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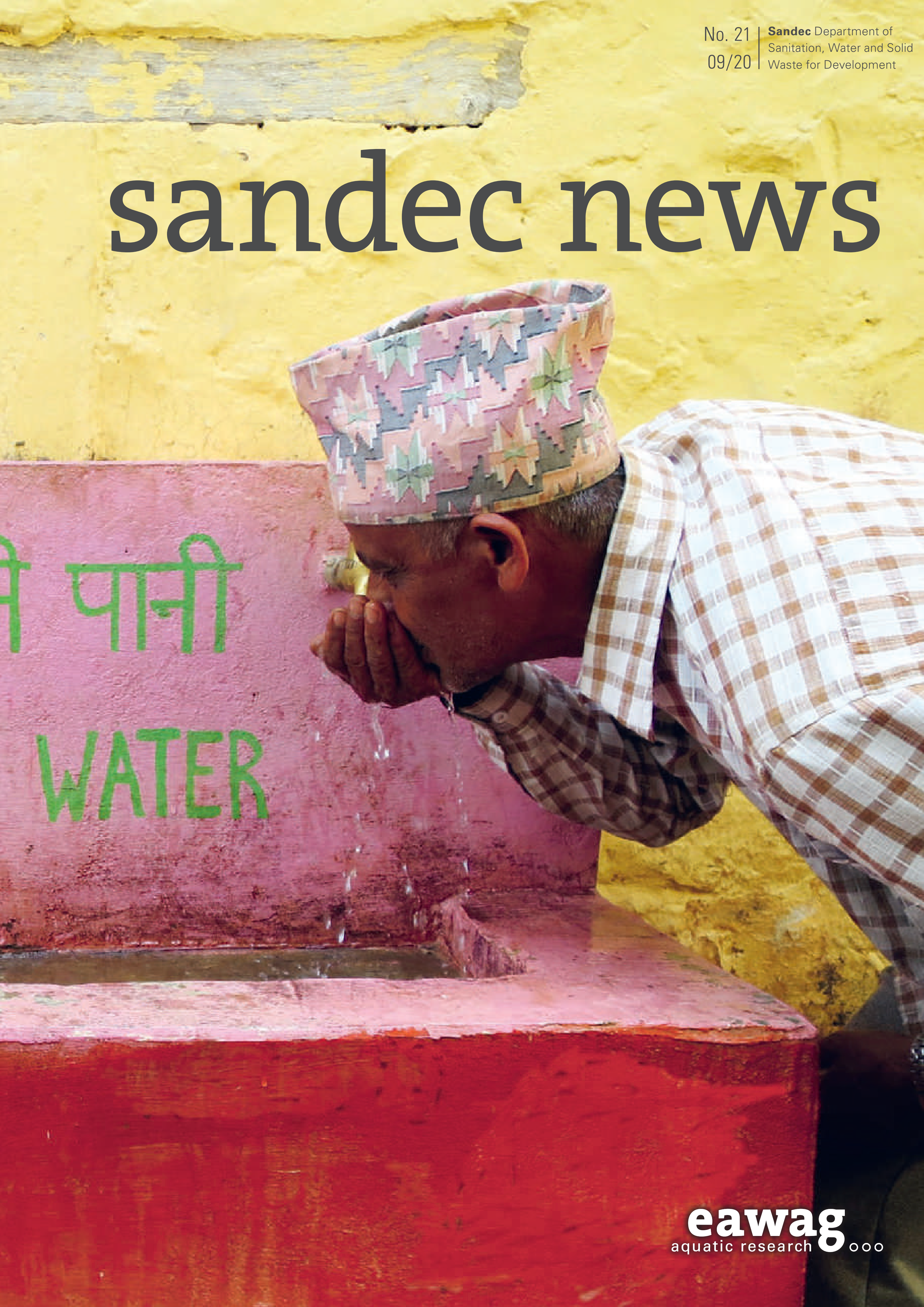

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Cover-Photo This picture was taken at the Khand Devi Secondary School, in Satakhani (Surkhet, Nepal). Helvetas Swiss Intercooperation Nepal together with the local NGO SAC Nepal supported this school to transition to a BLUE school (a WASH and environmental friendlier school). The drinking water stand on this picture is supplied by water treated with a UV filter and is safe to drink. The microbial water quality was tested and confirmed by a field laboratory installed as part of the REACH project (Sandec/Helvetas).

Photo by Ariane Schertenleib.

Water, sanitation and solid waste research are essential to protect public health.

Although the Corona pandemic has radically changed the way we live, work and conduct research, good hygiene and sanitation practices remain one of the best ways to protect public health, and the work of Sandec continues. Travel internationally for work or to international events, such as the World Water Week or FSM6, is not possible. However, we stay well connected virtually with our global project partners from our home offices, and find new ways to interact. Through online meetings, we remain in frequent contact, while greatly reducing our carbon footprint. We hope to continue applying the lessons we are learning for a more green future after the Corona pandemic ends.

We have had more time for reflection and writing, and have received new project funding. Two new projects with the International Federation of the Red Cross (IFRC) focus on WASH in refugee camps. The first is to strengthen the role of WASH committees in ensuring basic water and sanitation services during the pandemic, and the second assesses whether psychological ownership of handwashing devices increases handwashing. We have also received funding to expand our faecal sludge dewatering research with the aim to get our research more rapidly into action and uptake. We are developing departmental publications that reflect Sandec's long-term experience, such as the upcoming publication *A Sanitation Journey*, and a literature review on *Key Advancements in Water, Sanitation and Solid Waste for Development*. With our partners, we have finalised the forthcoming milestone IWA publication, *Methods for Faecal Sludge Analysis*, which is the first step in standardising the data collection and analysis methods required to advance scientific knowledge in this sector.

An indicator of how people are adapting their work and learning habits is enrolment in our Massive Open On-line Courses (MOOCs), where there has been a more than 5-fold increase in participant numbers in the past months. To address the challenges of disseminating knowledge and facilitating learning, this platform communicates our research findings, making them globally accessible to learners in the private and public sectors. In this regard, we have strengthened our eLearning efforts with the long-term employment of Fabian Suter as Sandec's "Digital Learning Manager". He will ensure that our research reaches a wide audience by developing quality educational training materials.

To assess the potential relevance and influence of our work, Sandec evaluated the impact of our research and capacity development efforts on 10 of the 17 Sustainable Development Goals (SDGs). The report, Eawag-Sandec's Research & Capacity Development Projects and the Sustainable Development Goals (SDGs), is available on our website.

Now, more than ever, please keep in touch with us via our social media channels on Facebook, YouTube, Twitter and Instagram, where we regularly post about new projects and events!

Stay healthy, stay safe
Linda Strande & Christoph Lüthi

Municipal Solid Waste Management

Municipal solid waste management is one of the major environmental challenges of urbanisation. Together with local partners, Sandec's research focuses on developing innovative concepts and appropriate solid waste management solutions with a strong emphasis on recycling approaches. Special consideration is given to:

- Researching how to treat biodegradable (i.e. organic) municipal waste and using appropriate technologies to derive products of value, thus, generating incentives and business opportunities in waste management.
- Assisting decision-makers with tools to apply sustainable and integrated waste management approaches, including financial mechanisms for cost recovery and cash flow, and evaluation of strategic alternatives.

Photo Staff of the waste management department transfers waste from a cart to a compactor truck in Bac Ninh, Vietnam. The high organic fraction in solid waste can be recycled by a variety of treatment approaches as studied in the projects FORWARD, SIBRE and SOWATT.

Photo by Adeline Mertenat.

From a Black Soldier Fly Pilot Site to Widespread Implementation

The Black Soldier Fly biowaste conversion system has proven to be technically and financially viable, with a showcase site developed in Sidoarjo, Indonesia. Now, the FORWARD project is assisting partner sites across Indonesia in setting up and optimising the developed system. Bram Dortmans[1], Julia Egger[1], Christian Zurbrügg[1]

Introduction

The FORWARD project (From Organic Waste to Recycling for Development) was set up in 2013 with the Indonesian Ministry of Public Works (PU-PR), and funded by the Swiss State Secretariat for Economic Affairs (SECO). Now, in the final third phase, the project assists 12 partners in developing and improving their Black Soldier Fly (BSF) waste conversion systems (Figure 1). This is possible thanks to the first two project phases, during which substantial experience was gained at the pilot site. This site proved that a small-to-medium-scale (1–2 tonnes/day) system, converting organic waste into protein-rich BSF larval biomass and a compost-like residue, is technically viable. Harvested larvae and compost can be directly marketed or further processed before being sold.

Activities

Given the limited resources available to assist in implementation, the 12 partners were carefully selected throughout Indonesia (Figure 2) based on three main criteria:

1) The partnership should explore new ways of implementing the BSF waste conversion technology – for instance, by implementing BSF sites within a community/neighbourhood or integrating BSF into the material recovery process of a factory;
2) The partnership should help to achieve specific research goals, such as comparative nursery performance between different setups, different post-processing and feeding trials with larvae, or evaluation of different business models;
3) The partner is committed to continuously collect data on BSF performance (rearing cycle and nursery output, waste conversion performance, etc.) and to share this data with the project team.

Figure 2: Overview of partners and their locations.

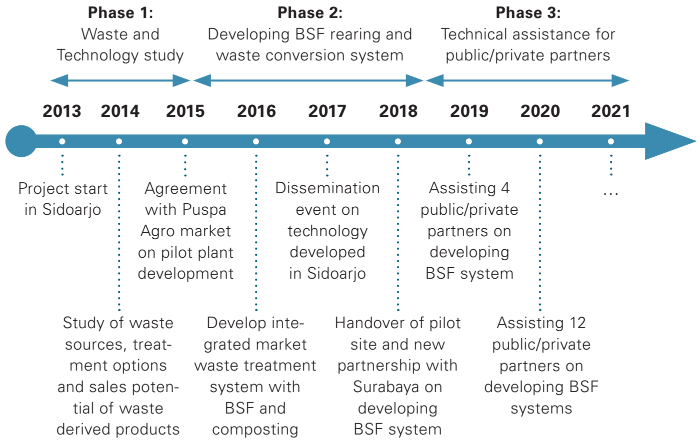

Figure 1: Timeline of FORWARD project with milestones.

Results

The 12 selected partners use the BSF rearing system as developed at the pilot site. There may be variations in scale or differing operational schedules due to local requirements. For waste conversion with BSF larvae, partners in rural areas set up cheaper systems, i.e. by constructing large concrete basins, using frames containing treatment crates, or completely redesigning the waste conversion system. As most partners are still in the start-up phase, the total amount of waste currently being processed remains low (a total of two tonnes/day). Larval yield is 12.5 %, and 10 % of the harvested larvae are post-processed into BSF products. The only site showing economic viability in terms of running costs is the former pilot site, now operated by one of the private partners. It has two revenue streams: the sale of waste-derived products and income from providing hands-on training at the site.

Conclusion

One year remains to achieve the targets of at least five tonnes/day waste treated and one tonne/day larvae harvested, post-processed and marketed by all partners combined. The focus this year is enabling the partners to increase the scale of their systems and post-processing of harvested larvae. BSF biowaste conversion has clearly become mainstream in Indonesia, given the many requests for assistance, the interest of the central government in the BSF system, and the increased use of BSF larvae protein as replacement for fishmeal in animal feed. •

[1] Eawag/Sandec, Switzerland

Funding of the FORWARD project funding is provided by the Swiss State Secretariat for Economic Affairs (SECO) and the project is implemented in Indonesia under a framework agreement with the Ministry of Public Works (PU-PR).

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Marketable Products Made from Black Soldier Fly Larvae

The economic viability of Black Soldier Fly (BSF) waste treatment typically depends on revenues from the sale of conversion products. Different animal feed products made from larval biomass were evaluated for their sales potential at the local pet food market in Surabaya, Indonesia. Julia Egger[1], Bram Dortmans[1], Christian Zurbrügg[1]

Introduction

Valorising organic waste with the Black Soldier Fly Larvae (BSFL) is becoming increasingly popular, especially in low- and middle-income settings, where potential revenues from the sale of conversion products provide an incentive to offset waste management costs. The goal of the Sustainability of Insect-Based Recycling Enterprises (SIBRE) project is to provide evidence of the economic impact of this treatment technology in Indonesia. A market assessment had identified the local pet food market (birds and ornamental fish) as the most promising business prospect for BSFL product sales. SIBRE is analysing product alternatives to animal feed based on BSFL at the market.

Methodology

All newly developed BSFL feed products undergo four product development stages: 1) identifying product manufacturing steps, 2) cost analysis of manufacturing, 3) product testing and 4) product validation. In stages one and two, a standard manufacturing process is developed, and costs are calculated, which include the operating costs of a BSF waste treatment facility (the facility in Surabaya, Indonesia), and the manufacturing costs. After successfully passing stages one and two, products are supplied to retailers in the local market at sales prices based on calculated costs and a fixed margin. Acceptance and competitiveness are tested by evaluating sales data, and retailer and end-user feedback. Specific performance and aesthetic indicators in animals fed with the BSFL product are analysed and compared with those reared on commercial products.

Results

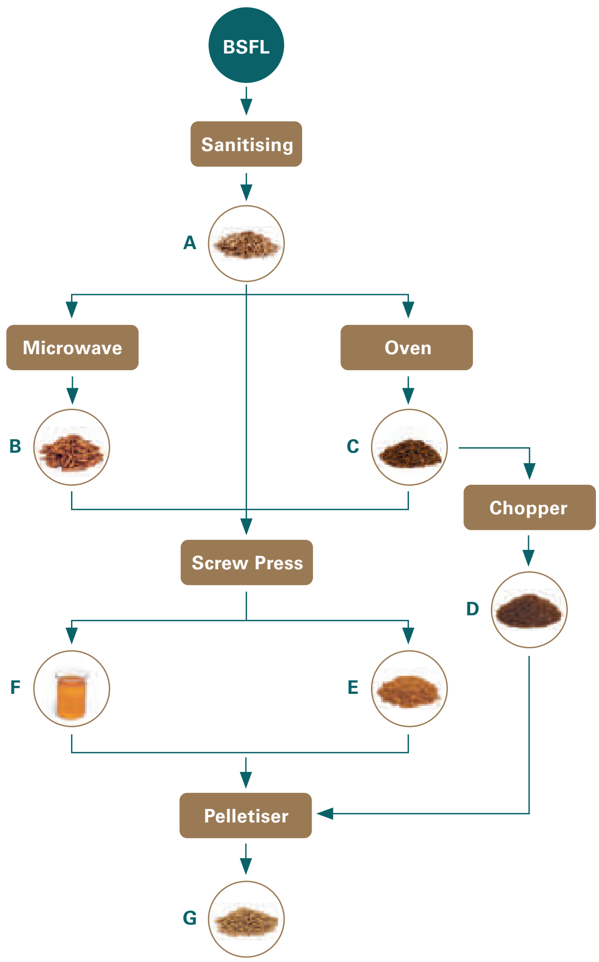
The Figure provides an overview of the production processes for BSFL products in Surabaya. Irrespective of the end-product, postprocessing should start with the sanitising step of rapid boiling. The next step is either microwave or oven drying, followed by pressing, chopping and pelleting to produce different products.

The "pop-larvae" and "crumble" have successfully passed all product development stages, and pop-larvae currently sells the best. Compared to oven-dried larvae, pop-larvae larvae – given their crunchy texture and puffed shape – are more appealing to customers and to the animals being fed. This was validated with various pet animals. Results indicate that pop-larvae could replace common feed, e.g. crickets, and fed to singing birds, ornamental fish, hedgehogs and sugar gliders. The crumble product is mainly used for smaller ornamental fish.

Although standard processes and production costs have been established for BSFL protein meal and oil, market evaluations show low acceptance and high competitiveness. Given the manufacturing costs, sales prices have to be set higher than local fish meal or oil prices. Customers also prefer processed feed, e.g. pellets. Mixing BSFL protein meal and oil into pellets may provide a more profitable option. Different types of BSFL pellets are now being tested in the market.

Conclusion

Based on the current research, the most promising product options for small-scale BSF waste treatment facilities in Surabaya are either pop-larvae or crumble marketed as a replacement for common feed products in the local pet market. Investment costs for the drying equipment are low, and they are simple to operate and implement at BSF waste treatment facilities. Other product options are still being evaluated, and the results will be disseminated to municipalities and enterprises throughout Indonesia. •



Schematic flow diagram of BSFL processing options.
A: sanitised larvae, **B:** pop-larvae, **C:** oven-dried BSFL, **D:** BSFL crumble, **E:** BSFL protein meal, **F:** BSFL oil, **G:** BSFL pellets

[1] Eawag/Sandec, Switzerland
SIBRE project funding is provided by the Swiss Re Foundation.
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Leveraging Waste Data in the World's Cities

The lack of reliable data on waste composition and amounts of waste generated, collected and recovered in cities is a critical challenge in the waste sector. The SDG 11.6.1 indicator assessment and Waste Flow Diagram tool are two new methodologies developed to ameliorate this situation. Imanol Zabaleta[1], Christian Zurbrügg[1]

Introduction

Despite growing awareness of waste management and marine pollution issues, basic data on municipal solid waste (MSW) generation and management are seriously lacking globally, especially in low- and middle-income settings. This lack of data hinders the development of management strategies and investments in infrastructure, leading to insufficient or not enough MSW management services in many countries. Poor MSW collection and disposal can trigger severe threats to public health and pollute air and water. Furthermore, mismanaged waste is the main contributor to plastic pollution in the marine environment.

There was an estimated 2 billion tonnes of MSW in 2016, and experts expect this number to grow to 3.4 billion tonnes by 2050, considering the global scale of urbanisation and economic growth [1]. If the municipal solid waste management (MSWM) challenges remain unaddressed, the negative impact that mismanaged waste has on human health and the environment will significantly affect all nations, no matter their level of development. This article introduces two new assessment methods developed to quantify MSW amounts in cities that offer solutions to their MSWM challenges.

Objective

Many new initiatives that address current MSWM challenges deal with the lack and/or unreliability of MSW data. The Sustainable Development Goal (SDG) 11.6.1 indicator assessment [2] and the Waste Flow Diagram (WFD) [3] tool also deal with these issues. UN-Habitat, the custodian agency of SDG 11.6.1, and Wasteaware, Eawag and the University of Leeds (UoL) have developed a methodology and step-by-step guide to assess the 11.6.1 indicator, measuring the *"proportion of municipal solid waste collected and managed in controlled facilities out of the total municipal solid waste generated, by cities".* GIZ funded and developed the WFD tool jointly with Eawag, UoL and Wasteaware. The WFD tool is based on an observation-based assessment to measure plastic leakage from MSWM systems.

SDG 11.6.1 and the Waste Flow Diagram

The SDG 11.6.1 assessment method has seven steps (Figure 1) to obtain the data necessary to calculate two sub-indicators (MSW collected and MSW managed in controlled facilities). Step 7 of the methodology consists of the WFD assessment. Doing these assessments require two to three weeks, a team of two to three MSW experts, and a team of at least 20 enumerators (in mega cities 30 enumerators). The enumerator team handles the waste generation and characterisation studies at households (Step 2), and the characterisation exercise at the disposal facility (Step 6). Identifying, then visiting the waste recovery and disposal facilities, making observations, and interviewing facility representatives is the basis of most of the information needed for the 11.6.1 indicator assessment.

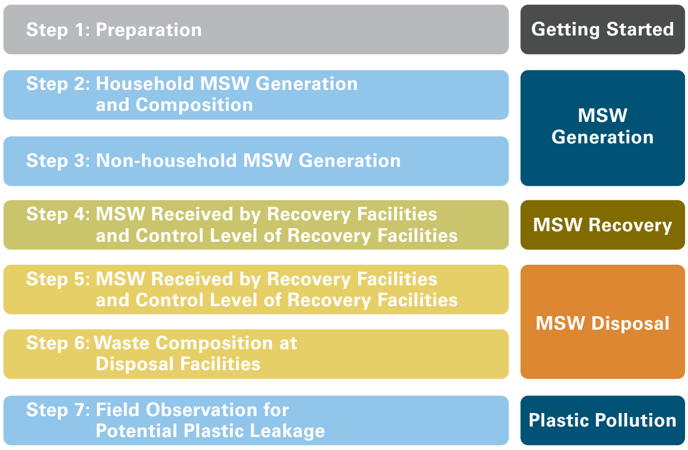

Figure 1: Steps of the SDG 11.6.1 methodology.

The WFD assessment (Step 7) consists of two activities. First, calculating the amounts of all plastic waste leaking from the MSWM system. Then, determining the fates (final destinations) of all plastic waste leakages.

Plastic waste can leak into the environment at each stage of the MSWM system – waste generation, collection, sorting, transportation and disposal. The MSW infrastructure and activities at each stage are *"leakage influencers",* according to the WFD tool. These affect the stages' *"leakage potential"* (using a scale from none to very high). The tool provides descriptors and "leakage factors" for each leakage potential. The user decides which descriptor best fits the observed reality. Based on this, the WFD tool automatically assigns the corresponding leakage factors (expert-estimated) to calculate the percentage of plastics that (could) leak into the environment at the different stages of the MSWM system.

Determining the final fates of the plastic leakage from each stage into the environment follows a similar observation-based approach. Users assess the amount of plastic they see on land, in storm drains, at open burning sites or in waterbodies. A description table helps them to assign a *"fate factor",* used to determine how much plastic leakage ends up in each fate.

Case studies

Testing of the SDG 11.6.1. indicator assessment and the WFD tool took place in different cities, resulting in good MSWM data. This enabled well-grounded comparisons between them. The Table shows the results of the assessments done in Nairobi (Kenya), Mombasa (Kenya) and Fnideq (Morocco). Figure 2 shows the WFD results of Fnideq, indicating that 3 % of the plastic waste generated ends up in water systems. This represents 1.7 kg / cap / year of plastic pollution.

Conclusion

User manuals, as well as video tutorials on how to do the SDG 11.6.1 indicator assessment and the WFD assessment, are now being finalised to facilitate their application. Increasing people's capacities to apply these tools could make the MSW datasets of cities and countries more accurate and improve MSWM evidence-based policymaking and interventions.

UN-Habitat is currently starting to leverage MSW data from a large number of cities throughout the world with the goal to set a global baseline for the SDG indicator 11.6.1 by late 2020. The aim is to motivate cities to prioritise and implement improvements in MSWM. Doing the assessments now and repeating them until 2030 will give an indication of whether the 2030 Agenda for the SDG 11.6 target is on track. •

References

[1] S. Kaza, L.C. Yao, P. Bhada-Tata, F. Van Woerden, *What a Waste 2.0 : A Global Snapshot of Solid Waste Management to 2050* (World Bank, 2018).

[2] UN-Habitat, (in press) *Waste Wise Cities Tool: SDG 11.6.1. A step-by-step guide for a rapid assessment of SWM systems in cities.*

[3] GIZ, University of Leeds, Eawag-Sandec, Wasteaware, (in publication) *User Manual: Waste Flow Diagram (WFD): A rapid assessment tool for mapping waste flows and quantifying plastic leakage. Version 1.0.* Will be available at: http://plasticpollution.leeds.ac.uk.

[1] Eawag/Sandec, Switzerland

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		Nairobi (4.6 million)		Mombasa (1.4 million)		Fnideq (92'000)	
		t/day	(%)	t/day	(%)	t/day	(%)
Total MSW generation		2'977		879		77	
SDG 11.6.1	MSW collected	2'215	74 %	405	46 %	70	91 %
	MSW managed in controlled facilities	654	22 %	42	5 %	66	86 %

Table: SDG 11.6.1 indicator assessment results from three case studies. The population size of each city is under the city name.

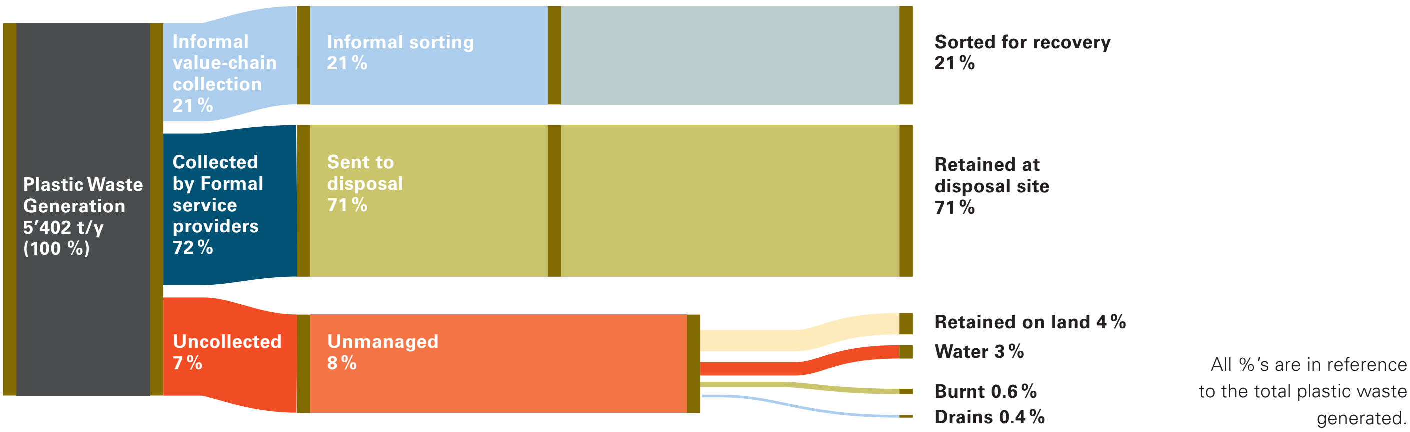


Figure 2: Plastic flow diagram for Fnideq (Morocco).

A Balanced Waste Diet for Black Soldier Fly Larvae

Biowaste treatment performance with Black Soldier Fly Larvae (BSFL) is often unreliable when treating different biowastes. Feeding BSFL with formulations of biowaste mixtures based on protein and digestible carbohydrates can increase performance reliability and efficiency. Moritz Gold[1,2], Cecille M. Cassar[1,2,3], Davis Ireri[4], Alexander Mathys[2], Christian Zurbrügg[1]

Introduction

In recent years, there has been a significant increase in treating biowaste with Black Soldier Fly Larvae (BSFL) worldwide. BSFL can convert a wide variety of biowastes into a compost-like residue and larval biomass. These are the raw materials for the production of high-value marketable products, such as animal feed and fertiliser.

The criteria for measuring the performance of BSFL biowaste treatment are typically waste reduction, bioconversion rate, larval weight and larval composition. A key challenge for BSFL biowaste treatment operators is variable and low treatment performance when using the same type of biowaste (e.g. different vegetable wastes) and when treating different waste types (e.g. vegetable waste compared to mill by-products). This affects day-to-day operation and compromises the sustainability (e.g. product output and revenue) and scalability of this treatment technology. A recently published article presents a systematic approach to increasing process performance by formulating a BSFL diet with balanced protein and digestible carbohydrate content [1]. The article is available free of charge at: https://cutt.ly/QyyiPhg.

Formulation of biowaste mixtures

As shown in the Table, the nutrient contents and ratios of different wastes vary widely. We hypothesised that formulating mixtures of biowastes to obtain both similar protein and digestible carbohydrate (i.e. starch and glucose) contents and similar protein and digestible carbohydrate ratios would result in similar process performance. Six different biowaste mixtures (referred to here as formulations) were set up with mill by-products and two to three other wastes to obtain 14–19 % protein and 13–15 % digestible carbohydrates (all based on dry mass).

Controlled feeding experiments

The next step was to perform feeding experiments with the same process parameters (i.e. feeding rate, larval density, feeding intervals, etc.). Eighty BSFL with a weight of 3.8 mg were placed in plastic containers (7.5 cm diameter, 11 cm height) and fed every three days for a total treatment duration of nine days. The treatment performance metrics were survival rate, waste reduction, bioconversion rate, waste conversion efficiency and protein conversion efficiency. These were calculated based on dry mass to account for different initial and final larval water content, and evaporation during the experiment. All results were expressed relative to poultry feed, which was used as a high performance benchmark.

Results of feeding experiments

As expected, results for all performance metrics varied when each waste was individually treated by BSFL, as each waste had a different nutrient content. For example, as shown in part A of the Figure, waste reduction was lower for all of the wastes when compared to the poultry feed. The lowest was cow manure and the highest vegetable canteen waste and mill by-products. Similar trends were observed for other performance metrics.

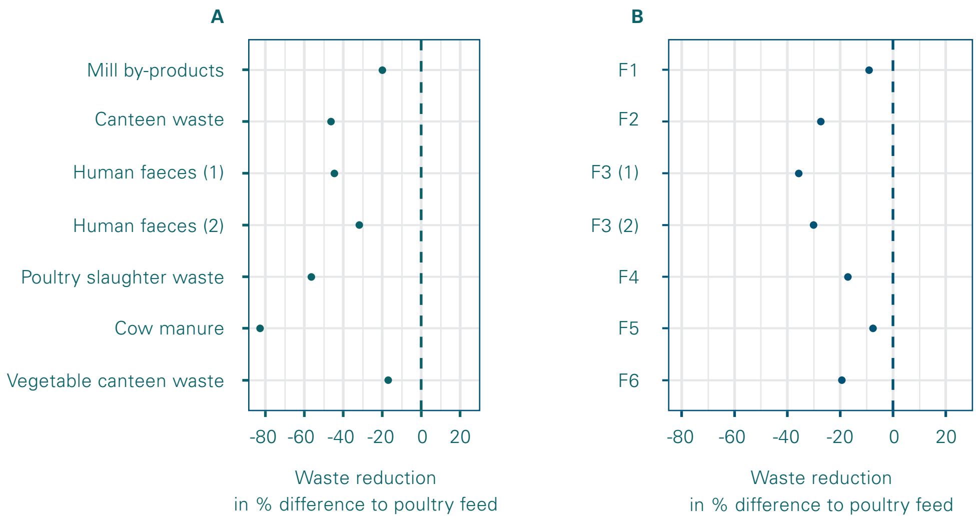
Compared to the set-up using each waste alone, the use of formulations significantly increased survival rate, waste reduction (part B of the Figure), bioconversion rate and protein conversion efficiency, but not waste conversion efficiency. However, despite targeting a similar protein and digestible carbohydrate content and ratio, the performance of BSFL reared on the six waste formulations differed significantly.
Comparing A and B in the Figure, it also becomes apparent that using formulations decreases the variability of performance. Relative to poultry feed, the results for the formulations had a range (i.e. difference between best- and worst-performing formulations) of 28 % for waste reduction, 87 % for bioconversion rate, 64 % for waste conversion efficiency and 31 % for protein conversion efficiency. In comparison, selected biowastes alone produced a range of 65 % for waste reduction, 96 % for bioconversion rate, 101 % for waste conversion efficiency and 68 % for protein conversion efficiency.

Limitations

Despite balancing protein and easily digestible carbohydrates, process performance variability was higher than expected. Our assumption is that this is due to the different fibre and lipid content among the formulations. In the formulation feeding experiments, lipid content correlated positively and fibre content negatively with waste

Waste	Proteins	Digestible carbohydrates	Fibres	Lipids	Volatile solids
Mill by-products	14.5	23.2	51.7	3.0	93.8
Canteen waste	32.2	7.5	36.2	34.9	93.0
Human faeces	20.1	1.7	27.9	20.9	86.4
Poultry slaughterhouse waste	37.3	0.3	20.8	42.9	94.0
Cow manure	11.1	1.8	58.4	4.4	80.7
Vegetable canteen waste	12.1	15.5	31.5	28.9	92.4
Poultry feed (benchmark)	19.1	28.5	22.0	4.8	98.2

Nutrient composition (in % dry mass) of typical biowastes used in BSFL treatment [1].



Waste reduction of A individual wastes and B waste formulations [1].

In practice, biowaste formulation is difficult due to the lack of available data on waste nutrient composition and the intrinsic variability of municipal organic solid waste.

reduction and the bioconversion rate. In practice, maintaining all macronutrients within fixed limits is difficult, considering that wastes vary in the amounts of each macronutrient. Furthermore, the unknown BSFL digestibility of the components of different nutrients and the different microbial numbers that are typical for different biowastes may also influence BSFL treatment performance, in spite of similar protein and digestible carbohydrate content.

Treatment facility implementation

The promising results encouraged the testing of biowaste formulations at a BSFL treatment facility in Kenya. Sanergy collects human faeces from low-income urban areas in Nairobi and treats them with BSFL. For the expansion of the facility, in collaboration with Sanergy, the project assessed the availability, accessibility and nutrient composition of organic wastes to formulate the most promising mixtures of biowastes (i.e., animal manures, vegetable and fruit wastes and hotel waste).

This collaboration demonstrated the practical considerations of working with biowaste formulations at scale. For example, homogenous or high nutrient wastes, such as mill by-products or canteen waste, which accounted for a dry mass proportion of at least 50% in the biowaste formulations used in the previous bench scale experiments, are already used in Nairobi as animal feed. They, therefore, have prohibitively high costs to source. In addition, municipal solid waste is intrinsically very variable. Furthermore, very little data is available on the complete nutrient characterisation of biowastes, especially with regard to digestible carbohydrates, as traditionally biowaste composition is expressed as C and N content or its ratio (C/N). Finally, the benefits of preparing biowaste mixtures need to be compared and balanced with the additional resources required (nutrient characterisation and mixing). •

Reference

[1] M. Gold et al., Biowaste treatment with black soldier fly larvae: Increasing performance through the formulation of biowastes based on protein and carbohydrates, *Waste Management*, 102, (2020), 319–329.

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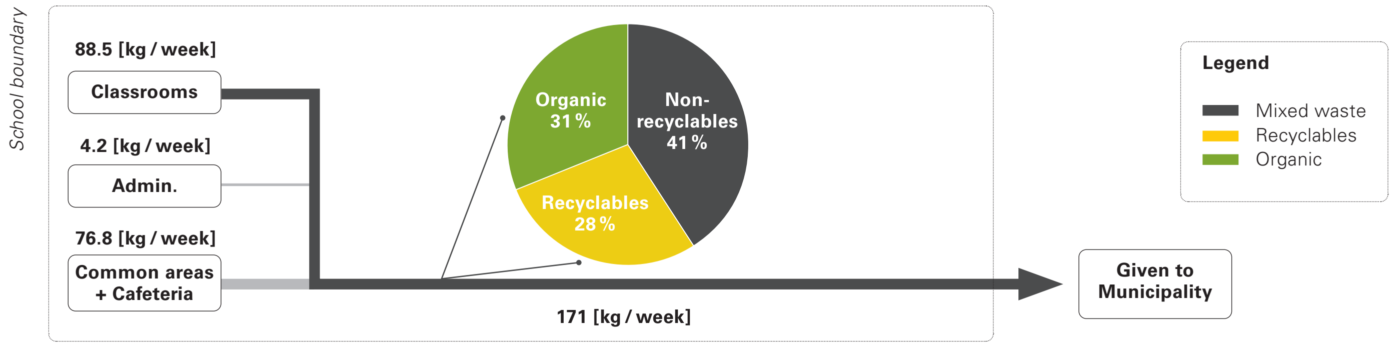
A Zero Waste Approach for a School in the Peruvian Amazonian Rainforest

“Towards Zero Waste at Schools” aims at systematically developing a circular approach to foster sustainable reduce, reuse and recycling practices in schools, and its replication in their communities. The approach was applied at a school in Iquitos, Peru. Adeline Mertenat[1], Anali Ochoa[2], Paloma Roldán Ruiz[2], Christian Zurbrügg[1]



Waste audit results from Cristo Redentor school.

Introduction

“Towards Zero Waste at Schools” (ZW@S) is researching innovative solutions to environmental sanitation issues in schools, maximising synergies between water, sanitation, waste management, food production, health, environment and energy generation. The first ZW@S school was in Kathmandu, Nepal [1]. Knowing about the increasing waste generation rates and waste management-related challenges faced by Latin American municipalities, the project team joined with Ciudad Saludable in Peru to replicate ZW@S in another geographical, social and cultural context. This Lima based NGO, active in the fields of inclusive recycling, integrated solid waste management education and communication, helped to identify the city of Iquitos in the Amazonian rainforest as a site appropriate for ZW@S.

ZW@S approach

The first step was to study and identify the key success and barrier factors of waste-related initiatives and programmes at schools in Peru. Results showed that the Education and Environment Ministries promote a supportive legal and institutional framework for environmental education. Also identified was the need of schools, NGOs, Ministries, etc., for guidance on how to do baseline waste assessments, which are the basis for designing successful integrated zero waste management systems. The school selected for the project was “Cristo Redentor” in San Juan, Iquitos. It has around 400 students at kindergarten, primary and secondary levels. Its director was supportive and showed great interest in working on environmental education, which is part of the school’s ecological vision.

Waste assessment

A key step was to do a waste audit with the help of a teacher’s group (see Figure). The school produces an average of 171 kg of waste per week. The waste is mixed and given to the municipality for further disposal. The audit showed that 31 % is organic, 28 % recyclable (paper, cardboard, PET, etc.) and 41 % non-recyclable. Of the non-recyclable waste fraction, 61 % is dust and fines, while the rest consists of plastic bags (13 %), Styrofoam (2 %), disposable cutlery (11 %) and food wrappers (6 %).

Based on the waste audit results, the school board installed a three-bin segregation system for organic waste, recyclables and non-recyclables to increase recycling. New rules were made to promote waste reduction and decrease the amount of non-recyclable waste. Because 31 % of the waste is organic, setting up a small-scale composting plant at the school and using the compost in the school gardens was a priority.

Next steps

The next steps are to consolidate institutional support and the school’s solid waste management plan, and incorporating environmental education topics in the school’s curricula in a cross-cutting manner. Also on the agenda are establishing educational green areas in the school gardens and promoting good environmental practices among teachers, staff and students. How such interventions at the school can influence the surrounding community will then be evaluated.

Conclusion

Doing an in-depth baseline assessment with the waste audit and communicating the results helped significantly in steering and facilitating actions at the school. Furthermore, the results show that the support and commitment of the school board is decisive for a successful ZW@S project. •

Reference

[1] A. Mertenat et al., Towards a Circular Economy at School – Insights and Best-practices from Nepal, *Sandec News,* 20 (2019) 4 – 5.

[1] Eawag/Sandec, Switzerland
[2] Ciudad Saludable, Peru

We would like to thank Cristo Redentor School for its great support throughout the process, as well as the Swiss Agency for Development and Cooperation (SDC) for funding this research.

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What About Disposable Diapers in Solid Waste Management?

The increasing prevalence of disposable sanitary products coupled with deficient solid waste services threatens human health and the environment. A study in Guatemala analysed current diapering practices to develop and promote improvement options. Adeline Mertenat[1], Andrea Francesca Leoni[2], Wilbert Velasquez[3], Daya Moser[3], Christian Zurbrügg[1]

Introduction

With increasing economic means and access to supply chains, people living in low- and middle-income settings have more access to disposable sanitary products. Their prevalence and increasing use pose a specific challenge for solid waste management. Where solid waste management systems already struggle to provide appropriate services, the shift from traditional reusable to disposable diapers (DD) augments threats to the health of the local population and increases environmental pollution. Inadequately managed diapers are a topic in both the sanitation and solid waste sectors; however, research on their impact and possible solutions is limited.

The present study focused on the use of DD in two rural areas of San Miguel Ixtahuacán, Guatemala. The aim of the project is to establish contamination paths and recommend options for improvement. The communities studied are part of the SAHTOSO project of Helvetas, a Swiss NGO.

Methodology

The project used a qualitative approach to gather information on local diapering practices and associated cultural and social factors via focus group discussions and household surveys among caregivers (Photo). A waste audit was also performed at household level to assess the average diapering frequency. Mass flow analysis was used to analyse and visualise the results. Scenarios for improved DD management were then developed for the household, community and municipal levels, highlighting the respective benefits, challenges and costs. Subsequently, discussions with key stakeholders took place based on the different scenarios to seek consensus on how to improve the current situation.

Results

Of the families studied, 37 % use only DD, 11 % rely on cloth diapers, and 52 % combine DD with cloth diapers on a regular basis, using DD mainly for outdoor activities (market, church, etc.). Among the reasons mentioned by households for using only DD were relief from the stress of having to change diapers frequently (35 %), water shortages (35 %), and time saving (25 %). The main reasons for not using DD are financial limitations (57 %), as well as adverse health effects on the baby's skin (37 %). The waste audit showed that an average of 2.8 ± 1.1 diapers were used daily.

The mass flow analysis revealed that an average of 1 tonne of DD are disposed of weekly in the two areas, with 75 % disposed of at home and 25 % outside. For those disposed outside, 66 % were deposited in public waste bins, while 25 % were littered. Of those diapers disposed of at home, 65 % were not stored but directly discharged, 24 % were unsafely stored (e.g. in an open basket kept indoors or a plastic bag hung outdoors unprotected from the rain) and only 11 % were safely stored. Of all DD disposed of at home,

Ileana Mazariegos

Focus group discussion.

36 % were dumped into the latrine, 30 % burned, 24 % buried in household premises and 6 % given to waste collection trucks.

Out of the scenarios presented, key stakeholders preferred the household level improvement scenario due to reduced logistical efforts and costs. They agreed that construction of a separate waste pit for DD disposal would be most suitable, rather than using the current latrine for disposal. Local families perceived rapid filling of the latrine as a severe financial burden due to the frequent emptying costs.

Conclusion

Doing an in-depth analysis of diapering practices helps citizens, local authorities and public health officials understand that it is a key sanitation and solid waste issue. Further research, however, is needed to quantify the environmental and health impacts, and to develop and promote contextualised solutions. The strong influence of cultural norms and taboos related to diapering was identified; this requires further study, as do social aspects and the involvement of mothers. •

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We would like to thank the team of the SAHTOSO project of Helvetas-Guatemala for their support during fieldwork, Alessio Boldrin from DTU for his supervision, as well as Swiss Humanitarian Aid for funding this research.
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Management of Excreta, Wastewater and Sludge

Globally, urban sanitation problems require equitable, safe and sustainable solutions. Access to safely managed sanitation can be achieved through implementation of a range of appropriate technologies tailored to the realities of rapidly growing cities, with integrated combinations of sewered and non-sewered, and onsite, decentralised and centralised technologies. MEWS research in this area includes:

- Collaborative research: Applied Research to develop the fundamental knowledge required for integrated management and technology solutions.
- Technology innovations: Research safe and effective management of excreta, wastewater and sludge with industrial and implementation partners to meet treatment and resource recovery goals.
- Sustainable implementation: Facilitate the uptake of research and integration of knowledge into policy through dissemination and strategic partnerships.

Photo Emptiers who collect and transport faecal sludge at the Kigamboni faecal sludge treatment plant in Dar es Salaam, testing a distance laser device to measure the dimensions of onsite containment technologies. These trials were part of the development of the Volaser measuring device.

Photo by Clara Pedrini.

Research Strategy for Overcoming the Faecal Sludge Dewatering Bottleneck

Our integrated research strategy to understand faecal sludge dewatering is providing new insights into its fundamental mechanisms, and generating a collection of empirical data. These will be translated into tools for practical applications. B. J. Ward[1,2], Stanley Sam[1,2], Kapanda Kapanda[3], James Madalitso Tembo[3], Eberhard Morgenroth[1,2], Linda Strande[1]

Stanley Sam

Photo 2: Reactors running controlled digestion experiments to mimic storage in onsite containments.

Introduction

Faecal sludge (FS) frequently contains 95–99 % water. High water content makes sludge heavy and expensive to transport, and means solid-liquid separation is necessary for treatment, resource recovery, or safe disposal of waste streams from non-sewered sanitation. However, common FS dewatering methods, such as drying beds and settling-thickening tanks, require large areas and long residence times, limiting capacity at faecal sludge treatment plants (FSTPs) and making them unsuitable in dense urban areas. To extend sanitation coverage to urban areas, high-throughput, low-footprint dewatering technologies (e.g. geotextiles and mechanical dewatering) need to be adapted for use with FS. Making these technologies work effectively with FS requires the ability to monitor and adjust their operational parameters to the high variability in influent faecal sludge. Therefore, our integrated research strategy combines fundamental research (to understand how FS dewatering works on a mechanistic level) with empirical research (to establish predictive models for dewatering performance) and applied research (to adapt this knowledge into schemes for monitoring and process control of dewatering technologies). The demand for tools that fill this knowledge gap is tremendous – new treatment plants are being constructed at an unprecedented rate and there are not enough laboratories or skilled operators to optimise or troubleshoot unpredictable dewatering performance and variable loadings of influent [1].

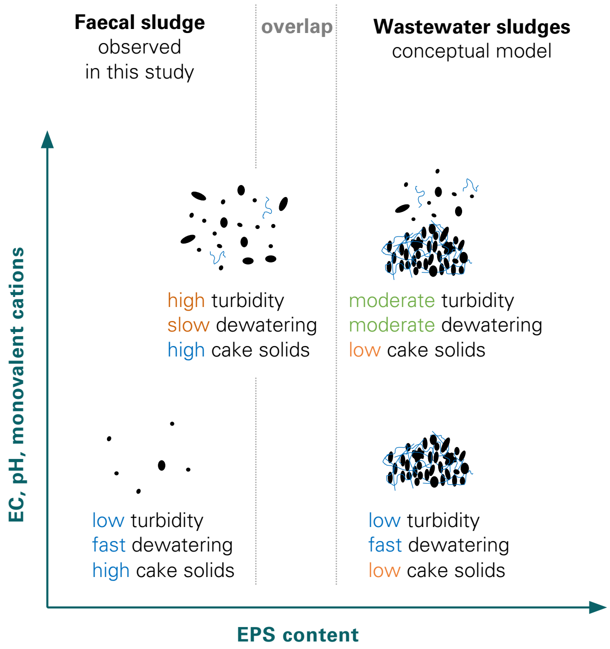
Research approach

Fundamental research has been carried out in Dakar, Senegal, and Dübendorf, Switzerland, focusing on investigating the mechanisms governing FS dewatering behaviour. Since sticky, gelatinous floc networks composed of extracellular polymeric substances (EPS) are largely responsible for poor dewatering in wastewater sludge, the EPS in FS from Dakar were characterised, along with dewatering performance, physical-chemical properties and their microbial community [2]. Ongoing research at Eawag is studying how and why the stabilisation of FS influences its dewatering performance. Batch reactors are used to observe the transformation of EPS during controlled anaerobic stabilisation, with periodic monitoring of dewatering performance.

Our empirical research is testing the conclusions of the fundamental research to identify the empirical relationships useful for FS treatment. Single- and multiple-parameter linear regression was used to evaluate the correlations between the physical-chemical parameters and dewatering performance in six different cities [2] [3]. In Lusaka, Zambia, more than 420 samples from pit latrines and septic tanks were collected and dewatering performance was measured along with other characteristics, e.g. colour, odour, pH, and electrical conductivity (EC), to identify possible easy-to-measure predictors of dewaterability.

B. J. Ward

Photo 1: Faecal sludge with colour checker chart.



Schematic depiction of the relationships between EPS content and physical-chemical parameters of faecal sludge from Dakar, and the currently accepted conceptual model for dewatering behaviour in wastewater sludges. The right side depicts the existing understanding for wastewater sludges and the left the Daker sludge. The area within the grey lines represents the overlap of faecal sludge dewatering with the conceptual model for wastewater sludges. EPS is depicted as blue lines. (Published in [2], licensed under CC BY-NC-ND 4.0).

Our applied research efforts focus on how to transfer fundamental knowledge/empirical research into solutions for better dewatering. A library of FS colour information is being assembled to generate quantitative colour data, which can be used for process control (Photo 1). This work is based on the results from Lusaka.

Outcomes

Fundamental research

Based on the results from Dakar [2], EPS appears to be important for FS dewatering, but differently than for wastewater sludge. High EPS concentrations in FS contribute to filter clogging and high turbidity, while in wastewater sludge they contribute to water-binding. FS with higher EPS behaves more like primary sludge during dewatering, whereas low-EPS FS is not comparable to wastewater sludges (Figure). During the course of data collection in Dakar, the perceived "freshness" of the sludge was found to be related to dewatering performance. This could be due to higher EPS concentrations in fresher, less stabilised sludges, and could help explain why practitioners report poorer dewatering performance in "fresh" sludge than in "older" sludge. Controlled digestion experiments designed to mimic storage in onsite containments confirmed that the EPS concentration decreases as FS is digested (Photo 2). Further experiments to better understand the transformation of EPS during stabilisation, and how it affects dewaterability are ongoing.

Empirical research

Several possible easy-to-measure predictors of dewatering performance have been identified. EC, which can be measured online with a probe, was strongly correlated to dewatering times in Dakar [2], and moderately correlated in Hanoi and Kampala [3]. The relationships between EC and dewatering performance, along with pH, colour and odour, are being validated with data collected in Lusaka. In Dakar, the sludge source (i.e. public toilet or private residence) was a strong predictor of dewatering performance [2], probably due to the level of stabilisation. The sludge source and other possible indicators (e.g. containment type, household income and water table level) were evaluated in Lusaka and are currently being analysed. In upcoming research in Lusaka, anaerobic reactors will be used to evaluate the relationship between stabilisation and dewaterability, and to further validate easy-to-measure predictors.

Applied research

One possible application of our results is a smartphone app that can use colour to predict dewaterability and the level of stabilisation of sludge. The next step will involve testing and adapting empirical relationships between influent predictors at FSTPs. A smartphone app could greatly improve treatment performance, with adaptive loading patterns in settings with no laboratory capacity [1], and/or be combined with online conditioner dosing to allow for the use of low-footprint transfer technologies. •

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The Trials of Developing a Biomethane Potential Method for Faecal Sludge

Variability in biomethane potential (BMP) tests and the need for replicable results requires the development of troubleshooting methods. This article discusses the challenges involved in developing a reliable BMP method for faecal sludge analysis. Stanley Sam[1, 2], Kapanda Kapanda[3], Barbara Jeanne Ward[1, 2], James Tembo[3], Eberhard Morgenroth[1, 2], Linda Strande[1]

Factors that were evaluated		BMP setup 1	2	3	4	5
Reactor vessel	500 ml media bottles with rubber septa	x	x	x		
	200 ml serum bottles with rubber septa				x	x
Gas measurement method	Continuous gas measurement with syringes	x				
	Intermittent gas measurement with syringes		x	x		
	Gas measurement with liquid displacement				x	x
Methane measurement method	Methane measurement with NaOH scrubbing				x	x
	Methane measurement with the gas chromatography (GC)				x	
Inocula	Different inocula		x	x	x	x
Incubation temperature	Incubation at 20 °C	x	x		x	
	Incubation at 37 °C			x		x

Table: Factors evaluated in establishing a BMP method for faecal sludge.

Introduction

Although the level of faecal sludge (FS) stabilisation could be a predictor of dewaterability [1], no standard methods currently exist to evaluate this. FS is highly variable in its characteristics and composition, and can remain in onsite containments for days to years, with little or no information on its level of stabilisation [2].

The biomethane potential (BMP) test is a standard method for evaluating the biodegradation of organic substrates in wastewater under anaerobic conditions, and for designing and predicting the performance of anaerobic digesters [3] [4]. Yet, applying the BMP method on wastewater yields variable results due to differences in instrumentation, test protocols and laboratory conditions [3], and there is limited information available on applications of the BMP test for FS. If the method was further developed for FS, the BMP test could potentially be used to assess the level of FS stabilisation, which would improve our understanding and ability to predict dewaterability.

In our research on the fundamental mechanisms governing FS dewaterability, BMP tests were conducted with different inocula to understand the biodegradation of organic substances in FS and the role that extracellular polymeric substances (EPS) and microbial communities play. Our goal was to develop a reliable method for BMP tests for FS, which can be adapted, depending on the resources and equipment available. During this work, many pitfalls took place while developing the method.
There is much demand in the FS research community to not only learn from our successes, but also to share and learn from our failures. Presented here are some of the difficulties encountered and results from lab work in Lusaka and Zürich together with troubleshooting strategies.

Method

The BMP test measures the ultimate methane production of organic substrates under anaerobic conditions over a period of time. To develop the BMP method for FS, tests were performed at 20°C, which is reflective of conditions in onsite containments. Tests were also conducted at the standard temperature of 37°C for comparison. These tests used different inocula, i.e. from an anaerobic digester, septic tank, pit latrine and animal manure (in the Table, set-ups 2 and 3 used two inocula and set-ups 4 and 5 compared all four inocula). Blank samples and microcrystalline cellulose (of which the methane yield is known) were used as negative and positive controls, respectively, to determine endogenous methane production from the inoculum and to verify the accuracy of the BMP method. The set-ups are shown in Figure 1 and the factors considered are summarised in the Table.

Challenges

In developing a BMP test for faecal sludge, several pitfalls were encountered. The most important ones were: (1) a high unrealistic initial gas measurement, (2) a variable gas volume measurement over the test period based on the BMP set-up, and (3) overestimation of the methane content of the biogas produced.

Systematic troubleshooting and quality assurances and control (QA/QC)

To overcome the observed challenges, three troubleshooting steps and QA/QC measures were carried out.

1) Inconsistencies in gas volumes were evaluated by assessing the gas-tightness of the reaction bottles and the efficiency of syringes in measuring gases. All reaction bottles were assessed for leakages, using Alka Seltzer as a positive control (Alka Seltzer tablets

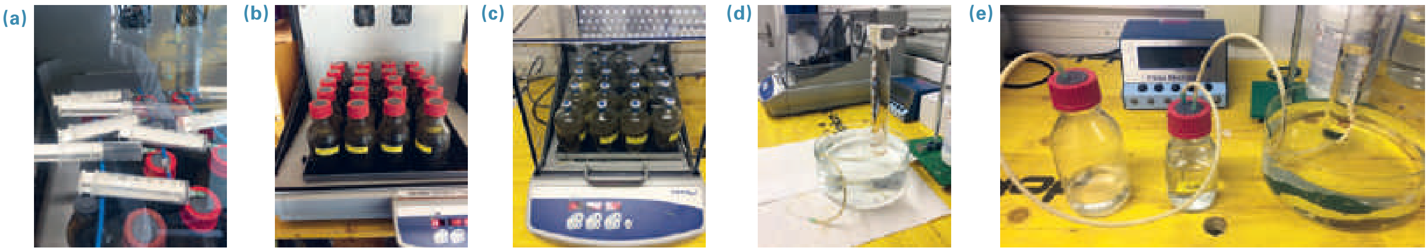

Figure 1: BMP set-ups: (a) BMP with continuous gas measurement using syringes, (b) BMP with intermittent gas measurement using syringes, (c) BMP with serum bottles, (d) liquid displacement set-upset-up, (e) liquid displacement with NaOH barrier solution.

produce around 260 ml CO_2 per tablet in 100 ml water). By applying soap onto the reaction bottles, leakages are indicated by rising air bubbles in the soap foam, i.e. foam bubbles forming on the septa of the reaction bottles.

2) Syringe efficiency was evaluated by measuring the volume of gas produced per tablet of Alka Seltzer with oil-lubricated and non-lubricated syringes and by comparing the results.

3) Overestimation of the methane content of biogas in the liquid displacement method was evaluated by using Alka Seltzer to produce a known volume of CO_2 and then absorbing the CO_2 with NaOH solution. This indicates if the CO_2 in the biogas will be absorbed by the scrubbing solution.

Based on the outcome of the experiments, the recommended BMP set-up for faecal sludge is 200 ml Serum bottles with butyl septa and metal crimps and shaking at 100 rpm. The total biogas production should be measured by the water displacement method. The percentage of methane in the biogas can be determined by gas chromatography (GC) where available, or by scrubbing in NaOH when not. It has been observed that the results of the liquid displacement method for biogas measurements is more accurate than using lubricated syringes. However, for methane content analysis, the liquid displacement method should only be used when the scrubbing solution has been tested to absorb CO_2, to confirm that volumes of CO_2 will not be counted as methane.

For the reproducibility of the BMP results and statistical analysis, all tests must be conducted in triplicate. To prevent a high initial gas volume, which is largely due to the purging gas building pressure in serum bottles, the pressure in the bottles must be re-equilibrated to atmospheric pressure before the start of the BMP tests. As in other BMP tests, all inocula have to be kept at the incubation temperature for about a week to reduce endogenous methane production. The theoretical methane production of the substrate must be calculated prior to the start of the BMP tests to serve as a guide.

Next steps

The BMP method is currently being used in Lusaka and Zürich to assess FS degradation during anaerobic digestion (Figure 2) and the fundamental mechanisms of how stabilisation affects dewaterability. Based on the results, anaerobic batch reactors will be run in both laboratories to further understand the processes occurring during storage in onsite containments and the role of EPS on FS dewaterability (See pp. 18–19). Stay tuned for the results! •

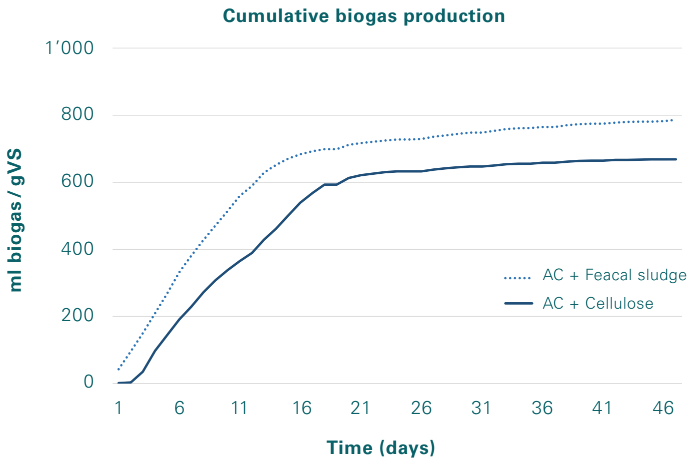

Figure 2: BMP results showing the cumulative biogas production from faecal sludge and microcrystalline cellulose (standard), using septic tank sludge from Accra (AC) as inoculum.

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The Volaser: *In Situ* Measurements of Volumes of Faecal Sludge

The Volaser is a device that can measure the volume of faecal sludge inside onsite sanitation containments. This article presents results from Volaser field-tests and the plan for scaling up the prototype. Nienke Andriessen[1], Linda Strande[1]

Nienke Andriessen

Photo 1: Using the Volaser with the smartphone app in a septic tank in Lusaka, Zambia.

© Tribecraft

Photo 2: The Volaser prototype set-up with the tripod, top part and laser.

Introduction

For sustainable faecal sludge management, it is essential to understand the quantities and qualities (Q&Q) of faecal sludge (FS) that need to be managed, for example, when designing treatment facilities or emptying programmes. However, the construction of containments has not been standardised and maintenance records normally are not kept for FS stored in them. This makes it difficult to know how much FS accumulates inside such systems.

To measure containment size and in situ volumes of FS and assist in determining FS Q&Q at the citywide level, Eawag has developed the Volaser with ETH Zurich, Zurich University of the Arts and Tribecraft AG [1] [2]. It consists of a tripod stand with a distance laser measuring head, a collapsible pole to measure total depth and a smartphone app to operate the device (Photo 1). In 2019, the Volaser was tested in Sircilla, India; Kohalpur, Nepal; and Lusaka, Zambia, where, respectively, a total of 31, 45 and 421 containments of varying shapes and sizes were measured (Photo 2).

Field experience

The Volaser makes good measurements despite the different configurations and shapes of containments. Measurements were accurate to within < 3.5 % of the total area measured and, according to professional emptiers and student researchers, it is easy to use. Measuring takes less than 10 minutes and can readily be combined with other tasks, i.e. containment inspections or emptying events. Production costs have been kept as low as possible; however, the trade-off is that it cannot be used in extreme cases – depths greater than 3 m or extremely large septic tanks. 3D printed parts made from commonly used polylactic acid (PLA) material are not robust enough to withstand temperatures in direct sunlight; thus, alternative materials for 3D printing are being investigated. A smartphone with a gyroscope is required and, although the Volaser can measure total volumes of FS inside a containment, it cannot distinguish between different layers (e.g. sludge blanket and scum). In the field, a core sampling device was used for this [3].

Next steps

Being able to make reasonably accurate estimates of FS accumulation rates without having to empty containments or rely solely on rough estimates is a great improvement. Based on the field-testing, the Volaser concept was validated, and we have received many requests for prototype versions. To meet this demand, Eawag and Tribecraft are currently developing a field-ready product, as well as guidelines on self-assembly and use. Stay tuned until early 2021 for the final version! •

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Developing Methods for Projecting Faecal Sludge Quantities and Qualities

Faecal sludge stored underground in onsite sanitation systems is very heterogeneous; thus, estimating quantities and qualities, which are needed for management and treatment solutions, is difficult. Here is a sneak peek into recent MEWS group research to develop and test an appropriate methodology. Nienke Andriessen[1], Linda Strande[1]

Key developments

In 2018, together with the Consortium for DEWATS Dissemination (CDD) Society, the MEWS group implemented the quantities and qualities (Q&Q) methodology in Sircilla, a town of 76'000 residents in India. Measurements were made of the build-up of the sludge blanket *in situ* over time and the accumulation rate of what is actually collected and transported for treatment. Different methods for measuring sludge volumes were compared, including emptying the containments and using a core sampling device (Photo). The study results are currently being prepared for publication with the help of Prerna Prasad from CDD, an Eawag Partnership Program Fellow [1]. One of the key outcomes is that the method for measuring sludge volume should be selected according to the study goal and availability of resources.

A large Q&Q study was done in Lusaka with the University of Zambia to help city authorities with faecal sludge management planning. At 421 onsite containments across the city, sludge volume was measured *in situ* with a Volaser [2] and samples were collected using a cone-shaped device for pit latrines and a core sampler for septic tanks (Photo). One key finding was the confirmation that containment type (septic tank vs pit latrine) is an important predictor of faecal sludge Q&Q.

Nienke Andriessen

A core sampler is being used to take a sample from a septic tank in Lusaka.

The MEWS group also collaborated with the Z_GIS Centre at the University of Salzburg to explore if remote sensing devices can gather data, such as land use, roof type, distance to green space, distance to water bodies and distance to treatment, and whether such data could be used to predict faecal sludge Q&Q [3]. The findings were cross-checked with data from the Q&Q study in Lusaka. The main findings were that Earth observation data could be useful to inform the sampling plan designs of future Q&Q studies, and assist decision-makers decide on focus areas for sanitation planning. None of the indicators had a statistical relation to quantities; however, building density, building size, street condition and building use were predictors of qualities (e.g. total solids content).

The findings of our work and how they can be applied are discussed in the book chapter, Estimating quantities and qualities (Q&Q) of faecal sludge at community to city-wide scales, in the IWA publication *Methods for Faecal Sludge Analysis* [4]. In-depth analysis of the information and data collected from different cities around the world (~1'000 data points) is being done to determine whether broader, fundamental patterns about faecal sludge can be inferred. This manuscript is currently in preparation, stay tuned!

Conclusion

In the future, these results may be used to spark discussions about improving methods to estimate accumulation rates, e.g. to think about how each of the components of the accumulation rate formula [*FS volume in situ/(#users * time since last emptying)*] can be measured more accurately. The Q&Q method will continue to be refined as more empirical knowledge is generated. MEWS looks forward to receiving feedback from people who implement the methodology described in the forthcoming book chapter. •

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Double A

Strategic Environmental Sanitation Planning

As the world becomes progressively more urban, the challenge to provide safe and effective sanitary arrangements becomes even greater. Sandec's research on Strategic Environmental Sanitation Planning aims systematically to address the complexity of urban sanitation. Our research combines aspects of engineering with planning methods and social science approaches, and includes three fields of activity:

- Developing and validating comprehensive approaches for planning Citywide Inclusive Sanitation that includes a variety of technologies and service delivery mechanisms.
- Exploring the governance and enabling environments that are necessary for sustainable local service delivery (including financial, technological, socio-cultural and institutional issues).
- Validating appropriate, cost-effective sanitation systems in peri-urban, slum and small town settings.

Photo As part of the QUISS study, a female resident from a low-income neighbourhood in Dhaka, Bangladesh, presents the daily sanitation challenges of women to a group of men. QUISS applied a qualitative data collection method that empowers women and men, as individuals and collectively, to collect, analyse and use information to improve and gain more control over their lives. By analysing and addressing gender particularities and inequities, participants learned about their strengths and achievements and developed visions for change.

Photo by Vasco Schelbert.

QUISS: Quality Indicators of Shared Sanitation Facilities

Shared sanitation has greatly contributed to sanitation access in urban areas, but is considered at best a "limited" solution, given the lack of SDG6 quality standards. QUISS identified key criteria for "high-quality" shared toilets in low-income urban contexts. Vasco Schelbert[1], Dario Meili[2], Mahbub-Ul Alam[3], Sheillah Simiyu[4], Prince Antwi-Agyei[5], Christoph Lüthi[1]

Introduction

The WHO/UNICEF Joint Monitoring Programme (JMP) monitors progress towards the Sustainable Development Goals (SDGs). To monitor access to safe sanitation, the JMP service ladder is used, which builds on the established improved/unimproved facility type classification. Improved sanitation facilities are those designed to hygienically separate excreta from human contact. The JMP service ladder divides improved sanitation facilities into three categories: limited, basic, and safely managed services. Depending on how excreta are managed, individual household sanitation facilities are categorised as either basic (improved facilities not shared with other households) or safely managed services (improved facilities not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite).

In contrast, shared sanitation facilities (SSF) are at best classified as a limited solution – irrespective of how excreta are managed. The exclusion of SSF from the basic and safely managed service levels is generally justified because of safety, privacy and health issues. There are concerns about 24/7 accessibility and safety, as well as the privacy of SSF [1], and that the lack of hygiene and cleanliness [2] may lead to adverse health impacts [3]. Yet, with infrastructure development lagging in low-income urban settlements worldwide, many of which have high population density coupled with high poverty levels, SSF are often the only viable option in these areas [4].

Worldwide, the total number of SSF users increased from 335 million (7.5 % of the global population) in 2000 to 626 million (9.1 %) at the end of 2017 [5]. There is evidence of sustainably functional, clean and hygienic SSF offering adequate sanitation, but also of SSF in dire conditions [2]. Many SSF are indeed of unacceptable quality. At the same time, there is uncertainty about the criteria that can be used to distinguish between unacceptable and acceptable quality [6].

Vasco Schelbert

Inspecting shared sanitation facilities in Manyatta, a district in the city of Kisumu, Kenya.

Furthermore, little is known about user priorities for shared sanitation. However, user perspectives on sanitation priorities are fundamental to consider to meet their needs with public investments, ensure user acceptance, and the success of interventions. Among other activities, the "Quality Indicators of Shared Sanitation Facilities" (QUISS) research project collected data on user satisfaction and the main problems associated with SSF in low- and middle-income settlements.

Methodology

QUISS was commissioned under the Urban Sanitation Research Initiative of WSUP (Water & Sanitation for the Urban Poor, www.wsup.com/research). Based on an extensive quantitative survey of shared toilets and their users, as well as qualitative studies, it aimed to identify key criteria for what constitutes "acceptable quality" of shared toilets in urban contexts. Data collection took place from January to July 2019 in low-income urban settlements in Kumasi (Ghana), Kisumu (Kenya) and Dhaka (Bangladesh).

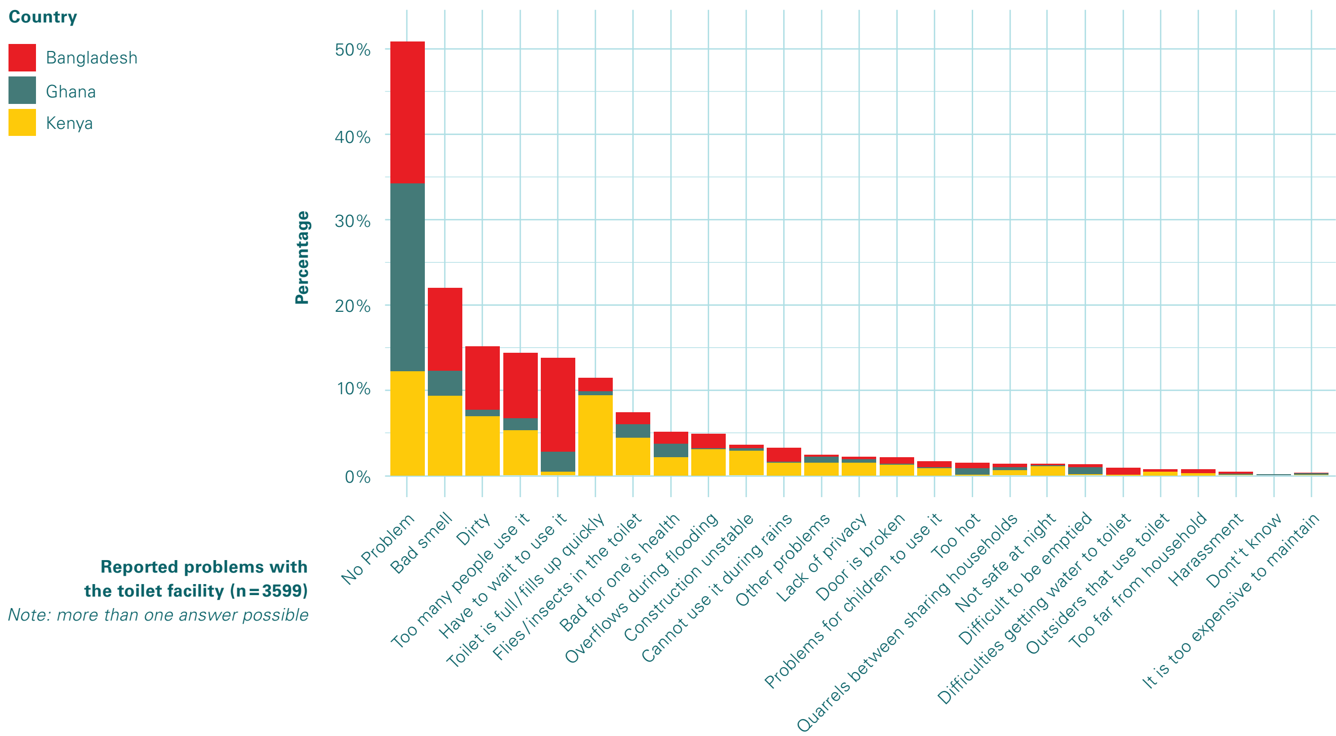
QUISS conducted an extensive survey, interviewing over 3'600 households, and performed more than 2'000 spot-check evaluations of SSF and individual household facilities (Photo). Households and toilets were sampled, using a combination of systematic and purposive sampling.

The respondents rated their satisfaction using a five-point level Likert-scale, ranging from "very dissatisfied" to "very satisfied". These reported results were then compared with observational data. For triangulation purposes, enumerators carried out a spot-check evaluation of the SSF, including the taking of photos. The photos were objectively rated for cleanliness by external research assistants. Observed cleanliness was measured by the presence of solid waste, insects inside the cubicle and visible faeces. In addition, enumerators evaluated SSF on safety/security and privacy measures. Observed safety/security was measured by the presence of a solid roof, solid floor (without cracks/holes) and (reported) use at night. Observed privacy was measured by the presence of a functional door (solid, without openings) and a solid wall (without openings).

Results

Survey data revealed that in all three countries a sizeable share of SSF toilet users reported having no problems with them whatsoever. Overall, *bad smell, dirtiness, the number of people using the toilet* and *long waiting times* were identified as the most common problems by the respondents (Figure).

Most users are "satisfied" or "very satisfied" with the cleanliness of their SSF. The share of satisfied respondents is lowest (66 %) in Kenya, compared with 75 % in Bangladesh and 92 % in Ghana.



Problems reported by toilet users, by country.

Comparing reported and observed cleanliness, the higher the users reported satisfaction with cleanliness, the more likely is the toilet observed as clean. Still, there is a large discrepancy between reported satisfaction and observed cleanliness: only 48 % of the toilets in Bangladesh, 52 % in Kenya and 67 % in Ghana, of which users were "very satisfied", were in fact observed to be clean.

The share of users reporting that they feel mostly safe using the SSF at night ranges from 63 % in Kenya to 93 % in Bangladesh and 94 % in Ghana. Generally, only a small share of users (5 %) report not using the toilet at night. Our results suggest a correlation between perceived security and actual use at night.

Regarding privacy provisions, the share of users who are at least "satisfied" is 82 % in Kenya and Bangladesh, and 95 % in Ghana. Similar to cleanliness and security, the satisfaction levels are correlated with observed privacy. The higher the users' reported satisfaction level, the more likely adequate privacy provisions are observed.

Conclusion

Users and their perspectives on sanitation priorities are fundamental to consider. Bad smell, unsanitary facilities, and a high toilet-user ratio, leading to long waiting times that limit accessibility, were the most common reported user problems. Reported use of a toilet at night has been found to be a good proxy for overall user satisfaction. When only a small share of users report not using the toilet at night, this indicates that most users seem generally satisfied with safety/security and privacy provisions.

Our findings will inform the development of a monitoring framework for SSF. Likewise, they will assist in the identification of quality indicators that are aligned with and respond to user needs and priorities. Increasing the likeliness of meeting user needs improves user acceptance and, thus, supports intervention success. •

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Project timeline: Oct. 2018 – Mar. 2020

www.sandec.ch/quiss
www.wsup.com/research

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Community Governance and Monitoring of Emergency Sanitation

This new Sandec research project on emergency sanitation aims to gain knowledge of the governance structures of the sanitation sector in humanitarian settings, test innovative community-based monitoring of sanitation systems and evaluate its impact on sanitation governance. Christopher Friedrich[1], Abishek S Narayan[1], Samuel Renggli[1]

Introduction

Although the United Nations General Assembly recognised that access to safe and clean drinking water and sanitation is a human right [1], the situation for many disadvantaged and vulnerable groups, such as refugees, remains dire [2]. In 2019, according to UNHCR, 79.5 million people have been forcibly displaced from their homes due to violence, conflict, human rights violations, persecution or events seriously disturbing public order. This number includes 26 million refugees, the highest number ever recorded [3].

In disaster areas and overcrowded camps, cases of diarrhoea often increase rapidly due to a lack of water, sanitation and hygiene services. Among children under the age of two, diarrhoea is the leading cause of death [4] [5] [6]. Implementing effective sanitation practices helps to reduce the spread of pathogens through the faecal-oral route, improving public health and decreasing child mortality [4] [5] [7].

Case study

Since late 2017, approximately one million people have fled violence in Myanmar and crossed the border to Bangladesh, where they settled at the southeast coast in the Cox's Bazar district. Their makeshift tents now form the largest camp for forcibly displaced persons in the world, with a population of about 860'000 [8]. Providing the people in this camp with access to sanitation poses a substantial challenge. The number of latrines in many areas of the camp is low and does not meet the minimum standard for latrine coverage in humanitarian emergencies, which is one latrine per 20 users [9]. Sanitation services, such as containment emptying and faecal sludge treatment, are insufficient in many areas of the camp [9] [10] [11]. The lack of sanitation services is further exacerbated by poor operation and maintenance [11]. These shortcomings put people at high risk of contracting acute waterborne diseases [12].

Water, sanitation and hygiene (WASH) interventions in emergencies are governed by many policies, laws and institutional orders. More than 30 actors, including the Bangladesh government, international NGOs and UN agencies influence the WASH sector in the camp [13]. This poses a great challenge to the coordination of WASH services, in particular, regarding how the various decision-makers obtain critical information and make use of this information to improve sanitation services. The project aims to test innovative methods of working with communities in camp settings to collect relevant and timely data on sanitation monitoring and, thus, improve stakeholder engagement in the overall governance of the sanitation systems and the day-to-day operation of the facilities.

Methodology

The overarching research question is *"How can community-based monitoring of sanitation systems strengthen the governance of such systems in humanitarian contexts"*? First, the existing governance structure of the sanitation systems will be analysed through policy analysis, stakeholder mapping and a novel social network analysis method [14]. Next, three community-based monitoring methods will be implemented and tested in one of the sub-camps:

1) Anonymous feedback mechanisms, such as pocket charts placed inside the latrine cubicles for voting on the cleanliness and functionality of the latrines.

Christopher Friedrich

Photo 1: Latrines painted by the community in the camps in Cox's Bazar, Bangladesh.

Photo 2: Sanitation infrastructure in the camps in Cox's Bazar, Bangladesh.

2) Photographic assessments of WASH infrastructure, introducing an additional means of communication among the camp community volunteers.

3) Engaging the WASH committee volunteers in the camp to increase their involvement in sanitation monitoring and governance.

Given that Rohingya is primarily a spoken language, it will be explored how to effectively communicate information about the study and its results to the community.

Expected results

Due to the spread of SARS-CoV-2, the project start has been postponed until October 2020. The results of the research project can be expected by the end of 2021. This will be the first study on WASH governance in the context of a camp for displaced persons. The study will further the understanding of the daily WASH challenges encountered by people living in camp situations and how their feedback on WASH infrastructure, operation and management can benefit decision-makers. A better understanding of how to improve governance of WASH infrastructure in such contexts will facilitate the planning and implementation of humanitarian WASH interventions in the future. •

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Community governance of emergency sanitation:

This new research project is co-funded by ETH for Development (ETH4D) and Sandec. Our researchers, together with partners from the Bangladesh Red Crescent Society, will start this project in September 2020.

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From Sanitation Technology to Sustainable Sanitation System Planning

Santiago (SANitation sysTem Alternative GeneratOr) is a tool developed to assist engineers in sanitation planning. It helps them make choices from the growing portfolio of sanitation technologies, systems and multiple sustainability criteria, and will soon be available online. Dorothee Spuhler[1], Christoph Lüthi[1]

Introduction

Reaching SDG 6.2, *Sanitation for all*, is very challenging in rapidly expanding urban areas where most population growth worldwide is taking place. Conventional solutions are often not viable as they rely on costly sewer networks, large quantities of water and longterm planning horizons. However, new technologies and system configurations have been developed, i.e. urine diversion toilets and container-based sanitation systems, independent from sewers, water and energy sources. These technologies also prioritise resource recover, enhancing sustainability.

Choosing among new technologies, system configurations and sustainability criteria, however, increases planning complexity [1] [2]. These choices also complicate structured decision-making (SDM) procedures, such as Community-Led Urban Sanitation (CLUES) [3], Sanitation21 or City Sanitation Planning. These methods were developed to facilitate sanitation planning.

A decision support tool

Santiago software (SANitation sysTem Alternative GeneratOr) was developed while conducting SDM procedures in Nepal, Ethiopia, Peru and South Africa. It does not replace feasibliity studies or the planning process, but enables engineers to systematically consider technology choices, system configurations and sustainability criteria appropriate for local contexts [4], and assists in SDM decision-making [5], as well as Citywide Inclusive Sanitation (CWIS) planning (Figure).

Benefits of a software approach

Santiago's main advantage is that it can handle large numbers and sets of technologies, sustainability criteria and systems. It facilitates decision-making, prioritises resource efficient systems appropriate for local conditions, citywide objectives and user prererences, and can provide a set of options suitable for every urban area. It also has a library, providing information on technologies and substance flows.

Next steps

Currently, an open-source online interactive tool is being developed, as well as a training package and a planning guide. Users will be able to add technologies and products to the database to keep it up-to-date. If you are interested in using Santiago in your planning process, please contact us. •

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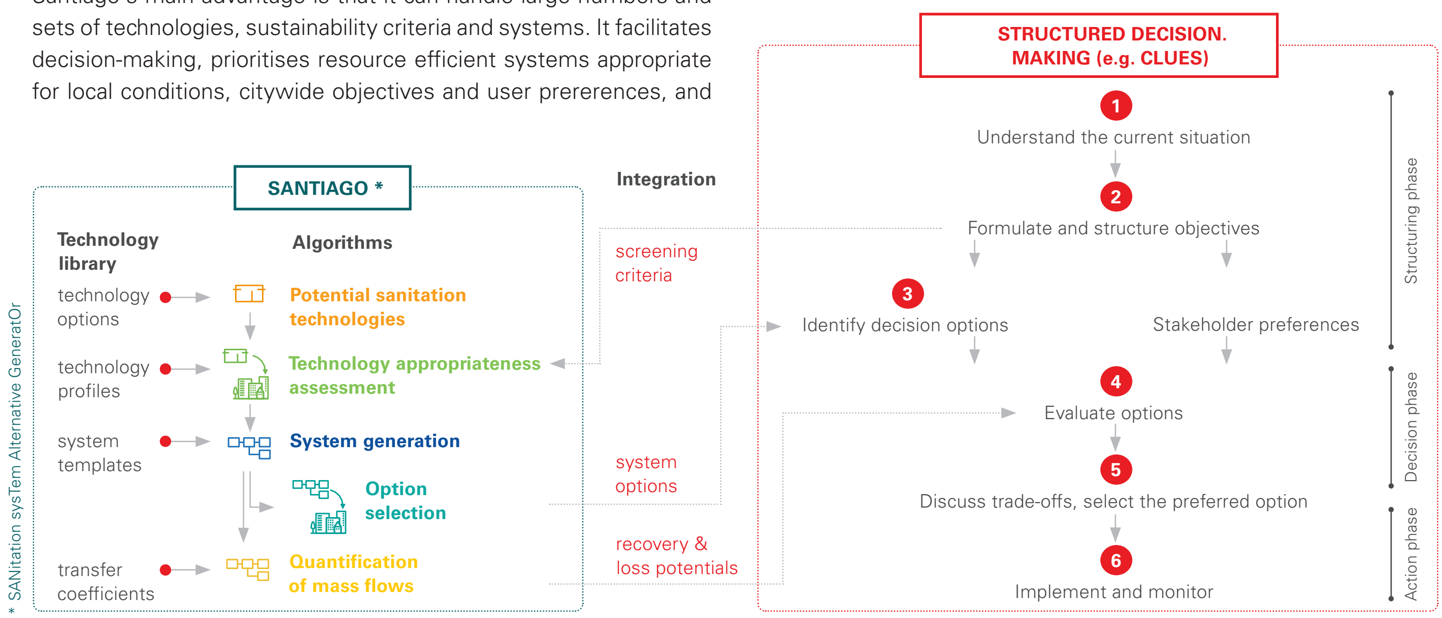

Integration of Santiago in the Structured Decision Making (SDM) process: the SDM process provides the decision objectives from which screening criteria are derived and Santiago provides a set of locally appropriate sanitation systems of manageable size, considering the full technological diversity.

Consultant Capacity Development for Citywide Inclusive Urban Sanitation

The multi-country Consultant Capacity Development (ConCaD) initiative aims at increasing consultant capacity to improve the delivery and sustainability of citywide sanitation services. The purpose of this article is to describe the project and to highlight the achieved results. Ashanti Bleich[1], Christoph Lüthi[1]

C. R. Lohri

Colleagues from ENPHO are developing a marketing plan for their ConCaD training during the digital learning workshop, Kathmandu, Nepal.

Introduction

The ConCaD initiative builds capacity in private sector consulting firms, as well as individual consultants, to conceptualise, plan, design and supervise the implementation of citywide inclusive urban sanitation services. In urban sanitation, consultants play a key role, working for governments, municipal councils and international funding institutions. They need to be at the cutting edge of development to provide high quality services to clients.

The purpose of increased consultant capacity is to improve the delivery and sustainability of sanitation services to poor and non-poor communities. Secondly, it is meant to increase the impact of sanitation investments at city scale in Sub-Saharan Africa and South Asia, with a particular focus on "at scale" sanitation services funded by governments and international financing institutions and development partners. The ConCaD project (June 2018 – May 2020) developed the educational materials, trained the future training providers, offered a workshop on production and contextualisation of digital learning materials, and produced an online course, covering all aspects of citywide inclusive sanitation.

Face to face training

ConCaD selected a partner training institution (PTI) in each of the six target countries (Ivory Coast, Uganda, Zambia, Nepal, Bangladesh, and India) to deliver the face-to-face training. These six PTIs benefited from a "training-of-trainers" approach to deliver the course. An EAWAG team of two to three people provided a week of training to the future trainers at the PTI in each country. This training-of-trainers aims to facilitate the use of participatory training methods and to contextualise materials for the focus countries.

The course covers a wide range of topics, including the main aspects of citywide inclusive sanitation from gender and equity to technology and governance / political will. There was also a workshop on how to produce and contextualise digital learning materials. The target audience is consulting firm staff and freelance consultants, working or bidding for "at-scale sanitation investment projects" in the respective countries. Most of the PTIs have already provided their first face-to-face in-country trainings to consulting firms or individual consultants. Sandec will remain available for any support needed to develop business plans for ensuring the sustainability of the face-to-face course delivery.

Online training

The ConCaD three-week online course is available on YouTube, covering all the aspects of citywide inclusive sanitation offered in the ConCaD face-to-face training. It is organised in three parts: Part 1 – Introduction & diagnostics, Part 2 – Urban sanitation programming in practice, Part 3 – Urban sanitation systems, and includes a final quiz in English and French for the participants to test their knowledge. Bonus videos on Citywide Inclusive Sanitation in the cities where the ConCaD Partner Training Institutes are located are also available.

This online course provides support for the PTIs offering the course. Trainers and participants also benefit from it. Furthermore, anyone interested in gaining knowledge on citywide inclusive sanitation can take the online course.

Conclusion

The ConCaD initiative has successfully conducted the training-of-trainers in the six PTIs, and educational materials and resources have been adapted to the local contexts. Our training partners have all the tools required to offer effective face-to-face training in the coming years, and are able to meet the growing demand for urban sanitation solutions. At this stage, what is crucial is the sustainability of the PTI trainings. This depends on the development of a strong and reliable business plan, the motivation of the PTIs and trainers, and finally sufficient in-country demand for trainings of this kind. •

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Project timeline: June 2018 – May 2020 www.sandec.ch/concad
The ConCaD initiative is supported by the Bill & Melinda Gates Foundation.
ConCaD YouTube Course: https://bit.ly/3jQHJmp
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Water Supply and Treatment

Providing sustainable access to safe drinking water sources is one of the greatest global public health challenges. Sandec's Water Supply and Treatment research focuses on decentralised treatment technologies and innovative monitoring strategies to improve access to safe and reliable water services in rural communities and small towns. Current research activities include:

- Implementing and evaluating risk management strategies.
- Improving field-robust water testing tools and methods.
- Field-testing novel passive chlorine dosing technologies.
- Identifying the factors determining long-term functionality of water supply infrastructure.

Photo A field team member collects a drinking water sample from a household storage container in Karnali Province, Nepal. The REACH project examines the influence of water security measures on the microbial water quality of spring-fed piped supplies.

Photo by Michael Vogel.

Assessing a Drinking Water Security Strategy in Rural Western Nepal

REACH aims to improve drinking water security for households reliant on spring-fed piped supplies through multi-barrier interventions and impact assessments. Findings show the importance of chlorination methods adapted to intermittent, low-flow conditions. Carola Bänziger[1], Ariane Schertenleib[1], Bal Mukunda Kunwar[2], Rubika Shrestha[2], Madan Bhatta[2], Sara J. Marks[1]

Introduction

Faecal contamination of drinking water supplies is a leading cause of diarrhoeal diseases globally, especially among children under the age of five [1]. Although the majority of Nepal's 29 million residents have access to an improved water supply, less than a third of the population have a water source free from contamination [2]. A team from Eawag's Water Supply and Treatment group and Helvetas-Nepal's Integrated Water Resource Management Project (IWRM-P) led the REACH Project, which aimed to implement and evaluate a combination of water safety interventions tailored to spring-fed piped water systems. The goal of the project is to extend access to safe water across the IWRM-P service area. The research was jointly funded by the Swiss Agency for Development Cooperation (SDC) and REACH: Water Security for the Poor (University of Oxford and the UK Department for International Development).

Study site and methods

Karnali and Sudurpashchim Provinces consist of mountainous and hilly terrain, with low access to safe water and high rates of childhood diarrhoeal illness relative to national averages [3]. The study was conducted in the Kalikot, Jajarkot, Dailekh and Surkhet in Karnali and in Achham district in Sudurpashchim (Figure 1). Helvetas' IWRM-P serves 45'000 people; the REACH project delivered piped supply upgrades to 10'966 of these people from 2017–2020. Some water schemes provide continuous (24 h) service, while others provide intermittent service with variable opening times and service durations throughout the year.

Carola Bänziger

Water quality analysis in the field.

Thirty-three rural communities were selected for the study based on the existence of a functioning drinking water system and community agreement to participate. All water schemes had a similar branched design, consisting of a spring source connected to a reservoir tank by a distribution line, with water then flowing to private or public taps. Of the study communities, 21 were assigned to the treatment group and 12 to the control group. Baseline data collection included a household survey to assess water-related perceptions and practices, standard system inspections from source to tap and water sampling at collection taps and household storage containers (i.e. point of consumption) (Photo). Next, five field laboratories were installed and a combination of interventions based on the findings from the system inspections were implemented within the 21 treatment communities. The survey and water sampling were repeated at the study endline (14 months after baseline).

The water safety interventions included:

- Quarterly inspections of the piped system;
- A centralised data management system linked to local labs;
- Targeted infrastructure improvements, e.g. intake protection, roughing filters at intakes and/or reservoirs, and general repairs and maintenance in pipelines, valve chambers, etc.;
- Local watershed restoration;
- Household hygiene and filter promotion;
- Training of community water safety task forces; and
- System-level chlorination in selected schemes.

In each of the five laboratories, the research team trained local technicians in standard water testing protocols (*E. coli*, total coliform bacteria, pH, free residual chlorine and turbidity) and conducted regular quality control visits. Additionally, water quality training was offered to regional and national government actors. Lessons learned and recommendations for establishing and operating rural water quality laboratories were disseminated through local, national and international channels.

Findings

Each study community consisted of 29 to 250 households and 15 households per community were interviewed for a total of 493 surveys. Among the households interviewed, water supply (34 %) was the biggest concern mentioned at baseline, followed by transportation and roads (23 %). Most respondents used piped water connections (97 %) and had access to improved sanitation (81 %).

E. coli concentrations at the point of consumption for the treatment and control schemes were comparable at study baseline. The percentage of households meeting the WHO drinking water quality guidelines of <1 *E. coli* CFU/100mL> was about 10 % for both groups. By study endline, treatment schemes had significantly

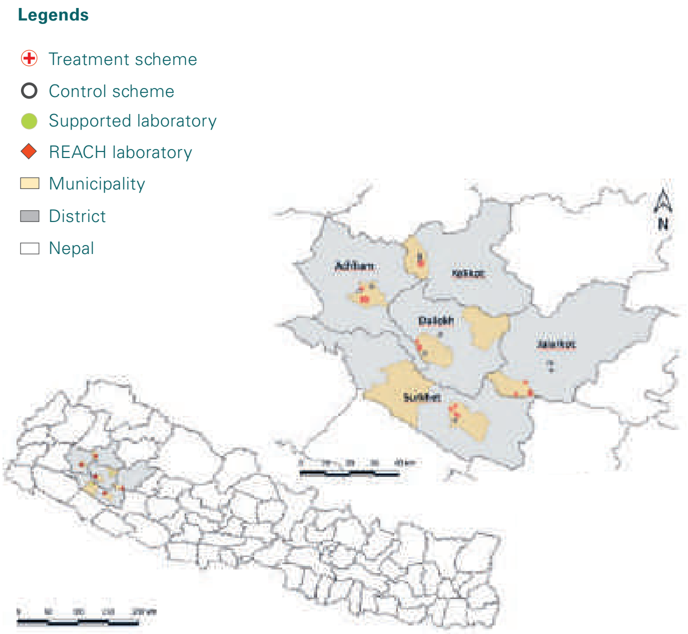

Figure 1: Map of Nepal, showing the five study districts.

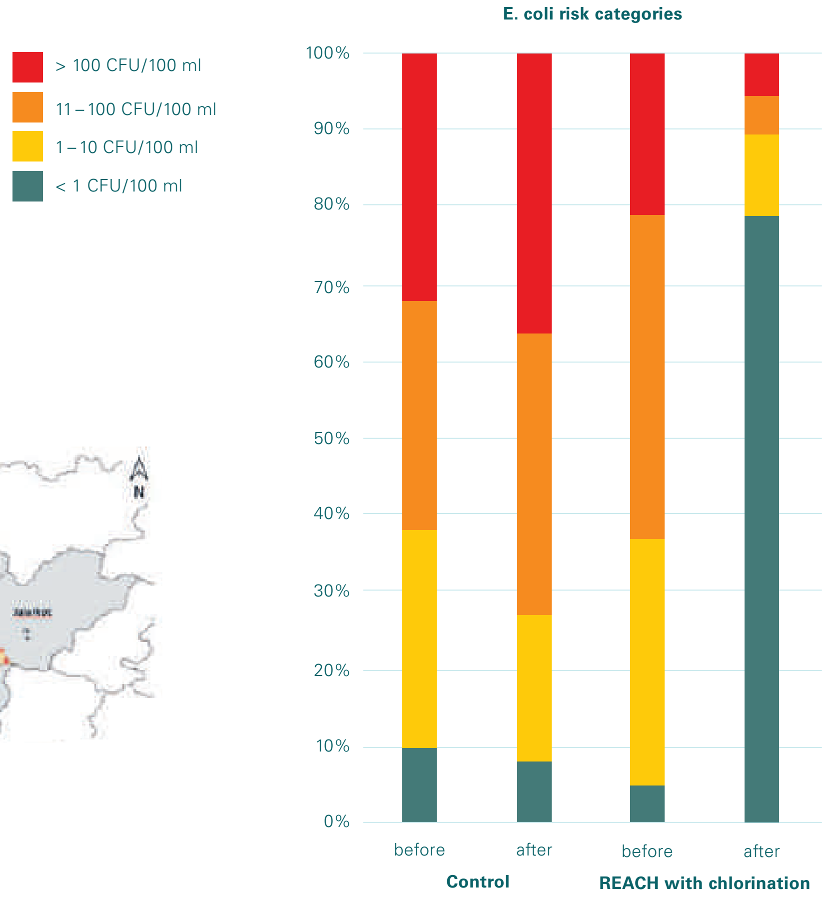

Figure 2: Microbial risk categories for stored water samples in chlorinated treatment communities and control communities.

lower levels of faecal contamination than control schemes, and the share of households with no detectable *E. coli* increased significantly to 19.8 %. The share of control scheme samples free of *E. coli* did not, however, change significantly. Treatment schemes that included chlorination delivered the highest water quality, with the share of samples with no detectable *E. coli* increasing from 5.3 % to 78.9 % (Figure 2).

In addition, the share of people in the treatment communities reporting confidence that the system would be functioning well in one year increased significantly, from 79 % to 93 % at the study endline, while no such increase was observed among the control communities. Similarly, the treatment communities showed significant gains when compared to the control communities in terms of reporting less service interruptions, user satisfaction, and service availability.

Conclusion

Chlorination was the most effective intervention for improving water quality at the point of consumption. Nevertheless, all interventions had a positive impact on system functionality, users' reported satisfaction, and their awareness of the risks posed by poor water quality. This study provides rigorous verification of the effectiveness of interventions at different hazard points for achieving improved water security in an underserved area. Evidence suggests that this water security strategy can be just as effective in improving drinking water safety in similar rural settings, and could be especially suitable for systems delivering intermittent, low-flow supplies.

Through close engagement with national and international stakeholders, the REACH project has integrated its water security approach with the current institutional knowledge in the sector. Project outputs include a video brief in Nepali and English describing REACH's risk-based strategy [4], a detailed inventory of upfront and ongoing costs and training requirements for operating rural water quality testing laboratories, and regular dissemination of the results at local and international knowledge-sharing events. •

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Psychological Ownership and Habits for Long-Lasting Safe Water Infrastructure

Safe water technologies often become dysfunctional quickly after installation. This could be due to the technology or social and behavioural factors. Project PACT investigates how the sense of ownership impacts the longevity of rural piped water supply schemes. Benjamin Ambuehl[1,2], Ashok K. Ghosh[3], Bharat Kumar Singh[4], Manoj Kumar[4], Sara Marks[1], Jennifer Inauen[2]

Introduction

Safe water technologies often become dysfunctional quickly after installation. This could be attributed to the technology, as well as social and behavioural factors. Project PACT investigates how the sense of ownership and habit impact the longevity of rural piped water supply schemes.

In rural Bhagalpur, in the state of Bihar, India, drinking and cooking water are very often unsafe due to natural (e.g. arsenic) and anthropogenic contamination (e.g. faecal bacteria). These contaminants pose significant health risks. Affluent people have easy access to bottled water, but infrastructure for the whole community is the only safe mitigation option for low-income households. While water treatment options can effectively mitigate adverse health effects [1], their acceptance, use, maintenance, and functionality is often low [2] [3]. For decades, water sector professionals have assumed that well-defined "ownership" is a key ingredient for successful community-managed water projects. However, little evidence exists to support the assumption that increased ownership leads to the longevity of infrastructure, even though it has extensive implications for participatory planning.

Psychological ownership and habit to improve infrastructure

The feeling that something is mine or ours, without necessarily legally owning it, is known as *'psychological ownership'* [4]. Psychological ownership has been examined as a key factor related to the acceptance, use and maintenance of safe drinking water infrastructure [5] [6]. These cross-sectional design studies investigated the role of psychological ownership among households using piped supplies and safe water kiosks. The studies examined three routes through which community members' psychological ownership could be fostered: control over, intimate knowledge of and investment of oneself in the target. However, it is unknown how psychological ownership of safe water infrastructure can best be promoted and whether increased psychological ownership, in turn, leads to better acceptance, maintenance and functionality in the long term.

Additionally, the consistent use of a safe water source often requires a change in people's individual routines in water collection behaviour [7]. Switching from an old unsafe source (e.g. water from an unsafe hand pump) to a newly installed safe source (e.g. a community-based piped water supply [8]) requires more than just breaking old habits. New habits would have to be established.

Project PACT

The Public Health Engineering Department (PHED) of the State of Bihar – under the Jal Jeewan Mission of the Indian Central Government and the Mukhyamantri Gramin Peyajal Nishchay Yojana Mission by the Government of Bihar – is installing community-based water treatment units with piped water supply to every household in Bihar by 2024. The villagers in the rural communities have to accept, use and maintain the infrastructure to mitigate the risk of health-related consequences. Project PACT (Participatory Action For Long-Term Arsenic-Safe Water) will conduct a 2×2 factorial cluster-randomised controlled trial (c-RCT; Figure 1) to determine how important psychological ownership and habit are to the acceptance, use, and functionality of this safe water infrastructure.

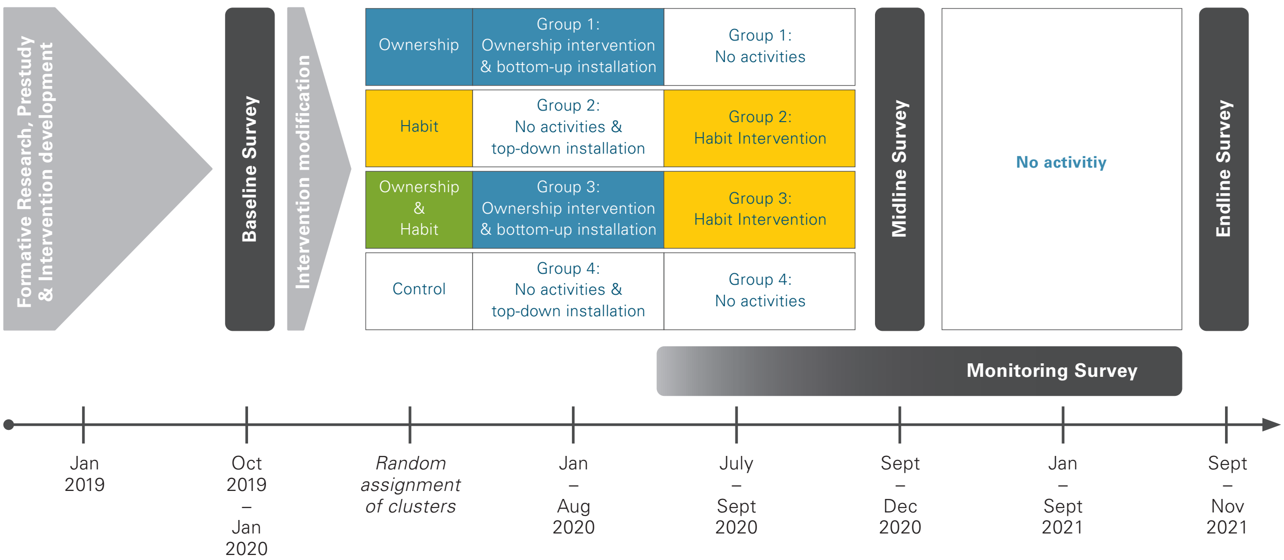

Figure 1: Study design of PACT. Two levels of ownership intervention (yes/no) are combined with two levels of habit intervention (yes/no) to four intervention arms (Ownership; Habit; Ownership+Habit; Control).

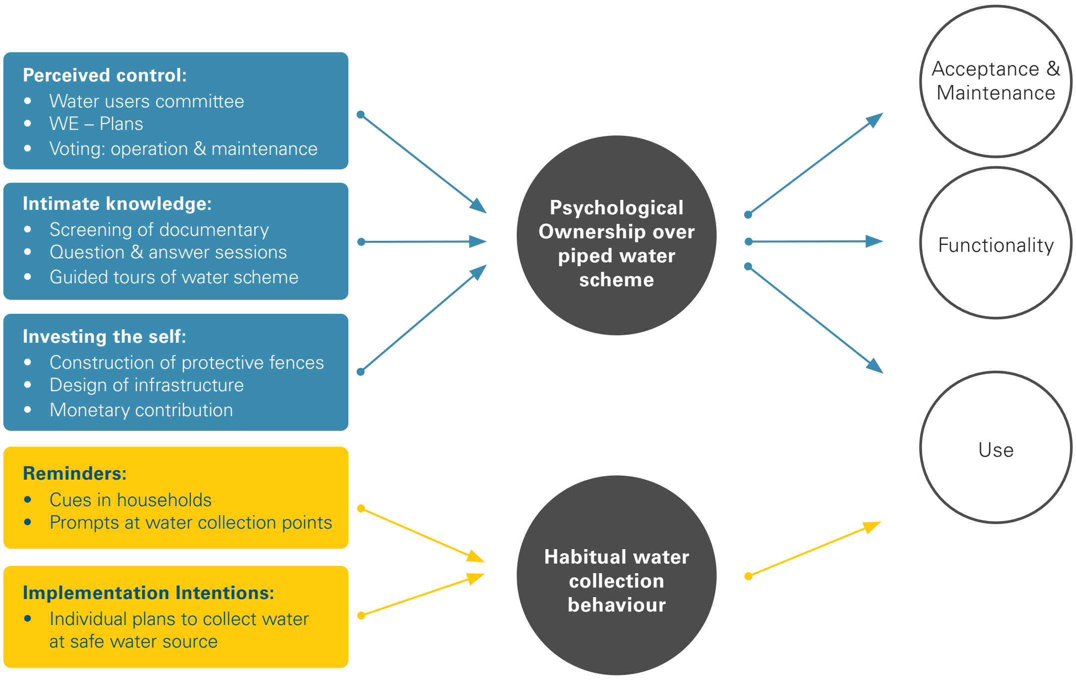

Figure 2: Conceptual diagram showing how psychological ownership of the water scheme and habitual water collection are linked to theorised routes (and intervention activities) and expected consequences.

In a participatory process, the local NGO Paridhi, Tilka Manjhi Bhagalpur University, Bihar State Pollution Control Board (BSPCB), and the PHED, Eawag and University of Bern jointly developed and are performing community-based interventions (Figure 2). The community-based interventions will aim to ensure social embedding of the safe water supply schemes by promoting psychological ownership over the infrastructure in the communities. The household-based interventions to foster habitual use of the safe drinking water sources are based on previous successful interventions [9].

A total of 64 water schemes were randomly assigned to one of the three intervention arms or the control arm. In the control arm, the water scheme is installed by the Bihar PHED, according to their regular protocol, without any additional interventions. The intervention protocol is to be implemented over a period of eight months and is currently about to be completed. Hypotheses concerning the effects on water system functionality, acceptance and use will be evaluated in a survey immediately after the interventions in autumn 2020, and in the long-term in a follow-up survey in autumn 2021.

Conclusion

The findings will contribute especially to Sustainable Development Goal (SDG) 6. Applicable recommendations will be made on how community members can be engaged to improve engineering efforts to achieve universal and equitable access to safe water in rural areas (SDG 6.1, 6.3 and 6.B.1). •

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Safe Water Promotion

About 1.8 billion people use a source of water that is unsafe and large disparities in access to water exist between rural and urban areas and among different regions worldwide. Sandec's research on Safe Water Promotion is developing and evaluating appropriate solutions to strengthen the access to and enhance the consumption of safe drinking water in vulnerable households in low-income countries. Research activities focus on:

- Developing and evaluating appropriate technologies for water treatment and safe storage.
- Assessing the impact of strategies to enhance access to safe water.
- Assessing and improving strategies to enhance demand for safe water and assure consistent consumption.
- Developing and evaluating business models for safe water products.

Photo Health assessments among children in remote areas of Nepal revealed significant associations between children's health and water, sanitation, hygiene and nutrition.

Photo by Rubika Shrestha.

Children's Health, WASH and Nutrition in Remote Areas of Nepal

A cross-sectional survey of 1'430 children in rural Nepal found significant associations of intestinal parasitic infections (56 %), undernutrition (56 %), nutritional deficiencies (64 %) and diarrhoea (17 %) with their sanitation, hygiene, nutrition and water supply. Regula Meierhofer[1], Jeanne Six[1], Dikshya Dahal[1], Rubika Shrestha[2], Madan Bhatta[2], Akina Shrestha[1], Sara Marks[1]

Regula Meierhofer

Interview with mother during children's health assessment.

Introduction

Inadequate water, sanitation and hygiene (WASH) conditions are major human health risk factors. In 2016, diarrhoeal diseases led to 829'000 WASH-attributable deaths, corresponding to 60 % of all diarrhoea-related deaths. Of the WASH-attributable deaths, 297'000 were among children below the age of five [1]. Improving access to safely managed drinking water, sanitation and hygiene protects against diarrhoeal disease [2], while improved WASH practices and infrastructure are associated with at least 33 % lower odds of intestinal parasite infections [3]. Recurrent diarrhoea or intestinal parasitic infections detrimentally impact children's health, growth and cognitive development [4]. Our study foci were the availability of WASH infrastructure and the application of WASH practices, and their association with diarrhoea, parasitic infections, malnutrition status and clinical signs of nutritional deficiencies among children.

Methods

A cross-sectional mixed-methods survey was done from March to May 2018, involving 1'427 rural households with children mainly below the age of five. Caregivers completed quantitative structured questionnaires on WASH infrastructure and practices, child health, nutrition and potential confounders, i.e. education and other demographic and socioeconomic factors. Interviews were complemented by structured observations of the household environment (Photo). Certified medical assistants assessed child growth via anthropometric measurements. Using WHO Anthro-Plus software, z-scores for weight for age (WAZ, underweight), height for age (HAZ, stunting) and body mass index for age (BMIZ, thinness) were done. Morning stool samples were collected from each child and assessed the same day [5].

Water samples were collected from household water sources and the containers used for drinking water transport and storage for water quality analysis. Both samples (100 mL) were analysed on site, using membrane filtration and Nissui Compact Dry Coli-scan plates, incubated for 24 hours at 35 +/- 2°C. Colony-forming units of total coliforms and *Escherichia coli* (*E. coli*) were counted after incubation.

In addition to frequency statistics, principal component analysis was used to calculate household wealth indices and several hygiene indices. Univariate and multivariate mixed logistic regression models with the areas at the random intercept were calculated to assess the relation between the four outcome variables: (a) diarrhoea; (b) intestinal parasitic infection; (c) undernutrition, including stunting, underweight, and BMIZ (thinness); and (d) clinical symptoms of nutritional deficiencies and risk factors. Multivariate models controlled for potential confounders of age, sex and socioeconomic status.

Results

WASH conditions and practices: The majority of households (75.5 %) in the surveyed area collect their water from community-based water taps, 20.7 % receive piped water on their premises and the others use open water sources or dangling pipes (2.3 %). 63.8 % and 79 % of the water samples collected at the source and at the point of consumption were in the intermediate or higher risk categories of WHO's guidelines for microbial drinking water safety. 8.3 % of the households used household water treatment methods; 53 % of these samples had less than 11 *E.coli*/100 mL (low-risk category).

A large majority of the households had a private water-sealed pit latrine (84.1 %), 9.6 % a simple pit latrine and 6.3 % reported practising open defecation. Half of the latrines (48.7 %) were in a poor hygienic state. Handwashing stations were available in 40 % of the households, and 36.7 % of these were equipped with water and 27.2 % with soap. Additionally, the presence of animals in the houses was widespread. 59.7 % of the households keep their animals in the home overnight. The Hindu practice of painting the mud floor with cow dung inside the house was also very common (84.1 %).

Table 1: Risk factors significantly associated with diarrhoea.

	aOR	95 % CI	p-Value
Interruption of water supply > 1 week	2.72	1.18–6.31	0.02
Floor is made of mud	2.29	1.20–4.37	0.01
Latrine is clean	0.68	0.47–0.98	0.03
Child's hands are visibly clean	0.62	0.40–0.96	0.03
Age of the child (> 5 y)	0.39	0.26–0.57	0.01
Frequency of washing hands (when they look dirty)	0.47	0.32–0.71	0.01

Prevalence of diarrhoea and associated risk factors: In the even days prior to the survey, 16.5 % of the children suffered from diarrhoea, 39.6 % suffered from fever and 40.4 % suffered from a respiratory illness (Table 1).

	aOR	95 % CI	p-Value
Type of toilet – pit latrine (vs water sealed latrine)	7.47	1.57 – 23.90	0.006
Type of toilet – no latrine (vs water sealed latrine)	3.93	1.08 – 14.25	0.006
Caregiver can read only (vs can read and write)	4.79	1.00 – 16.55	0.05
Caregiver's hands are visibly clean	0.61	0.41 – 0.89	0.01
No brush, drum and slippers available in toilet	0.25	0.07 – 0.86	0.03

Table 2: Risk factors significantly associated with intestinal parasitic infection.

Prevalence of intestinal parasites and associated risk factors: More than half of the children (51.1 %) had a parasitic infection. Polyparasitism was uncommon. The following prevalence was found: *Ascaris lumbricoides* (21.1 %), *Hymenolepsis nana* (4.6 %), hookworm (3.2 %), *Enterobius vermicularis* (2.7 %), and *Trichuris trichiura* (0.7 %). 23.4 % of the children were infected with *Giardia intestinalis* (Table 2).

	aOR	95 % CI	p-Value
Lower personal hygiene of child & caregiver	1.43	0.92 – 2.22	0.05
Better socio-economic status (vs poor)	0.43	0.25 – 0.75	0.01
Regular deworming	0.44	0.20 – 0.94	0.03
Received supplemental food (snacks)	0.57	0.38 – 0.84	0.01
Production of own food	0.67	0.46 – 0.97	0.03

Table 3: Risk factors significantly associated with undernutrition.

Prevalence of undernutrition and associated risk factors: The anthropometric measurements revealed that 55.5 % of the children suffered from undernutrition. 17.9 % were severely stunted (HAZ < -3), 26.6 % moderately stunted (HAZ < -2 and ≥ -3), 10.4 % severely underweight (WAZ < -3), 19.5 % moderately underweight (WAZ < -2 and ≥ -3), 4.1 % severely wasted (BMIZ < -3) and 7.1 % moderately wasted (BMIZ < -2 and ≥ -3) (Table 3).

Discussion

Our findings indicate that the prevalence of diarrhoea and intestinal parasitic infections was strongly associated with hygiene-related factors, i.e. sanitation, cleanliness and handwashing. People living in a home with a mud floor had 2.3 higher odds of diarrhoeal infection than did those living in houses with durable flooring. Painting mud floors with cow dung is a common cultural practice in the area, which leads to a high presence of faecal pathogens in the household environment. Children who play on the floor and put their fingers into their mouths are especially at risk of disease [6].

However, no association between water quality at the point of consumption and children's health outcomes was observed. This may be due to the water being contaminated in almost all of the households. The share of faecal pathogens present in the water was also low, relative to the general load of faecal pathogens of animal origin in the household environment.

The reliability of the water supply system was identified as an important risk factor for diarrhoea. People who experienced interruptions of the water supply for more than one week were at 2.7 higher odds of having diarrhoeal infection. This indicates the importance of reliable access to water for hygiene practices. Less evident was the association between undernutrition and WASH-related risk factors. A lower prevalence of undernutrition was associated with a better socioeconomic status, own production of food, children receiving food supplements and better personal hygiene among the children and their caregivers. Also, lower odds of undernutrition were observed among children receiving deworming medication.

Conclusion

The status of children's health in remote hilly areas of Western Nepal is alarming. More than half are malnourished and suffer from intestinal parasitic infections. In addition, 16.5 % suffered from diarrhoea during the seven days prior to data collection. Children from households with better sanitation and where handwashing and personal hygiene was practised had lower odds of diarrhoea and intestinal parasitic infections.

The painting of mud floors with cow dung was identified as an important risk factor and should be addressed during future WASH intervention campaigns to improve health outcomes. These interventions should also focus on nutrition and on increasing hygienic practises by providing access to regular and sufficient water, adequate sanitation, proper management and disposal of animal faeces, as well as adequate handwashing. •

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Low-Cost Chlorinators for Gravity-Driven Membrane Water Kiosks

The risks of recontamination of drinking water during transport and storage after collection at the gravity-driven membrane (GDM) water kiosks is high. Our project developed and tested several low-cost chlorinators that provide residual disinfection to the treated water to mitigate these risks. Lukas Dössegger[1], Regula Meierhofer[1]

Introduction

Over the last three to five years, five gravity-driven membrane filtration (GDM) drinking water kiosks have operated in Eastern Uganda [1]. While the water at the tap meets WHO guidelines, recontamination has been found to occur during transport and storage of the water at the household level. Several passive (no electricity needed) low-cost chlorinators that provide residual disinfection to the treated water were tested and analysed:

- Two in-line chlorinators: the T-chlorinator (from [2], adapted by Eawag) erodes chlorine tablets inside a T-fitting and the Chlorine Dosing Bucket (CDB, Eawag), which erodes chlorine tablets in a Floater inside a bucket.
- Three tap attached options: The AquatabsFlo® (Medentech) and the AkvoTur (Eawag) erode chlorine tablets in a small container right after the tap and the Venturi (MSR Group), which adds liquid chlorine using the Venturi effect.
- A Floater (e.g. Index) that floats in the clean water storage tank.
- A chlorine Dispenser (Evidence Action) is used to add chlorine to jerry cans manually.

Evaluation

The chlorinators were assessed using five criteria. Evidence for the assessments came from free residual chlorine (FRC) measurements, experience in the field and the laboratory, doing a market survey, and qualitative interviews with kiosk operators, local experts and households.

Dosing reliability is the ability of the device to constantly achieve a concentration of 2 mg/L of free residual chlorine (FRC) at the kiosk's tap, meeting WHO guidelines (0.2 mg/L FRC at the point of use). The T-chlorinator demonstrated the most reliable dosing in our field experiments (Table). The AkvoTur, AquatabsFlo®, Venturi and Dispenser were less reliable, while the CDB and the Floater were the least reliable.

	Mean FRC ± SD*	N	Chlorination cost (USD)
T-chlorinator	2.0 ± 0.3 mg/L	64	$ 0.03 – 0.05 / m^3
AkvoTur	2.1 ± 0.5 mg/L	78	$ 0.02 – 0.04 / m^3
AquatabsFlo®	2.2 ± 0.6 mg/L	8	$ 0.22 / m^3
Venturi doser	2.1 ± 0.7 mg/L	58	LM**: $ 0.87 – 1.12 / m^3, SP***: $ 0.25 – 0.97 / m^3
Dispenser	1.9 ± 0.7 mg/L	17	LM**: $ 0.97 – 1.00 / m^3, SP***: $ 0.23 – 0.73 / m^3
CDB	1.7 ± 0.9 mg/L	56	$ 0.03 – 0.11 / m^3
Floater	1.5 ± 0.9 mg/L	15	$ 0.01 – 0.03 / m^3

* standard deviation, ** local market, *** self-produced

Dosing reliability in the field and chlorination cost of the different chlorinators.

Several constraints were found. The AkvoTur overflows at flow rates above 12 L/min. Minimum flow rates are required for the T-chlorinator (2 L/min) and the Venturi (6 L/min), otherwise FRC concentrations rise above 4 mg/L. While a minimum flow rate of 2 L/min is realistic for the GDM kiosks, a minimum flow rate of 6 L/min is not possible given the current design. The FRC concentration provided by the CDB was flow dependent ($p = 0.003$, Pearson correlation, two-tailed) and, thus, not suitable for the GDM design. However, modelling of the impact of the flow rate on FRC revealed that, if the relative amount of water flowing through the bypass of the CDB is increased, the dosage would be less flow dependent.

Cost includes the cost of the devices, replacement parts and chlorine, and of assessments of their affordability for the kiosks. Except for the Venturi (ca. US$ 150 if mass-produced) and the CDB ($ 50), the devices cost $ 20 or less. The major cost is the chlorine. In the study area, chlorine tablets are cheaper than liquid chlorine, which is quite expensive on the local market ($ 3.20/L). Although producing liquid chlorine with a WATA reduces its cost, the WATA is expensive ($ 280), making self-produced chlorine also expensive. The Table presents cost ranges for chlorinating water over one to five years of operation and yearly volumes of 600 – 1'200 m^3 for all the chlorinators. A longer operation period and higher treatment volumes would decrease the cost per m^3 treated.

User-friendliness refers to the kiosk operator's and consumers' assessments of the handling of the device and user comfort. The in-line options (T-chlorinator and CDB) were easily accessible and easy to use. The tap-attached options (AquatabsFlo® and AkvoTur) were also easy to operate, but require removal at the end of the day to limit vandalism. This places an additional burden on the kiosk operator and poses the risk of damaging the device during handling. The AquatabsFlo® also only allows for limited dosing adjustments. The Venturi is an exception among the tap-attached options, as it is well protected in a metal box and does not need to be removed. The Floater is difficult to access in the clean water tank, and use of the Dispenser requires that the users be responsible for the dosing. The risk is high that this would not be reliably done.

Maintenance and durability relates to the need for external maintenance and the robustness of the device. While almost all the devices were robust, with few wearing parts and no external maintenance requirements, the tap-attached options were exceptions. The AkvoTur and the AquatabsFlo® are not durable. The AquatabsFlo® is replaced when new chlorine tablets are required, while the AkvoTur can be refilled. The Venturi has fragile parts, but they are well protected in a metal box.

a), d) Alan Tournefier, b) Timon Huonder, c), g) Lukas Dössegger, e) Laura Germann, f) Nicola Gärtner

Suitable chlorinator options for GDM kiosks are difficult to find, as the water pressure in the system is low (0.1 – 0.3 bar) and the flow rate is variable (determined by the water level in the clean water tank). Passive low-cost chlorinators commonly require minimum pressure and constant flow conditions for adequate operation. a) T-chlorinator, b) AquatabsFlo(R), c) Floater, d) AkvoTur, e) Chlorine Dosing Bucket, f) Venturi Doser, g) Chlorine Dispenser.

Supply chain refers to the market availability of the device, spare parts and chlorine. The three devices developed or adapted at Eawag (T-chlorinator, AkvoTur and CDB) can be manufactured in Uganda with locally available materials. While 3-inch TCCA (trichloroiso-cyanuric acid) tablets for the CDB are available in Kampala, 1-inch TCCA tablets for the T-chlorinator and AkvoTur were only available in Kenya and a supply chain would have to be established. The liquid chlorine solution for the Venturi and the Dispenser can be self-produced using a WATA [3] or purchased in the local market. Although the Dispenser is available in Kampala, the Venturi is a prototype and currently has to be imported from the US. The AquatabsFlo® and the Floater are available in Kampala as are the chlorine tablets required.

Conclusion

The T-chlorinator is the most promising option. It doses reliably, is easy to use and accessible, robust and made of low-cost, local materials. The in-line chlorination options (T-chlorinator and CDB) are recommended for permanent installations. They are more durable than tap-attached options, which need to be removed daily. Furthermore, they automatically chlorinate the water, while individuals must chlorinate the water themselves with the Dispenser. Tap-attached options (AquatabsFlo® or AkvoTur) are more suitable for temporary use, as they can be easily installed and operated, but are less robust. An exception is the Venturi, which has to be permanently installed. The Floater is not suitable in our case, as chlorinated water could flow back from the clean water tank into the membrane tank and impair the functioning of the filter membranes. Besides the device, a reliable and affordable supply of food grade chlorine is a critical factor for a sustainable operation. •

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Education and Training

Educating and training students and professionals in the WASH sector is a tremendous challenge, especially in light of COVID-19. Sandec's Education and Training Programme was established to close the global WASH capacity gap. It does this by offering a wide range of education and training initiatives, covering face-to-face, blended and online formats, as well as fellowships. Five of our main focus areas are:

- Offering free, high quality online education at scale continuously on Coursera with the MOOC series "Sanitation, Water and Solid Waste for Development".
- Fostering capacity development collaborations with partner institutions in Africa, Asia and Latin America.
- Conducting research on digital learning in the WASH sector.
- Teaching Masters courses on Sanitary Engineering at EPFL Lausanne and ETH Zurich.
- Offering Eawag Partnership Programme Fellowships to PhD students and visiting scientists from low- and middle-income countries.

Photo How to design a learner-centred online course? How to practically plan and produce learning videos? How to contextualise learning materials to the needs of your audience? These are a some of the questions that Sandec is addressing in its digital learning workshops. The picture shows a team during the development of a learning video on urban sanitation at the digital learning workshop at the Zambia College of the Built Environment in Lusaka.

Photo by C.R. Lohri.

Digital Learning in Times of the COVID-19 Pandemic

In light of the COVID-19 pandemic, Sandec is prioritising three lines of action in the field of digital learning – increasing accessibility to our MOOC-series, piloting and validating interactive online courses for small groups, and collaborating with partners to reduce the digital divide in the WASH-sector. Fabian Suter[1], Christoph Lüthi[1]

Introduction

Within a few months, COVID-19 has changed education on a global scale and led to a distinctive shift towards digital learning. UNESCO estimates that over 90% of global learners at all levels, from pre-primary to higher education, have been affected by school closures caused by COVID-19 [1]. Educational institutions were forced to build up or expand their online offerings in a very short period. With an estimated global digital population of 4.6 billion, a large proportion of global learners are currently left behind, due to the lack of reliable internet access, technology issues and/or deficiencies in digital learning literacy [2]. The pandemic and the predicted global recession could further increase the digital divide, severely impeding the achievement of SDG 4: "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" [3].

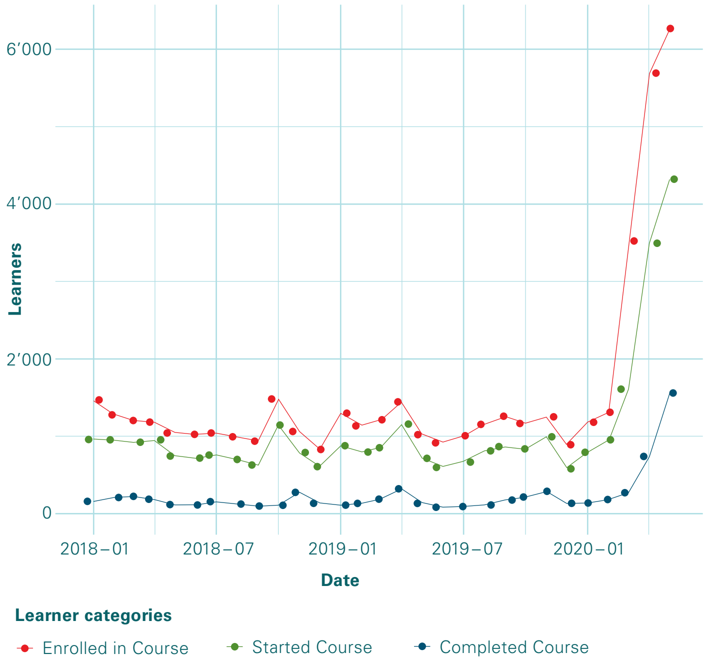
According to the World Bank, the crisis is an unprecedented shock to education, but also provides an opportunity to build stronger and more equitable educational systems [4]. Educational institutions have used this time to create digital solutions for their learners, gaining a wealth of first-hand experiences of the challenges and opportunities related to digital learning. These experiences will influence the design of post-pandemic educational systems and ideally lead to a systematic and learner-centred combination of digital and face-to-face activities.

Three lines of action for Sandec's digital learning programme

Since the beginning of the pandemic, Sandec has experienced a massive increase of learners in its MOOC series "Sanitation, Water and Solid Waste for Development". Normally, the series has approximately 1'200 newly enrolled learners every month. Since April 2020, however, this number has multiplied by five, i.e. about 6'000 new learners per month (Figure). Sandec is intensifying its efforts to interact with learners and to make the courses available to larger audiences by offering them, for example, with new subtitles (Bengali and Hindi).

In many countries, it is currently unclear, when and in what form onsite training will resume. As a result, Sandec is developing and validating online training formats for small groups, combining ready-made video lectures, reading materials, quizzes and practical assignments, and interactive live-sessions that offer high levels of interaction. The first training prototype will be on Citywide Inclusive Sanitation and be completed in autumn 2020.

The third line of action relates to experience sharing and mutual learning with partner organisations. Sandec aims at contributing to a diversified digital learning landscape in the WASH sector by sharing its digital learning materials and expertise through remote collaborations or, when the health situation allows, onsite workshops (See article on p. 47). •



Newly enrolled learners, active learners and course completers per month in the MOOC Series "Sanitation, Water and Solid Waste for Development" between January 2018 and May 2020.

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

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How to Kick-off a Digital Learning Programme

Since 2018, Sandec has offered digital learning workshops to build up digital learning programmes in the WASH sector. Three programme elements essential to consider are the makeup of a digital learning team, the initial investments, and how to kick-off a digital learning programme. Fabian Suter[1], Christian Riu Lohri[2]

C. R. Lohri

Production of a learning video during the digital learning workshop at ENPHO in Nepal.

Introduction

In 2019, Sandec facilitated five digital learning workshops at partner institutions in Uganda, Zambia, Ivory Coast, Nepal, and Bangladesh, supporting the build-up of their digital learning expertise. These collaborative activities underline the importance and enormous potential of digital learning programmes at universities and training centres in Africa and Asia. The following questions address common hurdles when initiating a digital learning programme.

How to compose a digital learning team?

While the structure and size of a digital learning team vary according to the scope and complexity of the programme, the following roles and clear allocation of responsibilities from our perspective build the fundament of successful digital learning programmes:

1) Programme manager: develops and ensures sustainable running of the programme by strategically aligning all institutional digital learning activities

2) Content expert: develops the content and leads the course instruction

3) User Experience-Designer: digital learning expert with in-depth knowledge in instructional design, responsible for providing an effective and inspiring user learning experience

4) Videographer: records and edits learning videos

What initial investments are required?

There are three main cost drivers at the beginning of a digital learning programme: people, a learning management system (LMS), and infrastructure / equipment. [1] Digital learning is a dynamic field. Reserving sufficient resources to build up a team and to develop capacities continuously are, therefore, essential. LMS requirements differ among institutions and defining its long-term institutional needs upfront will help to avoid costly duplication of efforts. An important question is: will the institution host the LMS itself (e.g. set up a Moodle-platform) or collaborate with a third-party institution (e.g. partner with Coursera or edX). Recording learning videos in fully equipped studios can doubtlessly contribute to the success of a digital learning programme. However, creative options exist to produce professional digital learning content with minimal equipment investment (a camera, a microphone and a computer with sufficient processing power for video editing). A famous example is the MOOC "Learning how to learn", which was initially recorded in a professor's garage that has reached over two million learners [2].

How to practically kick-off a digital learning programme?

Setting up a digital learning programme initially requires strategic thinking (about team composition, resource allocation, platform selection, etc.), backed up by the practical experience gained from a continuous institutional learning process. Our recommendation is to do a first project to acquire planning, execution and evaluation experience. Collaborating with a motivated and rhetorically skilled content expert and selecting a manageable course format and size will contribute to success. Based on this experience, capacity gaps can be identified and filled [3] [4] [5]. •

References

[1] F. Hollands and D. Tirthali, 'Resource Requirements and Costs of Developing and Delivering MOOCs', *IRRODL* [web document] (2014) http://www.irrodl.org/index.php/irrodl/article/view/1901/3069 (accessed 9 July 2020).

[2] J. Schwartz, 'Learning to Learn: You, Too, Can Rewire Your Brain', *The New York Times* [web document] (2017) https://www.nytimes.com/2017/08/04/education/edlife/learning-how-to-learn-barbara-oakley.html (accessed 9 July 2020).

[3] OCW IHE Delft, 'Designing and planning online courses', *IHE Delft* [web document] (2020) https://ocw.un-ihe.org/course/view.php?id=85 (accessed 9 July 2020).

[4] Coursera, 'Coursera for Educators', *Coursera*, [web page] (2020) https://blog.coursera.org/for-educators/ (accessed 9 July 2020).

[5] UC Davis, 'Developing an online course' *UC Davis* [web page] (2020) https://canvas.ucdavis.edu/courses/34528/pages/developing-an-online-course (accessed 9 July 2020).

[1] Eawag/Sandec, Switzerland

[2] momokofilm, Switzerland

Contact:

Please contact us if you are interested in a digital learning workshop facilitated by Sandec or to explore other opportunities for a digital learning

Collaboration: fabian.suter@eawag.ch

In Memory of Dr. Ives Kengné

Sandec would like to dedicate this Alumni Page to the memory of Dr. Ives Kengné, who died from COVID-19 in Abidjan, Ivory Coast, on 14 June 2020. Ives was one of Sandec's first Faecal Sludge Management PhDs from West Africa.

Stéphanie Nzickonan

Dr. Ives Kengné

Anonymous

At the summit of Jungfraujoch: (LTR) Halidou Koanda, Ives Kengné, Alain Serge Kouadio and Noah Adampté.

Remembrances

Ives was one of our PhD students under the Swiss National Centre of Competence in Research (NCCR) North-South co-funded by the Swiss National Science Foundation (SNF) and the Swiss Agency for Development and Cooperation (SDC). His PhD project was a research collaboration between the University of Yaoundé I in Cameroon and Eawag/Sandec. His objective was to define design criteria and operation and maintenance criteria of vertical-flow constructed wetlands for the treatment of faecal sludges produced in African countries. I always enjoyed my interactions and discussions with Ives. I remember him not only as a very motivated and hard-working PhD student, but also as a human being with a fine, humble and warm character.

Roland Schertenleib

I met Ives in Switzerland in 2008 during my postdoc at the Swiss Tropical and Public Health Institute (TPH) in Basel and Eawag/Sandec in Zurich. Ives and I developed a project together as co-project leaders, funded by SNF and SDC in 2009, in the fields of environmental sanitation and health.

I will remember Ives as a very good friend and colleague who was always smiling and very available when we needed his support. He was part of a group of African experts in water, sanitation, and health, most of whom have great links with Switzerland, in particular with Eawag/Sandec, EPFL and Swiss TPH.

Hung Nguyen

I met Ives during his PhD thesis in the NCCR-NS programme. Ives was a person who enjoyed life and he was passionate about sanitation, specifically faecal sludge management. He brought this topic and developed it in the research programmes in Cameroon, where he was a Professor at the University of Yaoundé I.

The photo at Jungfraujoch in Switzerland was taken during a trip organised by NCCR-NS and shows the ambitions we had concerning faecal sludge management in Africa. Take faecal sludge management to the roof of Africa! We are on the right track and Ives helped to sow the right seeds!

Halidou Koanda

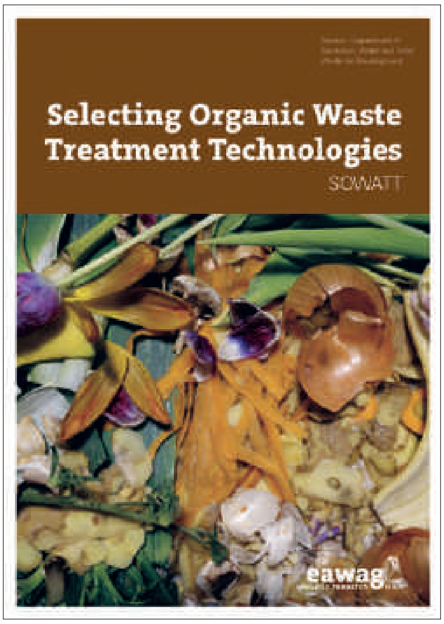
Thanks to the NCCCR program and Martin Strauss, head of Sandec's Faecal Sludge Management (FSM) team at that time, Ives and I were able to build a reference centre for research, and support technical consultants at the University of Yaoundé. Later in his career, Ives supported Sandec programmes in Africa and worked with the African Development Bank as a Consultant, as well as with the International Science Foundation (ISF) in Africa.

Ives was a happy man, always smiling, very optimistic. He was a passionate optimist and a change maker. Ives is an accomplished academic and international expert.

Doulaye Kone

The "SOWATT" Manual is Now Available!

SOWATT or Selecting Organic Waste Treatment Technologies is a decision support tool that helps to structure and facilitate the process of comparing and selecting the most promising biowaste treatment options for a given case study. The SOWATT manual provides an in-depth description of six technologies commonly used to treat organic waste in low- and middle-income settings: composting, in-vessel composting, vermicomposting, black soldier fly processing, anaerobic digestion and slow pyrolysis. Its launch was in January 2020.



The manual promotes a multi-criteria decision analysis approach known as Multi Attribute Value Theory. This approach assesses the treatment technologies against a range of criteria, such as local contextual information (e.g. climate) and information intrinsic to the technologies (e.g. water needs). Examples of the criteria are technical feasibility, economic feasibility, social impact, environmental protection and high contribution to waste management. The manual also explains how to weigh these criteria based on the preferences of local stakeholders, which are obtained through stakeholder analyses and structured interviews.

The underlying concept of the manual is that biowaste has a value and that recycling biowaste can contribute to the economic and environmental sustainability of solid waste management. Its target audience are readers with a basic knowledge of waste management, who want to work with waste and find a way to deal with the currently unmanaged amounts of organic waste.

www.eawag.ch/en/department/sandec/projects/mswm/sowatt-selecting-organic-waste-treatment-technologies/

Production of Our First SPOC!

Sandec is producing its first Small Private Online Course (SPOC) for the Asian Development Bank-Institute. Different than a MOOC, a SPOC is for a small group of learners, and allows for closer interaction between instructors and participants and more peer-to-peer communication. This SPOC will cover Citywide Inclusive Sanitation, be offered to sanitation professionals in Asia and take place in November 2020. If you would like more information, please contact Laura Baquedano or Vasco Schelbert (laura.baquedano@eawag.ch, vasco.schelbert@eawag.ch).


Ikonaut

World Café 2019

Paul Donahue

The Sandec group photo is normally taken at the retreat. This year's retreat in March 2020 was, however, postponed due to COVID-19.

This photo is of the World Café at the 2019 retreat. During the World Café, each of Sandec's thematic groups have a table to present their on-going research, and there is a PhD table where PhD students discuss their work. This photo features Stanley Sam, a MEWS PhD candidate.

New Faces at Sandec

Julia Egger completed her Master's Thesis in the ETH Sustainable Food Processing Research Group at ETH Zürich under the guidance of Moritz Gold in 2019, where she became familiar with the Black Soldier Fly (BSF) waste treatment technology. Shortly after completing her Thesis, she moved to Surabaya, Indonesia, and started working for the Municipal Solid Waste Management group's SIBRE and FORWARD projects, focusing on evaluating post-processing options for BSF products.

Maximilian Grau, MSc in Environmental Engineering from the University of Stuttgart, joined the Solid Waste Management Group in March 2020. He is supporting the Black Soldier Fly Larvae Project in Indonesia, a waste assessment study for a refugee camp in Zimbabwe, focusing on the potential use of biogas and the Waste Flow Diagram and SDG 11.6.1 activities. He lived in Durban, South Africa for the past nine years, where he worked for the University of KwaZulu-Natal, the eThekwini Municipality and engineering consultancies.

Laura Baquedano studied Law and Political Sciences at the University Carlos III in Madrid, and after acquiring professional experience in digital learning, she studied International Business Management at the University of Barcelona. Laura joined the Digital Learning Programme at Sandec in July 2020. In her current position, she identifies and implements solutions to increase the accessibility and user-friendliness of our digital learning courses and products.

Benjamin Ambuehl is a PhD candidate at Sandec's Water Supply and Treatment group and the University of Bern, Switzerland. His research project is a two-factorial cluster randomised control trial, testing whether psychological ownership and water collection habits can improve acceptance, long-term use, and sustainable functionality of community-based safe drinking water infrastructure in Bihar, India.

On the Bookshelf

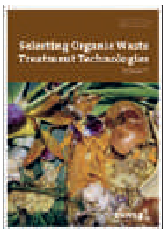
Apart from the publications cited in the previous articles, we would like to recommend the following new books and key readings in the areas of our research, including some of our own new publications.

Water Supply and Treatment

The United Nations World Water Development Report 2020: Water and Climate Change

This report aims at helping the water community address the challenges of climate change. It also informs the climate change community of the opportunities that improved water management offers in terms of adaptation and mitigation.

By: UNESCO, 2020. 219 pages.
ISBN: 9789231003714
It can be downloaded for free at:
https://bit.ly/3iaIXHW

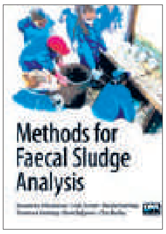


Municipal Solid Waste Management

Selecting Organic Waste Treatment Technologies (SOWATT)

This manual covers the challenges municipalities have in dealing with organic waste. It introduces the issues of biowaste treatment and presents a stepwise approach to support the selection of a biowaste treatment option.

By: I. Zabaleta et al, Eawag, 2020. 246 pages.
ISBN: 97839064848723
It can be downloaded for free at:
https://bit.ly/3gAzCc8



Management of Excreta, Wastewater and Sludge

Methods for Faecal Sludge Analysis

This book provides a basis towards standardised methods for characterisation and quantification of faecal sludge from onsite sanitation technologies. It also covers sampling techniques and health and safety procedures for faecal sludge handling.

By: K. Velkushanova et al, IWA Publishing, 2020. 350 pages.
ISBN: 9781780409115

Strategic Environmental Sanitation Planning

Compendium of Sanitation Technologies in Emergencies, 1st Edition

This book provides a structured and user-friendly guide and planning aid for sanitation solutions in humanitarian emergency relief. It presents a wide range of proven technologies and information on the key decision criteria for each technology.

By: German WASH Network and Eawag, 2020. 200 pages.
ISBN: 9783906484686
It can be downloaded for free in English at:
https://bit.ly/2XuTia2
and in French at:
https://bit.ly/3fyUdw2

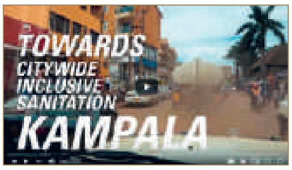
On the YouTube Channel

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

Adeline Mertenat Sandec Project Officer

The first in Sandec's Project Officer Video Portrait Series, this video highlights Adeline Mertenat, Project Officer in the Municipal Solid Waste Management Group. This series will portray the Project Officers, their motivations and educational backgrounds.

Produced by: Sandec-Eawag
Filmed and edited by: Paul Donahue, 2020. 1:00.
It can be seen at: https://bit.ly/3ke8AJU



Towards Citywide Inclusive Sanitation video series

The five-part video series portrays African and Asian cities moving to-wards citywide inclusive sanitation. Sanitation experts from Kampala, Lusaka, Kathmandu, Dhaka and Abidjan tell the sanitation story of their cities.

Produced by: Sandec-Eawag & momoko film
Filmed and edited by: Riu Lohri, 2019.
The series can be seen at: https://bit.ly/3kgdrdC

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