in Kenya and in Bolivia for ceramic filter marketing trials. 300 households at each site received trainings through household visits and community training events, and surveys were done at baseline and after 11 months. Household information was collected with quantitative questionnaires, while qualitative information and sales records were gathered from sales staff.

Kenya

Area 1: ***(Thika) Promotion – NGO, Sales – Water Utility & Local Entrepreneurs:*** The Community Water Project (CWP) operating committee organized the distribution and sale of ceramic filters, and sold 51 filters at 17.4 USD apiece.

Area 2: ***(Thika) Promotion & Sales – Community Health Workers (CHWs):*** CHWs of the official public health system handled community education and sold 40 filters for 17.4 USD each.

Area 3: ***(Mwala) Promotion & Sales – Community-based Organisations (CBOs):*** Two CBOs were trained to educate the community, and to sell chlorine products and ceramic filters. At the midterm evaluation, no filters had been sold, so the sales price was lowered from 18.5 USD to the subsidized price of 9.8 USD. The CBO with prior sales experience successfully sold 11 filters and chlorination products, while the other CBO without such experience did not sell any filters and hardly sold any chlorine.

Area 4: ***(Mwala) Promotion & Sales – NGO Promoters:*** NGO Promoters managed marketing and sales but, since the community demanded products for free from the NGO, they stopped selling them. At the midterm evaluation, only 1 filter had been sold for 18.5 USD. After lowering the price to 9.8 USD, 26 filters were sold.

Bolivia

Area 1: ***(Valle Hermoso) Promotion & Sales – CBO:*** A women's group with prior sales experience handled the promotion and sale of the filters, and 114 filters were sold for 30 USD each (See Photo 1). However, they sold filters in an area larger than the intervention site, and only 12 filters could be found at the site.

Area 2: ***(Villa Granado) Promotion & Sales – NGO Promoters:*** Community education and product sales were handled by NGO Promoters, who conducted three visits per household. They sold two filters for 31 USD apiece.

Area 3: ***(Arbieto) Promotion & Sales – CHWs:*** Health Centre employees and health workers were responsible for promotion and sales; however, they were not motivated and no filters were sold.

Area 4: ***(Villa Tunari) Promotion – NGO, Sales – Water Utility:*** A NGO Promoter did the promotion and chlorine product sales through household visits. Ceramic filters were sold through JASAP, a community-based enterprise that manages the local water supply. Customers received filters on credit and paid for them in three payment instalments that were added to their water bills. 46 filters were sold for 31 USD each.

Use of HWTS Products before and after the Intervention in Kenya

In Kenya, the frequent use (defined as using the method often to always) of household water treatment (filtration or chlorination, excluding boiling) increased by an average of 27.6 % to 53.7 % in all intervention areas. A significant increase in the availability of chlorine was observed in Mwala District, which is more agricultural than Thika District (27.3 % in Area 3 and 10.3 % in Area 4). In Areas 1 and 2 of Thika, there was a decrease in the availability of chlorine products in the households, but more people said they would be boiling the water. 5 % of the households in Area 1 and 10 % in Area 2 switched to using a ceramic filter, while only very few ceramic filters were used in Areas 3 and 4.

Use of HWTS Products before and after the Intervention in Bolivia

In Bolivia, 88.5 % (69.1 % at baseline) of the households stated that they boil their water. Figure 1 below presents data on the use of HWTS, excluding boiling (as the use of this method could not be verified in the households). Statistical analysis showed that a large number of households said that they would boil water; however, it is questionable whether this was carried out in practice. Also, frequent household water treatment increased by 21.2 % to 40.2 % (filtration, chlorination, solar water disinfection, and bottled water, excluding boiling). Ceramic

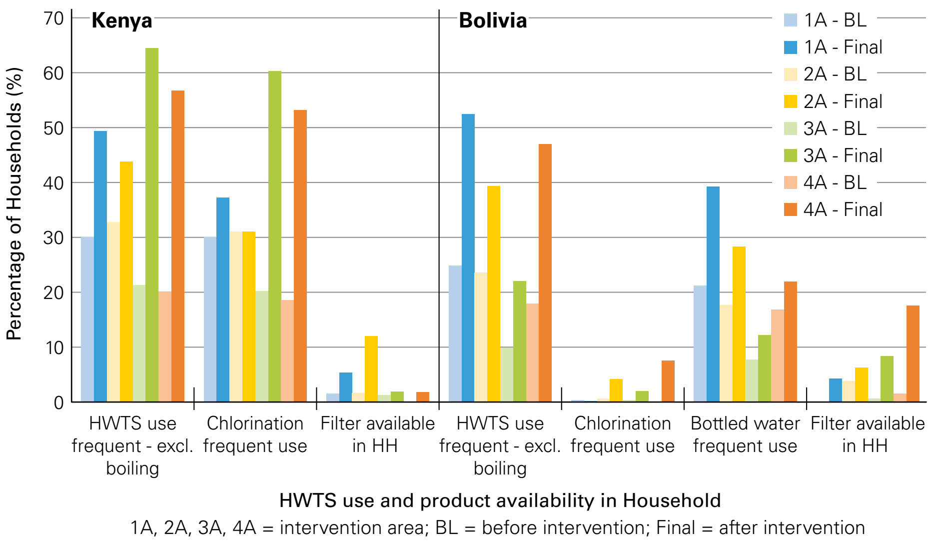


Figure 1: HWTS use before and after the intervention in Kenya and Bolivia.

Fundación SODIS

Photo 1: The women's group in Valle Hermoso in Bolivia sold 114 filters to households.

filter use increased by an average of 7.6 % in all intervention areas – and by 16 % in Area 4, Villa Tunari. The average use of bottled water (20 litre gallons) increased by 7.6 % to 25.5 %. Chlorination and Solar Disinfection were only marginally used at baseline and after the intervention.

Factors influencing frequent HWTS use and the purchase of ceramic water filters

For Kenya and Bolivia, logistic regressions were calculated for the outcome variables "Frequent use of household water treatment, excluding boiling" and "Filter available in the household". The factors included in all the regressions were: turbidity of water; if a promotion was received; whether information came from the health centre, a CBO, a Promoter, a shop owner, a community health worker, a community meeting, or through other sources; if the promotion was helpful; if the promotion changed behaviour; if the user likes the method; the importance of treating drinking water; the percentage of neighbours using HWTS; beliefs about whether untreated water is good or bad for one's health; money available per week; and willingness to pay for ceramic filters (See Photo 2).

Frequent use of HWTS

In Kenya, the factors significantly related to the frequent use of HWTS were: if the household perceived the promotion as helpful (Odds Ratio (OR): 4.4; Confidence Interval (CI): 1.3–14.7), if the household liked the method used most (OR: 2.1; CI: 1.8–2.5), if neighbours used HWTS (OR: 1.8; CI: 1.6–2.0), if they thought it important to treat drinking water (OR: 1.6; CI: 1.4–1.9) and if they stated a high willingness to pay for ceramic filters (OR: 1.3; CI: 1.1–1.6). Also significantly related, but with an odds ratio of less than 0.5 were if information was provided through the health centre or mass media and if the household stated that the promotion changed behaviour. (Model $x^2(19)= 440.1$; $p=0.000$; Cox and Snell $R^2=0.25$; Nagelkerke $R^2=0.33$).

In Bolivia, promotion activities significantly influenced the frequent use of HWTS: if information was provided through a CBO (OR: 2.4; CI: 1.1–5.3), a Promoter (OR: 4.7; CI: 2.2–10.4) or the mass media (OR: 0.4; CI: 0.1–1.0) and if the promotion changed behaviour. In addition, the turbidity of the water correlated with HWTS use (OR: 0.4; CI: 0.3–0.7). (Model $x^2(17)=70.1$; $p=0.000$; Cox and Snell $R^2=0.08$; Nagelkerke $R^2=0.12$).

Filters Available in Households

In Kenya, household visits by CHWs (OR: 3.4; CI: 1.7–6.7), if people liked the filters (OR: 2.4; CI: 1.6–3.7), if they stated a high willingness to pay for ceramic filters (OR: 2.4; CI: 1.7–3.3) and the amount of money available per week (OR: 1.4; CI: 1.1–1.7) influenced the purchase of ceramic filters. (Model $x^2(19)=142.86$; $p=0.000$; Cox and Snell $R^2=0.09$; Nagelkerke $R^2=0.27$).

Regula Meierhofer

Photo 2: A kiosk in Kenya that sells ceramic filters.

In Bolivia, ceramic filter purchases were most strongly influenced by the turbidity of the water (OR: 3.9; CI: 2.1–6.9), if they liked the filter (OR: 1.6; CI: 1.0–2.5), by risk awareness (if they think it is bad for their health to drink untreated water, OR: 0.5; CI:0.3–0.9), and by a high willingness to pay for ceramic filters (OR: 1.3; CI: 1.1–1.4). (Model $x^2(18)=91.1$; $p=0.000$; Cox and Snell $R^2=0.12$; Nagelkerke $R^2=0.24$).

Conclusion

The sale of ceramic filters through community-based enterprises responsible for the water supply worked well in Kenya and Bolivia. These enterprises already provide a basic service and are well suited to distribute higher priced products since they can easily collect payments by adding instalments to water bills. In both countries, the opportunity to pay by instalment was an important element that facilitated product sales.

The marketing trials showed that CBOs with marketing and sales experience successfully distributed and sold HWTS products. Collaborations with groups lacking in sales motivation and skills, however, were not successful. NGO Promoters proved to be effective at raising awareness and at providing information about water treatment, but were not productive at selling products. They generally lack marketing skills, and customers commonly expected that NGO representatives give them the products for free. In addition, the logistic regressions concerning the frequent use of HWTS and the purchase of ceramic filters revealed that information dissemination and training activities by Promoters, CBOs or Health Workers that directly reach individual households are very important to promote the purchase and use of HWTS products, especially when complemented with information disseminated through mass media. The economic status of the households in Kenya significantly influenced the purchase of higher priced products, such as ceramic filters.

The results also indicated areas to address in future marketing studies that influenced the purchase and use of HWTS products. These include: social norms (how many neighbours are using a method), risk awareness of the dangers of drinking unsafe drinking water, and emotional factors, i.e., liking a HWTS method.

[1] Eawag/Sandec, Switzerland
Contact: regula.meierhofer@eawag.ch

Finding Areas for the Distribution of Household Water Filters in Uganda

A new method was tested in Uganda to find the most suitable locations for household water filter distribution projects. This article explores the method and details how it provided a very sound basis for decision making and could prove to be useful to practitioners in the field. Stefanie Lehmann[1], Richard Johnston[2], Maryna Peter-Varbanets[2]

Introduction

When a NGO, researchers, or commercial or social enterprises launch a water project in a new country, it can be expected that some areas are less suitable than others. Factors such as lack of water, the lack or poor state of roads, population with too low income, projects distributing goods for free, and negative demographic developments, etc., minimize the impact of household water treatment projects. Furthermore, when local health offices or NGOs are involved in promotion and distribution, the scalability of their distribution approach depends on the geographical coverage that they can handle. Thus, the project location can influence the results and increase or limit their impact. In this study, we wanted to find out if a method that uses available data, geographic information systems (GIS) and a multi-criteria decision analysis (MCDA) approach could help in determining the areas most suitable for household water filter distribution in Uganda.

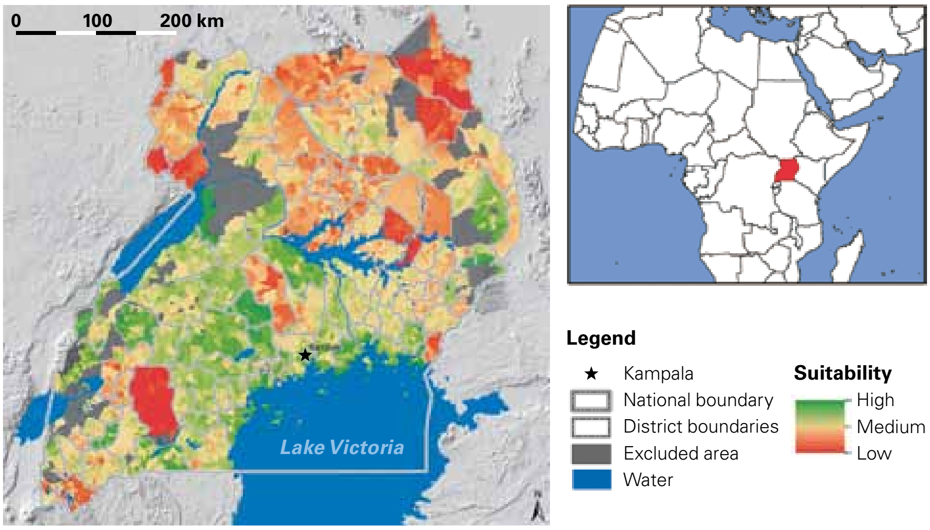


Figure 1: Suitability map for the distribution of household water filters in Uganda (unweighted).

Methodological approach

Various fields use GIS to support decision-making as it is well suited at handling and visualizing large data sets from different sources. It has not yet been applied, however, to drinking water treatment. Our method involved combining GIS with MCDA since the latter offers a sound way to structure decision making processes. A list of criteria was developed from literature analysis and expert surveys and their relative importance assessed by interviews with local experts. Criteria maps were created with GIS and a weighted linear combination of criteria and weights was used to derive the final suitability maps. The sensitivity of the results in terms of criteria, different weighting scenarios and resolutions were evaluated and data uncertainty assessed.

Criteria and weights

The following criteria were identified: accessibility – travel time from Kampala; competitors, i.e., organizations distributing water treatment products for free; the prevalence of water-borne diseases; income level, i.e., household income and poverty rates; the presence of partners, such as NGOs and health centres; population density; and access to improved water sources. Local experts had differing opinions about the criteria. Government experts assigned more influence to impact-related criteria: water access and disease rates, while private sector experts considered accessibility, income and population density as the most important.

Suitability analysis

Suitability analysis combines the criterion map layers and the respective weighting schema. In a first assessment, the data layers are aggregated without weighting (See Figure 1). Central and Western Uganda are shown to be generally more suitable for household water filter distribution than Northern Uganda. The most notable exception is the Kiruhura district in the Southwest, where the lowest suitability in the whole country was found, due to low population density, low precipitation and relatively large-scale ongoing household water treatment interventions. The low suitability in Northeast Uganda is due to low accessibility, high poverty rates and low population density.

A similar pattern was observed, using the weighting schema based on the opinions of government experts. The slight differences were mainly due to areas with low access to improved water sources and high water-borne disease rates. A different data structure emerges when using only private sector opinions. Accessibility and income levels were weighted higher than other criteria; therefore, areas around Kampala become more suitable for household water filter distribution, while north of Lake Kyoga was unsuitable.

The sensitivity assessment showed that 33 percent of the 112 districts were non-sensitive to variation criteria, resolution and weighting schemas. From these non-sensitive areas, three districts: Kiboga, Bundibugyo and Namayingo, show very high suitability across all weighting schemas. They can be recommended as areas where household water filter distribution could start.

Conclusion

This study demonstrated that the GIS-based MCDA method is useful at handling complex decision making about where to locate household water treatment projects. It readily defined the areas with the highest potential for water filter distribution.

[1] University of Bern
[2] Eawag/Sandec, Switzerland
Contact: maryna.peter@eawag.ch

Anthropogenic Chemical Pollutants in Low- and Middle-Income Countries

In the water, sanitation and hygiene sector, microbial health risks get much attention. There is, however, increasing concern about chemical pollution worldwide and its impact on environmental and human health. This article summarizes current research at Eawag on this topic. Frederik Weiss[1], Christian Zurbrügg[1], Rik Eggen[1]

Introduction

The production and use of chemicals is increasing, as is their impact on environmental and human health, especially in low- and middle-income countries (LAMICs). Chemical substances, for example, are used in agriculture to reduce crop yield losses by pests, for livestock rearing, and in human health care. Certain industrial processes, such as mining, require chemical substances, and chemicals are used in the metallurgical-, electronic-, and construction industries. Eawag is currently researching the chemical pollutants caused by the mining, pharmaceutical and agricultural industries, and e-waste processing.

Increase in chemical production

The world's population is growing and living standards are increasing, intensifying the global demand for chemicals. As a result, their production, use and impact are bound to increase, particularly in LAMICs. Chemical production has considerably shifted from higher income countries (HICs) to LAMICS over the past decade [1]. Data from the United States Geological Survey [2] show the regions with a high production of hazardous mining commodities and consequent possible regions at risk (See Figure 1).
Chemical pollution is increasing, specifically in LAMICs, where regulations and their enforcement are weak, infrastructure is lacking, obsolete production techniques are often used, and disposal of waste is poorly managed [4, 5, 6]. Yet, comprehensive information about the amount and impact of chemical pollution is difficult to obtain, making it impossible to fully assess the level of chemical contamination and the risks this poses to human and environmental health. Obtaining a comprehensive overview of the situation is a high priority in order to pinpoint the most important and hazardous sources of anthropogenic chemical pollution and encourage discussion that could lead towards appropriate management and mitigation options.

Objectives

The main objectives of Eawag's research are to: 1) identify chemical sectors or substance classes that are of the highest environmental concern; 2) assess the current state of the environmental burden caused by industry, particularly in LAMICs, by using publicly accessible data; 3) identify high risk areas; 4) develop general approaches for environmental remediation and recommendations on how to avoid pollution by using effective and affordable methods; and 5) identify areas of research where Eawag can contribute and lead to improvements in the environmental conditions in regions at risk.
This study relies on literature review and information from scientific publications, news articles, reports, and webpages of specialized organizations and NGOs. It also involves contacting experts and making maps, using conventional geographic information system software, to show data.

Conclusion

There have been international initiatives that focus on sound chemical management and use, such as the Strategic Approach to International Chemicals Management and the Basel, Rotterdam and Stockholm Conventions. However, there is still a pressing need to improve the implementation and enforcement of international regulations concerning chemicals.
More data is also required on the industrial production and use of chemicals, particularly in LAMICs, as this would allow for better and more effective evaluation of the risks that they cause. Research should also be promoted to develop innovative, effective and affordable techniques for the environmental remediation of chemical pollution.
On the governmental and jurisdictional level, sound policies, enforced regulations and standards, and economic incentives need to be increased to limit chemical pollution in the environment and its concomitant negative impact on environmental and human health. This would foster more sustainable, environmentally friendly and ethical industrial production of chemical commodities. The comprehensive report of Eawag's research will be available online by the end of 2014.

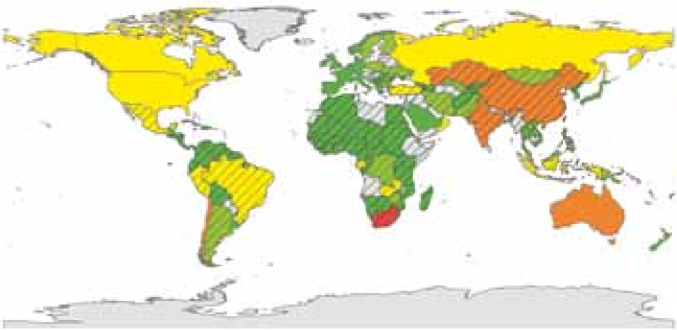


Figure 1: Locations of hazardous mining commodities production [2, 3].

[1] European Chemical Industry Council. The European Chemical Industry in Worldwide Perspective Facts and Figures 2012.
[2] U. S. Geological Surveys. Mineral Commodity Summaries 2013.
[3] Barrientos M., Soria, C. (2013): Indexmundi, (http://www.indexmundi.com/en/commodities/minerals/).
[4] International Labour Office. (2012): The Global Impact of E-Waste Addressing the Challenge.
[5] African Ministerial Conference on Environment and United Nations Environment Programme. (2004): Africa Environment Outlook - Our Environment, Our Wealth.
[6] United Nations Environment Programme. (2012): Global Chemicals Outlook Towards Sound Management of Chemicals.

[1] Eawag/Sandec, Switzerland
Contact: frederik.weiss@eawag.ch

Upcoming IWA-Eawag/Sandec Publication

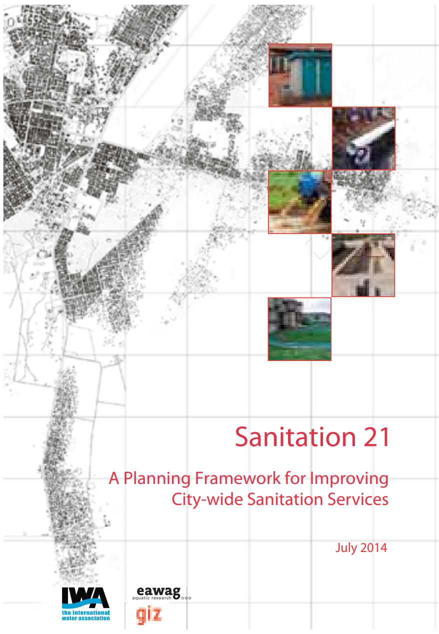
Sanitation 21 – A Planning Framework for Improving City-wide Sanitation Services. J. Parkinson, C. Lüthi and D. Walther

Sanitation21 aims to support municipal and local authorities prepare rational and realistic citywide sanitation plans. It outlines key principles and process guidelines concerning appropriate and affordable solutions to sanitation problems, and promotes the strategy of embedding decisions about service delivery improvements in local contexts. It is also a guide for planners/designers that draws on various approaches, including the SSA and the HCES. And it helps to bridge institutional analysis and technical planning by bringing together service delivery arrangement decisions with management options, institutional arrangements, and technology issues.

The Sanitation21 objective is to provide:

- A vision that planning sanitation improvements needs to be shared among different city stakeholders.
- A definition of clear and realistic priorities for city-wide improvement.
- A comprehensive sanitation development plan for the entire city that corresponds to users' demands and the different physical and socio-economic conditions.
- A supportive institutional environment in regard to policy and governance that promotes the implementation of the plan's proposed components.

The publication (36 pages) will be available in September 2014 on the Sandec website and at IWA's WaterWiki: www.iwawaterwiki.org/xwiki/bin/view/Articles/WebHome.



First Book Dedicated to Faecal Sludge Management

Over a billion people in urban and peri-urban areas of Africa, Asia, and Latin America are served by onsite sanitation technologies. Until now, the management of faecal sludge resulting from these onsite technologies has been grossly neglected. Financial resources are often lacking, and onsite sanitation systems tend to be regarded as temporary solutions until sewer-based systems can be implemented. However, the reality is that onsite sanitation is here to stay, either as an intermediate or permanent standalone solution, or in combination with sewer-based systems. The appropriate and adequate management of faecal sludge deriving from onsite technologies is imperative for the protection of human and environmental health.

Faecal Sludge Management: Systems Approach for Implementation and Operation compiles the current state of knowledge of this rapidly evolving field, and presents an integrated approach that includes technology, management and planning. It addresses the planning and organization of the entire faecal sludge management service chain, from the collection and transport of sludge and treatment options, to the final enduse or disposal of treated sludge. In addition to providing fundamentals and an overview of technologies, the book goes into details of operational, institutional and financial aspects, and provides guidance on how to plan a city-level faecal sludge management project with the involvement of all the stakeholders.

The book is published by IWA and is available as a free PDF download on the Sandec website: www.sandec.ch/fsm_book. Hard copies can be purchased at the IWA website.

Forthcoming Event

3rd International Faecal Sludge Management Conference
18–22 January 2015 Hanoi, Vietnam

The 3rd International Conference on Faecal Sludge Management (FSM3) aims to share research and experience, and build upon practical developments since the last FSM2 Conference, which was held in Durban, South Africa, in October 2012. FSM3 is organised by the World Smart Capital Initiative, a non-profit organisation that provides a platform for cities on social and sustainable urban innovation.

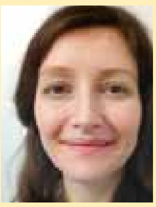
FSM3 will provide a forum for researchers, policy makers, practitioners and service providers with the aim to foster a productive dialogue on emerging technological and management solutions and promote effective approaches for the implementation of viable FSM solutions at scale. → For more information, please contact: organisation@fsm3.org

The Sandec Team

From left to right:
Front row: Innocent Kamara, Maryna Peter, Moritz Gold, Chris Zurbügg, Linda Strande, Paul Donahue, Jasmine Segginger, Caterina Dalla Torre, Frederik Weiss, Magalie Bassan, Hussain Etemadi, Sara Marks, Regula Meierhofer
Back row: Parfait Kouame, Phillipe Reymond, Christoph Lüthi, Imanol Zabaleta, Lukas Ulrich, Matthias Saladin, Lars Schöbitz, Fabian Suter, Sämi Luzi
Missing in photo: Ulrike Messmer, Christian Riu Lohri, Bart Verstappen

New Faces

Jasmine Segginger, Diplomas in Commercial Business and Event Management, initially worked for several years in the hotel industry in Switzerland. She was also employed as an Assistant CEO/Office Manager at a Lighting Design company, and began at Eawag in June 2013 in the Environmental Chemistry Department. Since January 2014 she has been an Administrative Assistant in the Environmental Social Sciences Department, and supports the Head of Sandec in various administrative issues, scheduling and project finances.



Sara Marks joined Sandec in April 2014 as Group Leader of the Water Supply and Treatment team. Sara received a PhD in Environmental Engineering and Science from Stanford University and completed a postdoctoral fellowship at Johns Hopkins Bloomberg School of Public Health in the United States. In the coming year, her group will focus on developing water supply monitoring tools under the post-2015 Agenda for Sustainable Development. She will also investigate health, gender, and environmental quality aspects of multiple-use water services. Project case studies are planned for rural Burkina Faso, Tanzania, and Nepal.

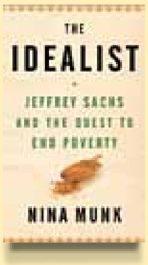
Arnt Diener, MSc in Environmental Science from Wageningen University, joined Sandec's water supply and treatment research group in August 2014. During the past two years he worked on rural environmental risk management in Ghana and supported the development of market-based solutions. He will coordinate the fieldwork for projects on household water treatment solutions in Nepal and multiple-use water systems in Tanzania.

Samuel Renggli, MSc in Environmental Engineering from ETH Zürich, specialised in urban water management. After completing an internship in India and a civil service in Zambia with Sandec, he will join the environmental sanitation planning group in September 2014. He will be the project officer for an applied research and development project on improving the sanitation planning in small towns of Bolivia. He will also further investigate WASH related issues in the context of maternal health and menstrual hygiene in India and Uganda.

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.

The Idealist:
Jeffrey Sachs and the Quest to End Poverty



The concept behind much of Jeffrey Sach's work is that the technologies (vaccines, pesticides, water filters, etc.) exist to end poverty, but that there is just not enough investment. He believes that if enough money and resources are dedicated in a multi-sector "big push", poverty can be eradicated. With $120 million in funding, he set up the "Millennium Villages Project" in 2006. It was meant to be a five-year demonstration of his ideas in practice: 12 communities across Sub-Saharan Africa were chosen to become examples that would be scaled up and replicated around the world, once the experiment was a success.
In writing this book, Nina Munk had unprecedented access to both Jeffrey Sachs and the Millennium Villages, and what she found was very different from the vision put forth in 2006. She explains clearly and methodically how a goal-driven, top-down development eventually led to the collapse and disbanding of the Millennium Villages Project. For anyone who has worked in large development projects, this story will be disappointing, but all too familiar. From unexpected results, to miscalculated budgets, to a fundamental disregard for local customs, *The Idealist* is a fascinating look into top-down decision-making and how it can lead to tragic consequences. It is smart, funny and engaging without preaching about the clear path to ending poverty, something that the Idealist himself could take a few notes from.
By Munk, N., Doubleday, 2013, 272 pages, ISBN: 9780385525817.

Municipal Solid Waste Management

Toward Sustainable Municipal Organic Waste Management in South Asia: A Guidebook for Policy Makers and Practitioners

This report aims to align South Asian cities with ADB's Strategy 2020 for environmentally sustainable growth and liveable cities. It provides a useful management resource, identifying key issues and pointing policy makers, city managers, and practitioners to improved waste treatment technologies.
By the Asian Development Bank, 2011, 88 pages, ISBN: 9789290924128.
It is available as a pdf download at: http://goo.gl/8dneDV.

Excreta and Wastewater Management

Fuel potential of faecal sludge: calorific value results from Uganda, Ghana and Senegal
This article provides an overview of research that tested the viability of using faecal sludge (FS) as solid fuel in three cities, Kumasi, Dakar and Kampala. FS samples were tested for their calorific value, and solids and water content, and experiments were done on how to properly dry the FS to make it more readily usable as a fuel. The results indicate that sufficient drying occurs within two weeks in open-air drying beds, or in a matter of days with simple drying bed innovations.
By Muspratt, A. M. et al., Journal of Water, Sanitation and Hygiene for Development, 2014, *4 (2)*, pp. 223–230. It is available as a pdf download at: http://goo.gl/CH5Qlf.

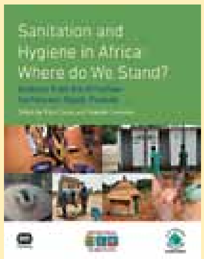
A value proposition: Resource recovery from faecal sludge—Can it be the driver for improved sanitation?
This article provides an overview of a study that evaluated the potential for resource recovery from innovative faecal sludge treatment processes to generate a profit that could help sustain the sanitation service chain. Products identified to have potential market value include dry sludge as a fuel for combustion, biogas from anaerobic digestion, and protein derived from sludge processing as animal feed. The findings should help policy and decision makers of sanitation services to design financially viable management systems based on resource recovery options.
By Diener, S. et al., Resources, Conservation and Recycling, *88*, (July 2014), pp. 32–38. It is available as a pdf download at: http://goo.gl/CH5Qlf.

Strategic Environmental Sanitation Planning

How to Design Wastewater Systems for Local Conditions in Developing Countries

This manual provides guidance in the design of wastewater systems in developing country settings. It promotes a context-specific approach to technology selection by guiding the user in the selection of the most suitable technologies for their area. It provides tools and field guides for source characterization and site evaluations, as well as technology identification and selection. The manual is primarily addressed to private and public sector service providers, regulators and engineers/development specialists in charge of implementing wastewater systems.
By Robbins, D.M. and Ligon, G.C., IWA Publishing, 2014, 130 pages, ISBN: 9781780404769.

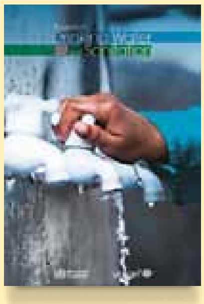
Sanitation and Hygiene in Africa: Where do We Stand? Analysis from the AfricaSan Conference, Kigali, Rwanda



This book takes stock of progress made by African countries through the AfricaSan process since 2008 and the progress needed to meet the MDG on sanitation by 2015 and beyond. It addresses priorities which have been identified by African countries as the key elements that need to be addressed in order to accelerate the rate of access to sanitation in Africa. It presents in depth, much of the learning and knowledge generated at AfricaSan 3, which took place in 2011 in Rwanda. The book is essential reading for government staff from Ministries responsible for sanitation; sector stakeholders working in NGOs, CSOs and agencies with a focus on sanitation and hygiene; and water and sanitation specialists.
By Cross, P., and Coombes, Y., IWA Publishing, 2014, 191 pages, ISBN: 9781780405414.
It is available for download at: http://goo.gl/XEO5wq.

Water Supply and Treatment

Progress on Drinking Water and Sanitation – 2014 update



Even though progress towards the Millennium Development Goal targets represent important gains in access to drinking water and sanitation for billions of people around the world, it has been uneven. Sharp geographic, sociocultural and economic inequalities in access persist and sometimes have increased. This report presents a progress update on MDG goals; highlights the stark disparities across regions, between urban and rural areas, and between the rich and the poor and marginalized; and provides a framework for monitoring WASH goals post-2015. It demonstrates that, with concerted efforts, water and sanitation for all is attainable.
By UNICEF and WHO, 2014, 75 pages, ISBN: 9789241507240.
It is available as a pdf download at: http://goo.gl/5WdWzj.