No. 22
09/21

Sandec Department of Sanitation, Water and Solid Waste for Development

sandec news

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Content

Sandec's work is made possible by our long-standing in-country partnerships and collaborations in Africa, Asia and Latin America.

Every one of us has been through an exceptionally difficult year – there has been no certainty, no planning possible and no familiar framework. Sandecers have not been able to travel abroad or interact and exchange with our global project partners for over a year. Although most of us are still working in home office, we are able to stay virtually connected both in Switzerland and with our research partners in the 20+ countries where we currently are conducting our research.

This is only possible thanks to our long-standing in-country partnerships and collaborations in Africa, Asia and Latin America. Integrity and mutual trust in conducting field research, data collection and paper writing are the most valuable currency in these trying times.

During the pandemic, enrolment in our Massive Open On-line Courses (MOOCs) has continued to grow and we are proud to announce having almost 160'000 participants and 25'000 course completers. We have also tested new promising online learning approaches together with the Asian Development Bank Institute, which are targeted for smaller, more interactive teaching environments, based on the *Coursera Private Session* platform.

I would like to highlight three new Sandec flagship publications that have just been published:

- The SuSanA publication *A Sanitation Journey – Principles, Approaches and Tools for Urban Sanitation* provides an orientation for both sanitation professionals and people from outside the sector about where the sector stands and where it should be heading. It describes a set of proven approaches and implementation tools that are now in demand in order to achieve progress in urban sanitation and hygiene. Against a historical background, it depicts how the situation of urban sanitation in the Global South has developed and how ideas on improving urban sanitation have evolved over the past decades.

- *Methods for Faecal Sludge Analysis* provides a basis for standardised methods for the analysis of faecal sludge from onsite sanitation technologies, for improved communication between sanitation practitioners and for greater confidence in the generated data. The book presents background information on types of faecal sludge, methods for sample collection, health and safety procedures for handling faecal sludge, case studies on experimental design, an approach for estimating faecal sludge at community to citywide scales, how to model containment and treatment processes, recipes for simulants and the laboratory methods for faecal sludge analysis currently in use.

- *Black Soldier Fly Biowaste Processing – A Step-by-Step Guide* contains all the information necessary to develop and operate a BSF waste processing facility. In this second edition, the guide suggests some adapted operational practices based on the results of our research and has two new chapters, one about a model for cost estimations and another on procedures for the post-processing of larvae to marketable products.

We hope you enjoy reading this edition of Sandec News!
Best regards and stay safe –
Christoph Lüthi, Director, Sandec

Municipal Solid Waste Management

Solid waste management is one of the major environmental challenges of urbanisation. Together with local partners, the research of Sandec's Municipal Solid Waste Management group 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 Manual sorting of waste at a material recovery facility in Central Java. Sorting waste is a precondition for sustainable recycling.

Photo by Sirajuddin Kurniawan.

Waste to Biogas in Refugee Camps: An Assessment in Zimbabwe

Our study assessed waste substrates and developed scenarios to evaluate and estimate expected biogas yield. Although the biogas would only offset a small percentage of the total cooking fuel used, the improved waste and sanitation system justifies implementing biogas reactors. Christian Zurbrügg[1], Adeline Mertenat[1], Max Grau[1], Miriam Bergqvist[2], Jay Matta[3]

Figure: Enumerators were asked to identify and photograph (from left to right) organic waste (non-edible and edible), mixed waste, and to weigh mixed and organic waste separately (right).

Introduction

Tongogara Refugee Camp (TRC) is in southeastern Zimbabwe and hosts ~14'500 people, mainly refugees from the Democratic Republic of Congo, Rwanda and Burundi. Key challenges voiced by the United Nations High Commissioner for Refugees, TRC camp management and residents are access to cooking fuel and waste management. Residents cook with firewood or charcoal provided by camp management, but also collect firewood from the nearby forest, resulting in tensions with the local host communities. Security threats to women who often gather the firewood and respiratory health risks from the indoor wood stoves are the main drivers for exploring cooking fuel options. Not all waste is collected and even less reused or recycled; large amounts are indiscriminately or openly burned.

Anaerobic digestion (AD) for organic waste treatment generates biogas, a renewable energy source that can be used in gas cooking stoves. Implementing AD systems in TRC could, therefore, tackle both the energy and waste management challenges. This study determined if and how much biogas could be produced in TRC and the main challenges and opportunities.

Method

The study was designed and coordinated from Switzerland due to COVID-19 travel restrictions, and consisted of interviews and surveys with TRC staff, biogas experts and companies. Surveys of 96 households (HHs) were done by trained enumerators, who were also hindered by COVID-19 safety regulations. The HH surveys determined: 1) the amount of waste generated per HH, 2) current practices with generated waste, and 3) willingness of people to use biogas. Waste was segregated at HH level and the different waste fractions were measured separately using a mobile scale (see Figure). For mixed waste, composition analysis was not performed, but national waste composition data was used to estimate the organic fraction. Recurring measurements of waste amounts were also not possible; instead, HHs were asked when the respective bin/container was last emptied during the weighing. A spreadsheet tool, based on available literature data, was used to estimate biogas yield for different waste feedstock types and amounts. After primary and secondary data collection, seven scenarios were examined, differing in degrees of centralisation in combination with different types and amounts of waste feedstock.

Waste and its management

The waste feedstocks available for biogas production are: HH organic waste, faecal sludge (FS), pig manure and agricultural waste. People with animals typically source segregate their organic fraction in a separate bin to feed them, and the segregated waste was not considered available for AD. Because the current sanitation system relies mainly on pit latrines that are closed when full, accessing the FS would be very difficult and restricted only to sludge from septic tanks. However, this could be a more prominent feedstock when new areas are developed for the increasing number of refugees. Pig manure from a nearby pig farm is also available in large quantities (~1 ton/day) and is suitable for AD. Agricultural waste is available, but in small quantities (~6 kg/day) and shows seasonal variation in types and amounts.

There is no specific waste management plan at TRC. Waste is collected weekly from the thirty-eight 200 litre containers in the camp and off the streets, and transported to one of the 10 to 20 dumpsites in the camp. Some HHs living close to dumpsites throw their waste directly into the pits, and dumpsites are set on fire to reduce waste volume. According to the HH survey, 65 % of the respondents dump their waste close to their homes, at a dumpsite, or bring it to a collection container, 20 % burn waste in their gardens or close to their homes and 4 % have their waste picked up at home.

Scenario	Feedstock	Daily Biogas Production	Digester Volume
Centralised approach with fewer larger biogas units			
1	• Pig manure • Kitchen waste	~170 m^3 ~115 households ~3% of camp	~220 m^3 (or 5 x 50 m^3)
2	• Pig manure • Kitchen waste • Agricultural residues	~170 m^3 ~115 households ~3% of camp	~220 m^3 (or 5 x 50 m^3)
3	• Pig manure • Agricultural residues	~70 m^3 ~45 households ~1% of camp	~42 m^3
4	• Pig manure • Kitchen waste • Agricultural residues • Faecal sludge	~170 m^3 ~115 households ~3% of camp	~220 m^3
5	Maximal amounts of: • Pig manure • Kitchen waste • Agricultural residues • Faecal sludge	~650 m^3 ~430 households ~11% of camp (max 13%)	~900 m^3
Decentralised approach with many smaller biogas units			
6	• One household's current production • Kitchen waste • Agricultural residues • Faecal sludge	0.3 m^3 ~0.2 household	~2 m^3 (minimal size)
7	• 15 households share 1 digester • Kitchen waste • Agricultural residues • Faecal sludge	~4.4 m^3 ~2.9 household	~13 m^3

Table: Summary of scenario results.

Scenarios

The Table summarises the seven scenarios. Results were estimated regarding daily biogas production in cubic meters per day, number of HHs served per day, (assuming a use of 1.5 m^3 biogas/day for ~4.5 hours of cooking) and percentage of total wood used as cooking fuel that could be substituted by the calculated biogas amount generated.

A centralised approach, "Scenario 1", is believed to be the most feasible and practicable in light of different technical, operational and socio-economic aspects. It would use pig manure and household organic waste from the entire camp, assuming a collection rate of 60 %. The digester should be located close to the one large point-source of waste, the piggery, to decrease the waste transport burden. The biogas produced could quantitatively cover 3 % of the overall camp's cooking fuel. HHs would need biogas stoves, requiring a significant investment and a change in behaviour. This approach should target only a few large biogas users, i.e. restaurants or shared kitchens, to reduce gas transportation costs and potential losses.

An optimistic decentralised scenario (Scenario 6) shows that when considering a daily HH kitchen waste generation rate of 0.37 kg/person/day, 0.35 kg/person/day of FS and agricultural residues of 0.1 kg/HH/day, 0.3 m^3 of biogas per person and day can be produced, corresponding to 20 % of the daily cooking needs. It requires many small-scale digesters at HH level and, thus, a high investment. Although HH members show interest in using biogas for cooking, the additional burden of training in operation and maintenance (O&M) must be considered.

Conclusion

The study concludes that the level of organic waste generation in TRC is moderate. Much food waste is given to animals or unseparated and mixed with inorganic waste, and FS is mostly inaccessible due to sanitation norms (pit latrines) and cultural factors. Uncertainties in the study relate to the data on quantities and composition of waste at HH level. COVID-19 restrictions did not allow for a more detailed and systematic sampling. Larger, centralised digesters are considered more efficient and centralised users might be best suited for biogas, such as restaurants or shared kitchens. Even a widespread application of biogas systems and biogas use as cooking fuel would not offset the large amounts of wood and charcoal currently used. However, accessing waste sources for biogas would incentivise an improved overall solid waste, FS and manure waste collection and treatment system, reducing the current pollution impacts on environmental and human health.

Key elements to consider are: a) adequate training for all stakeholders involved in O&M, b) a professional provider of equipment, ideally located in the region, that can ensure regular service and support, and c) provision of digestate treatment before disposal or reuse. To incentivise performance, a profit-based approach could also be envisaged; past biogas projects have shown that ownership and financial interest were key for medium and long-term sustainability. A business approach, with customers, such as restaurants, paying for biogas could be an interesting way forward. As this study limited its financial analysis only to capital costs, more detailed considerations would be required to assess an ideal business model and its financial viability. •

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We would like to thank TRC staff, as well as people from World Vision, UNHCR, SOWTech, BiogasSA, (B)Energy, The Rural Electrification Agency (REA) and Engineers Without Borders Norway, who provided valuable information and support for the study, as well as the Swiss Humanitarian Aid (SHA) for funding this research.

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Mainstreaming Black Soldier Fly Practical Knowledge

"FORWARD" and "SIBRE" come to an end this year. The aim now is to document and disseminate the generated know-how from these projects among our Indonesian partners to mainstream this biowaste technology for widespread application and replication throughout Indonesia. Bram Dortmans[1], Julia Egger[1], Christian Zurbrügg[1]

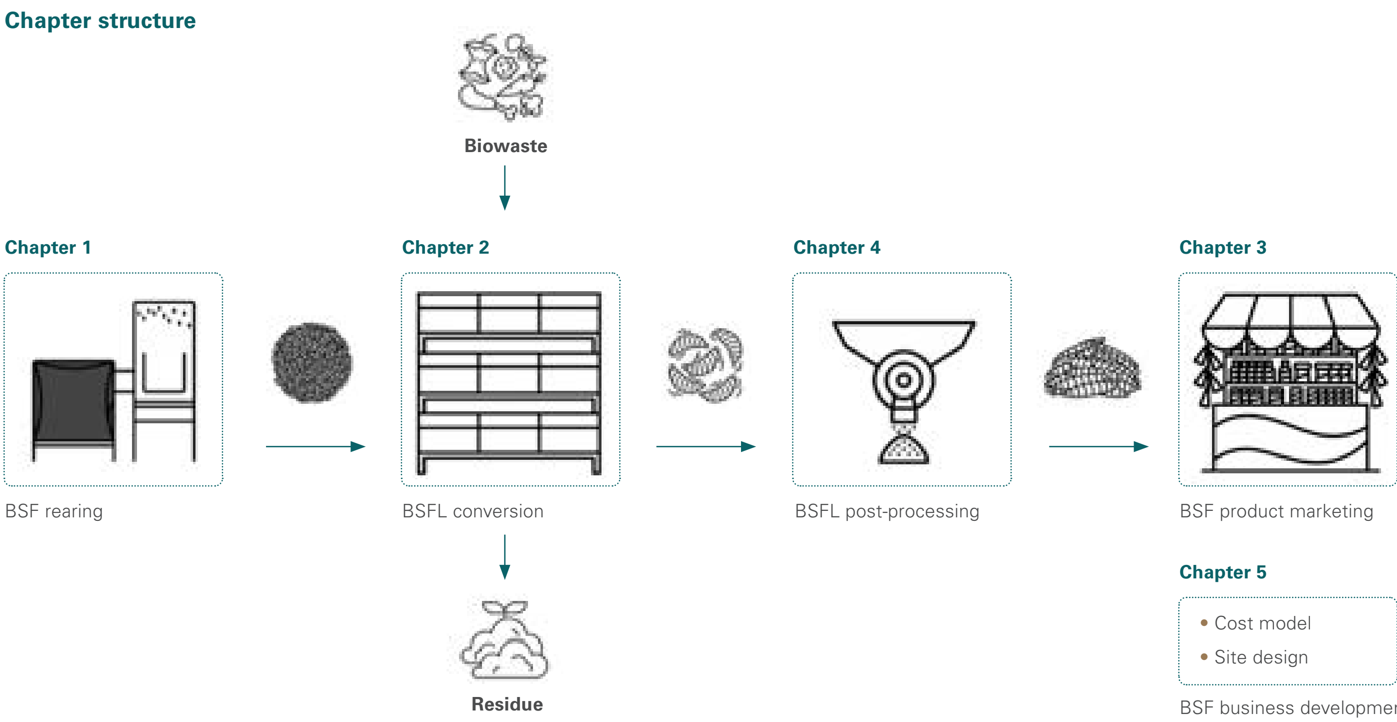

Figure 1: Overview of the chapters of the e-learning video series.

Introduction

The FORWARD (From ORganic WAste to Recycling for Development) project started in 2013 and was developed as part of a framework agreement with the Indonesian Ministry of Public Works (PU-PR) and is funded by the Swiss State Secretariat for Economic Affairs (SECO). By 2017, the project had showcased a technically viable integrated system for biowaste processing using the Black Soldier Fly (BSF) in Sidoarjo, Indonesia. The SIBRE (Sustainability of Insect-Based Recycling Enterprises) project was then launched with a focus on determining the financial viability of the BSF biowaste processing technology. This involved developing a cost-benefit assessment tool, as well as looking at the market potential of BSF products and how to produce them. Both projects are now in their final phases and as such, are disseminating and making available their results and lessons learned. The main target groups for these materials are managers and operators of waste transfer stations who have been trained under the auspices of the Ministry of Public Works (PU-PR), other Indonesian actors (private enterprises, NGOs, etc.), as well as the international community, which is increasingly interested in developing BSF waste processing systems as showcased by the FORWARD project.

E-learning video series

For hands-on training of the managers and operators of waste transfer stations, our team, together with one of our private partners, Waste 4 Change, arranged for the original pilot site of the FORWARD project to serve as a training location. However, as travel and training are not always feasible given the distance and costs, an e-learning video series on all steps of BSF biowaste processing operations is being developed (see Photo). The video series will serve as an introduction to this new waste processing approach and allow participants to assess if the technology would fit their needs before engaging in hands-on training (Figure 1). The series guides the audience through the BSF process, starting with the unit where Black Soldier Flies are reared, and covers BSF waste conversion, post-processing, marketing and business development units (Figure 2).

Step-by-step guide book

In addition to the e-learning video series, a step-by-step guide book has been developed that follows the structure of the e-learning chapters. The purpose of this book is to support the video series with written documentation about each operational step showing all the materials required; it even includes a work schedule template and operational schedules, which can be filled in by the managers and operators. This guide can be referred to while working at the site when additional information is needed, or as a reminder of the activities necessary to operate a BSF waste processing facility.

Bram Dortmans

Photo: The BSF Biowaste processing e-learning video series was recorded at the original pilot site of the FORWARD project.

Factsheets

Factsheets are also being produced as a means of knowledge dissemination, particularly to help BSF newcomers and practitioners enter into or expand their BSF operations. They summarise the lessons learned and results from the practical research trials. For example, the standard operating procedures to process larvae into different saleable products are documented in product development factsheets. Our research on using BSFL as animal feed and the results are presented in a factsheet. The highlights of the SIBRE project, which actively marketed developed BSFL products in the local pet food market in Surabaya, are in a case study factsheet. Each factsheet summarises and provides quick insights about one specific topic.

Workshops

This comprehensive dissemination package was launched through a series of workshops in selected cities in joint collaboration with the Ministry PU-PR. The cities selected were those that are part of the Emission Reduction in Cities (ERiC) program, funded by the German Development Bank (KfW) and the Swiss government (SECO). ERiC focuses on capacity building and infrastructure investment for construction of sanitary landfills. BSF biowaste conversion goes hand-in-hand with landfill development, as treatment of biowaste and its diversion from landfills increases their lifespan and decreases their financial burden on local governments. The workshops introduced theoretical know-how and follow the same framework as the e-learning video series and the guide book, and included practical sessions. Workshop participants are actively engaged through multiple Q&A refreshers, which also gives them the opportunity to win prizes (BSF products) for correct answers. The practical sessions include a touch and feel tour that demonstrates the whole BSF lifecycle in an engineered and controlled environment. These interactive elements have shown to be beneficial; the participants had better results in the post-workshop quiz than in the pre-workshop quiz.

Webpage as knowledge portal

All learning materials are available to practitioners worldwide for free download at our knowledge portal website "Practical know-how on Black Soldier Fly (BSF) biowaste processing", which can be accessed directly by scanning the QR-code shown here. This online knowledge portal is structured by such themes as operating a BSF biowaste processing facility, the economics of BSF biowaste processing, BSF larvae refining and products, and issues arising from the marketing of BSF products. •

Figure 2: Screenshot of one e-learning BSF session on BSFL roasting.

[1] Eawag/Sandec, Switzerland

The FORWARD project is funded by the Swiss State Secretariat for Economic Affairs (SECO) and implemented in Indonesia under a framework agreement with the Ministry of Public Works (PU-PR). The SIBRE project was funded by the Swiss-Re foundation.

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How Can We Enhance Waste Segregation at Source? Insights from Guatemala

The RANAS systematic approach guides the implementation of efficient behaviour change interventions. Applied in three municipalities in Guatemala, it showed promising results on waste segregation at the household level.

Adeline Mertenat[1], Dorian Tosi Robinson[1], Marta Julia Cuc Chiroy[2], Nexan Herrera[2], Fidel Saloj Yaxón[2], Christian Zurbrügg[1]

Mancomunidad Tzolojya

Photo: The flag used to identify households segregating their waste.

Introduction

Reaching the objectives of a circular economy starts with one key element: proper waste segregation at source. Indeed, ensuring that the different waste fractions are separated as close as possible to the generation source, usually at the household level, significantly increases the purity and economic value of recovered materials, which in turn fosters higher recycling rates. Yet, changing the behaviour of residents to segregate their waste at source is a challenging task for practitioners worldwide, especially in low- and middle-income settings. According to literature, a reason why there are only a few effective methods to achieve behaviour change is the weak connection between intervention-based research and psychological research on waste segregation determinants [1].

To overcome this challenge, Mancomunidad Tzolojya (Manctzolojya) in Guatemala set up waste segregation interventions based on the behaviour change approach RANAS. RANAS is a systematic approach to behaviour change interventions that helps identify which key psychological factors – Risk, Attitude, Norm, Ability and Self-regulation – need to be considered when designing behaviour change interventions [2]. This study presents the results obtained from waste segregation campaigns performed by Manctzolojya in three municipalities in Guatemala.

Context

Manctzolojya is an association of municipalities located in the Lake Atitlán Basin in Guatemala. It provides technical support and assistance to municipalities for environmental and proper waste management since 2005. Waste management in urban areas of these localities is carried out by municipalities that provide waste collection and disposal services to designated small disposal sites where recyclables are sorted and to a lesser extent organic waste is composted. Currently, no waste management services are provided in rural areas and, therefore, rural households either burn or dump their waste. In this region, controlled waste disposal sites are costly to establish and often poorly designed with undersized capacities, leading them to become quickly filled up. Furthermore, land availability for new sites is very limited. The amount of waste to dispose of should be minimised and as much as possible recovered. Yet, efforts to improve waste segregation at source have shown poor results. These have mainly been communication campaigns on the environmental risks of mismanaged waste. To improve the effectiveness of the intervention in terms of costs and impact, the RANAS approach was implemented in three municipalities.

Method

The RANAS methodology was used to foster behaviour change to separate the solid waste into three fractions, Organic, Recyclable and Non-Recyclable, among 1'085 households in 11 small communities in the municipalities of Santa Lucía Utatlán, Nahualá and Santa María Visitación. The interventions took place in the urban centres and surrounding rural areas from January 2018 to August 2019. Sandec provided technical assistance.

Following the RANAS guidelines [2, 3], first, the key behavioural factors for waste segregation were determined (see Figure). A trained facilitator speaking the local languages conducted RANAS surveys, using AKVO Flow, in 110 randomly selected households. The collected data helped identify the key psychological factors that influence waste segregation behaviour, by comparing the answers of those who segregate (doers) with those who do not (non-doers). Interventions were then designed to target these specific key behavioural factors and implemented over six months. An evaluation campaign was performed one month after the end of the implementation phase to evaluate the effectiveness of behaviour change in the targeted population.

Municipality	Behavioural factor *and sub-factor*	Behaviour change techniques
Santa Lucía Utatlán	Norm *Others' behaviour*	Flag given to households segregating their waste to make the behaviour visible.
Santa María Visitación	Ability *Confidence in continuation*	TV spots demonstrating that in spite of difficulties, behaviour can be maintained.
Nahualá	Ability *Confidence in performance*	TV spots with locally recognised people, teaching how to do the behaviour in a real scenario.

Table: Summary of main behavioural factor, sub-factor and behaviour change techniques per municipality.

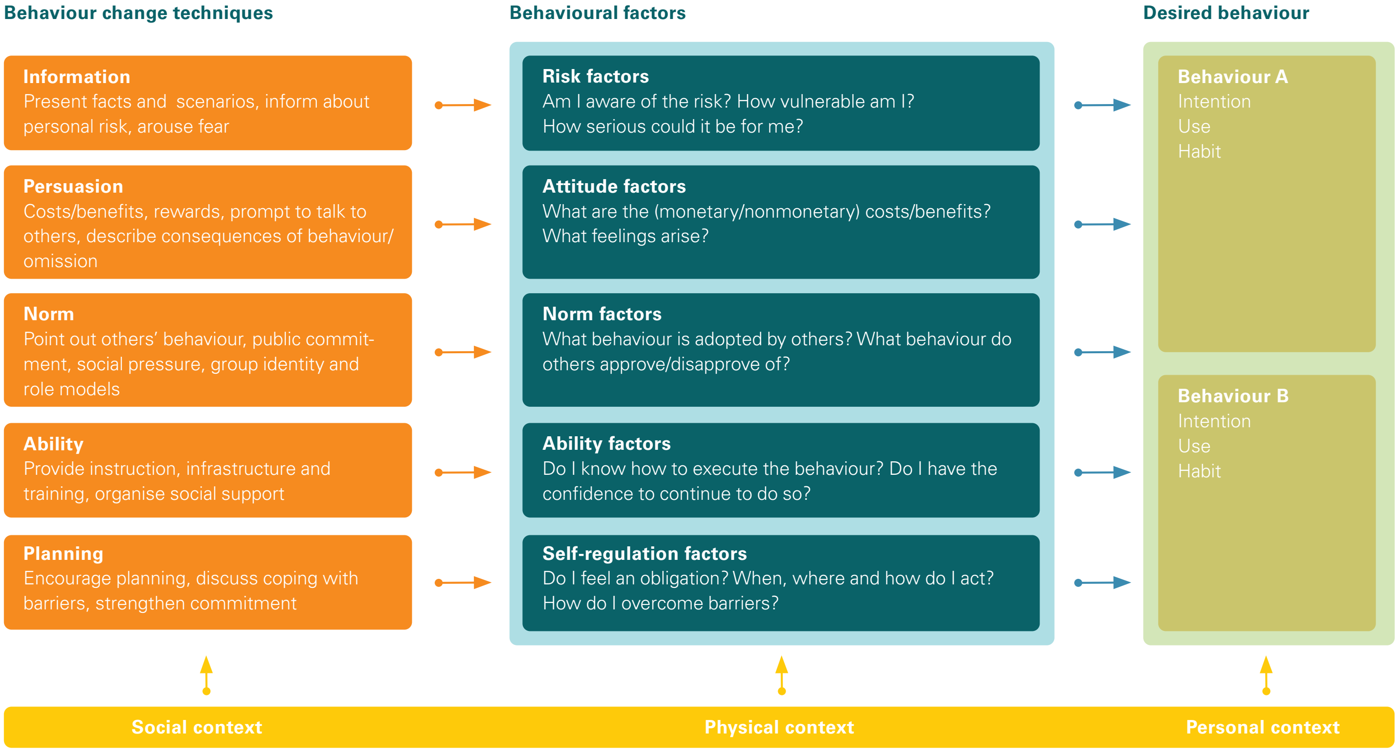

Figure: RANAS psychological factors and related behaviour change techniques [2].

Results

Results of the RANAS surveys showed that "Norm" and "Ability" were the two main psychological factors influencing waste segregation in the three municipalities. The Table summarises the main behavioural factor, sub-factor and chosen behaviour change techniques per municipality. In order to enhance these factors, several behaviour change interventions were conducted. Among others, flags were given to households segregating their waste to make their behaviour visible to others and foster the Norm factor (see Photo). TV spots about how to practically separate your waste at home, the challenges to maintaining this behaviour over time, and options to overcome these challenges were shown on local TV channels to enhance the Ability factor. The evaluation campaign showed an increase in waste segregation behaviour from 17.3 % of the households before the interventions to a 70.9 % rate of waste segregation at source after the interventions.

Conclusion

Using the RANAS approach in the design of the waste segregation project was effective; more than half of the households segregated their waste at source after the interventions. Yet, the impact evaluation was conducted very shortly after the implementations were carried out and, therefore, it is difficult to determine the long-term effectiveness of this behaviour change campaign. A key learning from this study, however, is that waste segregation at source requires the need for behaviour change, and that achieving significant compliance requires using appropriate methods and tools to design the intervention. Determining the driving behavioural factors first helps in the design of innovative, targeted and cost effective waste segregation campaigns that go beyond traditional risk-based communication strategies. •

Reference

[1] Varotto A. et al., Psychological strategies to promote household recycling. A systematic review with metaanalysis of validated field interventions, *Journal of Environmental Psychology, 51*, (2017), 168–188.

[2] Mosler H.J., A systematic approach to behavior change interventions for the water and sanitation sector in developing countries: a conceptual model, a review, and a guideline, *Int J Environ Health Res, 22/5*, (2012).

[3] Calvin V., Behaviour Change Manual, (Helvetas, 2017).

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This study was partially funded from the DR-CAFTA Small Grants Program 2018 and 2019 for Public Participation in Environmental Protection from the United States Department of State, administered by HELVETAS Guatemala. The opinions, findings and conclusions or recommendations expressed herein are those of the Author(s) and do not necessarily reflect those of the Department of State or HELVETAS Guatemala.

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Making Decentralised Insect Waste Processing Financially Viable

The lack of understanding how to make Black Soldier Fly larvae (BSFL) biowaste processing financially viable has been critical. Years of operational experience at a BSFL plant in Sidoarjo allowed for the development of comprehensive business models to fill this knowledge gap. Maximilian G. P. Grau[1], Bram Dortmans[1], Julia Egger[1], Christian Zurbrügg[1]

Introduction

Black Soldier Fly Larvae (BSFL) conversion is a promising approach for treating biowaste, given the low technological input required while producing high value products. The FORWARD project, funded by the Swiss State Secretariat of Economic Affairs (SECO), in collaboration with the Indonesian Ministry of Public Works (PU-PR) and executed by Eawag in Sidoarjo, Indonesia, has developed a simple BSFL plant setup [1]. This has fostered a widespread implementation of BSFL plants across Indonesia. BSFL processing can be setup in different ways and in various configurations, i.e. centralised or decentralised, as described by Diener, *et al.* [2]. Which approach, however, achieves best financial viability and best integration within a given municipal solid waste management system is an open question that our research tackled.

Business models and scenarios

Evidence from the BSFL waste processing facility in Sidoarjo was used as input for a newly developed business model (BM) tool. The tool segments each processing unit of the facility using Activity Based Costing. This differentiation of costing units allowed for the modelling of different scenarios of implementation with different degrees of decentralisation. The BM analyses give insights into the cost structure of each unit, indicating which part of the process has the highest operational costs. And it can indicate whether the planned BSFL plant is financially viable over a certain period of time, by calculating the Net Present Value (NPV). The NPV was calculated for a period of five years with a discount rate of 11 %. A NPV greater than zero indicates a viable project, whereas a negative NPV indicates an unviable project.

The business model outcomes of three distinct scenarios were compared to one another to analyse which implementation scenario would perform best in terms of financial performance. The three scenarios analysed were:

- Scenario 1: Integrated plant (Figure 1)
- Scenario 2: Decentralised waste conversion and post-processing (Figure 2)
- Scenario 3: Decentralised waste conversion (Figure 3)

As shown in the Scenarios, there is an exchange of crucial goods between the centralised and decentralised plants in Scenarios 2 and 3. The main goods exchanged are the 5-day-old larvae (5-DOL), which are used for the waste conversion, and the fresh larvae, the product of the BSFL waste conversion process. Analysis shows that there is a risk of over- or underpricing the intermediary products (5-DOL and fresh larvae). If the central nursery charges high prices for their 5-DOL, the decentralised unit cannot afford them and would run at a loss. Underpricing on the other hand would increase the decentralised business viability and attractiveness, but could make the centralised unit unviable. The established BM tool helps to find the sweet spot for pricing these products and determine the minimum scale to ensure viability. Using few inputs, the tool can indicate ideal pricing for materials and production scale (i.e. NPV greater than zero).

The case of Lombok

One of our project partners is the ISED project, funded by GIZ, in collaboration with the provincial government on the island of Lombok. Here, a system is being developed where a centralised nursery and processing unit supplies 5-DOL to six decentralised BSFL waste treatment plants and buys back the grown fresh larvae (17-DOL) from those units (Figure 3). The centralised unit has the necessary equipment to process the fresh larvae and to produce dried larvae and larvae meal and oil for sale. The decentralised plants create revenue by selling the fresh larvae back to the centralised unit. The centralised unit creates revenue by selling processed BSFL products, but also by selling 5-DOL to the decentralised sites (Figure 3).

According to implementation plans, each decentralised BSFL unit shall treat 730 kg of waste per day. Land and infrastructure are funded by the local government and are not considered as cost items for the units. No gate fee for the incoming waste is charged; thus, the main costs and revenue streams are the operational costs of each unit and the purchase or sales prices for 5-DOL and fresh larvae.

Results show that the centralised unit needs to collect and process the fresh larvae of the six decentralised units, which in total is about 172 kg per day. Only dried larvae are produced, using an industrial scale microwave oven that can cope with this daily load. The central unit needs to produce about 3.7 kg 5-DOL daily for the decentralised waste treatment units.

In this case, the scale of operations both at the centralised and decentralised levels is fixed and defined by the waste amounts to be processed. The sales prices for BSFL products are determined according to established current market rates, IDR 110’000 per kg for dried larvae, as shown in a market study by Antarest, *et al.* [3].

The BM tool was used to estimate the prices for 5-DOL and for fresh larvae that would allow for both centralised and decentralised units to be viable.

Results

The results show that only a small range of pricing structure allows both the centralised and the decentralised plants to be viable. This is at a price of IDR 25’000 per kg fresh larvae, and a price range of IDR 250’000 – 300’000 per kg 5-DOL. This would result in a NPV range of around IDR 15’250’000 – 57’000’000 for the decentralised BSFL plants and a NPV range of IDR

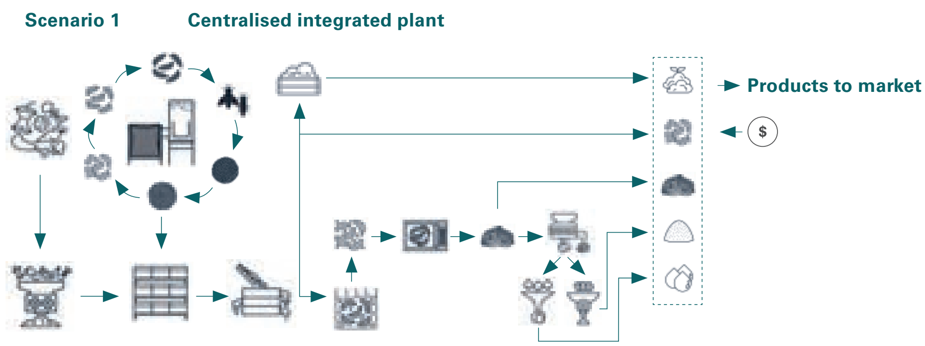

Figure 1: Scenario 1 consists of one centralised integrated plant that receives organic waste and converts it into BSFL products, such as fresh larvae, dried larvae and larvae meal and oil. The plant contains a nursery to grow young larvae for the waste treatment process.

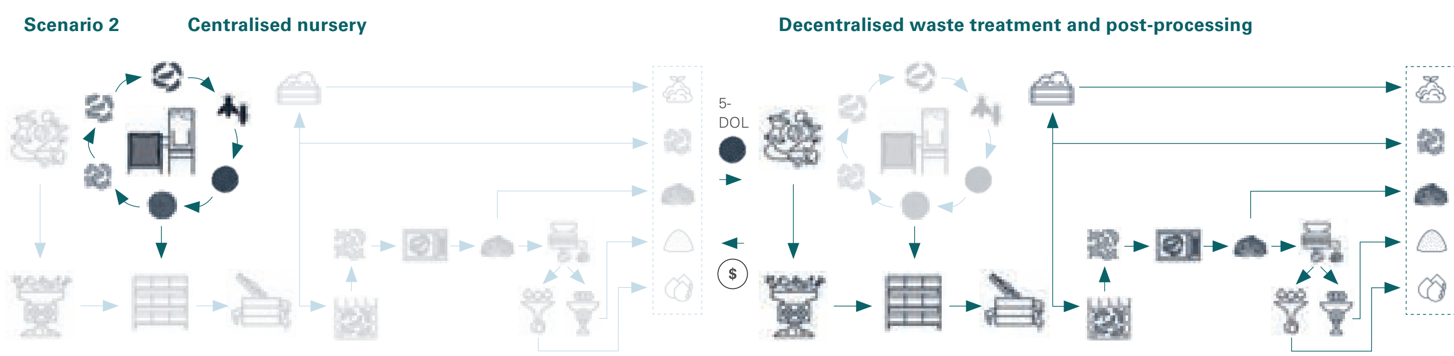

Figure 2: Scenario 2 has two separate units; a centralised nursery that exclusively produces young larvae (5 day old = 5-DOL) and supplies them to decentralised units. The decentralised units process the organic waste with the purchased 5-DOL and produce BSFL products to sell at the local market (fresh larvae, dried larvae, larvae meal and oil).

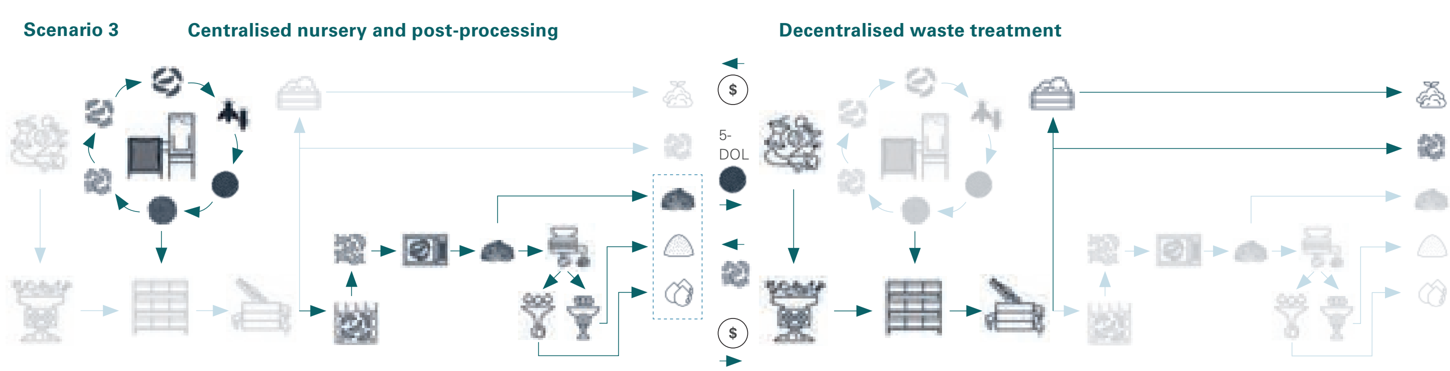

Figure 3: Scenario 3 is similar to scenario 2; however, here the decentralised units only process the organic waste treatment with the purchased 5-DOL. The produced fresh larvae are then transported back to the centralised unit, which besides the nursery, also processes the fresh larvae to BSFL products (dried larvae and larvae meal and oil).

19’300’000–269’000’000 for the centralised nursery with post-processing. The larger range of NPV for the central plant, compared to the smaller range for the decentralised plants, indicates that the central unit is a more profitable business than the waste treatment unit. This can be explained by the high sales price of dried larvae, which is almost five times higher than the buyback price for the fresh larvae, and by the lower operational costs of the central unit.

Conclusion

The business model tool helps existing BSFL facilities to analyse their costs and revenue streams and assists in the planning for BSFL projects. As demonstrated, it can also be used to analyse potential scenarios of how to implement the BSFL biowaste conversion process, and consider centralised or decentralised units. Finally, it also serves as a broader strategic tool for public entities, such as PU-PR, to mainstream BSFL waste processing throughout Indonesia. •

Reference

[1] Dortmans B.M.A. et al., *Black Soldier Fly Biowaste Processing – A Step-by-Step Guide*, (Dübendorf: Eawag, 2017).

[2] Diener S. et al., (2015): *Opportunities and constraints for medium-scale organic waste treatment with fly larvae composting*, (15th International Waste Management and Landfill Symposium, 2015).

[3] Antarest E. et al., (2020): *Market Assessment for BSF products*, (Dübendorf: Eawag, 2020).

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Black Soldier Fly Larvae Products and Their Applicability as Pet Food

The economic viability of Black Soldier Fly larvae (BSFL) biowaste processing depends on revenues from the sale of conversion products. In Surabaya, Indonesia, the effect of BSFL products on pets and their market potential in the ornamental fish and bird feed sectors were evaluated. Julia Egger[1], Bram Dortmants[1], Christian Zurbrügg[1]

Figure 1: BSFL products from left to right; BSFL pop (microwaved larvae), BSFL crumble (oven-dried and crushed larvae), BSFL pellets (60 % BSF meal) and BSFL mix (20 % BSF meal).

Introduction

Valorising organic waste with the Black Soldier Fly Larvae (BSFL) is becoming increasingly popular, especially in low- and middle-income countries. This is because the harvested larvae can be used as an alternative to conventional animal feed. The Sustainability of Insect-Based Recycling Enterprises (SIBRE) project analysed the economic viability of BSFL biowaste processing in Indonesia, and its first assessment indicated that the pet feed market would be a good entry point for BSFL products because commercial animal feed mills require a quantity of raw products that far exceeds the production capacity of small- and medium-sized BSFL facilities.

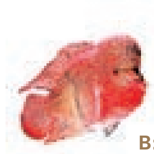
In Indonesia and other Asian countries, ornamental birds (OB) and ornamental fish (OF) are popular pets, and a large number of hobbyists and breeders often take part in OB and OF contests where judges evaluate the animals based on their physical appearance and behaviour. OB and OF owners carefully evaluate pet food products and select those that could positively affect animal behaviour and appearance. Because the effect of BSFL products on OB and OF development has not yet been proven, SIBRE fed selected OB and OF with BSFL products and evaluated their development in contest-like settings.

Methodology

Selected OB and OF were fed a variety of BSFL products over a period of two to three months (Figure 1) and control groups were fed conventionally available commercial products. Two types of OF were selected for the trials, Siamese fighting fish and Flowerhorn ciclid, as well as two types of baby OB, White-rumped shama and the Long-tailed shrike (Figure 2 A – D). A total of 11 Siamese fighting fish were used for the trials. Six were fed BSFL crumble, two a control of conventional pellets and three water fleas. For the Flowerhorn cichlid trials, three fish were fed BSFL crumble, two BSFL pop, three BSFL pellets and three conventional pellets. For the birds, one bird of each type was fed a BSFL mix and intermittently BSFL pop as a snack. For the control group, one bird of each type was fed a conventional mix and intermittently received an ant-based snack.

The method of expert ratings was used to evaluate the effects of the BSFL products on the development of the animals, similar to ratings in bird or fish contests or wine tastings. The experts were kept unaware of what the birds and fish were fed and evaluated certain OB and OF attributes, such as colour, body proportions and activity. Recognised expert hobbyists and breeders from the respective communities were recruited to do the assessments. Each animal was rated by each expert (n=8 – 10) on a seven-point-scale for ten attributes relevant for OF and eight attributes for OB. Prior to the ratings, the expert panel first discussed the attributes and the scale to reach a consensus on how to rate the animals and to determine what each level on the scale signifies. The resulting multidimensional data sets were then reduced using Principle Component Analysis (PCA), which defined the underlying components that capture most of the variance within the dataset. Results of the PCA were visualised in perceptual maps where each animal is presented as a dot in relation to the extracted components. These maps very effectively show the similarities or differences of the animals as perceived by the experts.

A: Siamese fighting fish *(Betta splendens)*



B: Flowerhorn cichlid (hybrid fish, Luohan)

C: White-rumped shama *(Copsychus malabaricus)*

D: Long-tailed shrike *(Lanius schach)*

Figure 2: Ornamental fish and birds selected for the trials.

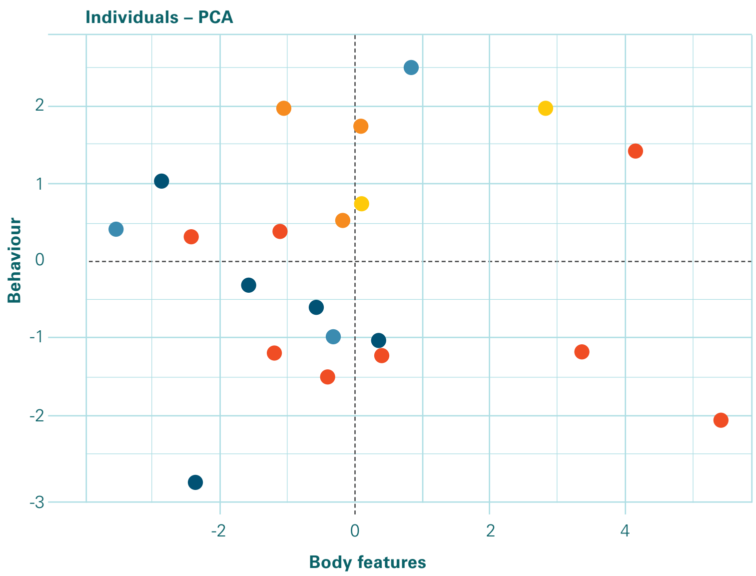


Figure 3: Perceptual map visualising PCA results and showing each fish in relation to the component 1 (fish body features) and component 2 (fish behaviour). Different colours indicate different feed products used to feed the fish.

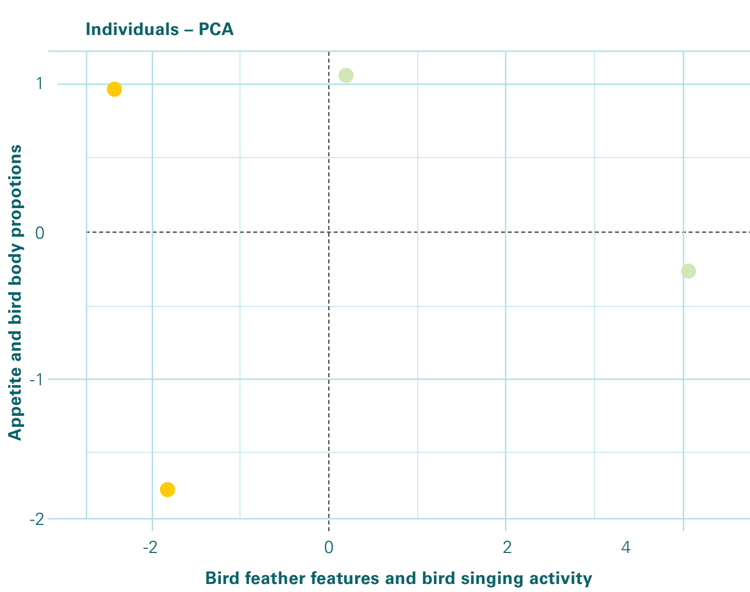


Figure 4: Perceptual map visualising PCA results and showing each bird in relation to the component 1 (bird feather features and singing activity) and component 2 (bird appetite and body proportions). Different colours indicate different feed products used for the birds.

Results

The results from the four OF trials are presented in Figure 3. The PCA extracted two components, which together account for 79 % of the variance within the dataset. Component 1 (56 %) is displayed on the x-axis and compiles the attributes related to fish body features, e.g. colour, body proportions or pattern. Component 2 (23 %) is displayed on the y-axis and summarises attributes related to fish behaviour. The colour of the dots represent the feed; the blue tones are for the control group and yellow, orange and red are for the fish fed with BSFL products. The distance between the points indicates similarities and differences; smaller distances between points indicate close similarity.

No obvious coloured clusters can be recognised, indicating that the experts did not perceive the BSFL fed fish as clearly differing from those fed with conventional feed. Three fish fed with BSFL crumble (red), as well as one fed with BSFL pop (yellow), stood out with very high scores for body features, meaning that they were rated especially high on attributes, such as colour or body proportion. Although BSFL pellet fed fish (orange) did not stand out in terms of their body features, they rated high on behavioural aspects.

The results from the two OB trials are presented in Figure 4. The PCA extracted two components, which together account for 96.6 % of the variance within the dataset. Component 1 (80 %) is displayed on the x-axis and summarises attributes related to the feather features and singing activity, while component 2 (16 %) is displayed on the y-axis and captures the attributes of appetite and body proportions. Yellow dots represent the birds fed with conventional feed, while the blue are the ones fed with BSFL. Although the sample size is quite limited, BSFL fed birds scored clearly higher for feather features and singing activity, indicating that the feed of BSFL mix, together with the snack BSFL pop, had a beneficial influence on feather development and singing activity.

Conclusion

The expert panel did not notice any negative effect of the BSFL products on the OB and OF attributes. Feeding the OF dried BSFL products, especially the BSFL crumble, seemed to show a positive effect on the development of their body features. For the birds, the BSFL mix combined with a BSFL pop snack seemed to have had a noticeable positive effect on their feathers and singing activity. Although the limited sample size of these trials does not allow for a distinct judgement to be made, the results strengthened our assumption that the four tested BSFL products can be used as ornamental fish and bird feed and compete with conventional products in terms of their performance impact on the animals. In terms of the price of the feeds, BSFL products are priced in a similar range as the tested conventional feed products. In Surabaya, dried BSFL products, especially the BSFL pop, became a popular product in its first year after being introduced on the market and now different brands are selling pop-larvae. Pop-larvae are, therefore, a promising product for revenue creation at BSF biowaste processing facilities. They are easy to produce and investment costs for small-scale drying equipment are low. •

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Pretreating High Fibrous Wastes to Enhance Larvae Development

Black soldier fly larvae grow poorly on highly fibrous organic wastes. A literature review is underway that examines pretreatment approaches to improve the digestibility of theses substrates and enhance the growth of black soldier fly larvae. Daniela A. Peguero[1,2], Moritz Gold[1,2], Alexander Mathys[2], Christian Zurbrügg[1]

Introduction

Managing organic waste in low- and middle-income countries remains a challenge. Yet, valorising such waste using the Black Soldier Fly Larvae (BSFL) offers a promising solution as BSFL can convert organic waste into insect biomass for animal feed and/or biodiesel and a compost-like residue that can be used as fertiliser. BSFL, however, have difficulties to digest and grow on waste streams with high contents of lignin (~10–25 %), hemicellulose (~20–35 %) and cellulose (~30–50 %) (see Photo) [1]. Therefore, many BSFL enterprises avoid such waste materials as feedstock. Although explicable from a business perspective, it is not an attractive solution from a citywide waste management perspective. How could waste materials be pretreated so that BSFL could grow well? To answer this question, a first task is underway, developing a detailed literature review on pretreatments that break down or remove lignin and disrupt the crystalline structure of cellulose. Thereby, substrates could be more amenable for hydrolysis by BSFL or microbial enzymes, increasing their digestibility and improving the larval growth when fed with these pretreated substrates. Other biowaste processing approaches, such as composting, anaerobic digestion or bioethanol production, face similar challenges with lignocellulosic waste streams. This rapid review investigates strategies used by these sectors that may be adaptable and transferable to BSFL processing.

Substrate pretreatments and BSFL

We distinguish three basic approaches in pretreatment, physical [2], chemical [3] and biological pretreatments [4]. Pretreatment performance specifically for BSFL rearing purposes will not only depend on the waste type and detailed composition and physical appearance, but also on the overall goal. For instance, reducing particle size by mechanical means increases surface area availability for microbial mediated substrate decomposition. Currently, the use of alkaline chemical and microbial pretreatments for fibrous materials (e.g. rice straw and banana peels) has shown to positively impact larval biomass. For example, chemically pretreated rice straw was found to remove lignin by 22 % and increase the availability of the cellulose (Liu *et al.* 2021). Larvae were then better able to degrade the cellulose, which led to an overall increase in larval mass by 32 % compared to larvae grown on untreated straw. Other research has suggested that larvae gut microorganisms can produce cellulose degrading enzymes. Therefore, it would be beneficial to find ways to create an environment that further promotes the digestibility and conversion of these fibrous substrates.

Bram Dortmans

Photo: Garden waste and leaves that will be used for composting – an important organic waste source in municipal solid waste management that is high in lignocellulosic contents.

Conclusion

Review of past research indicates that pretreatments have been effective for fibrous substrates used for composting and biogas production. Studies have shown that they can accelerate composting and increase biogas. However, comparing methods can be challenging due to the differing conditions, substrates and variation in seasons, as these can all impact the effectiveness of the method. Therefore, when considering the applicability of these methods to BSFL production, the composition of the substrate should be determined. Besides the effectiveness of the pretreatment, the operational consequences of installing and operating such a pretreatment step should also be considered. Isibika *et al.* (2019), for instance, has shown that 14 days microbial pretreatment provided the optimum pretreatment time; however, this needs to be weighed against the required operating and investment costs of such a measure. •

References

[1] Mishra S. et al., Microbial pretreatment of lignocellulosic biomass for enhanced biomethanation and waste management, *3 Biotech, 8/11*, (2018) 458.
[2] Palma L. et al., Managing high fiber food waste for the cultivation of black soldier fly larvae, *npj Sci. Food, 3/1*, (2019).
[3] Liu C. et al., Pretreatment is an important method for increasing the conversion efficiency of rice straw by black soldier fly larvae based on the function of gut microorganisms, *Sci. Total Environ*, 762, (2021).
[4] Isibika A. et al., Pre-treatment of banana peel to improve composting by black soldier fly (Hermetia illucens (L.), Diptera: Stratiomyidae larvae, *Waste Manag, 100*, (2019) 151–160.

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Waste Education in Schools – Insights From Country Overviews

Environmental education is key to foster change towards more sustainable waste and resource management. Five country overview studies were conducted to assess the status, success factors and barriers to integrating waste education in school curricula. Adeline Mertenat[1], Christian Zurbrügg[1]

Introduction

Education has long been recognised as critical to address environmental and sustainability challenges. The "Towards Zero Waste at Schools" (ZW@S) project fosters innovative solutions at schools that enhance circular systems. Learning and practice teaches students to become agents of change of sustainable behaviour. The ZW@S project conducted national overview studies in Burkina Faso, Ghana, Ivory Coast, Nepal and Peru to assess the current status of environmental and waste education strategies and initiatives. The studies were based on the "whole-institution approach" of UNESCO [1]: Governance & Policy, Curriculum & Teaching, Operation & Facilities, and Community Partnerships & Interaction, and this article summarises the main outcomes of the five country studies.

Governance & Policy

To mainstream solid waste management (SWM) in schools, SWM must be endorsed as a priority at the national level. In addition, strategies for environmental education must be in place to guide schools on how to tackle this in their teaching and operations. A good example is the national education strategy in Peru, where emphasis is given to environmental education (including SWM – see Photo) with different regulatory frameworks developed accordingly. One is the National Environmental Education Plan (PLANEA, 2016) set in motion by the Ministries of the Environment and Education. It gives guidance on how to "mainstream an environmental focus" in schools. In contrast, Burkina Faso did not include SWM in its national education strategy because it places emphasis on access to safe drinking water and sanitation.

Curriculum & Teaching

SWM education can ideally be incorporated into different subjects of the existing curricula, going beyond only science subjects. Yet, the country overviews showed that SWM was mostly absent in school curricula or only taught in natural science classes that focused on knowledge and comprehension, but lacked teaching about practical elements. Time constraints and lack of knowledge of how and what to teach were mentioned as barriers. These could be overcome through formal integration of SWM education in the national curricula, accompanied by teacher training and appropriate teaching materials, as promoted in Peru.

Operation & Facilities

Basic SWM facilities and services at schools are a prerequisite to promote good SWM practices and to foster experiential learning. Country overviews showed a main deficit in this area. In most cases, waste management at schools was characterised by dispersed litter and/or waste openly burned or dumped close to school premises. The lack of financial resources was mentioned as an overall problem. Involving student clubs as an approach to induce change, decrease littering, increase the sale of recyclables and/or initiate school gardens using compost was often promoted.

Clean up Nepal

Photo: Students training on waste segregation.

Community Partnerships & Interaction

To ensure that knowledge, practices and attitudes learned about SWM go beyond the school into homes and the community, the interaction between schools and communities is important. Although acknowledged as such, promotion of these interactions were not found in any of the overview studies.

Conclusion

Our analysis found that although there is increasing interest to address waste management and recycling in schools, these are not considered as priorities until basic water, sanitation and hygiene (WASH) services are ensured. School success stories described in the overviews include initiatives promoted by school staff, by NGOs, or facilitated by national regulatory frameworks. Sharing such best practices among countries and schools can be a good way to strengthen SWM education and make it globally widespread. •

References

[1] UNESCO, *Issues and Trends in Education for Sustainable Development*, (Paris: UNESCO Publishing, 2018).

[1] Eawag/Sandec, Switzerland

[2] 500B Solutions Pvt. Ltd., Nepal

Country studies performed by: Ciudad Saludable (Peru), 500B solutions Pvt. Ltd. (Nepal), Water Aid (Burkina Faso), University of Education Winneba (Ghana), and CSRS (Ivory Coast). Funding was provided by the Swiss Agency for Development and Cooperation (SDC).

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Methods for
Faecal Sludge
Analysis

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. The research of Sandec's Management of Excreta, Wastewater and Sludge group in this area includes:

- Collaborative research: Conduct applied research to develop the fundamental knowledge required for integrated management and technology solutions.
- Technology innovation: Research the development of safe and effective management of excreta, waste-water and sludge to meet treatment and resource recovery goals with industrial and implementation partners.
- Facilitating sustainable implementation: Promote uptake of research by integration of knowledge into policy through dissemination and strategic partnerships.

Photo Mai Thu Nguyen and Kelsey Shaw are carrying out a jar test to optimise real-time monitoring of faecal sludge and blackwater for dosing of conditioners, which is part of MEWS research on the dewatering of faecal sludge. These results will be applicable for a wide-range of applications, from off-grid, in-building treatment, to humanitarian settings and semi-centralised treatment facilities in urban areas.

Photo by Linda Strande.

Working Towards Standardised Methods for Faecal Sludge Analysis

The IWA book Methods for Faecal Sludge Analysis was recently published. The goal is to update it regularly to present new research. It is already being used in a Sandec field study with eight partners in multiple countries.

Nienke Andriessen[1], Konstantina Velkushanova[2], Mariska Ronteltap[2], Thammarat Koottatep[3], Damir Brdjanovic[2], Chris Buckley[4], Linda Strande[1]

The idea for this book (see Figure) originated from parallel conversations among researchers working in faecal sludge management over the last decade [1]. The lack of standard laboratory methods, specifically for faecal sludge and treatment and resource recovery products, has been a major gap in moving the sector forward, and has called into question whether results from different laboratories are comparable. Due to this gap, methods from other fields, such as wastewater, food, and soil science, are frequently adapted, but the characteristics of faecal sludge can be quite different from these other matrices. There is also a lack of standard methods for sampling, which is complicated due to the difficult nature of in situ sampling, the wide range of onsite sanitation technologies and potential sampling locations, and the heterogeneity of faecal sludge within and among onsite containments. Hence, there is a pressing need to establish common methods and procedures for faecal sludge characterisation, quantification, sampling, and modelling approaches. This book was published with the aim to provide a basis to move towards standardised methods for faecal sludge from onsite sanitation technologies, for improved communication be-tween sanitation researchers and practitioners, and for greater con-fidence in the generated data. It can be downloaded for free at: www.sandec.ch/fsm_methods.

CubeX SAL

Photo: Sampling team from CubeX taking faecal sludge samples from an onsite sanitation containment in Lebanon with the Volaser and a core sampler.

Figure: Cover of Methods for Faecal Sludge Analysis book.

Now that this first round of methods and methodologies has been completed and pub-lished, researchers can start the required steps to make them official 'standard' meth-ods. Standardisation will require international, collaborative vali-dation, where blind samples are independently analysed in parallel at different laboratories. A committee of members of the Global Partnership of Labo-ratories for Faecal Sludge Analysis will be coordinating these processes. Additional method development and adaptation is still required by laboratories around the world in order to increase the number of methods reported on in future editions. The process of making the book took five years, and during this time, the sector continued to rapidly change and evolve. It captured as many of these changes as possible; updates will be included in the next edition.

One example of how the book is being practically used is in the testing of Sandec's Volaser device with partner organisations from countries in Africa, Asia, and Latin America that started in March 2021 (see Photo). All procedures in this study are based on content in the book. For example, the Volaser is being used to estimate in situ volumes of faecal sludge as described in Chapter 3, laboratory analysis will be done for total solids (TS), volatile solids (VS), and chemical oxygen demand (COD) as described in Chapter 8, and estimates for quantities and qualities (Q&Q) of faecal sludge at the community scale will be based on the methodology presented in Chapter 5. This study will provide new information on sampling, estimating Q&Q, and laboratory methods. The Volaser manual for assembly and operation will also soon be available on the Sandec website, so that everyone can build and implement their own Volaser! •

References

[1] Velkushanova K., Strande L., Ronteltap M., Koottatep T., Brdjanovic D. & Buckley C. (eds.), *Methods for Faecal Sludge Analysis*, (London: IWA Publishing, 2021).

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Dewatering of Blackwater, the Missing Link for Integrated Off-grid Solutions

The innovative research building at Eawag/EMPA is home to the Water Hub, a platform to test technologies for dewatering and treating blackwater under realistic conditions. This article provides an overview of our research in the NEST building. Michael Vogel[1], Stanley Sam[1], Eberhard Morgenroth, Kai M. Udert, Linda Strande[1]

Zooey Braun

Photo: NEST Building on the Eawag/EMPA campus.

The innovative research building NEST (Next Evolution in Sustainable Building Technology) [1] combines living, recreation and work spaces. And it serves as a research platform to test innovative building and energy technologies, and off-grid and decentralised wastewater treatment technologies. One objective of this modular research building is to accelerate knowledge transfer from science to practice, providing a testing facility under realistic conditions.

Urine, blackwater, and greywater are separated at the source and piped in the NEST building to the Water Hub [2], a research space where integrated solutions for resource recovery from "waste" streams can be tested and developed. These operational tests are crucial to forward these technologies to industry and implementation partners for uptake. In this article, "blackwater" refers to blackwater, brownwater, and faecal sludge.

Globally, there is a need for more sustainable solutions for the treatment of blackwater. Our research focused initially on low- and middle-income countries. But, now it is helping to shape innovations in the Water Hub to develop a toolbox of relevant, resource recovery-based solutions appropriate for settings where onsite black-water treatment is the preferred option.

Our current research includes:

- Dewatering of Blackwater: Reduced footprint and energy consumption solutions are needed. A better understanding of the dewatering of blackwater is the missing link for achieving fully 'closed-loop' or 'off-grid' solutions. Testing and further developing existing dewatering technologies, including automated dosing of conditioners, is ongoing.

- Inline-Monitoring: In contrast to municipal wastewater, the characteristics of blackwater are even more variable, and dewatering performance is unpredictable. To dynamically adjust treatment technologies for variability, inline-monitoring is required, which facilitates real-time process adjustments and better process control. Relatively easy-to-measure metrics that could predict dewatering performance have been evaluated [3] and are being investigated.

- Modularity: Our goal is to be able to provide solutions based on building configurations (inputs) and forms of resource recovery (outputs) with the relevant treatment targets defined depending on the type of resource recovery required.

This first set of research projects is fundamental for further developments. For instance, automated dosing of conditioners can be used in mobile dewatering trucks in humanitarian settings to make them more efficient and adaptable. Another possible application of our work is the on-site treatment of blackwater from toilets in boats, trains, or other public forms of transport. In addition, to close the loop, well-dewatered blackwater is the basis for various valuable products, such as soil conditioners or fuel pellets to generate energy.

Stay tuned for the results of our dewatering and blackwater treatment research. •

References

[1] EMPA, NEST, https://www.empa.ch/web/nest/overview (accessed 30 March 2021)
[2] Eawag, Water Hub, https://www.eawag.ch/en/department/eng/projects/water-hub/ (accessed 30 March 2021)
[3] Ward B.J. et al., Predictive models using "cheap and easy" field measurements: Can they fill a gap in planning, monitoring, and implementing fecal sludge management solutions?, *Water Research, 196*, (2021) 116997, (12 pp.)

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Smartphone App and Predictive Models to Characterise Faecal Sludge

Sludge Snap: a smartphone app to estimate sludge characteristics in the field based on predictive models. This tool is quick and easy to use and could fill a gap in faecal sludge characterisation and monitoring.

B.J. Ward[1,2], Nienke Andriessen[1], James M. Tembo[3], Joel Kabika[3], Andreas Scheidegger[1], Eberhard Morgenroth[1,2], Linda Strande[1]

Introduction

Characterisation of faecal sludge is imperative for the design and operation of sustainable solutions for faecal sludge management. Rough but frequent characterisations are a valuable supplement to expensive and complex laboratory analysis. They could be helpful, for example, when planners and engineers want to know the physical and chemical characteristics of sludge in a city in order to design a plan for citywide sanitation, including selecting emptying and treatment technologies. Or, once a treatment strategy is operational, having them available could assist operators in adjusting loading rates based on the variability of influent characteristics.

Practitioners in the field frequently rely on qualitative or intuitive knowledge to predict thickness, level of stabilisation, or dewaterability based on observations of odour and colour, or technical information, such as whether sludge comes from a pit latrine or septic tank or household or public toilet [1]. Our aim is to quantify and standardise this expert knowledge so that it can be used more broadly and effectively to predict characteristics of faecal sludge.

Approach

The problem was approached by developing predictive models for Lusaka, Zambia, that could be used to estimate sludge characteristics based on simple and cost-effective field measurements. To do this, 465 samples from pit latrines and septic tanks were collected and characterised, as reported in our recently published study [2]. Characterisation included analytical laboratory characteristics of importance (total and volatile solids (TS and VS), chemical oxygen demand (COD), ammonium ($NH4^+$-N), total organic carbon and Kjeldahl nitrogen in the solids (TOC, TKN) and dewatering performance metrics (capillary suction time (CST), supernatant turbidity and TS after centrifugation). On the same samples, field measurements were also collected that could be used as predictors of laboratory analytical characteristics, including: questionnaire data (containment type, toilet type, type of establishment and water connection), expert assessments (odour and colour), and simple analytical measurements (photographs, electrical conductivity (EC), pH and foam height). The results were then used to develop a range of empirical models of varying complexities using field measurements to predict laboratory characteristics.

Outcomes

Predictions of TS, NH_4^+-N, CST, and supernatant turbidity could be made with moderate accuracy (R^2 from 0.55 – 0.66), using machine learning models, and with lower accuracy (R^2 from 0.21 – 0.51), using simple decision tree models based on containment type. EC was the best predictor of NH_4-N^+, photographs of the sludge (specifically sludge texture and sludge colour) were the best predictors of TS (Figure 1), and photographs of the supernatant and the sludge (specifically supernatant colour and sludge texture) were the best predictors of CST and turbidity. Using multiple field measurements as model inputs improved the prediction accuracy.

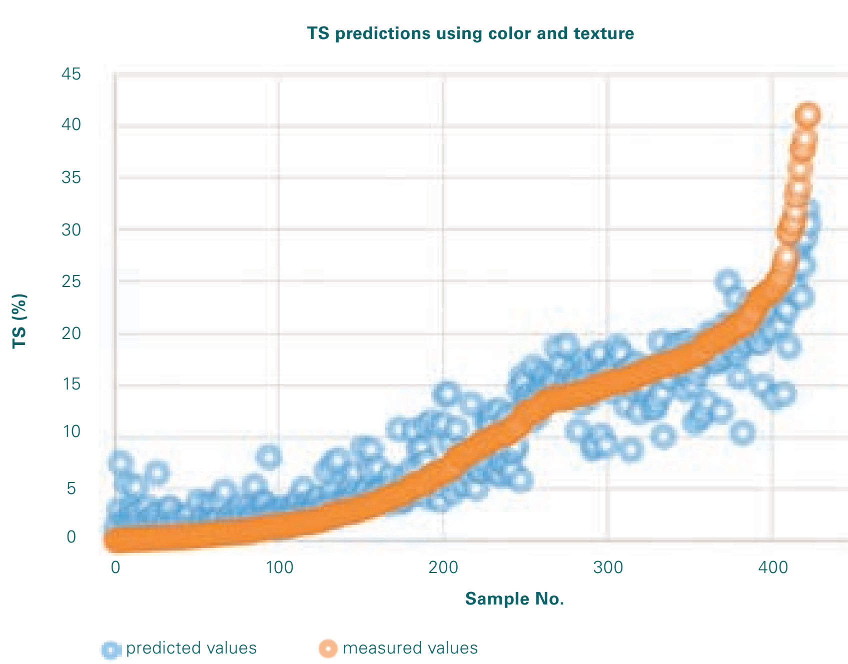
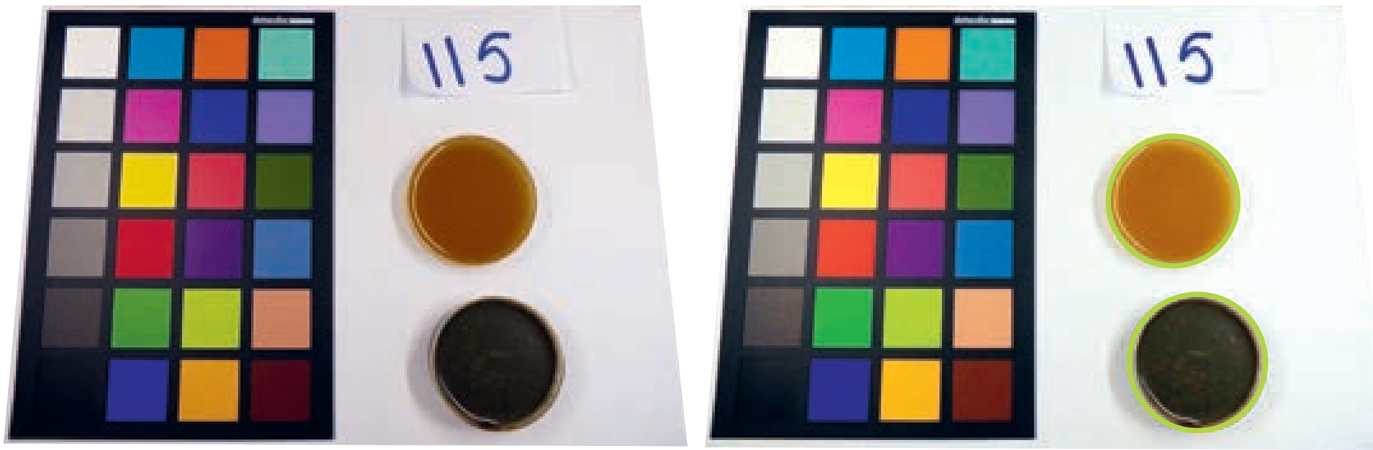


Figure 1: Comparison of measured and predicted total solids (TS) values, using a machine learning model based on colour and texture data from photographs.



uncorrected image **corrected image**

Figure 2: Images are processed automatically in the Sludge Snap app, first by applying a colour correction to the image using the standardised colour checker chart as a reference point, then by isolating the sludge samples using image recognition algorithms (shown with green circles). The app extracts colour and texture information from the sludge sample images and uses them as inputs to the predictive model.

For example, including EC and pH measurements and a photograph of the sludge incrementally improved the prediction accuracy of NH_4^+-N compared to using EC alone.

The models developed from the Lusaka dataset are a huge step forward in developing quantitative field methods to predict sludge characteristics. Based on this level of accuracy, if a sample had a TS concentration of 5 g/L, the output value would be a concentration between 2 and 8 g/L. This could already be accurate enough for some applications, such as calculating loadings on a drying bed. Yet, predictions could not be made of the measured organic fraction characteristics of COD, VS, TOC, and TKN. Ongoing research at Sandec and the University of Zambia is focusing on better understanding how to characterise and predict the organic fraction and level of faecal sludge stabilisation.

In order to make these predictive models accessible and useful to practitioners and researchers in the field, the prototype of Sludge Snap, an app for smartphones with real-time output of the estimated characteristics based on field data, was developed in collaboration with a team of students from Virginia Commonwealth University. As illustrated in Figure 2, Sludge Snap prompts the user to submit a photograph of their sample field measurements, such as pH and EC, and technical information, e.g. containment type. The app then uses our machine learning models to estimate characteristics based on the field measurements.

Sludge Snap still needs to be user-tested in Lusaka, but should be readily usable since the models are based on 465 data points collected there. For quality assurance purposes, a percentage of samples should be characterised in a laboratory. For detailed information about Sludge Snap and how it works, see Ward *et al.* (2021) [3].

Next steps

Our objective is to build a global database of sludge characteristics with Sludge Snap that would increase the accuracy of the models. Sludge Snap users are encouraged to upload their own photos and reference measurements to help build up the database; this local information can also be used to tailor the models for the specific location of a user. Research is also planned to incorporate Bayesian inference into our machine learning models to help estimate prediction uncertainties in cities in order to reduce errors in the results. Next steps are to improve the utility of the predictive models, including adapting them to work for specific treatment technologies. For example, developing models that work with real-time sensors to control online dosing of conditioners (see article on p. 23 in this Sandec News). •

References

[1] Ward B.J. et al., Experimental design for the development, transfer, scaling-up, and optimization of treatment technologies: case studies of dewatering and drying, *Methods for Faecal Sludge Analysis* (London: IWA Publishing, 2021), 85–114.

[2] Ward B.J. et al., Predictive models using "cheap and easy" field measurements: Can they fill a gap in planning, monitoring, and implementing fecal sludge management solutions?, *Water Research, 196*, (2021), 116997.

[3] Ward B.J. et al., *Sludge Snap: a machine learning approach to fecal sludge characterization in the field*, (42^{nd} WEDC International Conference, 2021).

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Funding: German Corporation for International Cooperation GmbH (GIZ), Eawag, the Swiss Agency for Development and Cooperation (SDC), the Swiss National Science Foundation (SNF), and the Engineering for Development (E4D) Doctoral Scholarship Program of ETH Zurich, funded through the Sawiris Foundation for Social Development.

Optimising Unplanted Faecal Sludge Drying Beds in Devanahalli, India

Worldwide, operators of unplanted drying beds constantly have to deal with the challenges of varying sludge volumes and characteristics. This article presents three modifications that operators in Devanahalli tested to improve unplanted drying bed performance. Anantha Moorthy[2], Nienke Andriessen[1], Rohini Pradeep[2], Linda Strande[1]

Introduction

Unplanted drying beds are commonly used worldwide for faecal sludge dewatering. Drying beds are passive gravity filters that are an attractive treatment option due to their ease of operation. However, several operational difficulties exist that affect the consistency of treatment performance, including sludge variability, environmental factors (e.g. temperature, humidity, wind and precipitation), and sand removal with dewatered sludge. This makes the reality of operation frequently different from design parameters, and can result in poor treatment performance [1]. To improve the reliability of treatment and operating performance, interventions are needed to adapt the actual operation of faecal sludge treatment plants (FSTPs) for this variability. Three strategies were tested at the Devanahalli FSTP in India to reduce maintenance costs and enhance the quality of resource recovery:

1) using linear models to evaluate optimal hydraulic loading rates;
2) installing greenhouses to increase drying speed;
3) utilising porous "Mangalore" tiles to avoid sand loss.

To learn more, please refer to two recent CDD publications [2, 3].

Methods

The Devanahalli FSTP was constructed in 2015 and has a total capacity of 6 m^3/day [2]. It treats faecal sludge from pit latrines and septic tanks, and is currently operating at 5 m^3/day. The process flow consists of a screening chamber, a settling tank, an anaerobic digester, an anaerobic stabilisation tank with three chambers for homogenisation and then settling. This is followed by 10 unplanted drying beds, with the liquid stream going to a combined anaerobic baffled reactor-anaerobic filter and a planted gravel filter [2, 3].

A total of 29 drying cycles were carried out to evaluate the effect of the three strategies on drying bed performance and each drying cycle entailed loading, drying, and removing the sludge. In this article, one drying cycle is referred to as drying time. Total solids (TS) and volatile solids (VS) were measured on the dried sludge. Air temperature and humidity were monitored with sensors inside the greenhouse, and were used to calculate an evaporation factor, defined as *(100 – Air humidity [%]) × Air temperature [°C].* To evaluate loss of sand from the filter media, the height of the sand was determined after the sludge was removed by measuring the height of the remaining sand layer in the corners and the centre of the bed. A linear model was fitted to both total drying time (days/drying cycle) and normalised drying time, which was defined as drying time per cubic meter of sludge. Model inputs were selected based on theoretical reasoning and evaluation of the possible input parameters.

Results

Linear models

The collected data was analysed to find out if it could be explained by a model, which could be used in the future to optimise loading rates for drying efficiency. The linear model for total drying time was *Drying time [days/drying cycle] = 36.6 + 1.4 × Hydraulic loading rate [cm] + 2.0×10^{-5} × TS [g/L] – 26.7 × VS/TS ratio – 0.023 × Evaporation factor*. In this model, the hydraulic loading rate was significant ($p=<0.001$) and best explained variability in the drying time. For instance, increasing the hydraulic loading rate (in cm) one unit, increased the drying time by 1.4 days. That means, when varying the hydraulic loading rate by 5 cm, the model predicts a seven day difference in total drying time.

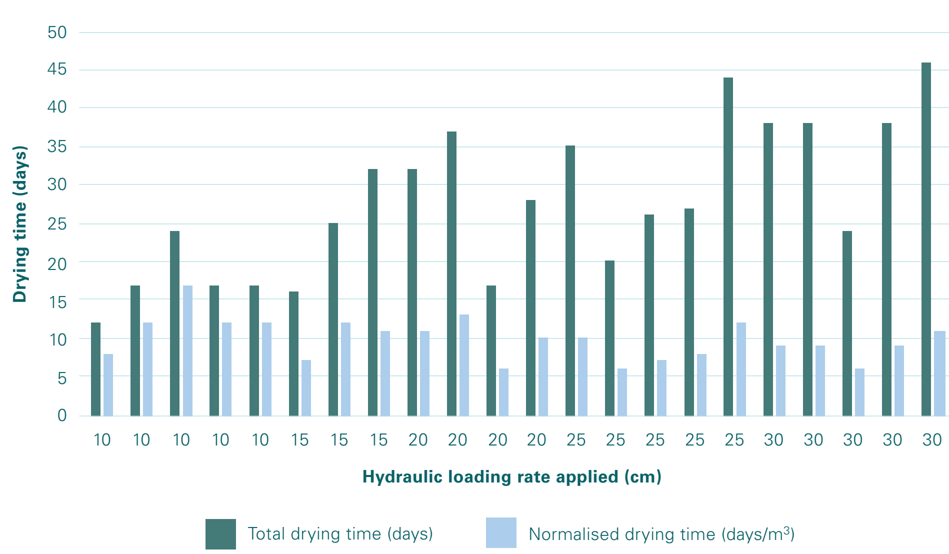

Figure 1: Time for drying of sludge on unplanted drying beds with applied hydraulic loading rates of 10, 15, 20, 25, and 30 cm. Each point represents one drying cycle. Shown are the total drying time/drying cycle in days (black circles) and the normalised drying time in days/m^3 (blue triangles).

Anantha Moorthy

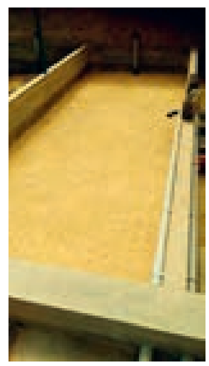

Photo: Mangalore tiles in a drying bed (top), sand added to the bed (middle), and greenhouses installed over drying beds (below).

The linear model equation for normalised drying time was *Normalised drying time [days/m^2] = 24.9 – 0.0088 × Hydraulic loading rate [cm] + 2.5×10^{-5} × TS [g/L] – 12 × VS/TS ratio – 0.0082 × Evaporation factor*. Here, hydraulic loading rate was not significant in the model (p=0.92), which means that for normalised drying time, the applied hydraulic loading rate was not as relevant. While drying time shows an increasing trend, normalised drying time shows a slightly decreasing trend with the increase in hydraulic loading rate, as seen in Figure 1. This suggests that if the operators wanted to dewater as much sludge as possible at Devanahalli, a hydraulic loading of 30 cm should be applied. These examples provide a first exploration of using linear models in the context of drying time, and can assist in predicting drying time for the case of Devanahalli.

Greenhouses

Installing greenhouses increased the average air temperature from 25 °C to 53 °C. Air humidity decreased from 56 % to 12 % on average, with the help of an integrated ventilation system. As shown in Figure 2, this resulted in a marked improvement in drying time, and more trials will be done. These initial results suggest that by installing greenhouses, operators could increase the number of drying cycles/year, and thereby treat a larger sludge volume on the same surface area. However, operators will need to do a cost-benefit analysis to justify the cost of building greenhouses (see Photo).

Mangalore tiles

Sand loss prior to tiles being installed was on average 6 cm per bed for 14 drying cycles that took place over two years of operation. After installation, sand loss was negligible during seven drying cycles/bed over six months and initial results are promising. Limiting the sand content for better product quality is beneficial when the sludge is used for resource recovery as a solid fuel or compost. Using locally available porous tiles can help reduce costs, but the decision to use tiles will also require a cost-benefit analysis, comparing different options and lengths of operation.

Conclusion

The research findings were the following:

- Empirical models developed with operating parameters specific to individual FSTPs are relatively easy to produce and could provide a way to optimise loading rates.
- Greenhouses are effective in reducing drying time.
- Mangalore and other types of locally available tiles can be effective in reducing sand loss.
- By rapidly testing and trying out adaptable solutions, treatment performance can be optimised during actual operation.

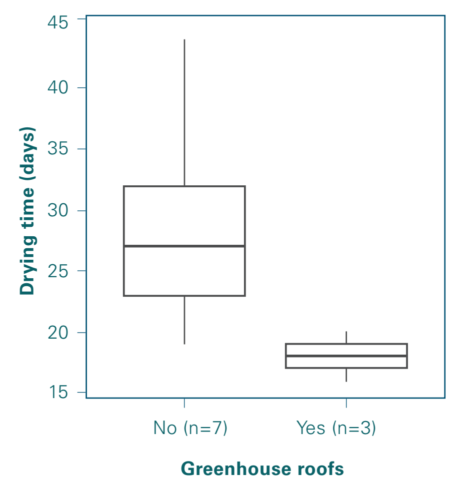

Figure 2: Total drying time per drying cycle with and without greenhouse roofs (applied hydraulic loading rate 25 cm, total 10 cycles).

References

[1] Klinger M. et al., *Scoping Study: Faecal Sludge Treatment Plants in South-Asia and sub-Saharan Africa*, (Bill & Melinda Gates Foundation, 2019).

[2] Consortium for DEWATS Dissemination Society, *Insights from Faecal Sludge Management in Devanahalli – Five years of operations*, (Bengaluru: CDD Society, 2020).

[3] Consortium for DEWATS Dissemination Society, *Guidance Document for Design of FSTP Based on Drying Bed Technologies*, (Bengaluru: CDD Society, 2021).

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We would like to thank Andreas Scheidegger for his help in making the models.

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Strategic Environmental Sanitation Planning

As the world becomes progressively more urban, the challenge to provide safe and effective sanitary arrangements becomes even greater. The research of Sandec's Strategic Environmental Sanitation Planning group aims to systematically 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 Simplified sewers being installed in Nala, Nepal, as part of the small town's sanitation planning priorities.

Photo by CIUD, Kathmandu.

The QUISS Project: Evidence from Kenya, Ghana, and Bangladesh

Shared sanitation provides sanitation access in urban areas, but is at best considered a "limited" solution due to the lack of quality standards within SDG6. QUISS identified key criteria of what constitutes "acceptable 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

While often the only viable option in densely populated low-income urban areas, shared sanitation facilities (SSF) are currently considered as a "limited" solution within the Sustainable Development Goal #6 (SDG6). To evaluate progress towards SDG6 regarding access to safe sanitation, the WHO/UNICEF Joint Monitoring Programme (JMP) service ladder is used to benchmark and compare service levels across countries. The service ladder is based on the established improved/unimproved facility type classification. Depending on how excreta are managed, *improved* sanitation facilities, which are those designed to hygienically separate excreta from human contact, are divided into three categories: *limited*, *basic*, and *safely managed* services. Private household toilets are categorised as either *basic* (improved facilities not shared with other households (HHs)) or *safely managed* services (improved facilities not shared with other HHs and where excreta are safely disposed of in situ or transported and treated offsite). In contrast, SSF are at best classified as a *limited* solution because they are shared between households – irrespective of the technology in use and how excreta are managed. Overall, there is uncertainty about what criteria can be used to distinguish between non-adequate and adequate quality for SSF [1].

Methodology

To identify potential indicators for measuring urban sanitation quality, the Sanitation Quality Index (SQI) was developed as part of the Quality Indicators of Shared Sanitation (QUISS) Project. The SQI considers three quality dimensions: the hygiene, safety, and privacy of sanitation facilities. It consists of eight aggregated variables, which were determined through formative qualitative research and using the WHO guidelines on sanitation and health [2,3]. The variables were selected based on identified user priorities [3] and the feasibility of observing them during spot-checks for validity and reliability concerns. Between May and July 2019, a cross-sectional study was done in low-income urban areas of Kisumu (Kenya), Kumasi (Ghana), and Dhaka (Bangladesh) [4–7]. 3'600 HHs were surveyed and 2'026 observational spot-checks of SSF and private household toilets were done, using a combination of systematic and purposive sampling (see Photo). The empirical approach followed three steps. First, the SQI was calculated based on the three dimensions and eight variables (see Table). Second, analysis of the relationship between the SQI, as a proxy for toilet quality, and currently used sanitation indicators (technology, sharing, etc.), as well as additional variables was done, using regression analysis (see Figure).[1] Third, the findings were incorporated into the current JMP framework to analyse the implications of new quality indicators for the sanitation service ladder.

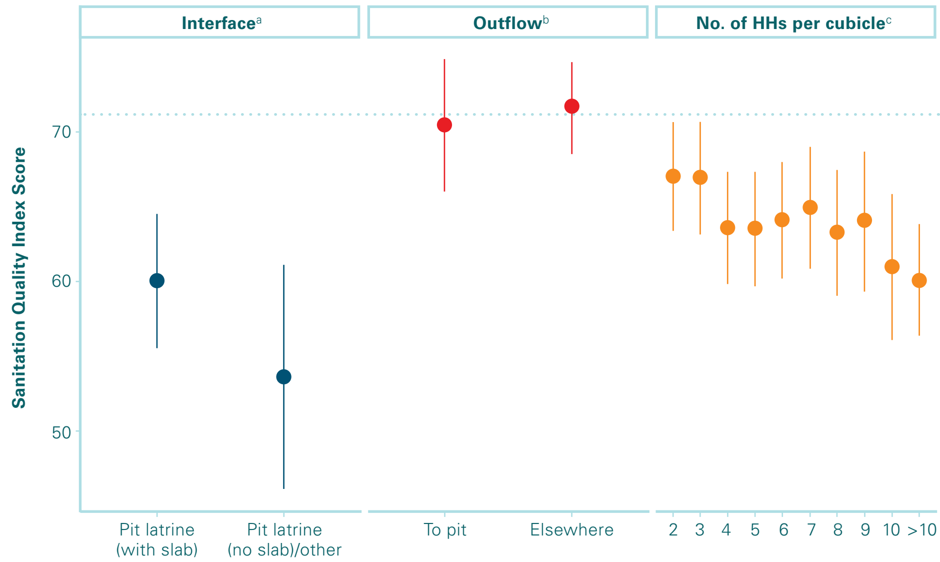
Results

As the Figure illustrates, our results suggest that relying on *improved technologies* as a single distinguishing indicator for toilet quality is inadequate in urban settings – even for private household toilets. In addition, SQI scores of *pit latrines with slab* are lower compared to *flush toilets*, even though both types are *improved* technologies. Therefore, classifying *pit latrines with a slab* as *unimproved* sanitation improves the prediction of sanitation quality as defined by the SQI. Regarding *sharing*, toilets shared by two to three HHs are mostly cleaner, safer and more private than toilets shared by four or more HHs. However, the relationship between the SQI score and the number of sharing HHs is not linear and varies considerably across countries [4]. Other strongly significant indicators included the toilet's *location, lighting, and a lockable door* (from the in- and outside). Further, the presence of a *cleaning rota* and *floor tiling* display a moderate positive correlation. The availability of water on the premises, gender-separate cubicles,

Outcome Measure	Quality Dimension	Quality Variables
Sanitation Quality Index	Hygiene	1. No solid waste inside the cubicle. 2. No visible faeces in or around the manhole/pan. 3. No insects inside the cubicle. 4. Available handwashing facility with soap. 5. Not clogged in the case of a flush toilet or not full in the case of a pit latrine.
	Safety	6. Solid roof (without holes): The roof protects the user from external (environmental) factors such as rain. 7. Solid floor (without cracks/holes): The floor separates the user from excreta and is, therefore, a gatekeeper for health hazards through both direct contact and indirect contact, e.g. insects.
	Privacy	8. Solid wall: The wall must be of solid material and have no holes that would allow a person to peek through.

Table: The Sanitation Quality Index (SQI), its constituting observable outcome variables and indicators.

[1] The additional variables were: the toilet's location, water on the premises, a handwashing facility with soap, functional lighting, a lockable door, floor tiling, gender-separated cubicles, a cleaning arrangement, the degree of user relationship, the toilet's age, the landlord living on the same plot, and a bin inside the toilet cubicle.



Notes:

Estimates show average SQI scores (0–100) conditional on control variables: *location, water on premises, handwashing facility w/soap, lighting, lockable door, tiling, gender-separated cubicle, cleaning arrangement, user relationship, age of toilet, landlord on plot, and bin inside cubicle;* Error bars represent 95%-CIs, with cluster-robust standard errors; the dotted line shows the unconditional SQI mean;
[a] *Ref: flush/pour-flush. Other* includes all types of unimproved toilet technology;
[b] *Ref: to piped sewer/septic tank. Elsewhere* includes toilets draining *to do not know where. Outflow* refers to any containment/conveyance system;
[c] *Ref: 1 household.*

Figure: Correlations between toilet technology, number of toilet users, and toilet quality (SQI).

the sharing users' relationships, the toilet facility's age, and a landlord living on the same plot did not significantly correlate with toilet quality.

Conclusion

QUISS showed that the current JMP sanitation service levels for SSF, which are exclusively based on *(improved) technology* and *sharing*, provide insufficient information regarding sanitation quality. These service levels should be revised and new indicators for determining adequate quality established. These indicators could be such factors as a toilet facility's *technology, location, lighting*, and having a *lockable door*. The indicators should then be applied to distinguish between adequate (defined as available and accessible, safe and secure, private and hygienic) and non-adequate SSF in low-income urban settings as part of the efforts to distinguish between "basic" and "limited" SSF. •

Dario Meili

Photo: Site visit to inspect shared sanitation facilities in the low-income area of Manyatta, located in the city of Kisumu, Kenya.

References

[1] Evans B. et al., Limited services? The role of shared sanitation in the 2030 Agenda for Sustainable Development, *Journal of Water, Sanitation and Hygiene for Development, 7/3*, (2017) 349–351.

[2] WHO, Guidelines on sanitation and health. (2018).

[3] Schelbert V. et al., When is shared sanitation acceptable in low-income urban settlements? A user perspective on shared sanitation quality in Kumasi, Kisumu and Dhaka, *Journal of Water, Sanitation and Hygiene for Development, 10/4*, (2020) 959–968.

[4] Meili D. et al., Indicators for sanitation quality in low-income urban settlements: Evidence from Kenya, Ghana, and Bangladesh. (submitted). (2021).

[5] Alam M.-U. et al., Shared Sanitation in Low-income Urban Settlements in Bangladesh, *Research for policy*, (2021).

[6] Simiyu S. et al., Shared Sanitation in Low-income Urban Settlements in Kenya, *Research for policy*, (2021).

[7] Antwi-Agyei P. et al., Shared Sanitation in Low-income Urban Settlements in Ghana. *Research for policy*, (2021).

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Project timeline: Oct. 2018 – Mar. 2020

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

Project partners: ETH NADEL, NHance Development Partners Ltd. (Ghana), Great Lakes University of Kisumu, (Kenya), icddr,b (Bangladesh)

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Sanitation Planning in India

Despite progressive sanitation policies, planning urban sanitation in India has been complex and ridden with ad-hoc practices. The CWIS Planning Framework is a useful lens to analyse this complexity and propose ways forward.

Abishek S Narayan[1], Christoph Lüthi[1]

Introduction

Over the past decade, India has witnessed a sanitation revolution; from the progressive National Urban Sanitation Policy (NUSP) to the flagship Swachh Bharat Abhiyan (SBM) or the Clean India Mission, which made sanitation a political priority. However, the latter focused predominantly on the construction of latrines, leaving the rest of the service chain unattended [1]. Despite the mandate of city sanitation plans in the NUSP, these plans have been mostly viewed as checklist documents.

In India, only a third of the urban population is connected to sewers, of which only a third of the collected sewage is treated (see Photo). This makes Faecal Sludge Management and Small Scale Sanitation Systems important strategies for providing safely managed sanitation. Yet, the implementation, operation, and management of these two systems have been a struggle [2,3]. A key reason for the challenges faced in urban sanitation provision in Indian cities is inadequate sanitation planning. Based on a mixed-methods approach, a detailed study was conducted to identify and analyse the barriers to sanitation planning in India through the framework of Citywide Inclusive Sanitation (CWIS) [4].

Sharada Prasad

Photo: Sanitation workers on the job in narrow and unplanned streets in India, where mechanised trucks cannot enter.

CWIS planning framework

The CWIS Planning Framework is based on the Principles developed in 2019 after the 2018 Convening in Manila [5]. It places comprehensive planning at the centre of sanitation initiatives, while operational outcomes are connected by functional linkages. Its planning targets are complex, especially given the objectives it has set for sustainability and equity.

Barriers to sanitation planning

Figure 1 summarises the key barriers to sanitation planning that were expressed in interviews: capacity, ownership, coordination, community involvement, scheme-based approach, planning frameworks, and political and financial support. Three of the eight identified issues are highlighted below:

1) *Capacity –* Local governments do not have adequate human and financial resources to carry out systematic sanitation planning in most Indian cities. Therefore, this work is often outsourced to consultants who lack technical expertise in designing alternative sanitation systems, in fostering community engagement, and in conducting gender-sensitive planning. Due to time and budget constraints, consultants are often forced to reproduce 'template solutions' from other cities, which may not be appropriate to the local contexts.

2) *Ownership –* City sanitation plans are mainly viewed as checklist documents for national funding schemes and are, therefore, not given adequate importance. In spite of sanitation being a State subject and local City Governments being in charge of service provision, the National Government spearheads the sanitation schemes, policies, standards, and narratives. While the national benchmarking system and the Swachh Survekshan (city sanitation performance ranking) have shown to boost ownership, the lack of involvement in the agenda setting and the planning process, of which the latter is outsourced, is reported to cause a decline in the overall sense of ownership among city agencies responsible for sanitation.

3) *Coordination –* Due to the cross-cutting nature of sanitation, multiple agencies and levels of government are involved in the process of planning and implementation. However, the overlapping jurisdiction, departmental silos, and constant shuffling of bureaucrats within the government lead to a lack of coordination and poor institutional memory.

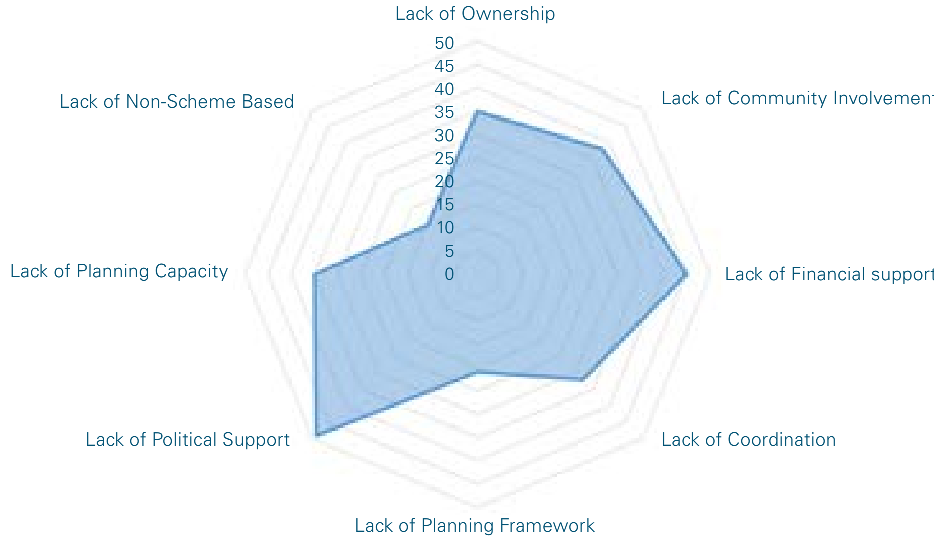

Figure 1: Key barriers to sanitation planning in India as stated in interviews. The scale indicates the number of unique mentions in interviews. [4]

4S pillars of comprehensive planning

The CWIS Planning Framework proposes the 4S pillars of comprehensive planning (Figure 2). In order to plan CWIS in India, in light of the aforementioned barriers to sanitation planning, these four pillars are explained below:

1) *Situational analysis* – A systematic methodology that emphasises analysing the local contexts when selecting appropriate sanitation solutions. This requires an explicit allocation of time, and of human and financial resources for planning.
2) *Stakeholder participation* – Community involvement in sanitation planning is essential to understand the needs of people, improve the acceptance of the sanitation interventions and, therefore, enhance its long-term sustainability. The planning process must be inclusive and actively uphold principles of equity.
3) *Synergy with other sectors* – The outcomes of safe sanitation cannot be achieved without the provision of safe water supply and proper solid waste management. The synergies of planning and implementing these services in an integrated approach help capitalise on the co-benefits.
4) *Strategy for long-term* – Planning must go beyond the election cycles and focus on incremental and long-term solutions. Therefore, strong institutional frameworks are required to ensure accountability in the long-term and to develop schemes and programmes that go beyond the immediate goals.

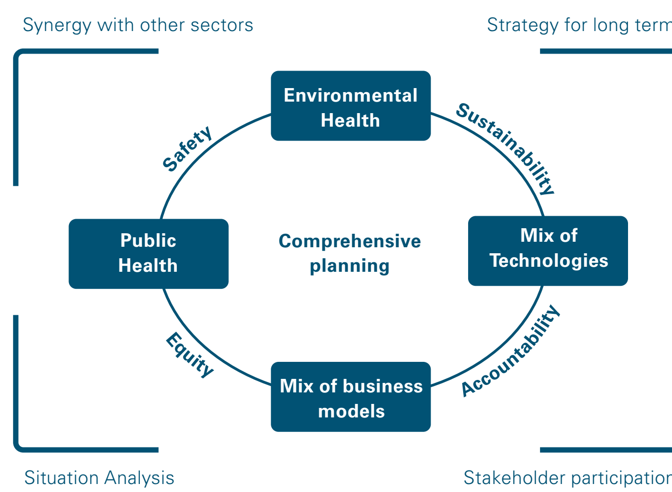

Figure 2: The CWIS Planning Framework. [4]

Conclusion

Planning citywide inclusive sanitation is a complex task and is even more complicated to do in cities of low- and middle-income countries, such as India. A wide range of barriers to sanitation planning have been identified in India, among which adequate political and financial support are considered as most critical. Comprehensive planning using the CWIS Planning Framework provides ways forward in overcoming some of these barriers. •

References

[1] Kumar A., Beyond toilets and targets: sanitation mission in India. *Dev. Pract. 27/3*, (2017) 408 – 413.

[2] Devaraj R. et al., Planning fecal sludge management systems: Challenges observed in a small town in southern India. *J. Environ. Manage, 281*, (2021) 111811.

[3] Reymond P. et al., Governance Arrangements for the Scaling up of Small-Scale Wastewater Treatment and Reuse Systems – Lessons from India. *Front. Environ., Sci. 8/72,* (2020) 16 pp.

[4] Narayan A.S., Maurer M., Lüthi C., (forthcoming). The Clean Plan – Analysing Sanitation Planning in India using the CWIS Planning Framework. *Submitted in J. Water Sanit. Hyg. Dev.*

[5] Narayan A.S. et al., Solving urban sanitation – sustainably and equitably. *World Water, 43/4,* (2020) 18 – 21.

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Citywide Inclusive Sanitation:

The CWIS initiative at Sandec consists of several projects that cover research, capacity development and expert consulting. Our PhD project contributes to the conceptualisation of the CWIS approach and the development of a planning methodology that bridges top-down and bottom-up approaches.

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Consultant Capacity Development for Citywide Inclusive Urban Sanitation

Citywide inclusive urban sanitation (CWIS) is a paradigm shift in urban sanitation planning. The Consultant Capacity Development (ConCaD) initiative contributes to building the capacity of sanitation professionals in conceptualising, planning, designing and supervising CWIS services. Vasco Schelbert[1], Abishek Narayan1, Christoph Lüthi[1]

Image: CWIS graphic depicting a mix of technologies for a variety of urban contexts.

Introduction

Most cities in low- and middle-income countries are growing bigger and denser, with vast underserved informal and peri-urban settlements. To provide a citywide solution for sanitation, a more integrated and inclusive approach is needed to cover all urban areas. Citywide inclusive urban sanitation (CWIS) is an urban sanitation paradigm shift that promotes the idea that all members of the city can have equitable access to adequate and affordable improved sanitation services. This novel concept supports a blended approach, encompassing a variety of solutions, such as onsite sanitation systems with faecal sludge management (FSM), decentralised or small-scale systems for areas too far from existing sewers or too dense for household solutions and, where this makes sense, piped sewers in, for example, central business districts (see Image). It is based on comprehensive planning, incremental implementation and sustainable operation and monitoring. While CWIS is still an evolving framework for informing urban sanitation investment programming, it has already started to shape the programmes and investments of development banks and major sector actors. Therefore, there is increasing demand among consulting firms and individual consultants to build their capacity in how to conceptualise, plan, design and supervise the implementation of CWIS services.

Capacity Development for CWIS

Funded by the Bill & Melinda Gates Foundation and starting in June 2018, the Consultant Capacity Development for Citywide Inclusive Urban Sanitation (ConCaD) initiative has established a network of collaborating Partner Training Institutes in Asia and francophone and anglophone Africa. Together, Sandec and the five Training Institutes have produced open source training materials. These comprise complete, interactive face-to-face and online training packages, including PowerPoint presentations, individual and group exercises and complementary quizzes. In addition, a YouTube channel with specifically produced videos and a comprehensive online platform have been established, providing a wide array of CWIS resources free of charge.

Training outreach

During 2019 and 2020, Sandec and the Institutes formed and trained a team of 22 trainers. In 2020 and 2021, each of the five Institutes conducted either a face-to-face (NWSC-IREC, Uganda) or an online training (CDD, India; ITN-BUET, Bangladesh, ENPHO, Nepal and UNA, Ivory Coast). To date, more than 120 participants have attended a ConCaD training. The course content provides an understanding of the CWIS paradigm shift, the main elements of CWIS and sustainable sanitation service delivery, and introduces diagnostic and planning tools appropriate to support the design of sustainable urban sanitation service delivery. Because winning bids for sanitation project tenders is day-to-day business for private consultants, participants must produce a comprehensive bidding document for a fictional tender, integrating CWIS elements.

Conclusion

Upcoming trainings in the second half of 2021 are currently planned by four Institutes. Ultimately, ConCaD contributes to increasing consultant capacity, which improves the delivery and sustainability of sanitation services to poor and non-poor communities, and to furthering the impact of sanitation investments at city scale in Sub-Saharan Africa and South Asia. •

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General Project Information:
Duration: May 2018 – May 2021
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Target Countries and Partner Training Institutes:

South East Asia:
- India: Consortium for DEWATS Dissemination Society (CDD)
- Bangladesh: International Training Network Centre – Bangladesh University of Engineering and Technology (ITN-BUET)
- Nepal: Environmental and Public Health Organisation (ENPHO)

Sub-Saharan Africa:
- Ivory Coast: Université Nangui Abrogoua (UNA)
- Uganda: National Water and Sewerage Corporation International Resource Center Bugolobi (NWSC IREC)

An Interactive Online Tool for Sanitation Planning in Humanitarian Contexts

The Compendium of Sanitation Technologies in Emergencies is a comprehensive and user-friendly reference document for sanitation solutions in humanitarian contexts. Its interactive online version is now being expanded with a case study section, an expert database and a technology watchlist. Dorothee Spuhler[1], Robert Gensch[2]

Introduction

The Compendium of Sanitation Technologies in Emergencies has been developed in a collaborative effort with Global WASH Cluster (GWC) partners and contributions from a large pool of both international humanitarian and development experts. It was developed under the leadership of the German WASH Network and Eawag with the financial support of the German Federal Foreign Office (GFFO) and the Swiss Agency for Development and Cooperation (SDC). It is a comprehensive and user-friendly reference document for sanitation solutions in humanitarian contexts along the entire sanitation service chain, from acute response to the recovery phase. It provides detailed information on tried and tested sanitation technologies, key decision criteria for selecting a context-specific configuration, and information on cross-cutting issues, such as inclusive design, making initial assessments and institutional and regulatory environments.

A flexible online platform

To make this resource more accessible for practitioners and to allow for continuous updating, an online version was developed: emersan-compendium.org (see Figure). The web-interface allows for a more interactive approach to the information and integrates a real-time filtering of technologies and hyperlinks to navigate between technology information sheets and access further references. It is currently hosted by the Sustainable Sanitation Alliance (SuSanA) and its secretariat at Deutsche Gesellschaft für International Zusammenarbeit (GIZ).

Recently added functionalities

The emersan-Compendium was successfully launched in 2020, and is now available in French and soon will be in Arabic. This newest expansion includes a case study section and a watchlist, where the user can save their favourite technologies and configure entire systems, which can then be shared via a URL. There will also soon be an expert database.

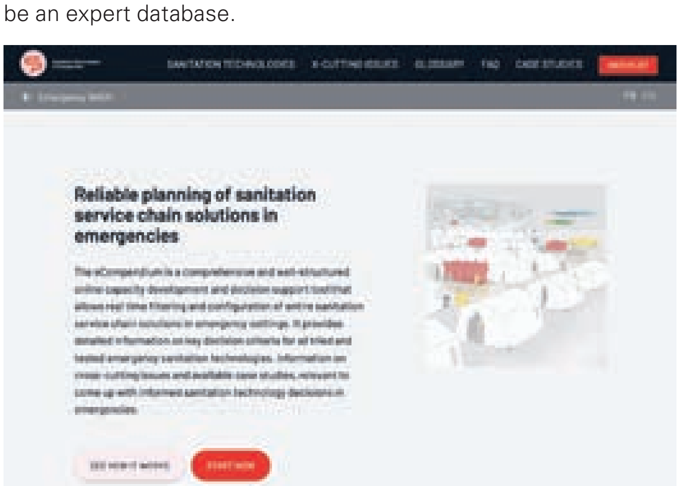

Figure: Compendium of Sanitation Technologies in Emergencies Website.

The new **Case Study Section** gives a concise overview of existing emergency sanitation and FSM related case studies. The user can filter by region, emergency phase, technologies and other key parameters. There are links to more in-depth information on such platforms as Octopus or SuSanA.

The new **Expert Database** is an attempt to respond to the need expressed by many humanitarian WASH organisations of wanting to be able to find experienced sanitation and FSM experts quickly for specific emergency contexts. It is directly linked to SuSanA and its individual SuSanA member database, and interested colleagues can sign up to be listed as emergency sanitation experts. This section will also allow for easy filtering of the pool of experts by region/country, expertise, experience and availability, and provide information on how to contact them.

The **Watchlist** permits the user to save and share technologies of interest and includes a sanitation service chain configurator – an in-built application that supports the identification and configuration of the entire sanitation service chain solutions (from the user interface to transport, treatment and final safe disposal or reuse). Depending on the local context, potential technology options can be selected and assembled into an entire system with an easy-to-use drag and drop option. A direct feedback function allows the user to check whether all the input and output products have been properly addressed. The results can also be shared with others and used as a basis for discussions with target groups or other experts.

Conclusion

The next step will integrate the emersan-Compendium into the larger Emergency WASH Knowledge Portal (www.emergency-wash.org), which has distinct platforms for the three WASH pillars: Water Supply, Sanitation and Hygiene. It is part of a larger effort within the sector to create a "GWC WASH Knowledge Hub", one of the cornerstones of the GWC roadmap initiative. This collaborative effort of GWC partners, the German WASH Network, Eawag, FHNW, and SuSanA, will also include contributions from a wide range of international sector experts and organisations, and is supported by GFFO and SDC. The portal will be constantly updated and users will be encouraged to provide direct feedback in order to ensure its quality and further improvements to the platform. •

[1] Eawag/Sandec, Switzerland

[2] German Toilet Organization, Germany

Links and references:
The eCompendium is here: https://www.emersan-compendium.org/en/
The free pdf version is in English and French and can be downloaded at the bottom of the respective intro page at www.emersan-compendium.org.

If you would like a hardcopy version in either English or French, or for any further inquiries and direct feedback, please contact:
dorothee.spuhler@eawag.ch or robert.gensch@germantoilet.org.

Psychological Ownership and Handwashing-device Functionality in Cox's Bazar

Our randomised controlled trial aimed to enable handwashing with soap by increasing monitoring and maintenance activities and strengthening psychological ownership of handwashing devices amongst the Rohingya population in Cox's Bazar, Bangladesh. Christopher Friedrich[1], Kh. Shafiur Rahaman[1], Miriam Harter[2], Khairul Bashar[3], Nadja Contzen[4], Christoph Lüthi[1]

Shafiur Rahman

Photo 1: Our research assistant visiting a household together with a Red Crescent volunteer.

Introduction

Handwashing is a simple, yet effective barrier to stop the spread of many infectious diseases, including gastrointestinal and respiratory infections. It is also one of the measures promoted by governments to stop the spread of the SARS-CoV-2 virus [1]. The functionality of handwashing devices is, of course, a prerequisite for handwashing. However, this functionality is oftentimes challenged, e.g. by insufficient maintenance [2]. This is the case not only but especially in humanitarian settings, such as the Rohingya camps in Cox's Bazar, Bangladesh, where this research was carried out. The lack of functionality of WASH infrastructure oftentimes is due to infrequent or inefficient monitoring and maintenance activities, i.e. repairing damages and refilling of water and soap (as seen on the front cover of this edition of Sandec News).

One reason why users of communal and private handwashing devices do not sufficiently monitor and maintain infrastructure is because they do not feel as if they "own" it. The feeling that an object, such as a handwashing device, is "mine" or collectively "ours", is called psychological ownership [3]. Research has shown that psychological ownership can be increased by involving users in decision-making concerning infrastructure or by asking them for financial or labour contributions towards infrastructure development [4]. Yet, in humanitarian settings, infrastructure is often provided without including the future users in the decision-making and/or they are often not asked to contribute financially or with labour, which might hamper their feelings of ownership. The goal of our research, therefore, is to find ways to strengthen a sense of ownership among users in such settings to improve the monitoring and maintenance (M&M) of communal and private handwashing devices and, thus, their functionality. This increase in functionality (reliable service without damages and constant availability of water and soap) and in perceived ownership is expected to enable more regular handwashing with water and soap than was previously done.

Methodology

This research project was implemented in collaboration with BDCRS, the Bangladesh Red Crescent Society (Photo 1). It follows a research design approach, consisting of two surveys: one baseline survey before the delivery of intervention activities and one follow-up survey afterwards (see Figure).

During the baseline survey, interviews were conducted with 340 households and 24 WASH committee members (Photo 2). People were asked when they usually wash their hands, which handwashing devices they use, and if these devices are functional or not. Current monitoring and maintenance activities and the users' perceived psychological ownership of their private and communal handwashing devices were also investigated. Spot-checks were conducted to assess the functionality of the devices and to observe handwashing behaviour at the communal handwashing devices located next to public latrines.

Analysis of the interview data led to the development of tailored interventions for individual households and user groups concerning communal handwashing devices. During the intervention phase, household visits were conducted and there were user group meetings of both the control and the intervention groups. Both groups received standard information on the importance of handwashing and COVID-19 prevention. There were also discussions on reporting mechanisms for cases when handwashing devices break or when there is no more soap. The intervention group additionally received tailored checklists for M&M of communal and private handwashing devices and assisted in the development of a mechanism to report malfunctioning. Furthermore, users' involvement and sense of ownership were increased among the intervention group by assigning responsibility for M&M, including specific tasks, for both shared and private handwashing devices. During the activities to strengthen ownership, the members of the intervention user group and household members were invited to write their names on the communal and private handwashing devices. Throughout the discussions of the devices, the facilitators referred to them with a second-person plural pronoun, as "your" device.

To test whether our interventions would result in the expected effects among the intervention group members, a follow-up survey was done four weeks afterwards. 263 household and 20 user group members from the initial sample were interviewed. This data is currently being analysed to see whether there has been an increase in feelings of ownership, increased functionality of the communal and private handwashing devices and, concomitantly, more handwashing with soap and water on a regular basis.

Carrying out such a research project during a pandemic presented unprecedented challenges, such as lockdowns in the camps in Cox's Bazar. To protect both the people living in the camps, as well as the research team, from contracting and spreading the SARS-CoV-2 virus, interviews were carried out via phone. The drawbacks of this were challenges due to interrupted networks and/or phones being out of use. Long telephone conversations were also very tiresome for both the interviewers and the interviewees.

Conclusion

Our findings will be presented to our implementing partner BDRCS and other members of the WASH-Cluster in Cox's Bazar to support their COVID-19 responses and handwashing interventions in general. Overall, it is expected that the results will assist in shifting the focus from raising awareness about health risks to improving the functionality of infrastructure and, thus, handwashing behaviour. •

References

[1] WHO, *Coronavirus disease (COVID-19) advice for the public,* (World Health Organization, 2021). Retrieved from https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public

[2] Ramos M. et al., *Handwashing. WASH in Emergencies. HIF Problem Exploration Report*, (ELRHA, 2016).

[3] Contzen N. & Marks S. J., Increasing the regular use of safe water kiosk through collective psychological ownership: A mediation analysis. *Journal of Environmental Psychology, 57*, (2018), 45–52.

[4] Marks S.J. et al., Does sense of ownership matter for rural water system sustainability? Evidence from Kenya. *Journal of Water, Sanitation and Hygiene for Development, 3/2*, (2013), 122–133.

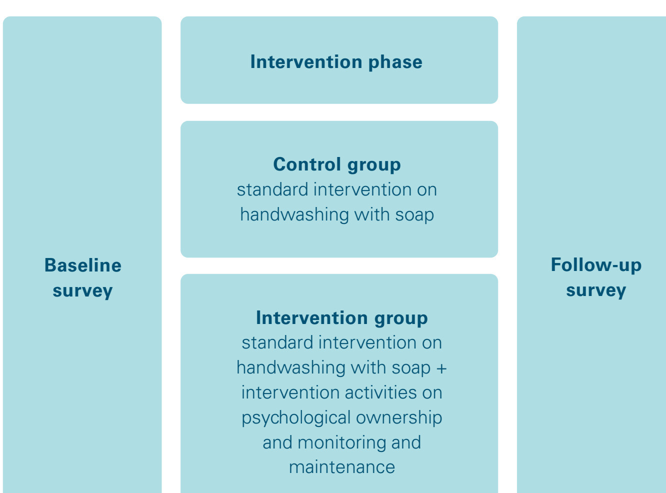

Figure: Research design.

Shairin Salma

Photo 2: A Red Crescent volunteer discussing the importance of handwashing, monitoring and maintenance of personal handwashing devices, COVID-19 preventive measures, etc., during a household visit.

[1] Eawag/Sandec, Switzerland

[2] RANAS Ltd., Switzerland

[3] Bangladesh Red Crescent Society (BDRCS), Bangladesh

[4] Eawag/ESS, Switzerland

Funding: This project is jointly funded by the Research for Health in Humanitarian Crises (R2HC) programme of ELRHA, a UK-based independent charity and by Eawag.

Project Partners: Bangladesh Red Crescent Society (BDRCS)

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Water Supply and Treatment

A safe and reliable drinking water supply is a foundation of health and well-being. Sandec's Water Supply and Treatment group examines treatment technologies, monitoring approaches and training tools in support of extending and sustaining access to safe drinking water in underserved areas. Current projects focus on:

- Implementing passive chlorination technologies at scale.
- Strengthening water quality laboratories in remote rural areas.
- Understanding how extreme natural events affect WASH infrastructure.
- Identifying the social and technical factors that determine the functionality of water supplies over time.

Photo Bal Mukunda Kunwar and collaborators from Helvetas-Nepal examine a roughing filter that was installed as part of the REACH project in Karnali and Sudur Paschim Provinces.

Photo by Ariane Schertenleib.

Investigating Packaged Drinking Water Quality in Nairobi, Kenya

A cross-sectional study of bottled drinking water revealed that one in five bottles contained unsafe levels of fluoride or *E.coli*. Gloria Magut[1,2], Zipporah Bukania[1], Gideon M. Kikuvi[3], Phillip Ndemwa[1], Sara J. Marks[2]


Phillip Ndemwa

Photo: Microbial analysis of bottled drinking water at the Kenya Medical Research Institute (KEMRI) laboratory.

Introduction
Consumption of packaged water is on the rise globally [1]. In low- and middle-income countries, where urban distribution networks are often unreliable [2], bottled water use has increased by 174 % over the past decade [1]. However, uncertainties persist regarding the safety of packaged drinking water, especially in urban Africa. In 2019, there were about 65 diarrheal cases per 1’000 people in Embakasi Central sub-county, the highest rate of diarrheal disease recorded in Nairobi, Kenya. The media attributed the outbreak to pervasive contamination of bottled drinking water. This study aimed to assess the physicochemical and microbial quality of bottled drinking water sold in retail outlets throughout Embakasi Central, Nairobi.

Methods
Using a cross-sectional design, the quality of bottled drinking water for eight brands sold at 38 minimarts, 85 kiosks, and 35 street vendors was assessed. First, a scoping visit was conducted to gather information on commonly consumed brands. Next, the Lot Quality Assurance Sampling (LQAS) method, a rapid assessment technique that maximises the robustness of results for limited sample sizes, was used to estimate the quality of water per brand for the most consumed brands. A total of 158 water samples from eight brands (18 to 22 samples per brand) were gathered in duplicate bottles from across the study area. Water samples were transported to certified laboratories in Nairobi for standard physiochemical and microbial analysis (see Photo). Data were compiled and analysed in Excel to investigate trends within and between brands.

Results
Findings indicate that 13 % and 12 % of all samples exceeded Kenya’s safety thresholds for fluoride (≤1.5 mg/L) and *E.coli* (<1 CFU/100 mL), respectively (see Figure). Brand 5 was particularly contaminated, with a mean *E.coli* concentration of 52 CFU/100 mL (SD = 223 CFU/100 mL) and 100 % of the samples in violation, as well as a mean fluoride concentration of 3.5 mg/L (SD = 0.57 mg/L) and 25 % of the samples in violation. Overall, 22 % of the samples had at least one violation of health concern and more than one-third of the samples were outside of the recommended pH range of 6.5–8.5, indicating the risk of operational ineffectiveness [3]. Additional parameters were monitored (e.g. nitrite, lead, magnesium, calcium and sulphate) [3], but no violations were detected. •

References
[1] Cohen A. et al., The global risks of increasing reliance on bottled water. *Nature Sustainability, 1*, (2018) 327–329.
[2] Opatunji O.S. et al., *Consumption practices and user perception of an emerging alternative drinking water option (sachet water) in Ibadan, Nigeria*, (35th WEDC International Conference, 2011)
[3] KEBS, *Packaged Drinking Water – Specification*, (Nairobi: Kenya Bureau of Standards, 2015).

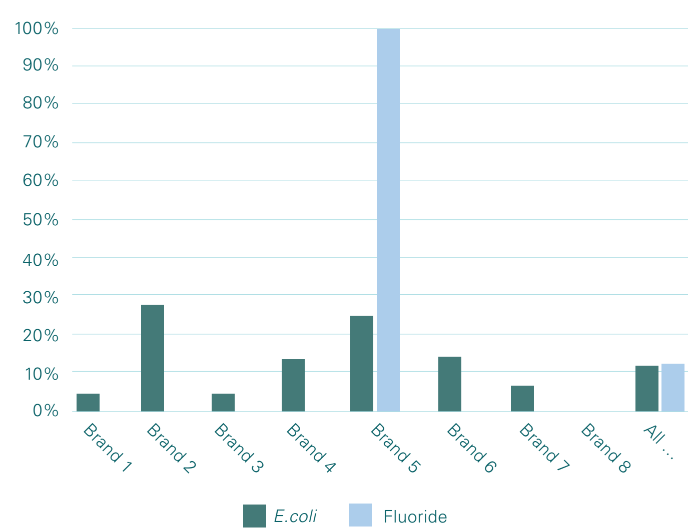

Figure: Percentage of samples exceeding *E. coli* (<1 CFU/100 mL) and fluoride (≤1.5 mg/L) standards.

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System-level Passive Chlorination: Technical and Experience Overview

System-level passive chlorination is a promising technology for centralised water treatment in low-income settings. Sandec is conducting research to test devices in different contexts and to build evidence of their functionality and performance. Ariane Schertenleib[1], Lukas Dössegger[1], Yoshika Crider[2], Regula Meierhofer[1], Sara J. Marks[1]

Country	Uganda	Nepal	Guatemala
Context	Post-treatment chlorination in gravity-driven membrane (GDM) kiosks	Scheme-level chlorination for community-managed piped supplies	Scheme-level chlorination for community-managed piped supplies
Technologies assessed	• Diffusion chlorinator (floater) • 2 in-line chlorinators (T-chlorinator*, CDB*) • 3 end-line chlorinators (AkvoTur*, Venturi, AquatabsFlo)	• In-line chlorinator (PurAll 100, Water-Mission Chlorinator) • End-line chlorinator installed at reservoir tank inlet (Aquatabs Flo) • 3 end-line chlorinators (AkvoTur*, Venturi, AquatabsFlo)	• End-line chlorinator installed at reservoir inlet (A'Jin*) • 3 end-line chlorinators (AkvoTur*, Venturi, AquatabsFlo)
Main findings	• Dosing consistency challenging (low flow in GDM systems) • >90% probability of T-chlorinator to achieve target concentration • Establishing a chlorine supply chain may be challenging • High cost of Aquatabs Flo & liquid chlorine in Uganda	• Easy to install but adjustments required • One year after installation, 80% of unchlorinated (upstream of technology) samples were contaminated with *E.coli* • Only 7% of downstream tap samples had *E.coli* • Acceptability of taste was high	• Study in progress

Table: Passive chlorination technologies tested and related findings. **Self-built chlorinators.*

Background

Ensuring a consistent supply of safe drinking water is a global challenge. Faecal contamination can occur at the water source itself, during distribution or when the water is manually transported and stored. In rural areas, it is difficult to implement centralised, scheme-level water treatment due to the costs and limited managerial capacities. Household-level treatment approaches also have many limitations, including incorrect and inconsistent use [1]. Passive chlorination is a promising technology for water treatment at the system-level that overcomes these challenges. It is low cost, works without electricity and has minimal maintenance requirements. The Safe Water Promotion and Water Supply and Treatment groups are evaluating various chlorination devices in laboratory and field settings.

Research

Several types of technologies for system-level passive chlorination are commercially available, and a growing number of self-built chlorinators are being developed. They are installed either directly within a distribution pipe (in-line), at a tap feeding into or out of a reservoir (end-line) or placed into a reservoir (see Photo). A selection of these devices is being evaluated with partners in Uganda [2], Nepal [3] and Guatemala [4]. Evaluation criteria include: disinfection effectiveness, dosing consistency, user acceptance, ease of maintenance, local supply chain availability and cost.

Conclusion

Sandec's research on passive chlorination devices is showing promising results in terms of treatment effectiveness and users' acceptance of chlorine taste (see Table). Challenges identified so far include dosing inconsistencies and the high cost of replacement materials. Future investigations are needed to longitudinally compare different chlorination alternatives across seasons. Furthermore, non-technical issues need to be better understood; for example, can local technicians with limited technical knowledge and tools operate and service the devices? Can a reliable supply chain for chlorine and spare parts be established in remote areas? Is chlorination affordable and complementary to existing water service delivery business models? The water groups at Sandec are committed to finding answers to these questions. •

References

[1] Brown J. et al., High adherence is necessary to realize health gains from water quality interventions, *PloS One, 7/5*, (2012), e36735.

[2] Dössegger L. et al., Assessment of low-cost, non-electrically powered chlorination devices for gravity-driven membrane water kiosks in eastern Uganda. *Waterlines, 40/2*, (2021), 92–106.

[3] Crider Y. et al., (in preparation). Evaluating performance of system-level, passive chlorination in community-managed water systems in rural Nepal.

[4] https://eth4d.ethz.ch/funding-opportunities/eth4d-research-grants/ETH4D-Challenges/previous-grantees/chlorination-intervention-for-rural-supplies.html

Yoshika Crider

Photo: PurAll 100 device installed in a water supply scheme in Nepal.

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Participation and Psychological Ownership Enhance Safe Water Outcomes

The REACH intervention study found that participation-focused activities that increase water users' psychological ownership improve long-term acceptance, use and maintenance of community-based safe water infrastructure. No effect on improved functionality was found. Benjamin Ambuehl[1,2], Bal Mukunda Kunwar[3], Ariane Schertenleib[1], Sara J. Marks[1], Jennifer Inauen[2]

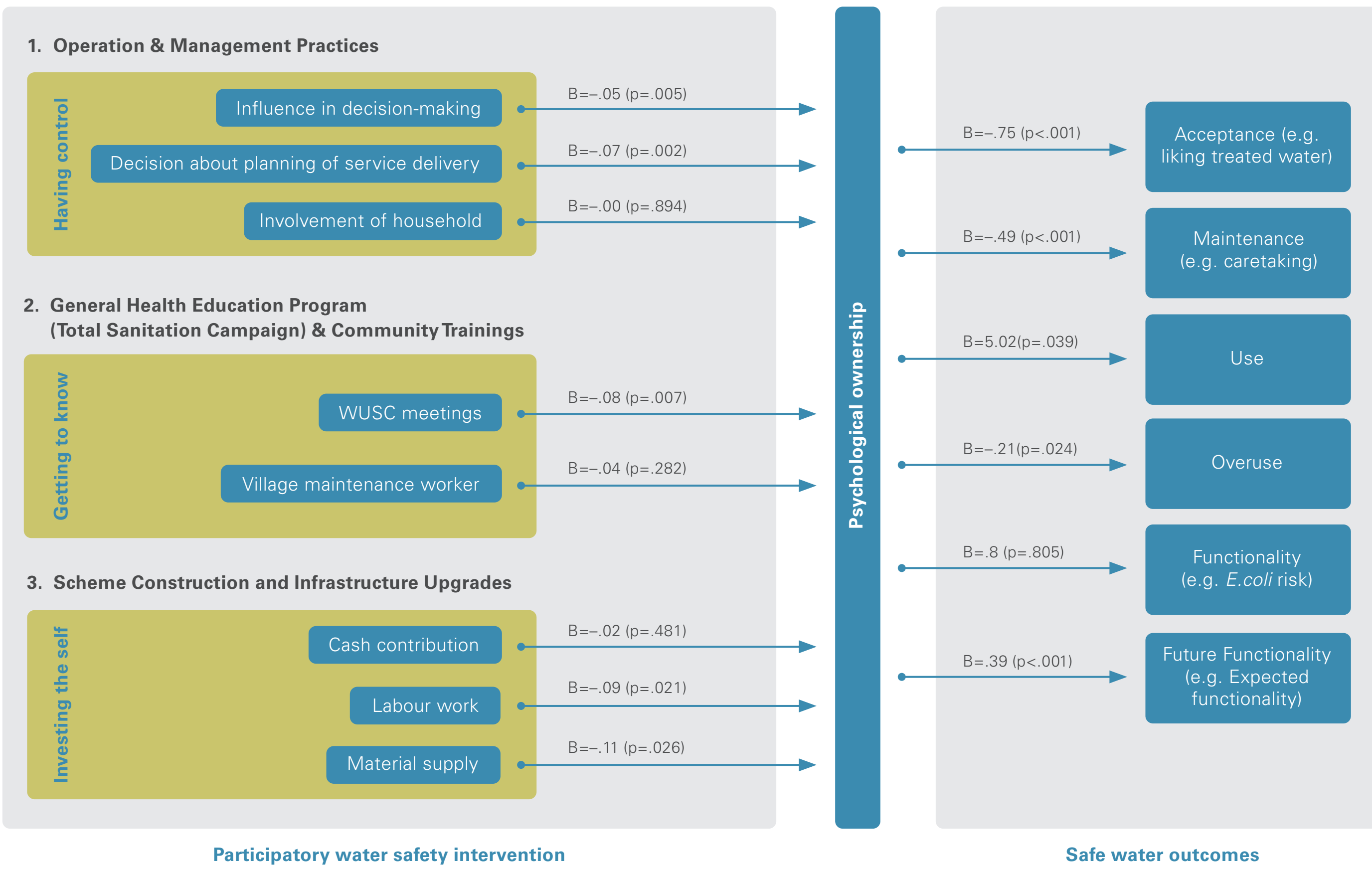

Figure: Summary of results illustrating how different forms of participation (left, blue) and their corresponding route to psychological ownership (left, green) are linked to safe water outcomes (right, blue) via psychological ownership. Note that no formal mediation analysis is presented here.

Introduction

Different forms of participation are applied by water sector professionals to foster the sustainability of safe water infrastructure in rural water safety planning. For example, communities are involved in decision-making, in organised meetings and people make cash, in-kind or labour contributions for installation and maintenance of infrastructure [1]. Participation of communities is assumed to be essential to tailor water services that meet community members' wants and needs and to instil a "feeling of ownership" for the infrastructure. It should lead to increased acceptance, use and caretaking/maintenance behaviour and promote the long-term functionality of safe water infrastructure.

Ownership theory defines psychological ownership, as the state, wherein a person or community feels as though a target of ownership is his/hers or theirs [2]. It is a feeling that one can have without necessarily legally owning the target of ownership. It is hypothesised that psychological ownership is evoked through three routes [3]:

1) Getting to know the target of ownership (e.g. experiencing the object)
2) Investing the self in the target of ownership (e.g. contributing resources and effort)
3) Having control over the target of ownership (e.g. involvement in decision-making)

Psychological ownership for safe water infrastructure was already investigated, for example, in Kenya. All else held constant, the infrastructure condition is positively associated with water committee members' sense of ownership, whereas users' confidence and system management are positively associated with households' sense of ownership [4]. In Nepal, a team from Eawag, University of Bern and Helvetas-Nepal sought to combine psychological theory and field practice and found the concept of psychological ownership to be relevant to the context of community-managed safe water supply [5]. However, what forms of participation could strengthen psychological ownership for safe water infrastructure and which safe water outcomes are linked to psychological ownership remained open questions. The REACH study investigated whether a participatory safe water intervention can instil psychological ownership and lead to improved safe water outcomes.

Methods

Study site & sample

We carried out a non-randomised cluster-based controlled trial with pre-post intervention assessments in mid-western Nepal, a region where safe water infrastructure in this region is often a challenge. The selected communities were served by Helvetas' integrated water resource management (IWRM) programme. The survey sample comprised N=369 end users in 21 treatment and 12 control communities in Karnali and Sudur Paschim Provinces.

Interventions

Intensive community participation and training were core features before and throughout implementing the IWRM programme. An overview of the participatory interventions and their corresponding routes to psychological ownership is shown in the Figure.

Results

We conducted a multiple generalised estimating equation (GEE) model to test whether participatory activities related to increased psychological ownership. Further, we conducted a series of GEEs to relate psychological ownership to safe water outcomes. The results are summarised in the Figure.

Several forms of participation were significantly related to changes in psychological ownership (Figure, left). In line with our assumptions, greater psychological ownership was found among respondents who reportedly had an influence on decision-making about the water system or service levels, who more frequently attended the water users' committee meetings and who contributed labour or materials. Greater psychological ownership among respondents was associated with their greater acceptance and increased caretaking of the water system and more frequent use of it (Figure, right). Further, lesser reported overuse and greater optimism regarding its future functionality were related to increased psychological ownership. However, *E.coli* contamination of household stored water containers was not associated with psychological ownership.

Discussion

Psychological ownership was associated with multiple positive outcomes for a safe water supply: increased acceptance and caretaking of safe drinking water infrastructure, increased health behaviour (use) and reduced negative behaviour (overuse). However, we found no relationship between psychological ownership and observed system functionality. This may be due to the fact that technical expertise and influence on functionality is often assigned to an exclusive selection of villagers (i.e. water user committees). Hence, users may not have a significant direct influence on water quality or other direct measures of functionality.

Our results point to several participatory activities that are promising to enhance psychological ownership. Water users' committees played a key role in participative interventions, with committee meetings being one of the strongest routes to psychological ownership. Users who attended committee meetings more frequently were presumably most likely to follow the news about the system and subsequently may have acquired more knowledge about and an increased influence on the water scheme and, thus, a higher sense of psychological ownership for it (see Photo).

Dorian Tosi Robinson

Photo: Water Users' Committee meeting in the main village of Ranchuli in Kalikot, Nepal.

A limitation of our study is that communities were not randomly assigned to the intervention or control groups. We also did not present a mediation model and, therefore, it cannot be concluded that psychological ownership acts as the causal mechanism between the intervention effects on safe water outcomes. Nevertheless, in line with the Sustainable Development Goals, our study supports the sector's assumption that participatory approaches increase favourable safe water outcomes. This research highlights that in the rural Nepal context, some forms of participation are more promising than others. Contributing labour and materials, having influence on project decision-making, and attending water user committee meetings seem promising activities to increasing safe water outcomes via enhancing psychological ownership for safe water infrastructure. •

References

[1] Jiménez A., et al., The enabling environment for participation in water and sanitation: A conceptual framework, *Water, 11/2*, (2019) 308–329.

[2] Pierce J.L. et al., The State of Psychological Ownership: Integrating and Extending a Century of Research, *Review of General Psychology, 7/1*, (2003) 84–107.

[3] Pierce J.L. et al., Psychological Ownership and the Organizational Context: Theory, Research Evidence, and Application, (Edward Elgar Publishing (2011).

[4] Marks S.J. et al., Does sense of ownership matter for rural water system sustainability? Evidence from Kenya, *J Water San Hyg Dev, 3/2*, (2013) 122 – 133.

[5] Ambuehl B. et al., The Role of Psychological Ownership in Safe Water Management: A Mixed-Methods Study in Nepal, *Water, 13/5*, (2021) 589–608.

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This research was supported by the Swiss Agency for Development Cooperation (Project number 7F-09963.01.01) and the REACH programme funded by UK Aid from the UK Foreign, Commonwealth and Development Office (FCDO) for the benefit of developing countries (Programme Code 201880). However, the views expressed and information contained in it are not necessarily those of or endorsed by these agencies, which can accept no responsibility for such views or information or for any reliance placed on them.

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 Safe Water Promotion group develops and evaluates 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:

- Laboratory and field-level performance evaluation of innovative methods for drinking water treatment and safe storage in low-income areas.
- Assessment of effective and sustainable safe water interventions, strategies and programs.
- Impact evaluations of improved access to safe drinking water.

Photo The use of unhygienic containers increases the risk of recontaminating treated water.

Photo by Regula Meierhofer.

Residual Disinfection and Cleaned Containers Keep Treated Water Safe

This study was about the recontamination of drinking water in jerrycans. Results showed that free residual chlorine of 0.4 mg/L during 24 h of water storage and containers that permit adequate cleaning are effective measures to reduce recontamination risks. Regula Meierhofer[1], Nicola Gärtner[1], Laura Germann[1], Kennedy Wanyama[2], Henry Ouma[2]

Regula Meierhofer

Photo: Water collection using common, uncleaned jerrycans is associated with a high risk of recontamination of the treated water.

Introduction

Recontamination of treated water during transport and storage is a frequently reported concern (see Photo). Containers with narrow openings prevent hands from entering the canister and preserved water quality better than containers with larger openings [1]. However, narrow openings hinder systematic container cleaning with a brush. Regular use of containers without proper cleaning leads to the formation of a biofilm on the container's inner walls, which harbours and protects bacterial colonies, thus, increasing the risk of recontamination [2]. Hence, thorough cleaning of the containers may be a method to eliminate this source of recontamination.

Chlorination provides residual disinfection and is another strategy to reduce the recontamination risk under poor hygienic conditions. WHO recommends dosing to a concentration of 2 mg/L of free residual chloring (FRC) for non-turbid water at the point of delivery. In stored water, a minimum chlorine concentration of 0.2 mg/L should remain to prevent recontamination [3]. A study in Uganda was conducted to assess the impact of providing residual disinfection at the point of collection and the use of normal and cleaned jerrycans or improved cleaned containers on the reduction of recontamination risks in treated water during transport and 24 h of storage [4].

Methods

The study was implemented using a quasi-experimental design with the inclusion of intervention randomisation at three sites where community-scale water treatment using Gravity Driven Membrane filtration (GDM) treat water from Lake Victoria. Three intervention strategies were implemented to reduce the recontamination risks of stored drinking water. Water was chlorinated to obtain a concentration of 2 mg/L of free residual chlorine (FRC) at the water kiosk's tap at all interventions except for the control site. The intervention strategies were designed as follows: a) use of uncleaned common jerrycans, b) use of cleaned common jerrycans, and c) use of cleaned improved containers that had a larger opening for easy cleaning and a tap for drawing water. At the control site, people used uncleaned common jerrycans.

The cleaning of jerrycans was done by inserting sand and soapy water and shaking them, and subsequently rinsing with chlorinated, treated water. The improved containers were cleaned with a brush and soapy water and were rinsed with chlorinated, treated water.

Water quality analysis to measure free residual chlorine (FRC) and contamination levels of *E.coli* and total coliforms was done with samples from the kiosk's tap, from freshly filled containers of 135 participants, and from the same containers after 24 h of storage in the households. Quantitative household interviews and structured observations were implemented with 135 households to assess the influence of water, sanitation, and hygiene infrastructure and practice on recontamination and to identify confounding variables.

The degree of recontamination was assessed by calculating the differences between water quality at the tap and water quality after 24 h of storage. Univariate and multivariate logistic regression models, controlling for intervention assignment, were

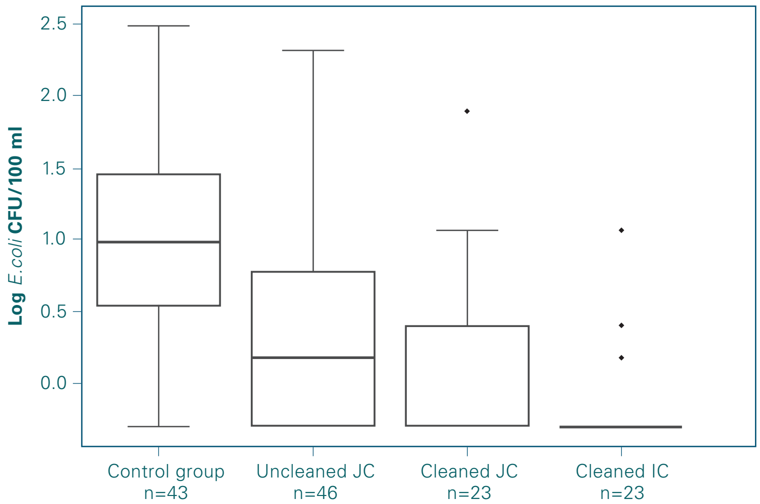


Figure 1: Recontamination with *E.coli* between kiosk's tap and 24 h of storage in households (JC=Jerry cans, IC= Improved Containers).

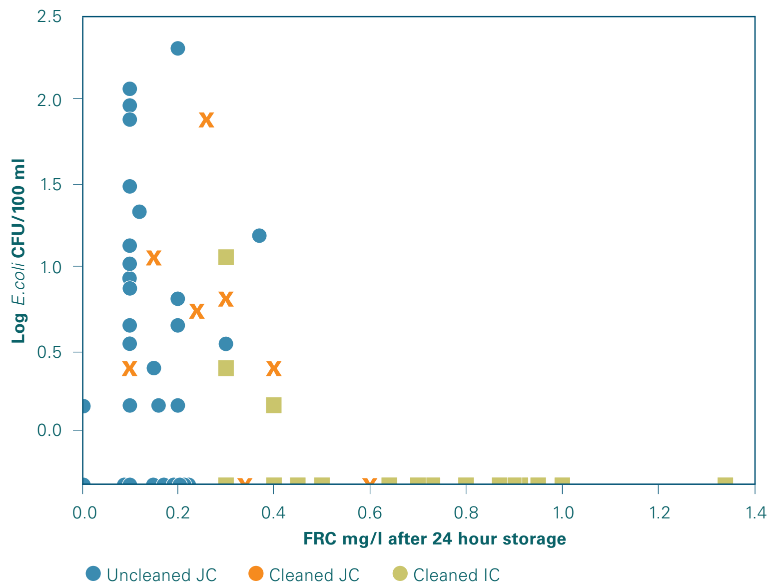


Figure 2: Log-transformed counts of *E.coli* versus FRC in different containers after 24 h storage (Detection limit: 0 Log; -0.3 log = non-detects).

calculated to investigate the impact of household factors on bacterial recontamination (0 CFU/100mL=0 and contaminated >0 CFU/100mL=1).

Results and Discussion

Microbiological recontamination

Water quality tests revealed that none of the samples taken at the kiosk's tap at any site, including the control site, contained *E.coli*. Total coliforms were detected at the control site (Median=11 CFU/100mL, Interquartile Range (IQR)=9 CFU/100mL). The kiosk taps at the intervention sites providing chlorinated water did not contain any total coliforms. The presence of chlorine protected the water in all three interventions after filling the jerrycans, resulting in a median of zero *E.coli* and total coliforms. In the control group, 74.4 % of the containers contained *E.coli* immediately after filling.

After 24 h of storage, *E.coli* was detected in 86 % of the containers of the control group (Median=9 CFU/100mL, IQR=25), 54 % of the uncleaned jerrycans (Median=1 CFU/100mL, IQR=6), 30 % of the cleaned jerrycans (Median=0 CFU/100mL, IQR=2) and 13 % of the cleaned improved containers (Median=0 CFU/100mL, IQR=0). The *E.coli* recontamination, calculated as the change in CFU/100mL between the kiosk's tap and 24 h storage in the container, in all three intervention groups differed significantly from that in the control group (Mann-Whitney U=539, p<.0083, r=–.32 for uncleaned jerrycans, Mann-Whitney U=167, p<.0083, r=–.39 for cleaned jerrycans and Mann-Whitney U=100, p<.0083, r=–.47 for improved cleaned containers, see Figure 1).

Degradation of free residual chlorine

Recontamination of *E.coli* and total coliforms were significantly associated with chlorinating water after filtration (OR=0.101; p=.001). The FRC degradation over 24 h in cleaned jerrycans and improved containers (Mean of degradation=1.2 – 1.6mg/L , SD=0.3 – 0.4 mg/L) was significantly less than in uncleaned jerrycans (Mean of degradation =1.8mg/L, SD=0.3mg/L, t(34)=2.466, p<.05, r=.39, see Figure 2). These results highlight that a thorough cleaning process is effective in removing organic material from the containers, thus, contributing to the stabilisation of FRC in stored water. Water quality in all jerrycans or containers containing FRC concentrations above 0.4mg/L after 24 h of storage met WHO guidelines (zero *E.coli* CFU/100mL) [3]. Contrary to earlier recommendations, our findings suggest that FRC concentrations above 0.2 mg/L may be required to ensure that water from Lake Victoria is safe to drink after 24 h of storage [3].

Factors associated with recontamination of water

The logistic regression models with presence or absence of *E.coli* recontamination in water stored for 24 h revealed that most water-handling and hygiene-related household factors did not significantly influence water quality during transport and storage. Significantly reduced odds ratios for recontamination with *E.coli* were found if water at the kiosk was chlorinated (OR=0.105, p=.003), containers were cleaned by the kiosk operator (OR=0.180, p=.009), customers used improved containers (OR=0.094, p=.002) or households had received WASH education visits (OR=0.54, p=.003).

Conclusion

Chlorinating water to provide residual disinfection and cleaning of storage containers are effective strategies to reduce recontamination risks during transport and storage of water. Although former studies recommend the use of containers with small openings, this study showed that containers with wide openings, facilitating proper cleaning of the inner walls, reduce recontamination. Containers with FRC residuals of at least 0.4mg/L after 24 h of storage did not exhibit recontamination with *E.coli*. •

References

[1] Mintz E.D. et al., Safe Water Treatment and Storage in the Home: A Practical New Strategy to Prevent Waterborne Disease. *JAMA, 273/12*, (1995) 948 – 953.

[2] Jagals P. et al.,The effect of container-biofilm on the microbiological quality of water used from plastic household containers. *Journal of Water and Health, 1/3*, (2003) 101 – 108.

[3] WHO, *Guidelines for Drinking Water Quality*, (World Health Organization, 2017).

[4] Gärtner N. et al., Keeping water from kiosks clean: Strategies for reducing recontamination during transport and storage in Eastern Uganda. *Water Research X*, 10, (2021) 100079 (8 pp.).

[1] Eawag/Sandec, Switzerland
[2] Africa Water Solutions, Uganda
Contact: regula.meierhofer@eawag.ch

Education and Training

Sandec's Education and Training Programme aims at reducing 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 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.
- Hosting Masters and PhD students and visiting scientists from low- and middle-income countries who receive Eawag Partnership Programme Fellowships.

Photo Preparing a video shoot for an online education initiative at the ETH Zurich video studio during the pandemic.

Photo by Artan Hajrullahu.

Designing a Small Private Online Course on Citywide Inclusive Sanitation

In collaboration with different partners, Sandec developed and piloted a new digital learning format, the Small Private Online Course. Characterised by content adaptation and a high level of interactivity, it offered a learning experience that led to high completion rates. Laura Baquedano[1], Vasco Schelbert[1], Fabian Suter[1], Christoph Lüthi[1]

Introduction

Digital learning formats have gained momentum during the COVID-19 pandemic and the global eLearning market is expected to continue its exponential growth [1]. To meet increased demand, together with the Asian Development Bank Institute (ADB-I), the International Training Network of the Bangladesh University of Engineering and Technology (ITN-BUET), and the Environment and Public Health Organization (ENPHO), Sandec piloted a Small Private Online Course (SPOC).

What is a SPOC?

A SPOC is designed for a smaller cohort of learners than Massive Open Online Courses (MOOCs). Participants have to meet specific pre-defined requirements to enrol. A SPOC also offers a high level of interactivity, and content and activities can be easily adapted to suit specific educational needs [2].

Reducing the cohort size is crucial for enabling interactivity between instructors and learners and to increase peer exchange among participants through hands-on exercises. In addition, because course access is restricted to a designated group, the course content can specifically address their training needs and interests. It also facilitates the personalisation of the learning experience.

How to design a SPOC?

The main steps taken to design the SPOC pilot were:

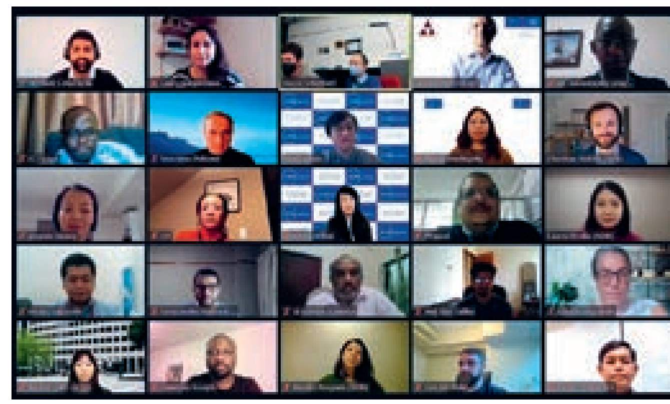
1) *Determine the topic and target audience.* The goal was to design an online course on Citywide Inclusive Sanitation (CWIS) to build sanitation consultants' capacities in low- and middle-income countries.

2) Conduct user research. Semi-structured interviews and open-ended question surveys were done to identify the target group's training needs and priorities.

3) Define targeted learning goals. The above information was key to develop tailored learning goals, which were defined using Bloom's Taxonomy [3].

4) Design assessments. The course evaluation was based on the learning goals. A group work bidding exercise was the core assessment; there were also quizzes and presentations required of participants.

5) Plan learning experiences and instruction. The learning goals and assessment methods guided the development of experiences and knowledge among the participants. In the case of the SPOC pilot, it was crucial to facilitate synchronous interactions to deliver the course content and foster group discussions.



Laura Baquedano

Image: Zoom-live session of the first CWIS SPOC, delivered with the Asian Development Bank Institute.

Conducting the SPOC pilot

The SPOC pilot, *"Winning Bids for CWIS: Principles and Application,"* was delivered twice: once in collaboration with ADB-I in November 2020 and once with ITN-BUET and ENPHO in January 2021. Overall, the course was divided into three blocks with a 24 h workload spread over three weeks. Zoom was used for the course's live sessions, and a Coursera Private Session of Sandec's Sanitation MOOC was the learning platform used to provide access to the materials.

Conclusion

The SPOCs achieved high completion rates, 91.3 % and 70.8 %, respectively. This confirmed the research findings of Ruiz-Palermo *et al.* [2]. The online training course tailored to a particular audience and delivered to a small group with frequent interactive elements received consistent positive feedback from the participants. •

References

[1] Statista, Size of the global e-learning market in 2019 and 2026, by segment, Statist [webpage] (2019) https://www.statista.com/statistics/1130331/e-learning-market-size-segment-worldwide/ (accesed 27 April 2021).

[2] Ruiz-Palmero J. *et al.*, 'The implementation of Small Private Online Courses (SPOC) as a new approach to education', *Int J Educ Technol High Educ, 17/27*, (2020).

[3] Armstrong P., Bloom's Taxonomy, Vanderbilt University Center for Teaching [webpage] (2010) https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/ (accessed 27 April 2021).

[1] Eawag/Sandec, Switzerland

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Synergies Among Global MOOCs and Contextualised Learning Initiatives

Since the outbreak of the pandemic, WASH institutes enormously expanded their digital learning content. Our newly launched initiative "WASH digital learning collaboration" aims at creating synergies between our MOOC-series and the contextualised learning initiatives of our partners. Fabian Suter[1]

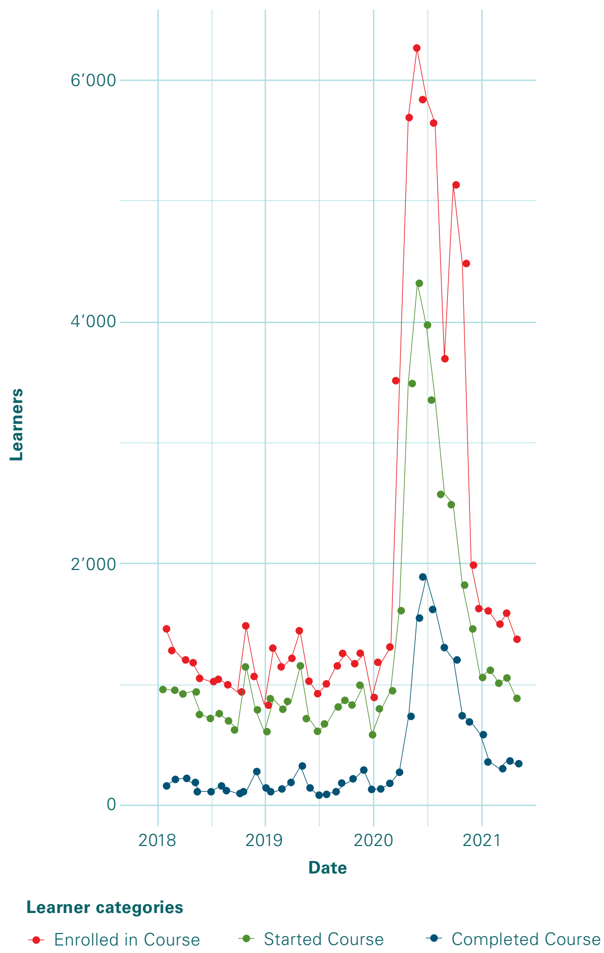


Figure: Newly enrolled learners in the courses of the MOOC-series "Sanitation, Water and Solid Waste for Development" between January 2018 and May 2021.

Introduction

The COVID-19 pandemic has amplified global educational challenges and the WASH sector has responded by developing much new digital learning content. The practical experiences gained over the past months will surely influence the design of the post-pandemic educational systems. They have also raised the expectation that the increasing number of digital learning initiatives produced by WASH institutions in Asia, Latin America and Africa will reduce the capacity gap in the sector [1].

MOOCs – an attractive format for the connected world

Since the rise of Massive Open Online Courses (MOOCs) in 2012, over 180 million learners have enrolled in a course. One-third of this audience did so in 2020 [2]. Sandec's WASH-MOOC series, "Sanitation, Water and Solid Waste for Development", also had record high enrolment and completion numbers in 2020 and an average of 127 newly enrolled learners and 30 course completers per day (see Figure). The learners are mainly well-educated, employed people, under 34 years of age, from low- and middle-income countries (LMICs). Many gained access to MOOCs despite the absence of reliable landline infrastructure where they live, thanks to the proliferation of affordable smartphones and mobile data plans. Technological advancements in cellphones and broadband make it possible for learners of all ages and socioeconomic backgrounds to become digitally literate and help to ensure that no one is left behind.

The importance of a diversified educational landscape

Although MOOCs are increasingly produced in LMICs, MOOC production is still mainly in high-income countries. This creates the risk that educational content can be misaligned with local cultures, languages and pedagogies [3] and there is the tendency to embed Western-centric epistemologies [4]. This can be best minimised when local institutions take the lead in developing courses for their learners.

Demand-driven collaboration

Our approach of sharing learning materials, providing planning advice and facilitating hands-on workshops based on demand has allowed Sandec to contribute to many contextualised learning initiatives led by partner institutions. With the newly launched project, "WASH digital learning collaboration", Sandec will expand these services by providing financial contributions to three selected projects per year. Their development will be documented with the aim at generating new practical insights about the design, production and evaluation of digital learning initiatives and to foster mutual learning exchange amongst partner institutions. Interested partners can find more information at: www.sandec.ch/elearning_collaboration. •

References

[1] Suter F. et al., Delivering WASH education at scale: evidence from a global MOOC series, *Environment and Urbanization, 33/1*, (2021), 99–116.

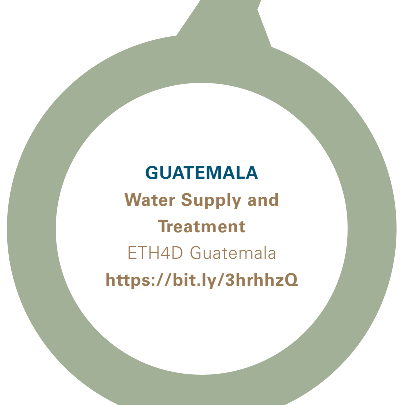
[2] Class Central, The Second Year of The MOOC: A Review of MOOC Stats and Trends in 2020, https://www.classcentral.com/report/the-second-year-of-the-mooc/

[3] Zhang K. et al., MOOCs and open education in the global South: successes and challenges in K. Zhang, et al., (eds.), *MOOCs and Open Education* in the Global South: Challenges, Successes and Opportunities, (New York: Taylor & Francis, 2020), 1–14.

[4] Taskeen A., Digital neocolonialism and massive open online courses (MOOCS): colonial pasts and neoliberal futures, *Learning, Media and Technology, 44/3*, (2019), 365–380.

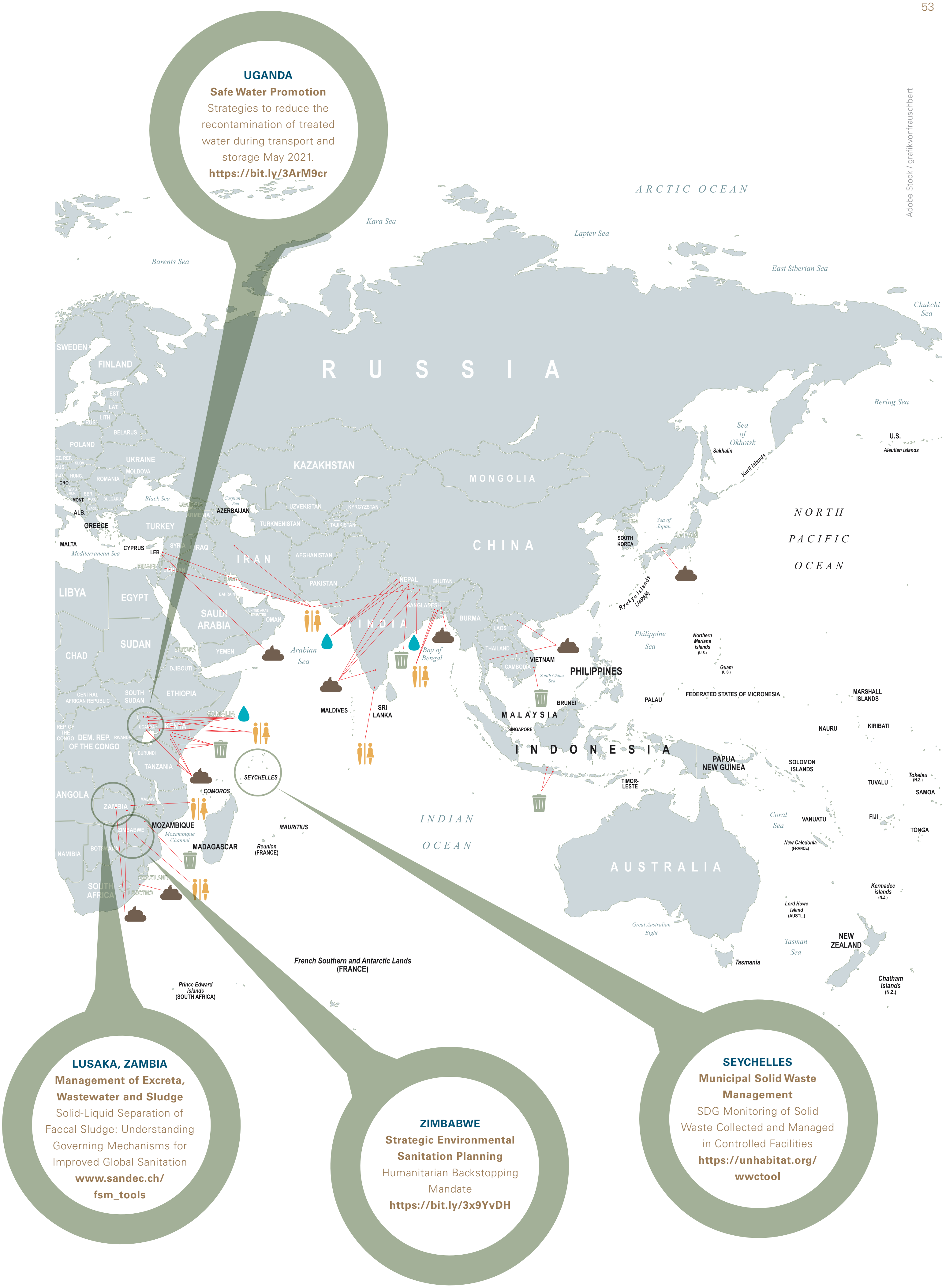
[1] Eawag/Sandec, Switzerland
Further information: www.sandec.ch/e-learning_collaboration
Contact: fabian.suter@eawag.ch

Global Research Projects and Partners Map



Legend:

- Strategic Environmental Sanitation Planning
- Municipal Solid Waste Management
- Management of Excreta, Wastewater and Sludge
- Water Supply and Treatment & Safe Water Promotion


UGANDA
Safe Water Promotion
Strategies to reduce the recontamination of treated water during transport and storage May 2021.
https://bit.ly/3ArM9cr
LUSAKA, ZAMBIA
Management of Excreta, Wastewater and Sludge
Solid-Liquid Separation of Faecal Sludge: Understanding Governing Mechanisms for Improved Global Sanitation
www.sandec.ch/fsm_tools
ZIMBABWE
Strategic Environmental Sanitation Planning
Humanitarian Backstopping Mandate
https://bit.ly/3x9YvDH
SEYCHELLES
Municipal Solid Waste Management
SDG Monitoring of Solid Waste Collected and Managed in Controlled Facilities
https://unhabitat.org/wwctool
ARCTIC OCEAN
Kara Sea
Laptev Sea
Barents Sea
East Siberian Sea
Chukchi Sea
Bering Sea
R U S S I A
SWEDEN
FINLAND
KAZAKHSTAN
MONGOLIA
CHINA
IRAN
INDIA
NEPAL
BHUTAN
BANGLADESH
BURMA
PAKISTAN
AFGHANISTAN
UZBEKISTAN
TURKMENISTAN
KYRGYZSTAN
TAJIKISTAN
AZERBAIJAN
TURKEY
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UKRAINE
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LIBYA
EGYPT
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CHAD
SOUTH SUDAN
ETHIOPIA
DJIBOUTI
SOMALIA
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ANGOLA
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MOZAMBIQUE
MADAGASCAR
NAMIBIA
SOUTH AFRICA
SEYCHELLES
COMOROS
MAURITIUS
Reunion (FRANCE)
SAUDI ARABIA
YEMEN
OMAN
Arabian Sea
Bay of Bengal
MALDIVES
SRI LANKA
THAILAND
LAOS
VIETNAM
CAMBODIA
PHILIPPINES
MALAYSIA
BRUNEI
SINGAPORE
INDONESIA
TIMOR-LESTE
PAPUA NEW GUINEA
PALAU
FEDERATED STATES OF MICRONESIA
MARSHALL ISLANDS
KIRIBATI
NAURU
SOLOMON ISLANDS
TUVALU
SAMOA
VANUATU
FIJI
TONGA
SOUTH KOREA
JAPAN
Sea of Okhotsk
Sakhalin
Kuril Islands
Sea of Japan
Ryukyu islands (JAPAN)
Philippine Sea
Northern Mariana islands (U.S.)
Guam (U.S.)
U.S.
Aleutian islands
NORTH PACIFIC OCEAN
INDIAN OCEAN
AUSTRALIA
Coral Sea
Tasman Sea
Great Australian Bight
Tasmania
NEW ZEALAND
New Caledonia (FRANCE)
Lord Howe Island (AUSTL.)
Kermadec islands (N.Z.)
Chatham islands (N.Z.)
Tokelau (N.Z.)
French Southern and Antarctic Lands (FRANCE)
Prince Edward islands (SOUTH AFRICA)
Black Sea
Mediterranean Sea
Adobe Stock / grafikvonfrauschbert

Hung Nguyen-Viet, Co-leader of the ILRI Animal and Human Health Program

REUTERS/Aly Song

Hung Nguyen-Viet and Peter Daszak, members of the World Health Organisation (WHO) team tasked with investigating the origins of the coronavirus disease (COVID-19) in Wuhan, Hubei Province, China, February 6, 2021.

Hung Nguyen-Viet is from Vietnam and is the Co-leader of the Animal and Human Health Program at the International Livestock Research Institute (ILRI).

How did you find out about Eawag-Sandec?

I learned about Eawag-Sandec after completing a PhD in Environmental and Life Sciences at the University of Franche-Comté in Besancon, France. I applied for a joint postdoc of the Swiss Tropical and Public Health Institute (TPH) and Eawag-Sandec to work on the impact of water and sanitation on people's health, and worked in Thailand, Vietnam, Côte d'Ivoire and Cameroon. The second part of the postdoc was with the NCCR North-South programme (National Center of Competence for Research North-South) and I was a Co-project leader with Dr. Ives Kengné.

How were Eawag-Sandec and Swiss TPH beneficial to your career?

I very much like the Swiss concept of partnership and capacity building for the Global South that was the mission of the NCCR North-South programme at that time. It was a very supportive environment and helped many young and early career people to grow in their research careers. There were several hundred PhD students and many moved to the South to develop research centres. In Vietnam, I co-founded and led the Center for Public Health and Ecosystem Research at the Hanoi University of Public Health (CENPHER).

What are you presently doing?

I am the Co-leader of the Animal and Human Health Program at ILRI and have recently moved to Nairobi, Kenya. I work on my personal research interests, which deal with zoonotic diseases, diseases that jump from animals to humans, and also oversee work in the area of food safety in developing countries, using a One-Health approach. In addition, I supervise different research teams, including those dealing with anti-microbial resistance, food safety, zoonoses, herd health management and vaccine development.

What was your work in Wuhan?

I was part of the WHO expert group that went to study the origin of the COVID-19 virus in Wuhan, China. The objective was to work with Chinese colleagues and research the origins of SARS-CoV-2. The report that was published calls for continuing the research on how the virus jumped from animals to humans. Our trip was highly politicised and received much media attention.

How has the Coronavirus outbreak affected your work?

Our work in general has been impacted by this pandemic because most field work and travel cannot be done as planned. Field work has been constrained by the conditions of COVID-19 in many countries. •

Contact: H.Nguyen@cgiar.org

Measuring SDG 11.6.1 and Plastic Pollution

Gathering data is a critical step towards improving solid waste management. It is the basis of all informed decision-making, developing strategic plans, and for measuring achievements towards the Sustainable Development Goals. SDG 11 seeks to make cities and human settlements inclusive, safe, resilient and sustainable. One of the indicators to monitor progress towards this goal is SDG 11.6.1, which looks at the proportion of municipal solid waste collected and managed in controlled facilities out of the total municipal solid waste generated by the city. The methods and processes to measure SDG 11.6.1 have recently been documented and published as the Waste Wise Cities Tool, under the leadership of UN-Habitat with contributions from Eawag Sandec and other partners. You can download the Waste Wise Cities Tool at:
https://unhabitat.org/sites/default/files/2021/02/Waste%20wise%20cities%20tool%20-%20EN%203.pdf

Sandec Supports Humanitarian WASH

Sandec will provide capacity development and advisory support to the Swiss Humanitarian Aid (SDC-HA) from 2021 – 2025. The aim is to strengthen Switzerland's humanitarian response on four thematic areas of WASH and solid waste management in humanitarian settings: (i) emergency sanitation, (ii) faecal sludge management, (iii) solid waste management, and (iv) behaviour change. In addition, Sandec will provide expertise and capacity development for WASH and solid waste management interventions to the Technical Support Section of UNHCR – the UN Refugee Agency – for one year. This support is coordinated by the Strategic Environmental Sanitation Planning group. Learn more about SESP's work on WASH in emergencies at:
https://www.eawag.ch/en/department/sandec/projects/sesp/water-sanitation-and-hygiene-in-emergencies/

IFRC

New Water Supply and Treatment MOOC

The water team will launch a new Massive Open Online Course (MOOC) in 2022 on water supply and treatment. The new Water MOOC is being developed with the Digital Learning team and covers topics on water supply planning, treatment technologies, monitoring approaches and social considerations. This MOOC will replace the previous one on household water treatment and safe storage, which has enrolled more than 32'000 learners to date. You can visit the Sandec MOOC series "Sanitation, Water and Solid Waste for Development" at:
www.eawag.ch/mooc

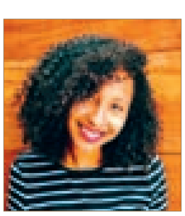
Michael Vogel

The Sandec Team per Zoom

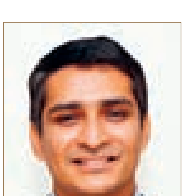
From left to right – Top row: Chris Zurbrügg, Caterina Dalla Torre, Christoph Lüthi, Juliano Silva, Dorian Tori Robinson, Akanksha Jain
2nd row: Fabian Suter, Paul Donahue, Linda Strande, Lukas Dösegger, George Wainaina, Michael Vogel
3rd row: Barbara Jeanne Ward, Sara Marks, Julian Fritzsche, Regula Meierhofer, Nienke Andriessen, Ariane Schertenleib
4th row: Vasco Schelbert, Daniela Seitz, Abishek Narayan, Cyril Willimann, Stanley Sam, Dorothee Spuhler
5th row: Benjamin Ambuehl, Kukka Ilmanen, Sital Uprety, Christopher Friedrich, Laura Baquedano, Dani Peguero
Missing in photo: Bram Dortmans, Julia Egger, Jasmine Segginger, Adeline Mertenat

New Faces at Sandec

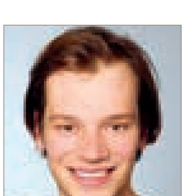
Anik Dutta completed a Bachelor's in Civil Engineering before working in the WASH sector for six years, designing and planning wastewater and faecal sludge management in India, Bhutan and Bangladesh. He finished his MSc at IHE-Delft Institute for Water Education in 2020 and has started working in the Management of Excreta, Wastewater and Sludge group on the technical backstopping mandate of sanitation-related technologies in humanitarian settings for Swiss Humanitarian Aid.



Daniela (Dani) Peguero is a doctoral candidate in the Municipal Solid Waste Management Group and the Sustainable Food Processing Laboratory at ETH Zurich. Her research focuses on determining the best practices for upscaling Black Soldier Fly Larvae (BSFL) production on different types of organic waste materials by investigating key aspects to improve their development. Her research is funded by the European Union Horizon 2020 SUStainable INsectCHAIN (SUSINCHAIN).



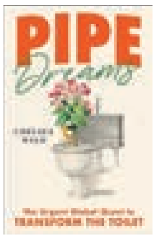
Sital Uprety is a 2020 Eawag Postdoctoral Fellow in the Water Supply and Treatment group. He is leading a research project to identify the effectiveness of the Total Sanitation (TS) campaign in flood-prone regions of Nepal, partnering with Kathmandu University (KU) and Oxfam Nepal. In addition, he is also leading an effort in producing a high-level policy brief on the sanitation situation in the pan-European region for the World Health Organization (WHO).



Michael Vogel completed his MSc in Environmental Engineering at ETH Zurich, focusing on urban water management. After an internship with the Water Supply and Treatment group in 2018, he has started working in the Management of Excreta, Wastewater and Sludge group as the Project Manager on blackwater in the Water Hub at NEST. He will work on upscaling current research on faecal sludge dewatering and treatment and collaborations with companies to test their research.

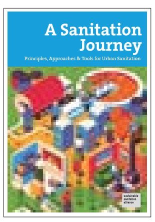
On the Bookshelf

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.



Pipe Dreams: The Urgent Global Quest to Transform the Toilet
A fascinating look at the centrepiece of our bathrooms, this book tells the tale of the scientists, engineers, philanthropists, entrepreneurs, and activists worldwide who are focusing their formidable skills on making toilets accessible and healthier for all.

By: C. Wald, Simon & Schuster, 2021. 304 pages. ISBN: 9781982116217



Strategic Environmental Sanitation Planning

A Sanitation Journey – Principles Approaches & Tools for Urban Sanitation
This book describes the paradigm shifts in the discourse and theories about urban sanitation, the history of how urban sanitation developed in the Global South and its current status and future direction.

By: R. Schertenleib et al., SuSanA, GIZ, Eawag, 2021. 80 pages. ISBN: 9783906484747
It can be downloaded for free at: https://bit.ly/36SeScD

Water Supply and Treatment

Self Supply: Filling the gaps in public water supply provision
Highlighting the magnitude of the contribution of self-supply to urban and rural water provision worldwide, this book focuses on Sub-Saharan Africa and explains how self-supply can fill gaps in public water provision, especially among low-density rural populations.

By: S. Sutton and J. Butterworth, Practical Action Publishing, 2021. 362 pages. ISBN: 9781788530439

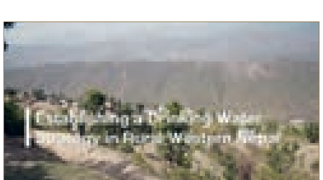
Management of Excreta, Wastewater and Sludge

Guide to Sanitation Resource Recovery Products & Technologies – A supplement to the Compendium of Sanitation Systems and Technologies
The Guide gives an overview of resource recovery from sanitation. It aims to support and enable decision-making for increased resource recovery by providing information on key decision criteria for a range of products and treatment technologies.

By: J. McConville et al., Swedish University of Agricultural Sciences 2020. 148 pages.
It can be downloaded for free at: https://bit.ly/3eHnKGw

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.



Establishing a Drinking Water Strategy in Rural Western Nepal
The REACH project used a community-based, participatory approach to establish an effective and sustainable water safety strategy for rural communities in Mid-Western Nepal. The video shows how this systems approach worked successfully at providing clean drinking water. It was produced to tell the story of the REACH project, to give an understanding of the region and insight into the culture, and to increase the engagement of audiences with the science behind water research and evidence-based decision-making.

Produced by: Eawag – Sandec
Filmed and edited by: Paul Donahue. 2021. 8:18.
It can be seen at: https://bit.ly/3f5dXKo

Publication Information

Sandec
Department of Sanitation, Water and Solid Waste for Development

Publisher: Eawag, 8600 Dübendorf, Switzerland, Phone: +41 (0)58 765 52 86
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Editors: Paul Donahue and Christoph Lüthi, Eawag

Content Production Manager: Simone Kral, Eawag

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

Layout and figures: Katja Schubert, grafikvonfrauschubert feat. Eawag

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

Printer: Effingermedien, Kleindöttingen, Switzerland

Circulation: 3’500 copies printed on BalancePure BA white, 100% Recycling-Phase

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ISSN 1420-5572

Eawag: Swiss Federal Institute of Aquatic Science and Technology

Cover Photo: WASH User group members filling the communal hand washing device with water so that community members in a Rohingya camp in Cox’s Bazar, Bangladesh, can easily access water and wash their hands after using the latrine.

Cover Photo by Ram Kirsno Dey.

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