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Sandec Department of Sanitation, Water and Solid Waste for Development

sandec news

Content

Sandec's Senegalese PhDs are key stakeholders in the non-sewered sanitation sector in West Africa.

2022 marks 30 years of "Sandec"! Before 1992, Sandec was known as the "International Research Centre for Waste Disposal". The name change to "Sandec: Water and Sanitation for Developing Countries" 30 years ago reflected its new orientation as an international research and capacity development centre in the Water, Sanitation and Solid Waste Management space, which was initiated in the early 1980s. Since 1992, Sandec has grown from a small group of seven dedicated researchers to the 20+ researchers, working in the five research groups that we know today. In 2015, we changed the name to "Sanitation, Water and Solid Waste for Development", to encompass our solid waste research and be more in line with contemporary development discourse.

2022 also marks the year that international travel and conferences came back – after two years of pandemic-induced closures and lockdowns. In late March, we took part at the World Water Forum #9 in Dakar, Senegal (WWF), the first post-pandemic international water event that went live. It took place with 8,000 participants from 21–25 March 2022. We participated in two Forum panels and did several presentations at the Swiss national pavilion.

One WWF highlight was reconnecting with our Senegalese PhD alumni who today play an influential role in shaping Senegal's (and the wider region's) non-sewered sanitation space. They are now spearheading the sector, working in academia, utilities and the private sector. The impact of Eawag-Sandec on the West African sanitation sector was highly visible and evident at the Forum, a recognition of our pioneering faecal sludge management research in Dakar. Senegal is now an on-site sanitation model for the whole region, with Senegalese stakeholders providing consulting services to other cities and Sandec alumni involved in providing knowledge in Citywide Inclusive Sanitation and FSM. Notably, Eawag was also the only international organisation without a presence in West Africa that was allowed to exhibit at the WWF Sanitation Village.

We are looking forward to starting a new four-year applied research programme on small town core services (water, sanitation and solid waste management) later this year; it will involve all of our five research groups in a truly integrated and synergistic way. The rationale of this applied research project is to work against the current fragmentation and siloed approach to service provision and foster the benefits of integration. The research will include the environmental, economic, social, technical, and political aspects of water, sanitation and waste management and, thus, accelerate the progress towards their respective SDGs. The main research outcome will be to validate the integrated, inclusive planning for safely managed services approach in small towns of Sub-Saharan Africa.

As always, we look forward to your comments and suggestions!
Best regards –
Christoph Lüthi, Director, Sandec

Photo Dorothee Spuhler, Alsane Seck, Elhadji Sonko, Stanley Sam, Jean Birane, Amadou Gueye, Christoph Lüthi, Sital Uprety, Sara Ubbiali, Christopher Friedrich, Philippe Reymond (left to right).

Photographer unknown.

Municipal Solid Waste Management

Municipal solid waste management is one of the major environmental challenges of urbanisation. Together with local partners, Sandec's MSWM group's research focus is 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 Sorted waste prior to recycling, Dominican Republic.

Photo by Adeline Mertenat.

A Cost Assessment and Modelling Tool for Municipal Solid Waste Management

A large share of budgets in low- and middle-income municipalities is used to manage waste. In collaboration with Helvetas Bolivia, we developed a tool to support practitioners and municipalities to assess and model costs, and evaluate scenarios of improved service delivery and cost efficiency. Dorian Tosi Robinson[1], Adeline Mertenat[1], Carlos García[2], Eddy Lemus[2], Sergio Morales[2], Christian Zurbrügg[1]

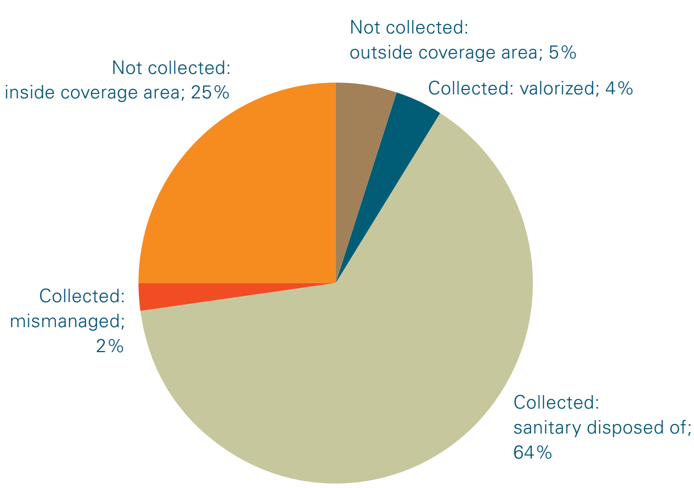

Figure 1: Efficiency assessment: fractions of managed and unmanaged waste from the total waste generated.

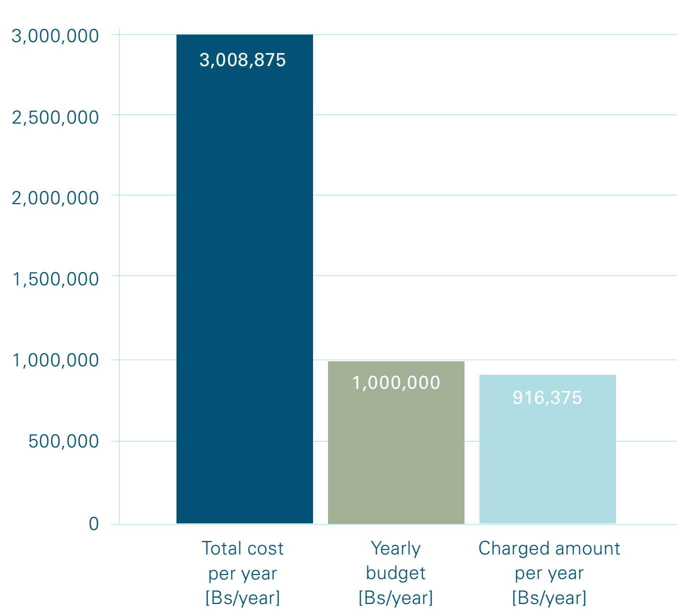

Figure 2: Cost and revenue assessment: yearly costs, budget, and income in Bolivianos (Bs).

Introduction

In low- and middle-income settings, limited financial resources, combined with low cost efficiency is often the cause for limited service delivery. Although a large share of municipal budgets are used for collection, street sweeping and disposal, the service quality generally remains low [1]. Municipalities and service providers often do not monitor, assess and evaluate solid waste management expenditures, nor do they compare this with service performance indicators. Fragmentation of expenditures amongst different administrative and organisational units of municipalities, as well as unaccounted, hidden costs, such as depreciation of infrastructure and equipment or use of land, complicate efforts to obtain a comprehensive overview. To support practitioners and municipalities in this regard, a collaboration with Helvetas Bolivia led to the development of an Excel-based cost assessment and modelling tool based on the work of Coffey and Coad [2]. Adapted to low- and middle-income settings, the tool was validated in three municipalities in Bolivia with 50,000–250,000 inhabitants. The tool guides the user through several steps to assess the situation of waste management in terms of: **1)** efficiency, **2)** costs and revenue, and **3)** provides estimated costs from the modelling of four types of collection systems.

Methodology

Efficiency assessment – waste management data input

Basic data is required to assess the current waste management situation. As a first step, the users have to gather and provide data, such as amounts of waste managed, characterisation of waste, population, length of roads, area of public spaces, and existing budget. With the input data, the tool then calculates efficiency indicators, such as the percentage of solid waste that is adequately managed or mismanaged.

Cost and revenue assessment

To assess the real costs of waste management, the tool proposes a structuring of the costs into four main categories: service provision, administration, planning and control, and education and communication. For each of these categories, the main cost line items are: personnel, equipment, infrastructure and operation & maintenance, comprising annually depreciated capital expenditures (CAPEX) and yearly operational expenditures (OPEX). The tool guides the user to identify all the activities – an example of the typical budget line is provided – and to enter the expenditures. In a second step, the user can enter existing revenue streams from fees, tariffs or earmarked taxes. This allows for the comparison of the costs with the income and determines the cost recovery rate. Based on the activity-based costing approach, the tool also allows for comparisons with other cities' costs at a national or international level.

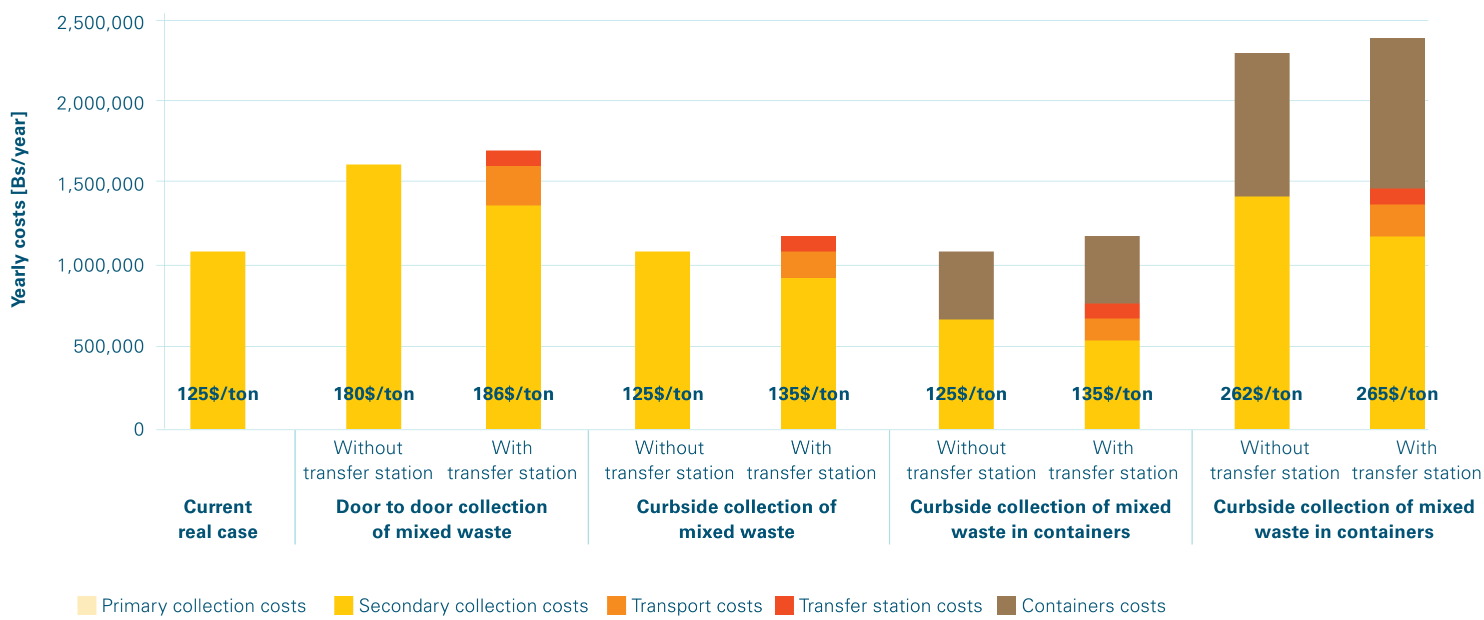

Figure 3: Cost modelling: yearly costs of collection and transport of solid waste for the current real case and for modelled scenarios in Bolivianos (Bs).

Cost modelling

The cost modelling tool provides an estimation of the costs for several collection systems: door to door, curbside, containers, and separate collection of source segregated waste from containers. In addition to the previously mentioned basic data inputs, users enter a few parameters to adapt the modelling to the local context. Given this information, the tool then calculates the estimated costs of the four collection systems, and, for each of them, assesses the costs with or without the use of a transfer station. The results can then be used to understand how the costs compare depending on the collection system.

Results

Applied to a real case study in Bolivia, the results shown here were simplified, but the main conclusions remain the same. Figure 1 shows the percentages of waste managed in a controlled manner (68%) compared to mismanaged waste (32%). This result contrasts with the 95% service coverage that was reported by the waste officers. The costs, revenue and budget of the service as presented in Figure 2 show that the city charges the service users most of the budgeted amount (92%); however, the real cost shows to be about three times higher than the budgeted amount. This quite common situation leads to unsustainable financial solid waste management (SWM) systems. Lastly, modelling of the collection costs, as shown in Figure 3, indicates that the use of a transfer station does not seem necessary and may even increase the costs of collection. Door to door collection is the most expensive approach to collect mixed waste, while curbside collection and collection with containers have similar costs. The most expensive collection method is separate collection of segregated waste by multiple containers. However, it is interesting to note that certain waste management costs would decrease (less disposal costs), while other new costs arise (recyclables or organic treatment). Although not shown in this article, the tool estimates the total costs of waste management, not only the costs of collection.

Conclusion

Having a good understanding of the costs of municipal SWM can support decision-making to improve cost efficiency and subsequently improve service delivery and coverage. Making the effort of gathering basic information on the SWM system can reveal deficiencies that could then be improved. The cost modelling tool can support practitioners and municipalities in this effort. The tool allows for better understanding of the financial aspects of SWM, the comparison of context specific costs, the identification of weaknesses and inefficiencies that could be improved, and supports the analysis of options towards more efficient collection systems. •

References

[1] Kaza S. et al., *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050*, (World Bank, 2018).
[2] Coffey M., Coad A., *Collection of Municipal Solid Waste in Developing Countries*, (UN-Habitat, 2010).

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Operating a Black Soldier Fly Nursery for Optimal Control and Efficiency

The importance of the black soldier fly (BSF) nursery is often underestimated because stable egg and neonate production determine the reliable and smooth operation of a BSF waste processing facility. A dark-cage/love-cage approach permits control over the BSF life cycle. Stefan Diener[1], Christian Zurbrügg[1]

Introduction

One key aspect of a BSF waste processing facility is ensuring a constant and reliable production of healthy neonates in the nursery. Consistency of larvae production enables the facility to fulfil its daily expected amount of waste processed and BSF products produced. Furthermore, consistency and efficiency of neonate production allows for optimal use of infrastructure, equipment and labour.

But, how can consistency and efficiency in neonate production be achieved? One prerequisite is to have knowledge and control over each of the individual steps in the BSF nursery system. Knowledge of the preferences and needs of the pupae, flies, eggs and neonates and how best to integrate this into daily operations at the facility is key towards fostering successful eclosion, fly mating, reliable oviposition and prosperous hatching. Control means ensuring optimal environmental conditions tailored to the needs of the animals and measuring its performance as it passes through its lifecycle stages. However, control also means being in the driver's seat with regard to how many flies develop and reproduce, when and where. It is achieved through the selection of suitable infrastructure and equipment, as well as maintaining a clearly defined operations schedule and hygiene standards. Maintaining hygienic conditions helps to prevent diseases and parasites that would impact production and benefits the staff, making a BSF facility a pleasant place to work.

Our experience shows a dark-cage/love-cage technology solution, harmonised with respective operating procedures, achieves stable and reliable outputs (Figure 1). With this infrastructure, the productivity of a BSF nursery can be significantly improved (Table).

Sirajuddin Kurniawan

Photo: Flies migrate from the dark-cage (left) to the love-cage, attracted by a light source.

The dark-cage/love-cage nursery approach

Many BSF facilities around the world operate nurseries with walk-in cages. These cages host a population of adult flies and are continuously supplied with pupae crates. In these cages, the life cycle steps of eclosure, mating and ovipostion is left to regulate on its own, while eggs are regularly extracted from the cage. Our suggestion is to operate the nursery with dark-cages for pupation and love-cages for mating and oviposition in batches of similarly aged insects. A defined quantity of pupae is placed in boxes with moist substrate in shaded nets, the "dark-cages". The males usually eclose a few days before the females and after about four weeks, almost all the flies have emerged. During this time, these dark-cages form a repository for adult flies.

Due to the lack of light in the dark-cages, the emerged flies remain inactive. Connecting a love-cage to the dark-cage with a tunnel and using a bright light source as an attractant will induce the flies to move from the dark- to the love-cage (Photo). Love-cages are mobile and can be sequentially connected for a certain duration to an array of dark-cages. This sequential operation ensures that: i) the sex ratio in the love-cage is well balanced and ii) there are a well-defined and sufficient number of adults of very similar age in the love-cage. This fosters the synchronisation of mating and egg-laying as a high density of flies in the exact same period of life are together inside the love-cage. The egg-laying peak can, thus, be clearly determined and all the eggs harvested after a short and defined time (4 days). After egg harvesting, the love cage is dismantled and washed. By separating a pupation and eclosure area from a mating area, key performance indicators (KPIs), such as eclosion rate, mating rate or eggs/female, can be more easily monitored. In addition, for the benefit of the staff, no direct contact between humans and flies is required and the cages can be washed at regular intervals, which prevents the spread of diseases.

Application in practice and results

The effect of changing from a walk-in fly space to a dark-cage/love-cage system is shown in Figure 2. Five rooms (3.2 m x 5.3 m = 17 m^2) were operated as a nursery from December to March. All rooms underwent regular cleaning and used artificial light. However, from January onwards, room 2 was run with four love cages (75 cm x 75 cm x 150 cm = 0.84 m^3). In the beginning, unsuitable lamps to enhance mating were used in room 2, but these were replaced in mid-February with the same type used in the other four rooms.
Results show that by switching to a love-cage system, the production of neonates could be increased by a factor of 43. In addition, a clear increase in staff satisfaction could be observed mainly because they did not have to be in direct contact with the flies while working in the fly rooms.

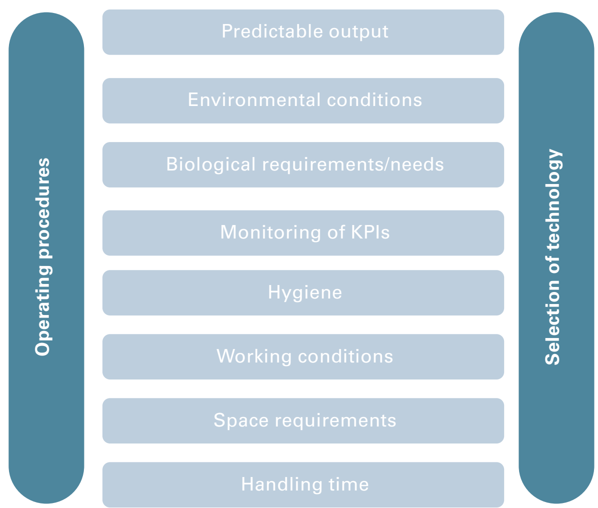

Figure 1: Mode of operation and technology selection influence the most important factors of a BSF nursery.

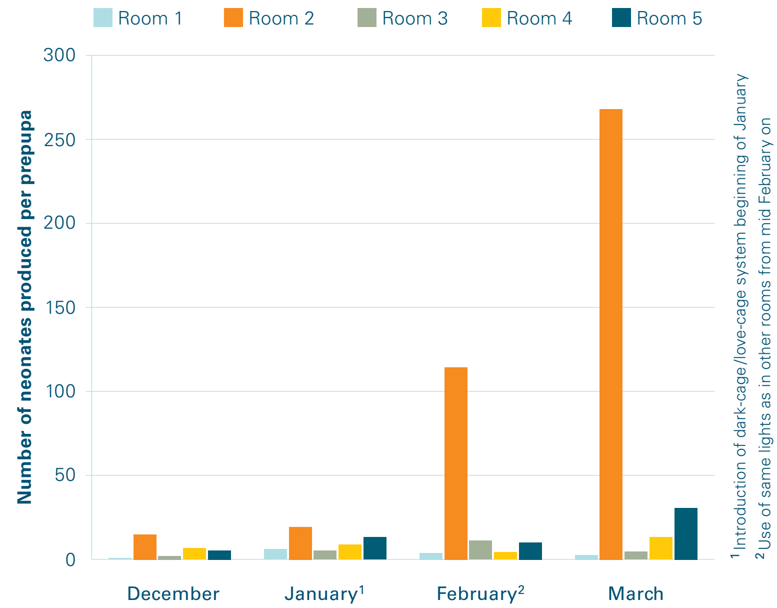

Figure 2: Change of neonate production when changing from a walk-in cage to the dark-cage/love-cage system in a black soldier fly nursery.

Conclusion

This example of the interaction between technology and operation in BSF management shows how control and performance can be increased, working conditions improved and, therefore, financial viability also increased. Research on technology and operation interaction can potentially be applied to all BSF system components, allowing for many different solutions. As long as the operator follows the principle of retaining control and having an overview of the production and its fluctuations, there are no limits to the imagination when it comes to the design and operation of BSF production systems. •

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	Trait	Factor "Technology"	Factor "Operation"
Predictable output	High and constant emergence ratio of adult flies	Suitable pupation material (texture and moisture) and stock density in pupation crates	Pupation crates are filled with an appropriate number of prepupae over a defined number of days
Biological requirements / needs	Lekking behaviour of males	Small love-cages provide a good surface / volume ratio and allow for resting / landing areas of adult flies	
	Activation by light	In the darkened cages, the newly emerged flies remain inactive until they are lured into the love cages by light where they immediately begin to mate	Mating takes place synchronously, which results in a short but intense peak of egg-laying activity
	Even sex ratio in love cages		Love-cages are stocked from several sources (dark-cages) with fresh, same-aged flies resulting in a balanced sex ratio
Monitoring of KPIs (key performance Indicators)	Eggs per fly	The number of flies (weight or fly counter), together with the egg yield from this particular cage calculates the eggs / fly ratio	Operating the love-cages in batches allows for the monitoring of single cages and can, thus determine the egg production in each cage
	Eclosion rate	Eclosion rate can be determined by counting empty pupa shells after dismantling of the dark cage	Dark-cages that have delivered the majority of their expected flies (> 95%) can be dismantled
Hygiene	Bacterial and fugal growth	Single cages can easily be washed entirely	Batch operated cages and containers allow for frequent thorough cleaning of equipment
	Contamination with pathogens and parasites	Personnel has no direct contact with the flies and the risk of contamination is, therefore, minimised	
Working conditions	Disgusting and unpleasant working conditions	No direct contact between flies and workers by non-walk-in love and dark cages. The work can be carried out undisturbed, without haste	
Space requirements	Egg production per area		Operation scheme for pupation containers, dark- and love-cage management and egg harvesting schedule reduces the standing time of each component, thus, improving egg production per area or time
Handling time	Egg production per time		A structured work plan designed for the specific tasks to be carried out can optimise workflows and reduce walking distances

Table: Interplay between technology selection and operational mode to optimise neonate production in the dark cage/love cage system.

Assessing BSFL Bioconversion Efficiency on Ammonia Pretreated Cow Manure

How can Black Soldier Fly Larvae efficiently transform high fibre substrates, such as cow manure? This study looked at improving larvae rearing on fibrous agri-food wastes and by-products through pretreatment with aqueous ammonia.

Daniela A. Peguero[1,2], Andrea Endara[2], Moritz Gold[2], Alexander Mathys[2], Christian Zurbrügg[1]

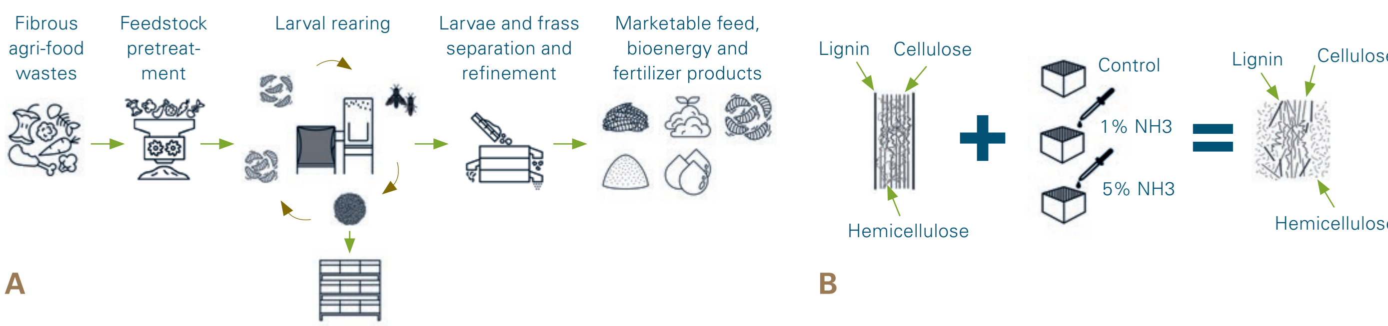

Figure: A) Schematic of the BSFL process, where a pretreatment step would occur prior to larval rearing for the production of insect-based feed, bioenergy, and fertiliser from agri-food wastes and byproducts. **B)** Schematic of the potential structural changes on lignin, cellulose and hemicellulose after ammonia pretreatment at a dose of 1 and 5%. Adapted from [1].

Introduction

Black Soldier Fly Larvae (BSFL) transform agri-food wastes and by-products into high quality nutrients for pet food, aquaculture, and animal feed, and leave behind a residue that can serve as a nutrient-rich soil conditioner. However, one current drawback is their low conversion efficiency of these wastes and byproducts due to their high consistency of difficult to digest fibres, such as hemicellulose and lignin. For example, cow manure can have high fibre content, with 12–21% hemicellulose and 6–14% lignin (based on dry mass), making it difficult for larval or microbial decomposition [1]. A previous study reported that larvae grown on cow manure resulted in a low bioconversion rate of 4% compared to 15% when grown on nutritious food waste (based on dry mass) [2]. The conversion efficiency of cow manure could potentially be improved by breaking down some fibres, using an ammonia pretreatment prior to larval rearing (as shown in the Figure), to facilitate larval or microbial degradation. Ammonia pretreatments have been widely used for other bioconversion technologies, such as anaerobic digestion, to improve the conversion of fibrous agri-food wastes and byproducts into biogas [1]. Therefore, this study evaluated if ammonia pretreatment can improve cow manure bioconversion.

Experimental set-up

There were two experiments in this study. The first assessed the optimal dose of ammonia for fibre degradation. Aqueous ammonia 25% was added at 1% and 5% to cow manure, mixed thoroughly, covered, and stored for three days at ambient temperature. Subsequently, neutral and acid detergent fibre were analysed to estimate the hemicellulose, and cellulose and lignin fractions. The second experiment assessed whether an ammonia pretreatment of 5% for three days could increase larval rearing performance. Larval feeding experiments took place in a climate chamber for nine days at 28°C and 44–70% relative humidity, with a larval density of 2.5 larvae/cm^2. Raw cow manure (without added ammonia) and a control (without added ammonia but stored for the same duration as ammonia pretreatment) were used for the feeding trial. Typical larval rearing performance metrics, such as larval weight gain, survival rate, and bioconversion rate, were determined.

Conclusion

Feeding trial results demonstrated that ammonia pretreatment did not influence the larval survival rate, which was >90% on all treatments (raw cow manure, control and ammonia pretreated). However, contrary to our expectations, ammonia pretreatment decreased larval rearing performance. For example, the mean bioconversion rate with the ammonia pretreated cow manure was 2% (dry mass), 58% less than the mean bioconversion rate of the control. The mean bioconversion rate of the control was similar to the 4% bioconversion rate reported in a previous study [2]. Surprisingly, the mean bioconversion rate on the control was 24% higher compared to the raw cow manure. This could be attributed to microbial decomposition of the fibres occurring during the three-day storage time. Average larval weight gain on ammonia pretreated cow manure followed a similar trend to the bioconversion rate. Further investigations are being conducted to evaluate the potential factors that led to low BSFL performance on ammonia pretreated cow manure. •

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

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[2] ETH Zurich, D-HEST, Sustainable Food Processing, Switzerland

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South-South Knowledge Exchange for Plastic & Biomedical Waste Management

Why reinvent the wheel when success stories can be shared for replication? This project targets learning among local authorities from India, Nepal and Sri Lanka on identified key solid waste issues. Adeline Mertenat[1], Pia Hollenbach[2], Sudarshan Rajbhandari[3], Jayanthi TA[4], Babu Ambat[4], Damitha Samarakoon[5], René Véron[2], Christian Zurbrügg[1]

Janathakshan

Photo: Video on plastic waste issues in Negombo.

Introduction

The Transformation Accelerating Grant (TAG) project entitled "Participatory Training 4 Sustainable Waste Governance: South-South Knowledge Transfer Program" is a one-year project that started in June 2021, funded by the SNSF Research for Development (r4d) programme[1]. This project grew out of an ongoing R4D project that started in November 2018 focusing on learning from post-crisis municipal solid waste governance initiatives in South Asia[2]. The overarching objective of the TAG project was to transfer and adapt successful waste technologies and governance practices from Kerala, India, to the sociocultural and political contexts in Nepal and Sri Lanka, using co-creation of knowledge, capacity building and local stakeholder involvement. As part of the team, Sandec supported the knowledge exchange by providing technical know-how and assisted coordination of the activities.

The first step of the TAG project was to identify the solid waste issues that local stakeholders in the municipalities of Kirtipur (Nepal) and Negombo (Sri Lanka) perceived as priority problems. Exchange and dialogue facilitated by local country partners found that plastic and biomedical waste management were priority issues. In a second step, videos were produced to describe the current, problematic situation regarding these issues in Nepal and Sri Lanka. Thirdly, the project facilitated an exchange with partners in Kerala (India), where successful systems and technologies had been developed.

Plastic waste management

Both Kirtipur and Negombo municipalities have been facing a steep increase in plastic waste generation in the last decade. Some fractions, such as PET bottles and hard plastics, have value on the market and are, therefore, being collected by (in)formal waste recyclers. However, other plastic waste, such as food wrappers and plastic bags, having little to no value, continue to not be recycled. This burdens waste management and fills up space at landfills, clogs drainage systems and water bodies, and results in air pollution through open burning.

Faced with a similar situation, Kerala implemented the Green Protocol. Now, households are encouraged to drop off low-value plastic at a resource recovery centre and the municipality provides regular collection for specific plastic types. This low-value plastic waste is then used as a binder in bitumen for road construction.

Biomedical waste

Waste from healthcare facilities (HCF) is composed of non-infectious waste (85%), infectious biomedical waste (10%) and chemical and radioactive waste (5%). From a technical perspective, managing infectious biomedical waste is not difficult; yet, it requires an appropriate system to make sure that this fraction is separated from the rest of the waste so that adequate measures of sterilisation and disinfection can be implemented prior to disposal.

Authorities in Kirtipur highlighted the challenge of proper biomedical waste management by HCFs where the financial means for proper onsite treatment and disposal infrastructure are often lacking. In Kerala, by contrast, the concept of a Common Biomedical Waste Treatment Facility (CBWTF) was introduced in 1998 to treat waste from various HCFs with the goal to prevent the proliferation of small treatment facilities that often do not function properly. The Indian Medical Association Goes Eco-Friendly (IMAGE) has operated the CBWTF in Kerala since 2003; it now serves more than 19,000 HCFs. Equipped with incinerators, autoclaves and shredders, the facility treats around 55 tons of biomedical waste per day.

Conclusion

South-South exchange and practical learning were affected significantly by travel restrictions related to the Covid-19 pandemic. This project responded to these constraints by producing videos of the situation, as well as factsheets on successful approaches. With the recent easing of the pandemic, an in-person knowledge transfer workshop is planned to take place in Kerala in mid-2022 with the aim at bringing together solid waste experts and local authority representatives. The workshop will organise field visits to encourage replication and adaptation of good practices from Kerala to Sri Lanka and Nepal. Emphasis will be given to finding ways to break down barriers that hinder the implementation of effective systems, and to enable replication. Video documentation will accompany this process so that the learnings can be widely disseminated. •

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[1] Research for Development (r4d) programme website: http://www.r4d.ch
[2] Visit the project website for more information: https://lifeofwaste.com

Waste Flow Diagram: Identifying Waste Management System Leakages

The Waste Flow Diagram is a rapid assessment methodology developed for mapping and visualising the flows of macro-waste and leakages of plastic waste in a municipal solid waste management system at the city/ municipality level. Christian Zurbrügg[1], Dorian Tosi Robinson[1], representing the WFD project team[2]

Background

Municipal solid waste management (MSWM) is a global challenge, particularly impacting low- and middle-income countries, as recognised by its inclusion in the United Nations Sustainable Development Goals (SDG 11 "Sustainable cities and communities"). Indicator 11.6.1 aims to monitor the *"proportion of municipal solid waste collected and managed in controlled facilities out of total municipal solid waste generated by cities".* Mismanaged waste has severe impacts both on human health and the environment, with one rapidly emerging problem being plastic pollution.

Plastic pollution is a reality that affects all ecosystems of our planet. It causes severe danger to animals, blocks drains and waterways, triggering and worsening floods, degrades landscapes, and is almmost already present everywhere, including the food chain. Currently, only 9% of the total global plastic waste is recycled, while 12% is burned or incinerated. The remaining 79% accumulates on landfill sites or pollutes the natural environment. Oceans are one of the final sinks for some of this plastic as about > 80% of marine litter are believed to derive from land-based sources. For macroplastics, this is largely a result of poor waste management practices and infrastructure. Many efforts are underway to try to reduce plastic pollution entering oceans, including beach clean-ups, bans on single-use plastics, and the continued development of reuse and recycling options. However, for countries to adequately meet the SDG targets, an important step is to understand the systems and practices in their cities, particularly those that could lead to plastic being released into the environment so that government authorities can identify the high priority areas for intervention.

Methodology

The Waste Flow Diagram (WFD) tool was developed in collaboration between GIZ, the University of Leeds, Eawag and Wasteaware with co-financing from the German Federal Ministry for Economic Cooperation and Development, to provide a rapid assessment approach for mapping the flows of macro-waste in a municipal solid waste management system at the city or municipality level. It includes quantifying the sources and fate of any plastic pollution and providing a standardised visualisation of the results. The WFD tool is harmonised with the SDG indicator 11.6.1, and seamlessly integrates with the UN-Habitat Waste Wise Cities Tool (WaCT) [1], which is the assessment methodology underpinning SDG 11.6.1. Whilst there are other ongoing initiatives on assessing plastic pollution with a similar scope, such as the ISWA Plastic Pollution Calculator, the aim of the WFD is to give a first-level approximation. The detail and accuracy of the analysis is traded for a more rapid assessment with fewer data requirements.

The WFD tool estimates the plastic leakage throughout the entire MSWM stages based on leakage potential levels, which are selected by the user, following an observational assessment in terms of leakage influencers (Table). The total plastic leakage from the MSWM system is calculated as the sum of the plastic leakages from each MSWM stage. The WFD tool estimates this by multiplying the leakage percentages by the total amount of plastic flowing through the system at each specific MSWM stage. Combined leakage percentages are calculated based on the interdependency of leakage factors, as illustrated in Figure 1,using the decision tree for the transport stage.

Uncollected plastic waste and plastic leakage is quantified together as unmanaged plastic waste. Fates then represent the locations where this unmanaged plastic waste is retained (sinks). The WFD considers four default fates: burnt, disposed on land, in storm drains, and in water systems; with the latter being the fate of interest to marine litter monitoring.

The WFD tool allows for visualisation of outcomes and results in tabular form for both MSW and plastic waste, represented both in tonnes per year and as percentages, for all waste flows throughout the MSWM system. It visualises waste flows in the area of focus (citywide, regional, etc.), using the system map or creating a standardised Sankey diagram (Figure 2). The tool also allows for the generation of up to three scenarios to assist in planning interventions and visualising the outcomes from those interventions.

Waste management stage	Leakage influencer
Collection services	collection containers, loading method, primary transportation, multiple handling, transfer
Informal value-chain collection	recyclables extraction, transportation
Formal sorting	plastic reject rate, disposal of rejects
Informal sorting	plastic reject rate, disposal of rejects
Transportation	capacity vs load, waste containment, vehicle covering
Disposal facilities	environmental hazards, exposure to weather, waste handling, coverage, burning, fencing
Storm drains entering waterways	frequency of rainfall/storm events, drain clean-up

Table: Leakage influencers form different stages in the waste management system.

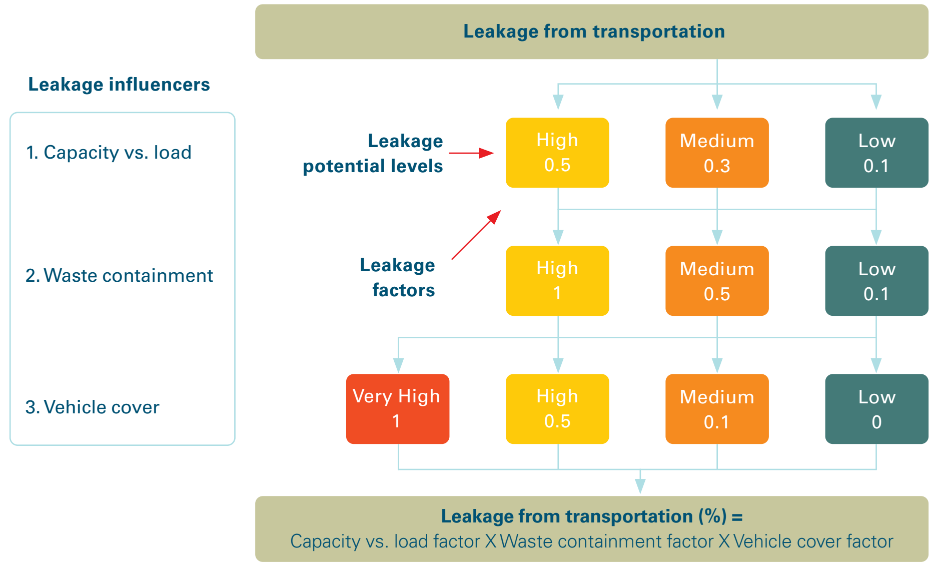

Figure 1: Decision tree and combined leakage calculation for transportation.

Current developments

Since the launch of the WFD in September 2020, the tool has been applied in more than 100 cities worldwide, in locations with markedly different waste management practices, and across a wide diversity of social and cultural contexts. The WFD assessments have been implemented in a variety of ways. In most cases, the WFDs have been undertaken by trained international and/or local experts, but in some cases they have been implemented by city/municipal waste managers with training and backstopping support (e.g. during the Covid-19 pandemic when travel to and from cities was restricted). The results of selected case studies are now being compiled and synthesised for a publication. Although the tool already provides an accompanying manual [2] and online tutorials [3], feedback from the users still highlight the difficulty of doing field applications and other limitations. The WFD only provides a snap-shot, indicative, assessment of plastic leakages, which depend on an observational assessment performed in the field. The leakages are not actually measured, rather they are approximated based on factors attributed to leakage potentials.

For this purpose, further development of the tool and its functionality is underway. This comprises a series of training materials for a face-to-face training, as well as an online training session. Furthermore, an online portal will help users with the tool and also allow users to upload their data into a central database. Also, the WFD team is exploring opportunities to combine actual field measurements with a WFD assessment so as to verify the approximated factors.

If you are interested in applying the WFD to your city, please do not hesitate to contact us for help in its application. We can also provide a template for terms of reference for mandating consultants in this regard. •

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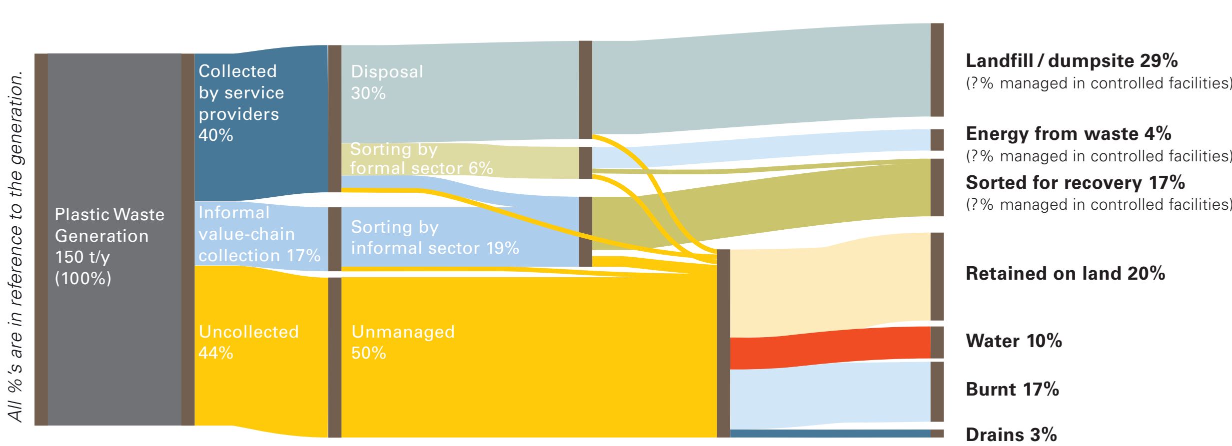

Figure 2: Standardised Sankey Diagram visualising the results of the WFD calculations.

[1] Eawag/Sandec, Switzerland
[2] The WFD project Team: for GIZ: Steffen Blume, Mira Nagy, Nidhi Thakkar; for Wasteaware: Andrew Whiteman, Maya Zataar, Andreea Oros-Baias, Andrei Pintea, Joachim Stretz; for DNA: David Newby, Mark Grice; for University of Leeds: Costas Velis, Josh Cottom; for Eawag: Christian Zurbrügg, Dorian Tosi Robinson

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Food Waste Recycling at Household Level with Black Soldier Fly Larvae

This project piloted segregation and recycling of food waste at the household level in Pakistan, using adapted waste bins containing Black Soldier Fly Larvae. Perceived practicability by household members and larvae performance in such bins were assessed. Saleha Mahmood[1], Christian Zurbrügg[2]

Background

Food waste is the largest fraction of municipal household waste in Pakistan. Whereas other waste types are scavenged and recycled by the informal sector, food waste is currently not perceived as having sufficient economic value to warrant segregation. Therefore, it generally ends up in the waste bin, mixed with other low value materials, and is either disposed of indiscriminately in open spaces or at disposal sites, causing serious environmental and health threats. The heterogeneous nutritious nature of household food waste makes it an ideal feeding substrate for the growth of Black Soldier Fly Larvae (BSFL). Recycling food waste at household level with BSFL, thereby generating valuable products, such as protein rich animal feed and soil conditioner, can provide a promising incentive to segregate food waste at source, relieve the burden on waste collection services by diverting organics from disposal sites and reduce greenhouse gas emissions.

This study conducted in Sahiwal, Pakistan, was inspired by a two-tier BSFL waste management scenario proposed by Diener et al. (2015) [1] in which a centralised BSFL rearing facility serves several small satellite waste treatment units by providing young larval offspring for waste treatment. At these decentralised units, larvae are fed and grown with food waste until the time of harvest and are collected by the centralised BSFL unit for further processing. This pilot study utilised BSFL food waste recycling bins and analysed the acceptance level by households, the increased workload for households, and BSFL growth performance [2].

Methodology

In the first phase of the study, 20 households were selected. Informational sessions with the household members took place, highlighting the significance of placing BSFL bins in the homes and the households were requested to sign up for a first trial period. Out of these 20 households, 17 agreed to join the pilot. Following pre-experimental hands-on bin handling training, 10 households committed to join the next phase of the study. The households' concerns and suggestions during the first phase were incorporated in the co-design of the bins and the development of standard operational procedures. A bin (11 × 32 × 60 cm), containing a defined number of young larvae relative to the expected amount of waste generated, was placed for 15 days at each household. Data sheets, bin handling tools and a weighing balance were also provided to the households for daily recording. After 15 days, the bin was collected and delivered to the central facility and replaced with an empty and clean bin containing BSFL (Photo). Three cycles were executed for each household during the study. Residue and larval samples were analysed to determine treatment performance and larval development.

Saleha Mahmood

Photo: Household waste bin for food waste recycling with Black Soldier Fly larvae in Pakistan.

Results

Results showed that half of the initially selected households were willing to pursue BSFL-assisted food waste treatment. The majority of the households who opted out of the trial, mentioned that limited available space and the time-consuming extra workload were the main reasons for not participating. Performance analysis showed dry matter weight and volumetric reductions of 90% and 81%, respectively. Around 13% of the waste dry matter was converted to prepupal biomass and 77% metabolised, leaving behind 10% of residue (Photo). The initial moisture content of the waste was found to be a significant factor influencing waste reduction.

Conclusion

Based on these results, there can be up to 70% cost savings related to waste collection, transport and disposal when compared to conventional solid waste management systems. Feedback from the households and adapted user instructions could provide a starting point for scaling up such BSFL household recycling systems, as well as the content for educational materials for people from government, industry and academia. •

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A Technology Evaluation Tool for Effective Organic Waste Recovery

Numerous technologies can be chosen to treat organic waste. To support practitioners, MSWM has developed a Technology Evaluation Tool that assesses the technical suitability of technologies based on the types of waste and informs users of outputs and design considerations. Dorian Tosi Robinson[1], Adeline Mertenat[1], Christian Zurbrügg[1]

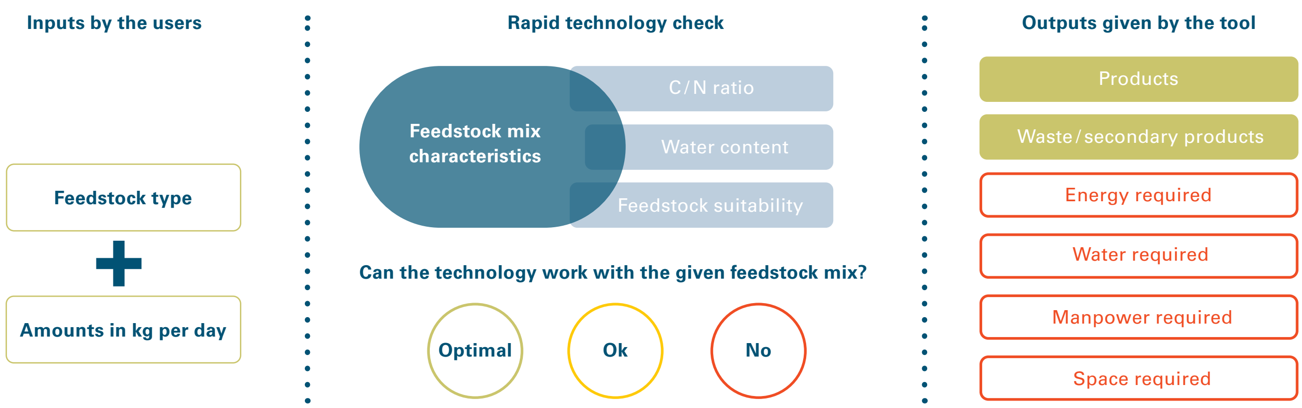

Figure: Schematic representation of the TET functionalities, inputs required and outputs produced.

Introduction

Numerous options exist to treat organic waste – the highest share of waste produced in low- and middle-income settings [1]. From our experience, a decision on which technology to use is often made without evaluating the specific local context and knowing the full spectrum of technology options. To overcome this knowledge gap and support practitioners in making technology decisions, MSWM developed the SOWATT – Selecting Organic Waste Treatment Technologies decision support manual [2]. SOWATT helps in the identification of the technical, economic, and social parameters that influence the performance of treatment technologies, and assists in making comparisons and rankings among treatment options for a given location.

One aspect of doing a technical evaluation of biowaste treatment technologies is to consider the type and suitability of organic waste to be processed, and the quantity of products that can be expected from the treatment process. To this end, MSWM recently developed an Excel-based Technology Evaluation Tool (TET) to assist practitioners in assessing the suitability of a given mixture of organic waste (feedstock) for a given technology and inform them of the main requirements, outputs, and design considerations. This rapid assessment tool considers three technologies found in the SOWATT manual that are often used to treat organic waste. They are:

- Windrow composting
- Anaerobic digestion
- Black Soldier Fly

The TET also gives the user the option to include sanitation waste into the feedstock mix. Such co-treatment and integration of sanitation and solid wastes can be particularly useful in humanitarian settings.

Tool functionalities

To use the TET, the user must input the type and amounts of feedstock that are available to be treated (Figure). The TET database offers several types of feedstocks to choose from, i.e. different organic wastes and sanitation waste and the user has the option to add other feedstocks. The tool then calculates the characteristics of the feedstock mix, verifies if key parameters, such as moisture content and C/N ratio, are in the desired range, and informs the user about the suitability of the three different technologies. Once this first rapid technology check is done, the user can dive into the details of a specific technology and access key information results, such as the required inputs, estimated outputs, and basic design considerations.

Conclusion

The TET supports practitioners to rapidly assess the suitability of three technologies (composting, anaerobic digestion, and Black Soldier Fly) for organic waste treatment. The TET cannot replace a detailed feasibility study, which is required to make the final technology decisions, but can give a valuable understanding of the suitability of a project based on the available waste to be treated. It informs the user of the approximate outputs that can be expected, including valuable outputs, such as compost, biogas, or insect feed, as well as wastes produced, which should not be overlooked when considering a technology. This tool was developed to fit the humanitarian context, but is not limited to this field and can be widely used to assess organic waste treatment. The TET will soon be open source and available to the public on the Sandec website. •

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Management of Excreta, Wastewater and Sludge

Globally, sustainable solutions that are equitable and safe are required for urban sanitation. 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 MEWS group research 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, wastewater and sludge to meet treatment and resource recovery goals with industrial and implementation partners.
- Facilitating sustainable implementation: Uptake of research by integration of knowledge into policy through dissemination and strategic partnerships.

Photo Derrick Muhumuza from Ugandan Red Cross is taking a sample for laboratory analysis from the maturation pond at Imvepi faecal sludge treatment plant in West Nile, Uganda.

Photo by Nienke Andriessen.

Not Measured, Not Managed: Faecal Sludge Management in Pakistan

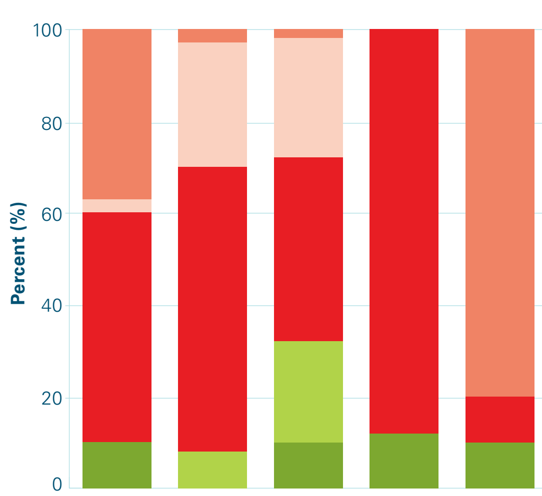
114 million people in Pakistan rely on onsite sanitation systems; nevertheless, the service chain for these systems is largely non-existent. The fate of faecal sludge is not monitored, and policies and guidelines for faecal sludge management do not yet exist. Nida Maqbool[1,2], Sher Jamal Khan[1], Stanley Sam[2], Linda Strande[2]

Introduction

Pakistan has seen tremendous progress toward meeting the Millennium Development Goal on sanitation and reducing open defecation (although it is still at 7%, with a population of 220 million), and has adopted the Sustainable Development Goals (SDGs) Agenda 2030. This has resulted in a 360% increase in the use of onsite sanitation systems (OSS) since 2000. About 83% of the households have flush toilets, 27% are connected to sewers, 21% have septic tanks (OSS), 17% have pit latrines (OSS), and 18% have open drains [1]. In most regions, open drains contain supernatant from septic tanks, or wastewater directly from households and is being discharged directly in rivers and agricultural fields [2]. The safe containment of faecal sludge (FS) that accumulates in containments remains a big challenge.

Unlike other South Asian countries, little is known about safely managed sanitation in Pakistan. The Shit Flow Diagram (SFD), a tool used to understand the safe/unsafe management of excreta, exists for only five cities in Pakistan compared to 72 for India and 50 for Bangladesh (www.sfd.susana.org). SFDs have been produced for Karachi, Lahore and Islamabad [3] and WaterAid Pakistan has done them for Jatoi and Thatta (available online).

The Figure summarises the findings of the SFDs; Pakistan's sewer coverage is 60% in Karachi, 63% in Lahore, 50% in Islamabad, 100% in Jatoi and 20% in Thatta (dark green and red). However, the sewers in the major cities are old and leaking, and only a limited amount of wastewater reaches the treatment plants. The offsite safely managed wastewater (dark green) in Karachi, Lahore, Islamabad, Jatoi and Thatta is 10%, 0%, 9%, 15% and 10% respectively. The onsite safe sanitation in Lahore (8%) and Islamabad (25%) is coming from FS buried in situ (light green). With non-functioning wastewater treatment plants and no FS treatment plants in the five cities, overall only 10%, 8%, 34%, 12%, and 9% of excreta is safely managed in Karachi, Lahore, Islamabad, Jatoi, and Thatta, respectively [3].



Not contained (toilet directly connected with open drains, open defecation)
Onsite unsafely managed (unsafely buried in situ / emptied / disposed)
Offsite unsafely managed (transported in sewer, not reaching to treatment plant / treated)
Onsite safely managed (safely buried in situ)
Offsite safely managed (transported in sewer, treated)

Figure: Safely and unsafely managed sanitation in Pakistan.

Challenges

The National Sanitation Policy (2006) and Pakistan Approach to Total Sanitation (2010) highlight behaviour change among the population as a fundamental building block for improving sanitation. Recently, the Clean Green Pakistan Movement identified liquid waste management as a key pillar for safe sanitation. A strong political will at the national level exists, but the majority of political leaders are poorly oriented to understand the SDG commitments and equity-based resource allocation. Lack of coordination among government departments and stakeholders, non-existent FSM policies, lack of financial resources, poor implementation of existing policies, lack of FSM capacity among practitioners, political instability and natural disasters have led to there being limited safe sanitation in Pakistan.

Conclusion

Pakistan could benefit from lessons learned in India and Bangladesh, where FSM policies provide institutional and regulatory frameworks, and rapid improvements have been taking place. Ways to implement services include: successfully operating FS treatment plants and adapting business models to local contexts. Evidence-based advocacy about the SFDs, a decentralised approach toward awareness-raising, behaviour change and capacity building, along with properly defined FSM policies will help in moving towards sanitation targets. This would require a combined effort among different stakeholders, i.e. government departments, NGOs, funding organisations, research institutes, and strong public private partnerships in the development, operation and maintenance of the FSM service chain at regional and national scales. •

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Open Datasets of Faecal Sludge Characteristics

MEWS has made the characterisation results of 850 faecal sludge samples from six countries openly and freely available. Open access to data will be valuable for the design of faecal sludge management solutions, and desk-based research projects. BJ Ward[1], Stanley Sam[1], Nienke Andriessen[1], Linda Strande[1]

City, Country	Number of samples	Link
Kampala, Uganda	180	https://doi.org/10.25678/0000tt
Hanoi, Vietnam	60	https://doi.org/10.25678/0000tt
Lusaka, Zambia	421	https://doi.org/10.25678/00037X
Sircilla, India	164	https://doi.org/10.25678/0002VH
Dakar, Senegal and Dar es Salaam, Tanzania	25	https://doi.org/10.17632/w5y55vf3cn.1

Table: Description of MEWS open datasets of faecal sludge characteristics.

Introduction

Historically, information on the characteristics of faecal sludge has been difficult to access or simply lacking. Faecal sludge characterisation campaigns are resource intensive and expensive. Generating quality data requires infrastructure, experienced technical staff, and standard methods, which are only recently being developed for faecal sludge. The Management of Excreta Wastewater and Sludge (MEWS) research group is contributing to filling this information gap by sharing open data. MEWS has produced extensive characterisation of 850 faecal sludge samples from Uganda, Vietnam, Zambia, India, Senegal, and Tanzania, with an additional 212 characterisation samples to be released next year.

Available datasets

The data presented here are from faecal sludge samples from cities in Sub-Saharan Africa and Asia. All of our published datasets include physical-chemical characterisation, and many include additional characteristics covering demographic, environmental, and technical data about the sampling location, microbial community and pathogen characterisation, dewatering performance, accumulation rate, and qualitative assessments of sludge (odour and colour). Next year, MEWS will publish characterisation results from Ghana, Guatemala, Lebanon, Canada, Switzerland, Uganda, Kenya, Zambia, Sierra Leone, and India, which will include further results on treatment performance data (e.g. dewatering). The current open datasets, including links to access them, are outlined in the Table.

How can you use open characterisation data?

Access to open characterisation data can be used to investigate useful trends. For example, Englund et al. (2020) [1] used two existing datasets from Hanoi, Vietnam, and Kampala, Uganda, to evaluate whether demographic, environmental, and technical data could be used to predict the quantities and qualities (Q&Q) of faecal sludge generated across the two different cities. They investigated which trends were specific to each city, and which persisted across both cities. Strande et al. (2021) [2] examined empirical relationships between total solids and chemical oxygen demand in datasets collected in six cities, and looked at how relationships differed between cities and different containment technologies. Research that investigates these types of relationships across cities could be helpful for making projections about loadings for faecal sludge treatment facility design, and could allow for fewer samples having to be collected during characterisation campaigns.

Using open data and freely available, open source analytical software (e.g. Rstudio, Jupyter or GNU PSPP) increases scientific knowledge and makes it possible to complete projects with significantly fewer resources than was previously required. This benefits:

- Designers of city-wide planning and of faecal sludge treatment facilities who can access information about sludge characteristics to supplement or inform sampling and characterisation campaigns and make estimates of faecal sludge Q&Q.
- Researchers who can access information about faecal sludge characteristics for desk-based modelling and research projects, for example, to estimate greenhouse gas emissions from storage in onsite containments.

How can you generate open characterisation data?

MEWS has made a commitment to share our faecal sludge characterisation data and encourage others to contribute to the growing body of open data on faecal sludge. More accessible information about faecal sludge characteristics can help increase scientific understanding and help researchers and practitioners address sanitation challenges.

When publishing open datasets on faecal sludge, it is especially important to ensure that data is replicable and reliable with well-quantified and documented methods and quality assurance and quality control (QA/QC) measures. To help design your next sampling campaign, you can consult the open access textbook Methods for Faecal Sludge Analysis (www.sandec/fsm_methods), which contains standard methods for faecal sludge sampling and characterisation, and recommended steps for QA/QC. For resources on best practices for data management and archiving practices, see: https://opendata.eawag.ch/eawagrdm/resources.html •

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Quantifying Greenhouse Gas Savings from Container-based Sanitation

Container-based sanitation has the potential to generate carbon credits through avoided greenhouse gas emissions. However, no official methodology exists to quantify these emission savings. This article describes how a draft methodology was developed. Nienke Andriessen[1], Daniela Seitz[2], Raluca Anisie[3], Mona Mijthab[3], Linda Strande[1]

Introduction

Container-based sanitation (CBS) is a sanitation solution where human excreta is collected in sealable, removable containers, which are then collected on a regular basis by a service provider, who safely treats the excreta for end use or disposal. CBS provides safe sanitation if the entire service chain is managed adequately. Currently, there are nine CBS service providers worldwide, who are members of the umbrella organisation: the Container Based Sanitation Alliance (CBSA). Because excreta is only briefly stored in the containers and then processed into reusable products, CBS systems could avoid the greenhouse gas (GHG) emissions that are associated with other common onsite sanitation technologies [1]. Reporting such GHG savings on the carbon market could generate revenue from selling carbon credits.

Carbon offset schemes allow companies and individuals to compensate for their GHG emissions by investing in projects that reduce or remove GHG elsewhere. The reduction or removal of GHG can be sold on the voluntary carbon market in the form of carbon credits. One tonne of avoided CO_2 emissions equals one carbon credit. To date, no methodology exists that allows CBS businesses to systematically calculate their GHG emission savings.

The MEWS group and CBS enterprise Mosan developed a draft methodology to quantify the GHG mitigation potential of CBS solutions in order to register for carbon credits on the voluntary carbon market [2]. This draft methodology was based on existing and approved carbon methodologies, and previous work by the CBSA [3]. Key expert advice was provided by Sebastian del Valle Rosales, a former South Pole employee. The draft methodology was tested in collaboration with Mosan at Lake Atitlán in Guatemala. Mosan operates a CBS service in an indigenous dense, rural community, using the Mosan toilet (Photo 1), manual transport and pyrolysis as the main treatment process (Photo 2).

Carbon credit methodologies

Existing verified carbon methodologies are based on an internationally recognised standard, which allows for assessing different projects to calculate emission savings in a fair and systematic way. Clean Development Mechanism (CDM) is a standard that regulates official international carbon credit trading. A GHG reduction 'project' could be a project or business that has a reduced GHG impact. Emission savings are calculated as the difference between the situation before and after the GHG reduction 'project' was in place: *emission savings = baseline scenario emissions - project emissions*, in tonne CO_2-equivalents (Figure). This means that a baseline needs to be identified and quantified, and then the project boundaries defined and related emissions quantified. For quantifying emissions, standardised values are commonly used, supplemented with direct measurements that are project specific; this helps the annual monitoring of emissions.

Carbon credit methodology development for CBS

The new methodology was drafted based on a template from the Verified Carbon Standard (VCS), an established carbon standard for the voluntary carbon market. First, existing methodologies under the CDM that are relevant for waste handling and disposal were reviewed, to identify how these could be used or adapted to fit onsite sanitation. Then, the system boundary was defined. In this case, it included emissions from storage, transportation and treatment/disposal of the excreta. Since collection and transformation (treatment) of human waste to end products are integral to CBS businesses, the draft methodology needs to account for the associated emissions. As the draft methodology has to be globally applicable in the CBS sector, all transformation processes (e.g. composting, black soldier fly treatment, or pyrolysis) that are currently applied by the eight main CBS companies (Mosan, Clean Team, Loowatt, Sanergy, Sanitation First, Sanivation, SOIL, and Sanima) were included, as well as emissions from transportation.

Mosan

Photo 1: A Mosan toilet in a user's home in Guatemala.

Mosan

Photo 2: The Mosan faeces treatment process: drying faeces on a drying bed (right) and pyrolysis (reactor in the front).

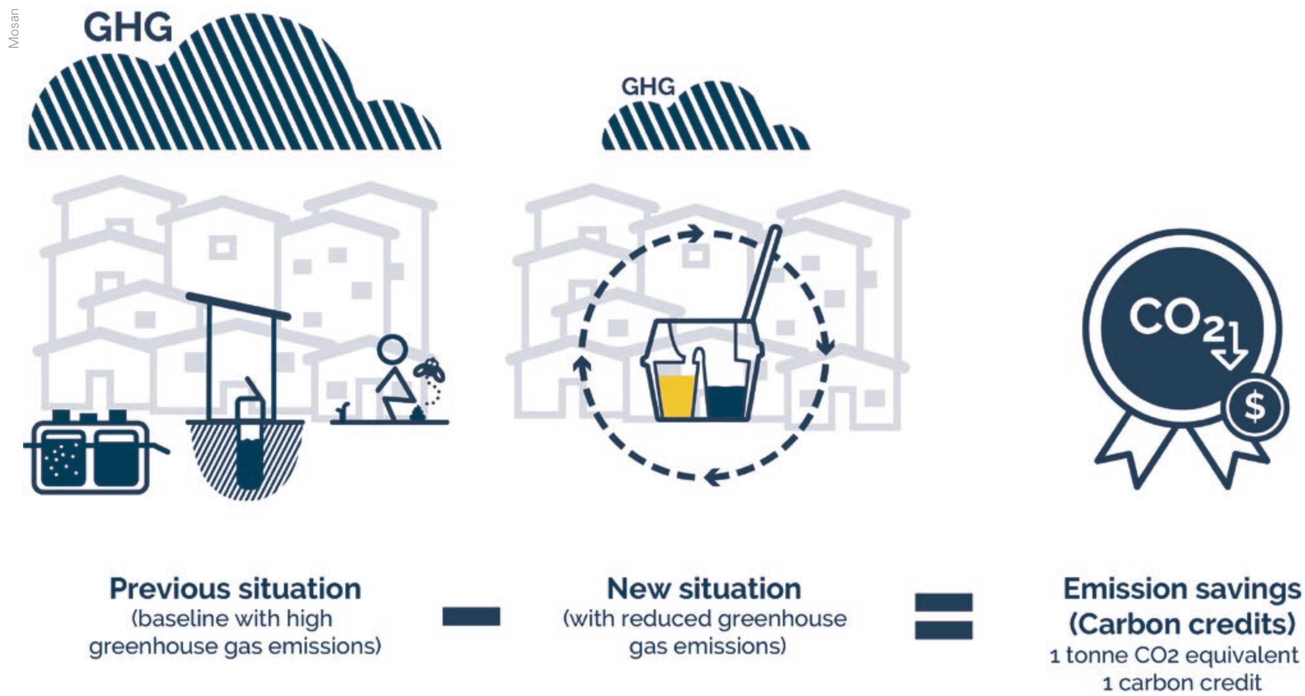

Figure: The carbon crediting process, using CBS as an example.

An important part of the work is the formulation of the baseline: defining existing sanitation systems (that could potentially be replaced by CBS). The challenge here is that there are many different types of onsite sanitation around the world, which are named differently everywhere, and they often operate differently than designed. Thus, coming up with concepts that are valid throughout the world will require assumptions and approximations. To assess the case of Mosan, site visits were made in the Mosan service area in Guatemala, to gain an understanding of the real operating conditions of common onsite sanitation systems used in dense rural areas.

After defining what the baseline is, both baseline and project emissions should be calculated. For this, default values were compiled from existing methodologies and literature. The challenge here is that substantial simplifications and assumptions had to be made, while at the same time, maintaining accuracy and rigour to assure the integrity of the carbon credit methodology. Additionally, some values need to be measured on site, for example the number of users per system, and the volume of human waste collected. One focus of the draft methodology was to optimise and find a balance between the scientific accuracy of the methodology and the cost effectiveness of its application and monitoring, so that it is accessible to (CBS) actors everywhere. Taking local measurements are encouraged whenever possible and this is one way by which the draft methodology accommodates this balance. However, optional default values are provided almost everywhere to allow project proponents to choose what approach fits their abilities, thereby including applications in more resource-limited contexts.

Finally, monitoring requirements were defined. Project proponents (i.e. CBS businesses applying for carbon credits) must document and report certain project parameters for annual auditing to the carbon standard.

Way forward

Completing a carbon crediting methodology from initiation to certification takes time, generally 1–2 years. At the moment, the CBSA is further developing this draft methodology, working in collaboration with carbon finance consultancy companies and investors to assess the feasibility of developing a complete certified methodology. •

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Using Conditioners for Improved Dewatering of Blackwater

Dewatering is the limiting step for efficient treatment and resource recovery from blackwater. Our research is working on optimising the dewatering process, looking at conditioners, conditioner dosing, real-time monitoring and supernatant treatment. Michael Vogel[1], Kelsey Shaw[1], Nienke Andriessen[1], Caetano Dorea[1], Kai Udert[1], Eberhard Morgenroth[1], Linda Strande[1]

Introduction

Blackwater is the wastewater that comes from toilets, and consists of urine, faeces, flushwater and cleansing materials. Management and resource recovery options for blackwater rely on multiple scales of infrastructure, which are appropriate when based on local drivers. Blackwater treatment can be off-grid, decentralised and semi-centralised (non-sewered) or centralised (sewered), as illustrated in the Figure.

Sewered sanitation has been successful in protecting public health over the last century. Globally relevant solutions for non-sewered sanitation, however, have only recently been acknowledged as a sustainable alternative to sewered sanitation. Existing non-sewered treatment plants rely mostly on passive and area-intensive solutions (i.e., drying beds, settling tanks and stabilisation ponds), while in dense urban areas, non-sewered sanitation services should be low-footprint and require robust blackwater treatment systems. Solid-liquid separation (dewatering) remains the missing link to efficient non-sewered sanitation treatment solutions and resource recovery. The Management of Excreta, Wastewater and Sludge (MEWS) group has shown that chemically-enhanced dewatering through the use of conditioners (coagulants and flocculants) can improve the dewatering of blackwater [1]. However, using conditioners for blackwater dewatering is not yet at the level of an established technology, and still requires technical backstopping and a research-based approach for implementation. This is due to the highly variable characteristics of blackwater and the complexity of floc-formation with conditioners, which depends on blackwater characteristics, conditioner type and operational parameters, such as dosing. MEWS is currently researching these steps missing for dewatering to be accepted as an established treatment option.

Implementation of research results

MEWS tested two synthetic conditioners (cross-linked and linear) and three bio-based conditioners (starch-based, tannin-based, and chitosan) with 14 blackwater samples from five countries. The blackwater originated from a variety of sources, including public toilets, septic tanks, holding tanks in refugee camps, and directly from flush toilets. After dewatering with these conditioners, the reduction of chemical oxygen demand (COD) and total suspended solids (TSS) was varied, and found to be mostly induced by changes in pH and electrical conductivity (EC), which can impede both dewatering properties of the conditioners and the floc structure. All the conditioners formed flocs in the samples, and after settling, a minimum reduction of COD of 55% was achieved. The COD in dewatering supernatant is mainly attributed to soluble inert or soluble bio-degradable COD.

The sensitivity of floc formation of blackwater to pH and EC highlights the fact that proper estimation of quality and quantities (Q&Q) of influent blackwater is needed. If the blackwater has high pH and high EC, alternative dewatering methods could perform better. The selection of conditioners is also important for the overall treatment scheme. Although bio-based conditioners are as efficient as

Michael Vogel

Photo: *Left side:* Filter press test to evaluate compressibility of conditioned blackwater. *Right side:* Accuracy-test of optical TSS sensor for blackwater dewatering.

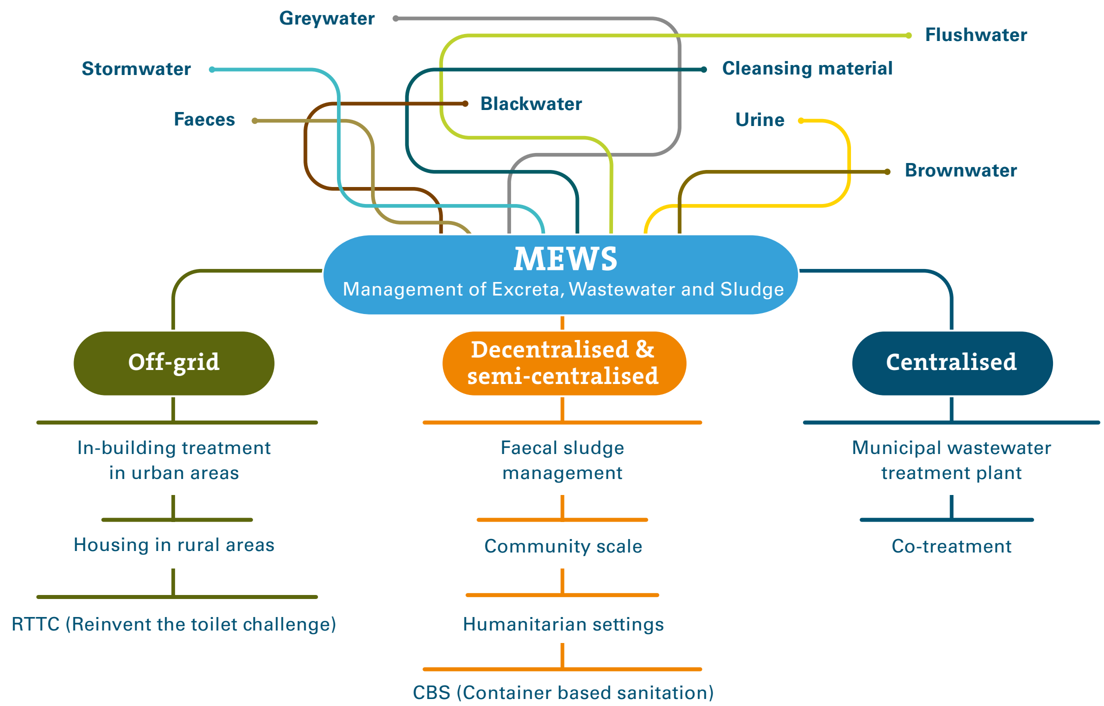

Figure: Overview of infrastructure scales for the management of blackwater.

synthetic conditioners when it comes to settling, their flocs are less resistant to high shear stress. Resistance to shear stress is a requirement for many mechanical dewatering technologies, such as centrifuges or presses, which could also help to cut down on space requirements. Yet, synthetic conditioners might contain substances that are not completely bio-degradable (such as poly-acrylamide), which could pose a risk to the environment and human health, in particular, if the reclaimed solids are used in agriculture. Additionally, supply chain issues associated with commercial products have been identified as a frequent reason for treatment plant failures in low-income countries [2]. Both these concerns could be circumvented by local production of bio-based conditioners.

Dosing conditioners

Under- and overdosing of conditioners can lead to insufficient floc formation, and in the worst case, to process failure. In addition, systemic overdosing increases the costs of operation. To predict dosing, parameters need to be identified that can be measured rapidly in the field or in real-time with sensors. MEWS has identified that TSS, pH, EC, colour and texture are parameters that can potentially assist in the prediction of conditioner dosing in real-time. MEWS is currently evaluating sensors to measure TSS for blackwater dewatering (Photo). These sensors are already applied in municipal wastewater treatment, but it is unclear whether they can accurately measure blackwater.

Further treatment after conditioning

Once the conditioner is dosed, the formed flocs need to be separated and the remaining liquid fraction is called supernatant. Although this can be achieved by passive settling. there is a risk, however, of floating flocs and the sludge not thickening to high TS (20–25%), which is important to reduce transport needs and to enable further treatment for resource recovery [3]. MEWS is, therefore, evaluating different dewatering technologies. In humanitarian settings where electrical power is limited but manual labour is available, geotextiles or manually operated presses are potential alternatives. As an example, MEWS dewatered blackwater with a simple fruit press to a TS concentration of more than 20%. Additionally, MEWS is collaborating with the Lebanese start-up CubeX, which is developing a drumfilter mounted on a truck to empty and dewater onsite septic tanks and cess pit sludge in humanitarian settings and rural households. In contrast, in-building treatment systems require fully-automated and compact technologies, such as small presses or micro-sieves. MEWS is leading the blackwater research in the NEST building at Eawag/Empa, which is a platform to test these technologies under real conditions.

Supernatant after dewatering requires additional treatment before safe discharge or reuse. The high removal of particulate COD and particulate nitrogen through the use of conditioners opens new possibilities for supernatant treatment. In the Eawag laboratories, MEWS is testing attached growth processes, such as the moving bed biofilm reactor and the rotating biofilm contactor. These technologies could be more resistant to loading variations and have lower footprints than conventional biological processes.

Conclusion

Overall, including more efficient dewatering technologies, solids handling and supernatant treatment to the non-sewered sanitation treatment process could reduce the required footprint space of treatment plants threefold. Follow us on our social media channels for upcoming publications about the optimised blackwater dewatering process with the use of conditioners for blackwater. •

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Strategic Environmental Sanitation Planning

As the world becomes progressively more urban, and humanitarian needs are on the rise, the challenge to provide safe and effective sanitary arrangements becomes even greater. The research aims of Sandec's Strategic Environmental Sanitation Planning group are to address the complexity of urban sanitation systematically. Our research combines aspects of engineering with planning methods and social science approaches and includes four 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 necessary for sustainable local service delivery (including financial, technological, socio-cultural and institutional issues).
- Validating appropriate, cost-effective sanitation systems in peri-urban, slum, small town and refugee camp settings.
- Providing backstopping services to humanitarian aid partners on water, sanitation and hygiene in emergencies.

Photo Setting up the Eawag booth at the World Water Forum #9 in Dakar, Senegal.

Photo by Christoph Lüthi.

Tracking Manual Faecal Sludge Transport in a Camp for Displaced People

Can spatiotemporal data of faecal sludge management in a camp for displaced people optimise collection services? This project used dual-band global navigation satellite system trackers to analyse the service coverage of a manual faecal sludge collection system. Christopher Friedrich[1], Mélanie Droogleever Fortuyn[2], Kh Shafiur Rahaman[3], Md. Khairul Bashar[4], Christoph Lüthi[1]

Kh Shafiur Rahaman

Photo 1: Transporting faecal sludge barrels.

Photo 2: Tracker placement.

Introduction

In 2017, nearly 1 million people fled violence in Myanmar and crossed the border to Bangladesh. They found refuge in the more than thirty camps in the Cox's Bazar district of southern Bangladesh, which now house over 860,000 people [1]. Each camp is divided into so-called Majhee blocks that delineate internal community boundaries and support the planning structure and work of aid organisations. The Bangladesh Red Crescent Society (BDRCS), a key partner, manages sanitation services in 24[1] of the 74 Majhee blocks of Camp 18. This research specifically addressed the sanitation challenges of the approximately 27,000[2] inhabitants of Camp 18 [1], furthering the work done by Mélanie Droogleever Fortuyn in her Master's thesis [2].

The most prevalent sanitation technologies in the camps are latrines with dry or pour-flush user interfaces. The faecal sludge (FS) generated is usually collected in (partially) lined pits or septic tanks. Once the latrines fill up, desludging teams use pumps to empty them into transportation barrels and manually carry them to the camp's faecal sludge treatment plant (Photo 1). The hilly topography, dense housing, narrow path network, and monsoon flooding make motorised faecal sludge transport within Camp 18 impractical. The research goal was to analyse the spatiotemporal characteristics of the coverage of the current faecal sludge management system (FSM) to gain insight into how to do sanitation planning in future emergency settings.

Methodology

In Camp 18, there is a lack of information on the spatial service coverage of manual FS transport [3]. To overcome this lack, the project explored how dual-band global navigation satellite system (GNSS) data could be used to optimise FS transport. The first part was to obtain high-quality data to understand the service coverage of the desludging service of the FSTP in Camp 18 and the limitations of the management system. Twenty dual-band GNSS data loggers were attached to the lids of FS transportation barrels for ten weeks (Photo 2). Analysis of this data was done using python scripts and spatial analytics tools in QGIS software (Figure 1). The desludging team leads and barrel carrier volunteers were interviewed to provide context for the data and a weekly schedule was set up by the desludging team to cross-check the results.

Results

49% of the latrines in the service area were emptied during the research period of ten weeks. One Majhee block within the service area was never visited, while others were serviced up to seven out of ten weeks. Analysis of the spatial pattern of the emptying events with elevation and population density maps showed that, rather than taking the shortest possible path from the latrine to the FSTP, the emptiers chose to circumvent hills (Figure 2). Interviews with the desludging team confirmed these findings. A correlation between shelter density and emptying events was also found. The Majhee blocks with the highest population density were among the most serviced.

[1] In August 2022, the number of Majhee blocks serviced by the BDRCS had already increased to 37 out of the 74 in Camp 18.
[2] In June 2022, the population in Camp 18 had increased to 28,800 people [https://data.unhcr.org/en/documents/details/94162].

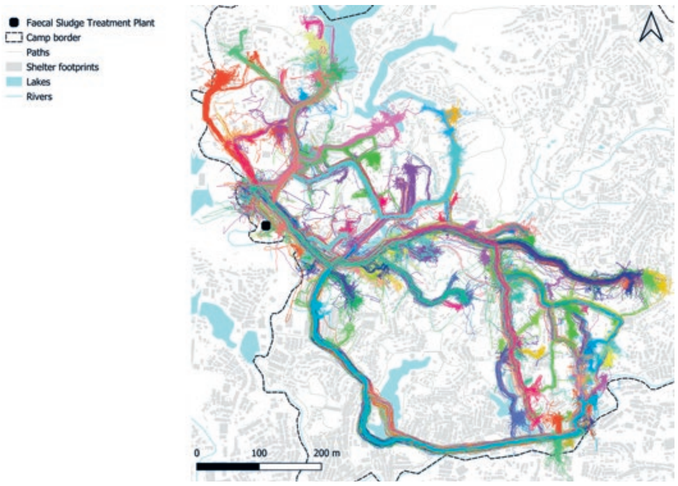

Figure 1: Desludging activity paths recorded by GNSS data loggers (colour variation based on collection date) [2].

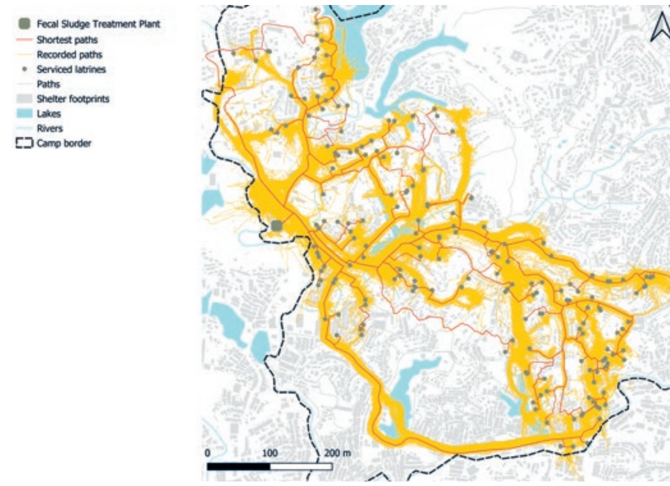

Figure 2: Shortest route assessment of chosen collection paths [2].

Furthermore, the influence of distance and elevation change on average transportation velocity was assessed to determine the desludging team's limitations. Results showed that elevation change has a significant negative influence on average velocity. In contrast, distance positively influences average velocity as it was found that the average velocity was higher on longer distance journeys.

Discussion

The findings show that the desludging teams are achieving extensive service coverage and prioritise the more densely populated Majhee blocks. Notably, about half of the latrines were not serviced within the 10-week research period. What could not be established is whether the desludging teams and treatment plant operators were satisfied with the service coverage, if our results were biased by latrines being recently decommissioned, or if the publicly available latrine coordinates were inaccurate [4]. Because the desludging team was aware that GNSS data loggers were being used for the research, this could have influenced and created a bias in their activities.

The positive influence of distance on the average velocity, with average velocity being higher for longer distance journeys, was a surprising result. In the interviews, the desludging team leads indicated that latrines at high elevations and far from the FSTP are the most difficult to service. This might indicate that action was taken to minimise the strain of these challenging journeys on the emptiers. For example, reducing the quantity of FS carried per barrel when servicing difficult latrines could explain the positive relationship between distance and average velocity because the carriers could then walk faster. Further research is needed to clarify the causes of this unexpected result.

Conclusion

This research explored the unique context of a FS collection system employing manual transport within a camp of displaced people. Although the use of primary spatiotemporal data collection is rare within low-income countries, and especially within camp settings, it was found that this method can provide valuable insights and complement interview-based methodologies in a camp context. Through these methods, the researchers gained a solid contextual understanding of the area and the services provided. The research aim is to contribute towards more informed decision-making of sanitation planning projects in camp settings. •

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Rapid Mobile WASH Assessment Tool for National Cholera Control Plans

Cholera remains a global public health threat. Eawag-Sandec collaborated with the Global Task Force for Cholera Control to develop a customised Rapid Mobile WASH Assessment Tool to inform the development of national cholera control plans. Vasco Schelbert[1], Christophe Valingot[2], Eva Turró-Font[2], Thomas Mollet[2], Alexandra Machado[2], Abel Augustinio[2], Christoph Lüthi[1]

Vasco Schelbert

Photo 1: Nigerian IFRC staff introduced to water sampling to properly assess drinking water quality.

Introduction

Cholera is an acute diarrhoeal infection and remains a global threat to public health and an indicator of inequity and lack of social development. It is mainly a risk in developing countries and in those areas where access to WASH (water, sanitation and hygiene) infrastructure is still inadequate. Therefore, investing in well-functioning WASH services and behaviour education in cholera hotspots are central to control and long-term prevention. Having disaggregated data on WASH services at the district level or lower is key to plan and budget WASH investments. Because disaggregated data is often not available from national WASH information systems, field data collection is required.

In 2017, the Global Task Force for Cholera Control (GTFCC) launched the Global Roadmap to 2030, which aims to reduce the number of cholera deaths reported every year by 90%. In 2020, the GTFCC established the Country Support Platform (CSP). The CSP is hosted by the International Federation of the Red Cross to help cholera-affected countries develop and implement national cholera control plans (NCPs) aligned with the GTFCC roadmap. Funded by the Swiss Development Corporation/Humanitarian Aid, Sandec collaborated with the CSP to develop the Rapid Mobile WASH Assessment Tool, a customised mobile data collection and analysis tool that allows for rapid mobile WASH assessments in cholera hotspots.

The Rapid Mobile WASH Assessment Tool

The Rapid Mobile WASH Assessment Tool collects the WASH data necessary to develop the WASH component of NCPs. The collected data will be used to address four objectives:

1) Cholera hotspot prioritisation for NCPs;
2) Cost estimations of WASH investments;
3) Advocacy and resource mobilisation;
4) Monitoring.

This simple, adaptable and easy-to-use data collection tool offers state-of-the-art online/offline mobile data collection of WASH delivery services on an open source platform. The tool is based on standardised WASH indicators [1] and designed for non-WASH experts.

The questionnaire developed as part of the Tool has two main parts. Part one collects household data on the WASH service level, such as the household's access to a drinking water source and to sanitation and handwashing facilities. If water quality test kits are locally available, the section on drinking water quality allows for entering the test results for bacterial analysis (H_2S-test) or free residual chlorine (Photo 1). The Tool's second part covers the general knowledge, attitudes and practices of the respondents regarding cholera and the household's access to health services. The questionnaire covers both reported and observed data and takes approximately 15–20 minutes to complete. Once an internet connection is available, the enumerators can upload the completed surveys to a password-protected online platform.

Vasco Schelbert

Photo 2: Nigerian IFRC staff conducting household surveys using the Rapid Mobile WASH Assessment Tool.

Training workshop and field test

A team of WASH and public health experts, as well as epidemiologists, developed the draft version of the questionnaire in late 2021. From 14–18 March 2022, together with ten colleagues from the Nigeria Red Cross Society (NRCS), there was a one-week capacity development and training workshop for the team in Abuja, Nigeria. The training covered basic WASH knowledge, such as how to differentiate safe from unsafe drinking water sources and how to identify basic sanitation technologies and functional handwashing facilities. In addition, the enumerators practised how to collect and analyse water quality samples. Following a full day of theoretical input, day two consisted of a practical survey pre-test, where five gender-mixed enumerating teams headed out into the field (Photo 2). After their fieldwork, the enumerators attended a feedback and survey adaptation session, and the questionnaire was edited accordingly to improve the survey flow and fit it more to the Nigerian context. Three-days of field tests also took place to further contextualise the Tool and familiarise the enumerator teams with it. There were feedback sessions each day to discuss challenges encountered and to adapt the survey form.

Workshop Outcomes

During the three field test days, the five enumerating teams completed 225 surveys. Reviewed and cleaned by experts, the collected data contained only minimal errors and was, thus, reliable, indicating that the workshop was a success and the survey ready for use. The NRCS now possesses the capacity to undertake survey campaigns with workshop participants. Several NRCS state branches have already started training some of their volunteers on the Rapid Mobile WASH Assessment Tool.

During the pre-test, there were unanticipated logistical challenges. For example, because water quality test kits were not delivered on time, water-sampling activities were only performed as class facilitation activities. In addition, because the enumerators at times did not adequately perform according to the agreed-on random sampling strategy, a household sampling strategy that guarantees data validity still needs to be developed.

Recommendations and next steps

At the national level, the next step will be to present the Rapid Mobile WASH Assessment Tool to the relevant public authorities, the national cholera platform and the WASH working group for the Nigerian NCP. Our recommendation is that WASH data collection campaigns should be organised in selected priority hotspots where adequate WASH data is missing to inform the NCP. A further recommendation at the global level, is for UNICEF and other GTFCC members to collaborate and pilot the Rapid Mobile WASH Assessment Tool in a joint data collection exercise at one hotspot. The experience gained by doing this could be used to further improve the tool and prepare it for use in other cholera-affected countries.

In the future, the Rapid Mobile WASH Assessment Tool data will allow for the prioritisation of WASH interventions based on WASH vulnerability scores and provide cost estimates for investments in cholera hotspots. These data are important for the development of the NCPs, as well as for advocacy and resource mobilisation. •

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Five Years of Citywide Inclusive Sanitation

In the last five years since the advent of Citywide Inclusive Sanitation (CWIS), the approach has been widely accepted as a paradigm shift in the urban sanitation sector. This article provides an overview of its uptake globally and of a few major developments in the CWIS approach. Abishek S Narayan[1], Christoph Lüthi[1]

Eawag

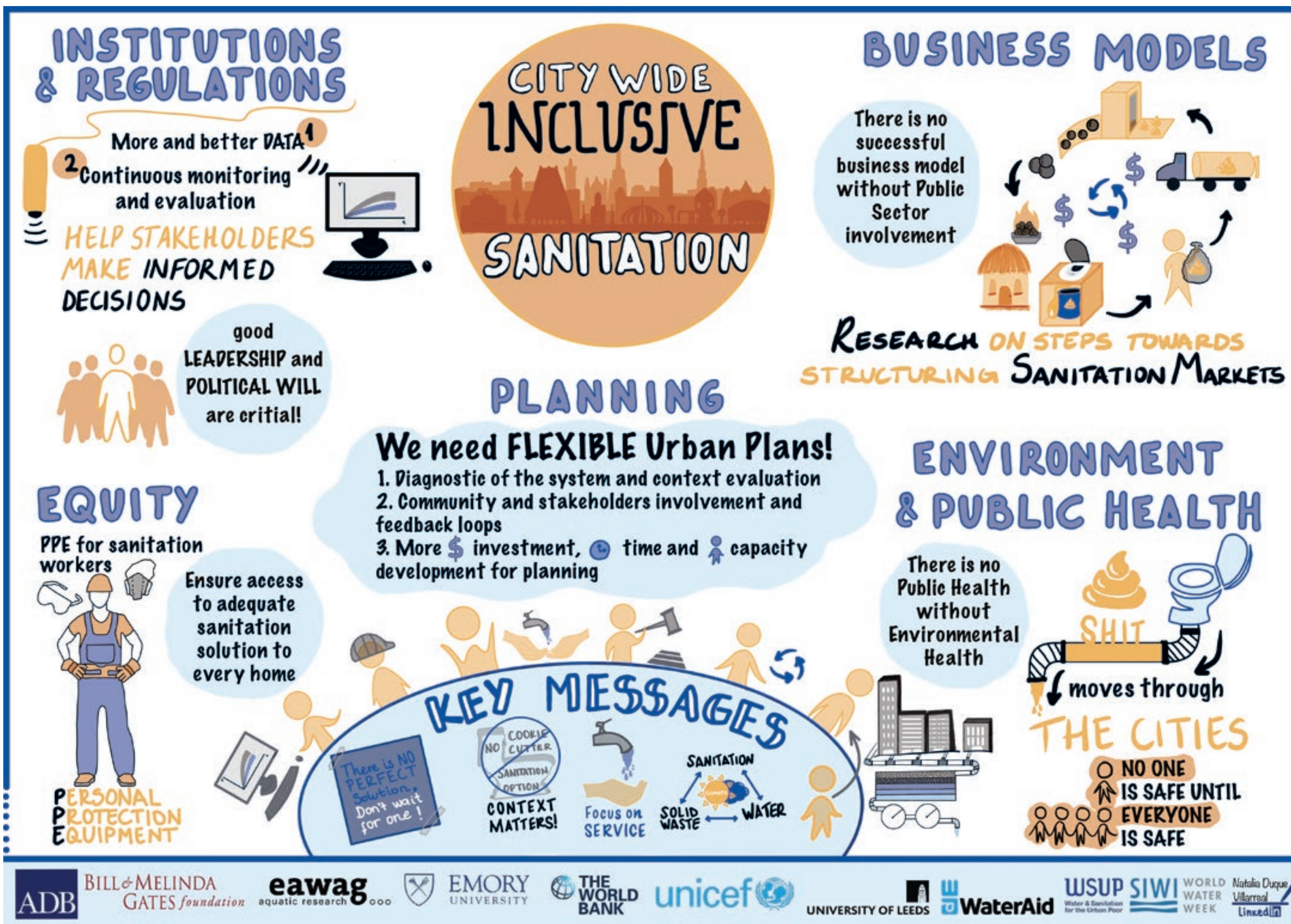

Figure: CWIS Session at World Water Week 2021 brought various players together and mapped the missing pieces to further the agenda.

Introduction

The acknowledgement of the global sanitation challenge and the need for a radical shift in urban sanitation practices led to the launch of Citywide Inclusive Sanitation as a call to action at the Stockholm World Water Week in 2017 by key sector players [1]. Since then, CWIS has gained significant acceptance in the sanitation sector and has developed into a unified concept for collaboration to achieve the SDGs. Currently, several urban sanitation projects are mainstreaming the CWIS approach globally. Academic research and training, and the development of tools and guidelines are helping to scale CWIS implementation.

Varying Interpretations

Although CWIS brought together a number of organisations working in the urban sanitation sector, from governments, multi-lateral development banks, philanthropic organisations to NGOs and academia, there have been slightly varying interpretations of the CWIS concept in the last two years. For example, the Bill and Melinda Gates Foundation has a 2 x 3 matrix of CWIS outcomes and functions [2], the World Bank has eight aspects for a CWIS project [3], the Asian Development Bank more recently introduced a "CWIS House" with impact, outcome, elements and ways [4], and at Eawag, the six principles of CWIS are used [5]. Despite these differences in the packaging of CWIS, the contents of the approach remain fundamentally the same – to ensure equitable, sustainable and safely managed sanitation for all through context appropriate technologies and service models

Global Uptake and Support

DCWIS is widely seen as a gold standard for urban sanitation interventions in international development. The World Bank CWIS initiative is supporting more than 30 projects amounting to several billion USD. The Gates Foundation, with its dedicated CWIS division, has been piloting the approach in eight cities in Sub-Saharan Africa and South Asia and documenting the learnings from them. The Asian Development Bank more recently started its initiative to mainstream CWIS in its operations. The African Development Bank is raising USD 500 million for new CWIS investments from public and private sources. At least 30% of those resources will finance non-sewered sanitation innovations that directly serve low-income communities. The Islamic Development Bank too has embraced the CWIS approach and is actively fostering partnerships to promote it within its operations and client counterparts.

Sector associations, such as the Eastern and Southern Africa Water and Sanitation (ESAWAS), International Water Association (IWA), and the UN Habitat's Global Water Operators' Partnerships Alliance, have been promoting efforts to mainstream CWIS among water utilities and regulators worldwide. Governments in Colombia, India, Kenya and Nepal, among others are increasingly adopting policies that facilitate the uptake of CWIS. In order to support implementational clients with the mainstreaming of CWIS in their operations, CWIS Technical Assistance Hubs have been set up in Asia and Africa.

Planning CWIS is more complex, owing to its multi-dimensional targets of equity, safety, sustainability, responsibility, accountability and resource management. To support planning, several tools and were developed. Athena Infonomics, in partnership with the Gates Foundation, has developed 89 indicators to monitor and measure progress in CWIS projects [6]. Sandec recently developed the CWIS Planning Framework and the accompanying Bridged Approach to Inclusive Sanitation (BAIS), which bridges top-down and bottom-up planning approaches [7]. Several existing and new tools have also been tweaked and developed to support the design and implementation of CWIS interventions throughout the project cycle [8].

CWIS is one of the uncommon cases where the practice was ahead of academia in embracing change. In early 2018, when several CWIS pilot projects had already begun worldwide, there was not a single academic publication on CWIS as a concept. However, in the last five years that has changed, with several fundamental research contributions made to the initiative from various water and sanitation research groups across the world. Apart from the research on the concept, itself, Sandec's work on alternative systems to conventional sewerage, including Faecal Sludge Management (FSM) and Decentralised or Small-Scale Sanitation (SSS), adds a critical knowledge base for enabling the scaling up of the CWIS approach in the sector.

However, scaling up CWIS sustainably requires teaching a new generation of planners, engineers and water managers, as well as exposing and training existing professionals in the sector to this approach. In that regard, several academic and training institutions have established Master's level degree programmes and regional capacity development programmes. The Global Sanitation Graduate School, a platform with 43 Universities globally, has trained over 2,000 sanitation professionals online and over 200 have graduated with post-graduate diplomas since its establishment in 2018. Another example is Eawag's ConCaD programme, a comprehensive online or hybrid training on CWIS that targets private consultants, which has set up partnerships with training institutes in five countries.

Recent consensus

Several organisations convened a session on CWIS at the Stockholm World Water Week 2021 that took stock of the major developments in the approach, including most of the aforementioned points. There were also discussions on what was missing to further CWIS (Figure). Some of the missing pieces identified are:

- Achieving political commitment for equitable sanitation.
- Turning evidence into policy.
- Synergy with other urban development sectors.
- Accurate baseline data for better design of projects.
- Market structuring for private players to come into the sanitation business.

Conclusion

In the relatively short period of five years, CWIS has significantly changed the aspirational approach to urban sanitation projects. The huge uptake in practice and the strong support that the CWIS ecosystem offers the sector in terms of training programmes, planning tools, implementational guidelines and operational support is helpful for CWIS to sustainably scale towards becoming mainstream. However, the mainstream sanitation sector also has to embrace the CWIS approach for this scaling up to take place with the same trajectory in the next five years. •

CWIS Resources

1) ADB CWIS Hub: https://adb.eventsair.com/online-adb-sanitation-dialogue-2021/cwis-knowledge-hub
2) BMGF CWIS Cities Page: www.cwiscities.com
3) Eawag-ConCaD Resource Platform: www.sandec.ch/concad
4) World Bank CWIS Hub: https://worldbank.org/cwis

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How Women and Men Pee – Assessing Gender-specific Urination Practices

Little effort has been done to design toilets that account for physiological differences among males and females. This project developed a urine-stream-simulator and designed a new user-friendly NoMix squat pan with improved separation efficiency. Vasco Schelbert[1], Lena Kriwanek[2], S. Ramesh Sakthivel[3], Lotte Kristoferitsch[2], Harald Gründl[2], Christoph Lüthi[1]

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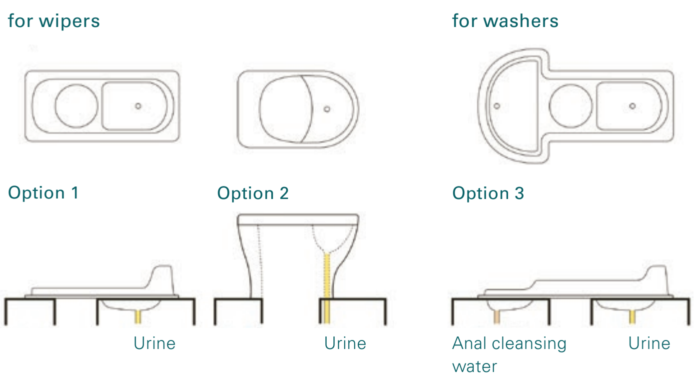

Figure 1: Example of NoMix squat pan for people using toilet paper ("wipers", left) and for those using water for self cleaning ("washers", right), and a commode toilet model (middle). A NoMix toilet has a divider so that urine is collected and drained from the front area, while faeces fall through a hole in the back (Source: Tilley, Ulrich [1]).

Introduction

When separated at the source, urine and faeces can become valuable resources, while combined with water they become faecal sludge that requires resource-intense processing. NoMix toilets are a promising technology that separate excreta for resource recovery. They normally have two compartments to collect faeces and urine separately, can be water-based or dry systems, and made for sitters (commode toilet), as well as squatters (squat pan) (Figure 1, [1]). However, the squat pan models in particular are facing a variety of challenges. Because of the two compartments, the user is forced to squat at a specifc angle to aim for the urine and faeces compartments, respectively. For women, especially, this decreases comfort during use (e.g. urine splashes), which leads to inadequate use and, thus, inefficient source separation.

This situation is partly due to the fact that technology development teams tend to be male dominated and often lack understanding of gender-specific practices and priorities [2, 3]. Current NoMix technologies are not responsive to sex-specific physiological differences and the bodily functions of females, decreasing their user-friendliness. A design that overlooks the habits and practices of users is unlikely to enhance user-friendliness or control the variability of stream flows and limit splashing. Development teams should have a better understanding of individual urination practices, how body postures vary and how this affects urine stream flows and not allow design issues to hamper the transformation of NoMix toilets into desirable products. Therefore, there is a need to (re-)design NoMix squat pans to account for user priorities and practices that would increase their user-friendliness and separation efficiency.

Methodology

Our target was threefold: first, to develop an ethical gender- and sex-sensitive research method that allows for assessing urination practices and urine stream flows. Second, using this data to develop a device to simulate urine streams, which designers and engineers could use to test and improve NoMix squat pans. And third, using this device to design a new user-friendly squat pan model with increased separation efficiency. Regarding the first target, inspired by Mahieu, Pringot [4], the project collected empirical infrared video data through the use of a mobile phone with an infared camera on top of a tripod (Figures 2 and 3). To guarantee user privacy, a non-transparent physical barrier (frosted glass) was installed. The participants noted their sex and the time of use on a list. Ethical requirements (consent, confidentiality, privacy and anonymity) were addressed, according to Wiles, Prosser [5].

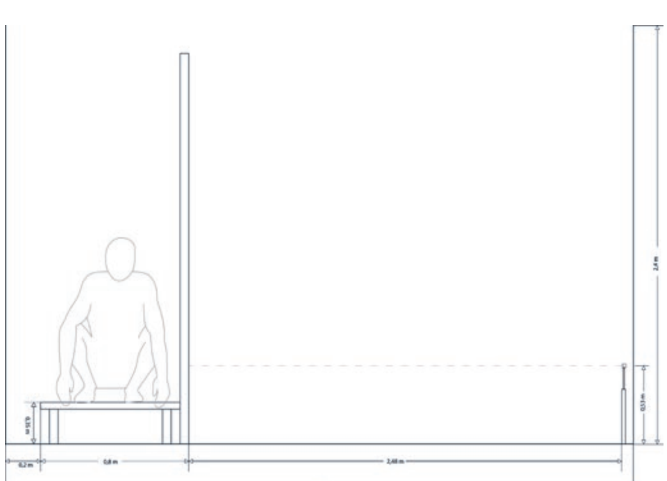

Figure 2: Front view of the real world test setup (toilet setup on the left hand side, camera tripod on the right).

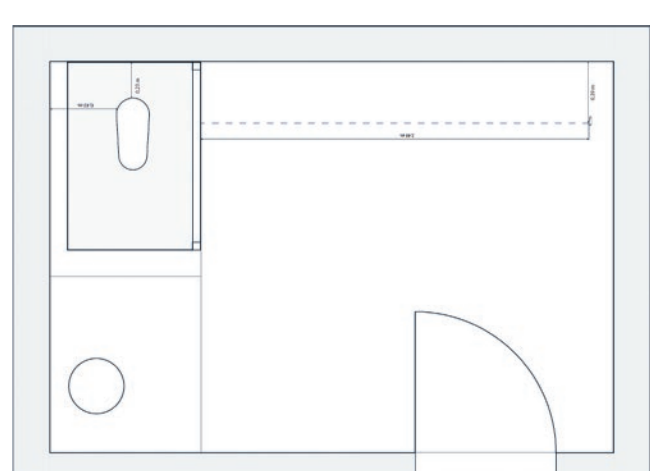

Figure 3: Plan view of the real world test setup (toilet setup in the upper left corner).

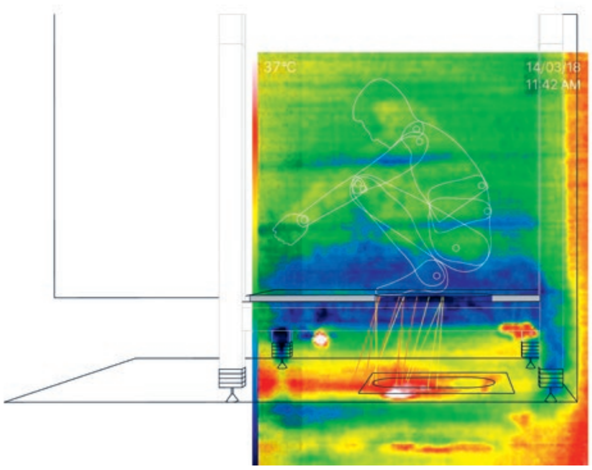

Figure 4: Side view with infrared data, comparing digitalised male (orange) and female (yellow) urine stream.

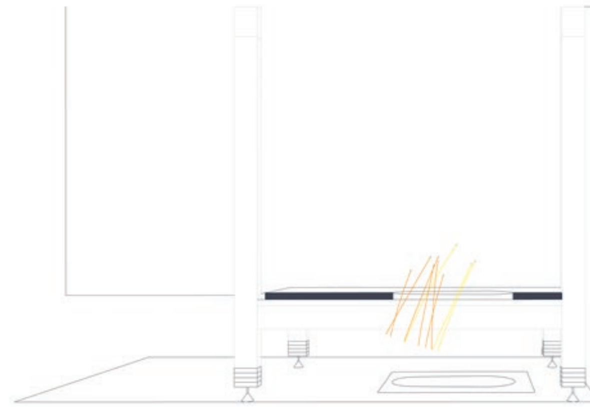

Figure 5: Calculation of urethra positions based on the urine stream trajectory.

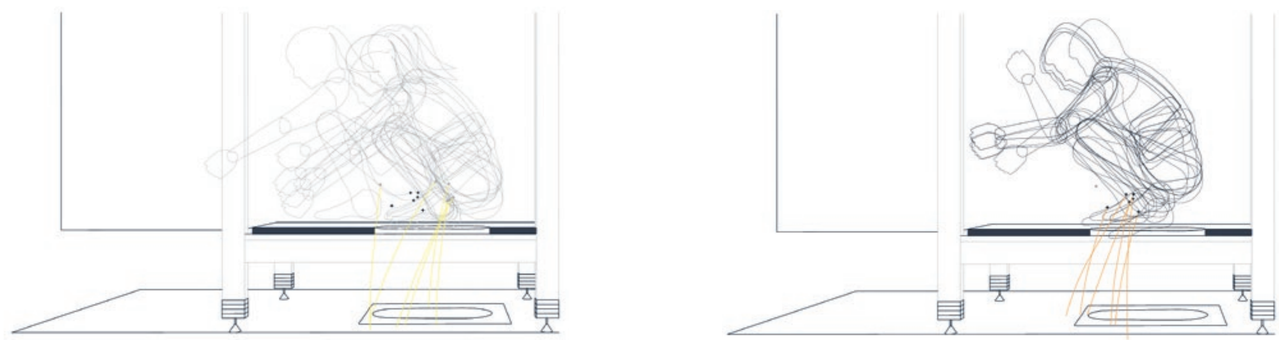

Figure 6: Reconstitution of body positioning (extract) of females (left) and males (right).

Data was collected at the Rural Technology Park of the National Institute for Rural Development (RTP-NIRD) in Hyderabad, India, between February and March 2018, and 23 volunteers, 17 males and 6 females, participated. At the end, 164 recordings were usable (62 female / 102 male). For the analysis, the thermal images were first transferred into the side view of the test setup and urine streams digitalised (Figure 4). Second, the urethra positions were calculated based on the urine stream trajectory (Figure 5) and male and female body positions were reconstituted (Figure 6). Next, the urethras were placed at the identical position to compare and evaluate minimum and maximum urine angles (Figure 7, female example).

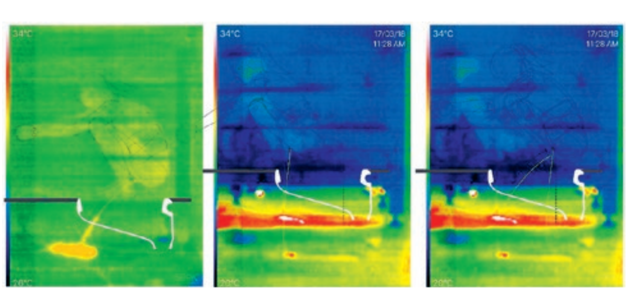

Figure 7: Side view illustration of maximum (left) and minimum urine exit angles (middle) and overlapped comparisons (right).

Results

In terms of the first target, from a design research perspective, our data confirms that infrared recordings are suitable for research. Unsurprisingly, while males can more easily steer their urine stream, females show a higher level of body posture variation to limit splashing. Females also had a larger urine stream range (7° – 70°) compared to males (5° – 45°), which complicates urine separation. In other words, females are forced to adapt to the predominant technology to a higher degree than male users.

Based on the study data and according to the second target, EOOS developed the *Urinator* [6], a simple urine stream flow simulator (Photo and Figure 8). The construction and installation drawings are available open source[1] and designers can use these to test and improve NoMix toilets. Thanks to the Urinator, the geometry of the new NoMix squat pan was adjusted, the user interface separation efficiency improved and a new design was made [7]. This newly developed separation system limits splashing and allows for collecting the urine from females and males to the same extent – which is unprecedented. It also permits the separation of flushing water from solids (faeces and toilet paper).

In the first treatment step, the "Urine Trap" separates urine from flush water and faeces at source (Figure 9)[2]. Second, a liquid-solid separator separates solids and liquid fractions for further treatment (Figure 10)[3]. This allows for a nearly undiluted urine stream and the solids have very little water content. Because it is an entirely passive separation system, no energy is required.

[1] https://www.urinetrap.com/src/assets/img/Urinator.pdf
[2] https://www.urinetrap.com/
[3] https://www.aquatron.se/products/aquatron-separator/

Conclusion

While a variety of NoMix toilets are readily available, design issues and the lack of user-friendliness hamper their transformation from unattractive to aspirational products. The inadequate design of current NoMix squat pans forces females to adjust their body postures, which leads to inadequate use and inefficient source separation. Little effort has gone into developing methods to understand and account for sex-specific physiological differences, body postures and urine stream flows and how these affect NoMix toilet designs. Our research contributes to bridging this knowledge gap. The project developed an ethical and reproducible low-cost research method, collected empirical evidence, and designed a simple device that allows for simulating male and female urine streams. In doing so, this research contributes to a better understanding of gender- and sex-specific urination practices and supports engineers in developing more user-friendly and reuse-oriented sanitation technologies. •

All EOOS

Photo: Top view of the Urinator connected to a garden hose to test separation efficiency for male urine streams.

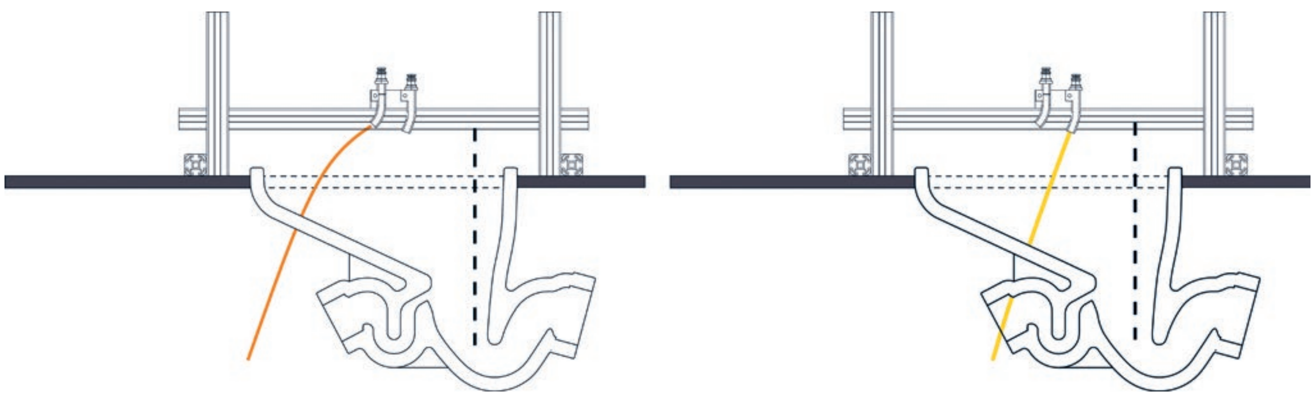

Figure 8: Side view illustration of maximum (left) and minimum urine exit angles (middle) and overlapped comparisons (right).

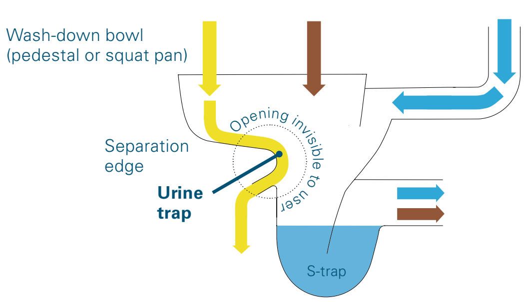

Figure 9: Newly developed "Urine Trap" for commode and squat pan toilets (Source: www.urinetrap.com).

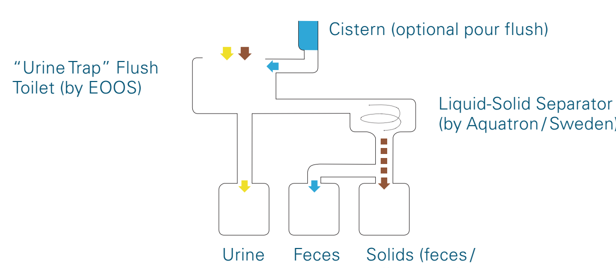

Figure 10: Secondary separation system, which separates the liquid fraction from the solids (Source: www.urinetrap.com).

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[7] Gundlach J., et al., 'Novel NoMix toilet concept for efficient separation of urine and feces and its design optimization using computational fluid mechanics', *Journal of Building Engineering*, 33 (2020), p. 101500.

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An Open-source Template to Produce Robust NoMix Toilets Locally

The EOOS NEXT Open Design Mould allows for the local production of urine diversion squatting toilet pans, using a do-it-yourself template, a metal sheet, and concrete. Results of tests of these toilets in Nepal have led to design improvements. Dorothee Spuhler[1], Bal Kunwar[2], Lena Beigel[3], Lotte Kristoferitsch[3], John Brogan[2], Christoph Lüthi[1]

EOOS, Bal Mukunda, Dorothee Spuhler

Figure: The EOOS ODM concept, a pan produced in Nepal and installed in a toilet and a women holding a poster used to inform future toilet users on the operation and maintenance and handling of urine in crop production.

Introduction

Urine contains most of the nutrients required to produce our food [1] and has to be collected at the source for fertiliser production. EOOS NEXT, a social industrial design enterprise, and Eawag have researched how to do this efficiently for more than 10 years (see also pp. 34–36 in this issue). A result of this work is the design of the patented "Urine Trap" that separates urine invisibly and effectively [2]. To make the UrineTrap accessible and affordable in remote areas where sewers and/or vehicular emptying of toilets are not possible, EOOS NEXT has developed the EOOS NEXT Open Design Mould (ODM).

Proof of Concept in Nepal

This project tested if ODM-based toilets can be cost efficiently built in Nepal and accepted by users. Eawag, Helvetas Swiss Intercooperation and the Nepali partner NGO SEWA collaborated with local manufacturers on ODM prototyping and testing. The first three pans made from the first mould had disappointing results as the pans had many cracks and a rough surface. SEWA then produced ten more pans with different concrete ratios and drying periods from this mould. Although these also had rough surfaces and cracks, and it was difficult to remove pans from the mould, their urine separation efficiency was 75%, close to the target of 80%. Artisans made several innovations to the design, including a metal base plate and casing and reinforcement bars. Extracting the pan from the mould after a few hours drying time while it was still wet became easier, leading to smoother surfaces and less cracks. Urine separation efficiency rose to 90% because of the improved surface.

To increase the pans' attractiveness, white cement was added to the surface. Ten pans were produced for testing in five households, and double vault dry toilets were constructed with two pans installed in each toilet. As anal cleansing with water is the common practice in Nepal, there was an additional basin added at the back of the toilet for washing to block liquid from entering the faeces chamber.

Currently, the toilets are in use and the collected urine directly applied as fertiliser. Faeces are collected in the first of two faeces storage vaults. After six months, this vault is closed; the faeces are stored for six additional months before use as a soil amendment [3]. The final production costs per pan were around 55 Euros, including the mould production. Although this is approximatively five times the price of a normal ceramic pan in Nepal, higher production volume could decrease the price. In addition, even though the cost of the double vault toilet was nearly double the price of a single pit toilet, its advantages outweighed the disadvantages (less humidity and odours, possibility of storing products before use, etc.). Regular field visits showed user acceptance to be high and there were no signs of misuse that would result in higher humidity in the faeces collection chambers. There was also a total absence of odour and flies, which are unpleasant aspects common to pit latrines.

Upscaling

A project report and a technical note document the innovations from Nepal, and four posters developed for user training. These materials are available for organisations that want to take up the ODM approach. Remaining challenges include the heavy weight of the pan, which requires adaption of the vault construction, the high price of the entire toilet set-up, limitations regarding anal cleansing, and the lack of ash as a cover material for the faeces in the user community. The next steps are to improve the ODM design, conduct further testing and globally disseminate the ODM design as a sanitation solution. •

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[1] Eawag/Sandec, Switzerland

[2] Helvetas Swiss Intercooperation, Switzerland

[3] EOOS Next, Austria

Resources: urinetrap.com and eoosnext.com

EOOS NEXT's contribution to this project was funded through the BMGF grant INV-007442.

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Lighthouse Initiatives for Decentralised Urban Water Management

Resource-oriented decentralised urban water management systems improve the flexibility, resilience and sustainability of water and sanitation infrastructure and are, thus, key in sustainability transitions. The Lighthouse Project is assessing some of the most prominent examples. Vasco Schelbert[1], Anant Mitra[2], Christian Binz[3], Christoph Lüthi[1]

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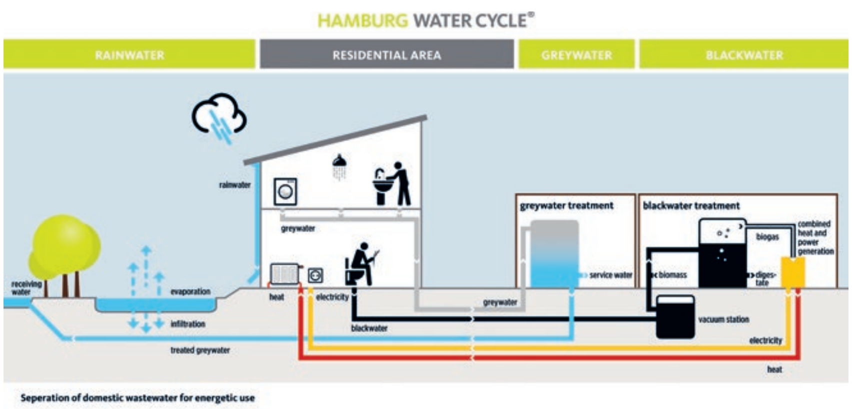

Figure: The lighthouse initiative in the Jenfelder Au in Hamburg, Germany. The concept of the HAMBURG WATER Cycle® separates blackwater, greywater, and rainwater, making it possible to treat and recycle flows individually.
(Layman's Report: www.hamburgwatercycle.de/downloads/bewohner-interessierte)

Introduction

Increases in urban population density, climate change and the ensuing competition for scarce water resources all expose the inherent limits of conventional, centralised water and sanitation infrastructure. It is increasingly acknowledged that resource-oriented decentralised urban water management systems (DUWMS) will play a key role in enabling sustainability transitions in the water and sanitation sector. DUWMS close loops, recover valuable resources, produce marketable products, reduce the energy and water demands of wastewater treatment systems and can quickly be adapted to changing conditions, such as population size. Despite increasing evidence of the potential benefits of DUWMS in improving the flexibility, resilience and sustainability of water and sanitation infrastructure, only a few cities worldwide have successfully implemented them at scale. We call these successful examples "lighthouse initiatives" (LHs). Systematic evidence of the key factors that make LHs a success and how they can best be implemented in cities in developed and emerging economies is lacking.

Targets

The Lighthouse Project aims to conceptualise, identify, assess and synthesise international best practices of LHs. The targets are threefold: **1)** to identify distinctive characteristics of LHs, **2)** to identify cities and neighbourhoods that have established LHs and assess technological and institutional best practices, and **3)** to synthesise the results and produce templates for the diffusion of DUWMS in cities in developed and emerging contexts.

Methodology

The project will use a mixed-methods approach and will last 18-months. To address target one, a literature study was done to develop the conceptualisation of LHs. Key characteristics identified are:

a) Comprehensive arrangement: integration of new technologies into a matching socio-economic and institutional context.

b) Long-term perspective (project length and available funding): creation of stable incentives that enable 'adaptive learning'.

c) Broad-scale adoption: at the neighbourhood/city district level (with a fully developed value chain comparable to the centralised approach).

d) Visibility and impact beyond immediate context: examples that can inspire/guide initiatives to replicate core features.

For targets two and three, a cross-comparative case study is being done to synthesise the results of prior Eawag projects (see 4S and BARRIERS). Secondary data and information from interviews with experts about successful cases in developed (San Francisco, USA; Jenfelder Au, Hamburg, Germany; and H+ Oceanhamnen, Helsingborg, Sweden) and emerging economy contexts (Bangalore, India; and Nirvana Country and M3M Merlin, Gurgaon, India) will also be analysed (Figure).

Conclusion

The project will investigate examples of successful LHs that resulted from long-term implementation processes to identify key actors and understand how they were able to establish LHs 'that work' over time. To this end, an integrative assessment framework has been developed to categorise LHs. The goal is to produce a guidebook to assist in the large-scale implementation of DUWMS in cities in both developed and emerging economies. The guidebook will synthesize theoretical and practice-oriented knowledge and explain how to best implement and scale DUWMS for sustainability transitions. •

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Project Duration: October 2021 – March 2023
Funding: Eawag Discretionary Fund
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SANIHUB – The Humanitarian Sanitation Knowledge Platform

Numerous emergency sanitation and faecal sludge management tools and guidelines exist, yet, finding and accessing information specific to a particular context, project or response phase is a challenge. The Global WASH Cluster developed SANIHUB to fill the knowledge and information gap. Dorothee Spuhler[1], Robert Gensch[2]

Introduction

Many faecal sludge management (FSM) resources are often only available through personal contact with practitioners, academics or from the private sector. In response to this need, the German Toilet Organization (GTO) leads a consortium, consisting of BORDA, CAWST, Eawag, IHE Delft, Netherlands Red Cross and Solidarités International, to produce SANIHUB.

Aim and scope

SANIHUB will enable humanitarian WASH practitioners with simple, quick and easy access to contextualised and relevant resources, tools, advisory services and forums that fill the knowledge gap for improved humanitarian sanitation interventions. There will also be an actively operated helpdesk to assist you when planning and implementing sanitation and FSM interventions. SANIHUB also aims at building a community of practice, involving national and international humanitarian sanitation actors, and users can become part of this community.

The community will help in:
1) keeping SANIHUB up to date with the latest evidence and best practices; **2)** collecting real time user feedback; and **3)** developing moderation and curation skills.

Timeline

The first SANIHUB beta version, including an operational helpdesk, will be available at the end of 2022. With assistance from the user community, the platform and its features will be continuously tested and improved in the coming years and additional tools and features will be added based on demand. A first glimpse of the preliminary design of the platform is shown below. •

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German Toilet Organization

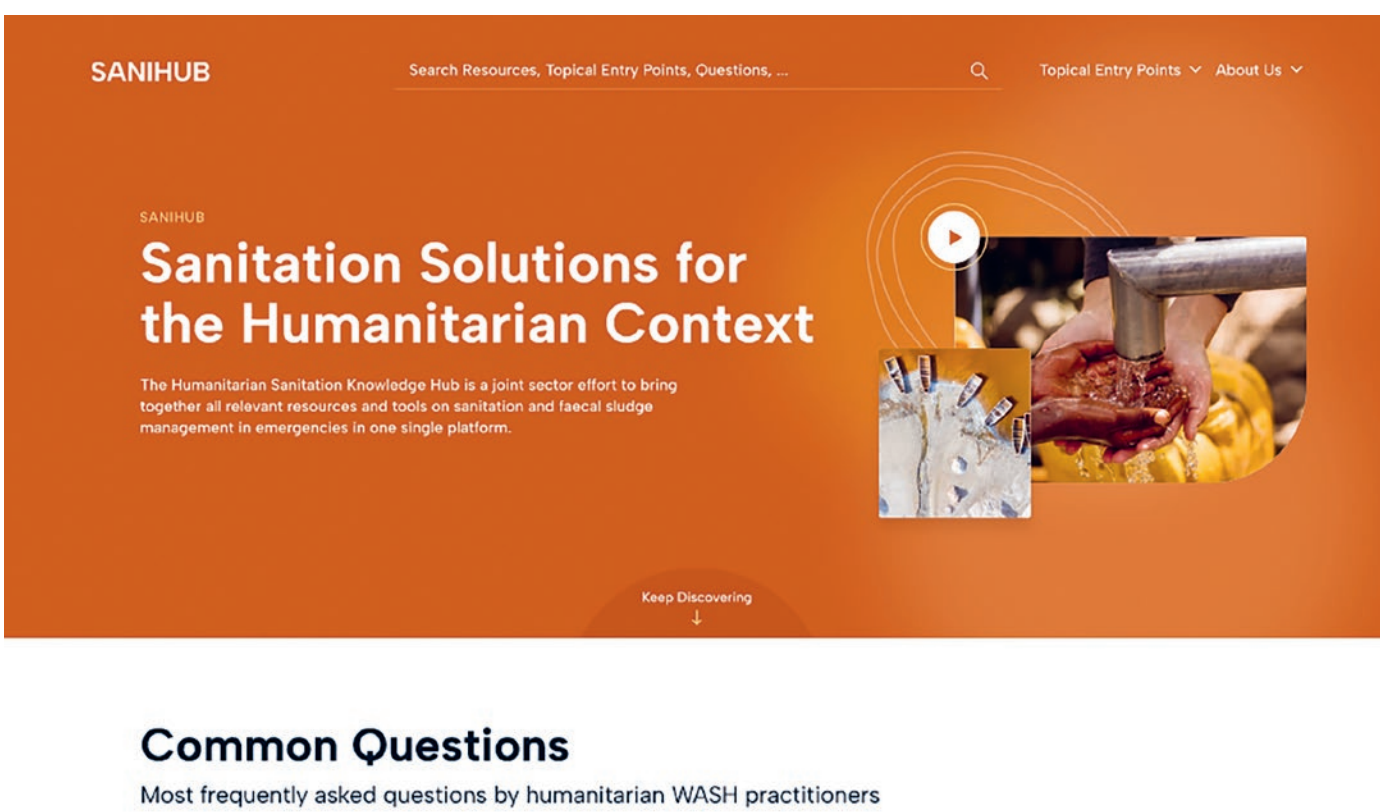

Figure: Visual prototype of SANIHUB website.

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 A public water tap in Karnali Province, Nepal.

Photographer unknown.

In-line Chlorination Technologies: Insights From the A’jin Device

Chlorination is an effective treatment approach to ensure safe drinking water in small community supplies. Locally constructed dosing devices are low cost and easy to maintain. Our joint research investigated the dosing stability of the A’jin chlorinator. Margot Plassard[1], Dorian Tosi Robinson[1], Giezy Sanchez[2], Nexan Herrera[2], Ariane Schertenleib[1], Sara Marks[1]

Ruk’u’x ya’ Program, Helvetas Guatemala

Photo: A’jin chlorinator installed inside a water tank.

Introduction

Access, reliability and quality of drinking water are worldwide challenges. One in three people globally do not have access to safe drinking water [1]. Contaminated water can transmit diseases and cause deaths, with children under 5 years old being especially vulnerable. Chlorination is the most common drinking water disinfection method worldwide. It is applied at all scales, from household to centralised treatment, and offers the added advantage of providing residual protection from recontamination.

In-line chlorinators are particularly promising because treated water is directly provided to the point of collection and requires little behaviour change from the users. In Guatemala, the A’jin[1] chlorinator (Photo) was designed by Helvetas Guatemala and uses solid calcium hypochlorite tablets that slowly dissolve, providing a continuous chlorine dose into the water reservoir tank. A research team from Sandec and Helvetas are collaborating to optimise the design of the A’jin and assess its effectiveness and ease of use over time.

Achieving the right dosage

To treat water, proper dosing of chlorine is essential, both for the efficiency of the treatment and to ensure that some chlorine will remain in the water after the disinfection. The amount that has been used up is referred to as the “chlorine demand”, and the amount remaining is known as “free residual chlorine” (FRC). FRC should range between 0.2 – 0.5 mg/L, with a concentration of at least 0.2 mg/L at the point of delivery to users. In order to reach this level for low turbidity water (< 5 NTU), the total chlorine dosage must be approximately 2 mg/L. In emergency situations, twice that value (4 mg/L) can be used to disinfect water with higher turbidity levels (> 10 NTU). High turbidity can lead to the formation of disinfection by-products, which can cause health problems in case of long-term exposure. However, these potential risks are low in comparison with the confirmed acute risks associated with unsafe water. At the right dosage, at least 30 minutes of contact time is recommended to effectively remove all bacteria and most viruses. Underdosing or low contact times might lead to incomplete disinfection and overdosing can lead to an unpleasant chlorine taste or smell, which could affect users’ acceptability of the technology [2].

A’jin chlorinator

The A’jin chlorinator can be constructed using locally available materials, including PVC pipes and fittings of different sizes (Photo). Basic tools, including a drill, a saw, PVC glue, scissors and foam tape, are required. Food grade solid calcium hypochlorite tablets are used to dose chlorine. Equipment for monitoring residual chlorine, such as a pool tester kit, is necessary to adjust the dosage and monitor the performance of the system. The device is locally produced, low cost and adapted to the rural water supplies. This contrasts with other in-line chlorination technologies that exist on the country’s market, which are expensive, adapted for bigger water systems and rely on deficient supply chains.

Applicability

The A’Jin device is installed at the inlet of the reservoir tank from which water is distributed through a piped network to the users (Figure 1). The installation can be adapted to multiple types of pipe systems with lower and higher flowrates as multiple devices can be installed in parallel. In the Sololá region only, about 170 small water systems, supplying water to 88,000 people, could benefit from this technology. The A’jin device could also potentially be distributed to the other 339 municipalities’ in Guatemala.

Operation and maintenance

The FRC must be initially adjusted and monitored over time. Fluctuating water quality, flow rate and temperature require frequent monitoring and adjustments. Particular attention is advised during the rainy season. Water samples from the distribution network must be taken and tested to verify that the FRC stays within the desired range. Solid chlorine tablets need to be replenished regularly. To guarantee the proper functioning of the system, training of the local water operator is an essential step.

[1] *A’jin* means “let’s talk about water” in the Mayan Mam language.

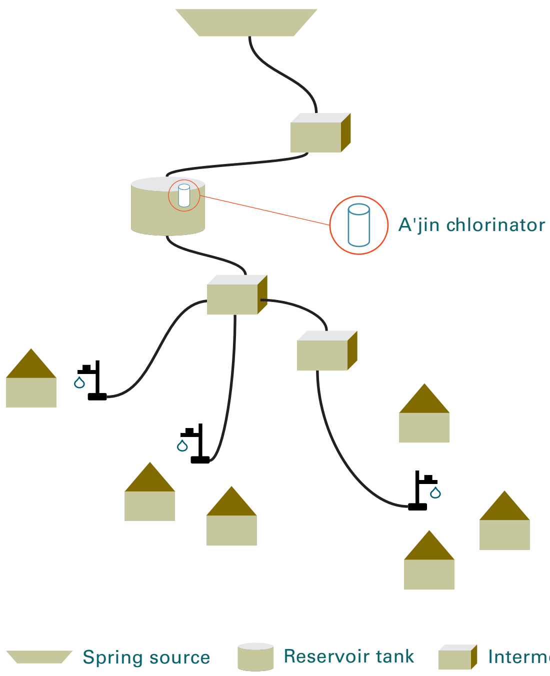

Figure 1: Sketch of a typical gravity-fed piped water scheme. Adapted from Tosi Robinson et al. (2018), https://doi.org/10.3390/ijerph15081616.

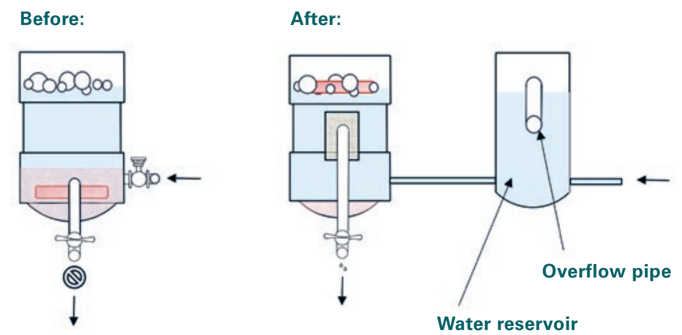

Figure 2: Schematic of the A'jin device, before and after proposed improvements to limit clogging.

Lab experiment results

The dosing performance of the A'jin device was tested in Eawag's laboratory. Preliminary results show that frequent clogging of the device impairs proper dosing of chlorine and the device needs to be frequently cleaned. Several improvements were suggested, based on these tests, such as the use of a fine plastic mesh grid, lifting the position of the tablet in the chlorinator, placing the outlet higher, and replacing one of the dosing valves with a small reservoir with overflow to keep the water level constant (Figure 2). The experiments showed the importance of using high quality, slow dissolving tablets to avoid clogging.

Costs

Chlorination is generally cheaper than other disinfection methods. The A'jin device costs 160 USD to construct and install, and the chlorine tablets are about 2 USD each. This sums up to approximatively 20 USD per month for a community of 500 people (0.04 USD per person per month). Community-based efforts are required to operate and maintain the system and the people doing this are mostly not compensated.

Social considerations

Acceptance by users is one key factor to consider with chlorination technologies. The dosage should be increased progressively when the chlorination system is implemented for the first time until reaching the concentration goals. If the chlorine is overdosed, the taste and odour of water will be impacted, and some users may be reluctant to use or drink it. In Guatemala, there are strong beliefs around water, that it cannot be contaminated or cause illness because it is a divine and natural gift. Additionally, misconception and fear about chlorinated water exists; people think that it can cause illness, loss of hair, sterility or damage clothing. Ignoring these aspects can result in users' rejection of chlorinated water and their switching to non-chlorinated, potentially contaminated, sources of drinking water. Effective awareness-raising, communication and consumer engagement is needed to manage such concerns and to ensure that the health benefits of drinking chlorinated water are understood and accepted.

Conclusion

In-line chlorination devices are a promising technology to ensure safe drinking water. The next steps of our research will provide evidence on the functionality and effectiveness of the A'jin device to improve water quality and the health of local communities on the ground. This will contribute to the current knowledge of the effectiveness of in-line chlorination technologies, specifically in rural areas of low- and middle-income countries. •

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Sustainability of Borehole Water Kiosk Services in Western Kenya

Sustainability of community-managed water kiosks remains a major challenge in rural areas of Kenya. This research investigates the influence of systems' technical design layouts and governance practices on the long-term functionality of water services. Jacktone Akelo[1], Daniel Muasya[1], George Owiti[2], and Sara Marks[3]

Jacktone Akelo

Photo 1: Alwala borehole water kiosk.

Photo 2: Lower Kanyango borehole development point.

Introduction

A major challenge for the water sector is ensuring equitable access and sustainable management of safe and affordable drinking water [1]. Global and national policy documents commit to water services as a basic human right, and that they should be optimally managed. In 2017, the WHO/UNICEF JMP highlighted that the top six African countries have over 90% access to safe drinking water and the lowest seven African countries have below 50%. In Kenya, access to safe drinking water is only 59%. Three quarters of the Kenyan population reside in rural areas, the majority of whom live with limited access to safe drinking water [2].

Low access to safe and sustainable drinking water is partly driven by breakdowns of existing infrastructure. Approximately, one-third of the boreholes in rural Sub-Saharan Africa (SSA) fail within five years of construction [3]. Observable causes of failures can be categorised into technical and governance factors (i.e., system design, water metering, siting of boreholes and financial management practices).

Scoping Activities

A scoping study was conducted in July – August 2021 by a PhD candidate and his supervisor, including reconnaissance field visits to Kisumu County in western Kenya to interact with water stakeholders. The purpose of these visits was to observe the status and service area of community-managed borehole water kiosks (Table), identify factors driving service outcomes, and build consensus for the proposed research concept.

A set of meetings took place with two County Water Officers to discuss the research, the models and status of water supplies in the County, and the roles and responsibilities of local actors. Other topics explored included the functionality of local water committees; frequency of disruption; ownership of the water space; management and governance of water points; representation of the users; arrangements for commercial users; and perceptions of service quality.

The field visits took place in Nyakach, Nyando and Seme Sub-Counties, where six boreholes were assessed in collaboration with two to three water committee members at each borehole, when available. Another activity was meeting with two researchers with experience in Kisumu County, at JOOUST and Maseno University. The purpose of these visits was to learn from their research experiences within the region. The final activity was mainly based on interaction with staff of three INGOs providing safe water services within Kisumu County. The purpose was having a better understanding of their perspectives on establishing a sustainable management of water points once they are handed over to the communities.

BH ID	# of kiosks	BH status	BH Location	Beneficiaries
BH A	1	non-functional	School	300 students
BH B	3	1 out 3 kiosks not working	Market	18 homes
BH C	Unknown	Unknown	Open field	Not ascertained
BH D	Unknown	non-functional	Open field	Not ascertained
BH E	2	functional	School	350 students, 100 homes
BH F	2	functional	Open field	About 50 homes
BH G	6	functional	School/community	35 homes
BH H	4	functional	Community	About 150 homes
BH I	4	functional	School	About 410 students

Table: Characteristics and functionality status of boreholes (BH) at the time of the scoping visit.

Preliminary Findings and Observations

The boreholes and water kiosks visited were established by the County Government, UN and INGOs in Kisumu County (Photos 1 and 2). Borehole users also frequently relied on unprotected sources (pans and rivers). The boreholes had no documented commercial customers. The Table presents a list of boreholes visited and their status. Water kiosks are extended water points from the boreholes (BH).

In Nyando, Borehole A (BH A) served a school, but was not functional at the time of the field visit. BH B, located within a market, had three water kiosks and extensions to 18 individual homes. The first kiosk of the BH B was established at the entrance of a school, the second kiosk was located at the market near the borehole, and the third kiosk was not functional. The two respondents at BH B reported that water was sold at KES 5.00 (USD 0.05) per 20-litre jerrican; the water taste was salty; the technician never took the meter readings; and there were frequent breakdowns of boreholes due to failure to pay electricity bills.

In Nyakach, five boreholes were visited. The functionality of BH C was not ascertained as no one was on site during the field visit. BH D was accessed, but non-functional at the time of the visit. In Seme, three boreholes were visited. At BH E, there was a water point at a school serving 384 users and another kiosk serving 100 households. BH E was seemingly well managed, but was in need of expansion. BH F showed issues of no clear land ownership where the borehole was sited, no installed meter, poor plumbing and unaccounted for water leakages with no active water management committee. Additional results for BHs G, H and I are presented in the Table.

The discussions with the researchers revealed that an estimated four out of ten kiosks in Kisumu break down after about three years. This is due to the location of the boreholes or the kiosks and because the decision-making processes did not adequately involve communities during planning and implementation. When donor funding is used up, community participation reduced considerably, resulting in the projects' failures.

Governance and management of boreholes and water kiosks were varied. Some water points had very functional committees, while others had no or non-functional committees. Some points were locked and not accessible, while at others, infrastructure was being used for unintended purposes. Current membership lists were often unavailable, and the records of water daily access, water sales and expenses were often not kept.

Land ownership was an additional risk factor for infrastructure failure. There were fears that boreholes, pipes or water kiosks located on individual lands might be grabbed by those who inherit the land. Additionally, the overbearing attitude of land donors or institutions was also mentioned as a detriment. Piping on privately owned land and roads was prone to vandalism, and damage during ploughing or construction sometimes occurred.

Finally, cases of households still accessing their drinking water from unprotected sources were reported, indicating that affordability and/or convenience were barriers to accessing kiosk water services. The commercial users buy water at the same price as other users, USD 0.05 for a 20-litre jerricans, and re-sell it at USD 0.10. The vendors come with several jerricans and spend a long time to fill their containers, thereby elongating the time necessary for household users who only fill one container at a time.

Conclusion

The scoping visit in Kisumu County provided an opportunity to observe the design and layout of local kiosks and to identify governance issues influencing service outcomes. These observations provide the basis for future user surveys and focus group discussions on kiosk sustainability in the region. •

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[2] Department of Water, Kisumu County

[3] Eawag/Sandec, Switzerland

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Safe Water Promotion

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

- 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 Contamination of drinking water stored in unhygienic containers is a widespread challenge for water safety.

Photo by Lisa Appavou.

Locally Produced Passive Chlorinators in Kenya

The risk of drinking water recontamination after collection at water kiosks is high. In rural Kenya, this project produced and evaluated different passive in-line chlorinators with locally available materials to provide residual disinfection of water sold at kiosks. Lukas Bouman[1], Lisa Appavou[1], Regula Meierhofer[1]

Introduction

In many parts of rural Kenya, people still rely on collecting water from community water points. Even though the water might have been safe for consumption at the point of collection, it is prone to recontamination during transport to and storage in the individual households, especially in environments with hygienically critical conditions [1]. Chlorination provides residual disinfection, which means that active chlorine persists in the water beyond the point of treatment and, therefore, can significantly reduce the recontamination risk of drinking water. Although passive chlorinators are available in markets and stores worldwide, supply chains for consumables and spare parts are often missing in remote regions and high operation and maintenance costs might limit the use of these devices [2]. Locally produced chlorinators can serve as an alternative. This article presents an analysis of two locally produced chlorinators and their performance.

Methodology

Two different chlorinators were constructed and tested, first at Eawag, then in Kenya (construction manuals see [3]):

1) The T-chlorinator (adapted from Orner by Eawag, see [2, 3] and sketch in Table 1) erodes chlorine tablets and is installed in-line. The tablets are placed in a cylinder that is placed inside a T-fitting.
2) The AkvoTur (Eawag, see [2, 3] and sketch in Table) erodes chlorine tablets and is installed right after the water tap. The tablets are placed in a cylinder, which can be rotated and is installed in a ~1L container.

In total, four devices (2 x T-chlorinator, 2 x AkvoTur) were installed at water kiosks managed by FundiFix Limited, a local water service provider. The four kiosks were located in the semi-arid county of Kitui in eastern Kenya. The chlorinators were operated and evaluated in autumn 2021 over two months. The assessment criteria were: can the chlorinators be locally produced and installed, the availability of chlorine supply, their robustness, ease of operation and the dosage consistency. Regarding dosage consistency, free residual chlorine (FRC) was measured with a digital DC1500 LaMotte colorimeter at 15–30 min intervals on two different days.

Results

Local production and installation

Although some tools were not available in Kitui and the manufacturing process in Kenya was different then the procedure followed at Eawag, it was possible to replicate the two different chlorinators with parts and tools found in Kenya. Altogether, the construction and installation of the T-chlorinator required approximately seven hours and the complexity of the procedure was rated as medium (Photo 1). The AkvoTur was easier to construct and less complicated to install, requiring about five hours. The cost of the materials for each device was ~$10–20.

There were various technical challenges during installation. For the T-chlorinator, the main challenge was the intermittent water supply. During periods of water not flowing, the chlorine tables that were in contact with the stagnating water, continuously eroded, which led to an overdose of chlorine. In one kiosk with an automatic vending machine, intermittent flow was less of a problem, as an automatic valve was installed prior to the T-chlorinator. This allowed for automatic draining of the T-chlorinator, if it was installed at a slight incline. At the other kiosk with a manual water tap, the kiosk operators were instructed to drain the T-chlorinator manually during periods without water flow.

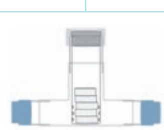
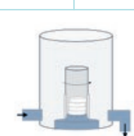
	T-chlorinator		AkvoTur	
	Automated draining	*Manual draining*	*Kiosk 1*	*Kiosk 2*
Target (mg / L FRC)	1.3	1.3	1.5	1.1
Mean (mg / L FRC)	0.6	1.3	1.5	1.1
SD (mg / L FRC)	0.3	0.7	0.7	0.4
Dosage consistency	89%	41%	59%	79%
N	27	32	34	34
				

Table: Chlorine dosage consistency of the T-chlorinator and AkvoTur.

Photo 1: Locally produced T-chlorinator installed in a water kiosk in Kenya.

Lisa Appavou

Photo 2: Fundifix staff producing chlorinators in Kenya.

The AkvoTur was originally designed for a maximum flow rate of 12 L/min. As the flow rate at the tap was higher (15 L/min) than the design maximum, avoiding overflowing the device was the main challenge. To prevent overflow, the size of the bulkhead adapters were increased and the position of the cylinder containing the chlorine tablets was slightly shifted to reduce the resistance of the outflow.

Chlorine supply

A supply chain of 1" TCCA chlorine tablets was lacking at the time of the study. In 2020, when we evaluated the same chlorinators in Uganda [2], the tablets were available in Nairobi, Kenya. In search of alternatives, we conducted tests with 3" Calcium hypochlorite 65 % ($Ca(OCl)_2$) tablets that are easily available in Kenya, which were cut to small pieces. However, the results were not satisfactory (clogging of the device and inconsistent dosing). Finally, the study was conducted with 1" TCCA chlorine tablets from our partner in Uganda.

Chlorine dosage consistency

The target concentration, mean concentration, standard deviation, dosing consistency and the number of samples are presented in the Table for the four installed devices. Correct dosing is defined as the target concentration of ± 0.5 mg/L FRC. The AkvoTur dosed correctly in 69% of the cases. These results are comparable to a previous experiment in Uganda (67%, [2]). The T-chlorinator achieved a dosing consistency of 89% at the kiosk where a valve was installed prior to the chlorinator to allow for automated draining. This is also consistent with findings in previous experiments in Uganda (90%, [2]). However, at the kiosk with manual draining, the dosing consistency of the T-chlorinator was significantly lower - 41%.

Robustness and Ease of operation

During the operation period (~ 2 months), the T-chlorinator did not suffer any breakdowns or damages, while the AkvoTur had only one minor problem (detachment of the bottom plate from the container), but this could easily be fixed. The only operation task for the AkvoTur is refilling chlorine tablets approximately twice per week, depending on the water consumption. The same goes for the T-chlorinator installed at a kiosk with an automatic water vending machine that allows for automated draining. However, for a non-automated kiosk, manual pipe draining is necessary when the taps are not in use to avoid overdosing.

Conclusion

It was possible to produce four passive chlorinators (2 x T-chlorinator and 2 x AkvoTur) with locally available materials and tools in Kenya (Photo 2). With some adjustments, the chlorinators could be installed at four different water kiosks in Kitui County. The installation of the tap-attached AkvoTur was the fastest and easiest. It was robust, easy to operate and had a dosage consistency of 69%. The T-chlorinator, however, had a better overall performance. Even though it was slightly more complicated to fabricate and install, it was more robust and had a higher dosage consistency of 89%, provided that automated drainage was available. In an intermittent water supply scheme, the T-chlorinator should be installed in a way that allows for automated draining. A reliable supply of the necessary chlorine tablets (1" TCCA) is absolutely critical for a sustainable and smooth operation and should be well investigated prior to installation of the chlorinator. •

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[1] Eawag/Sandec, Switzerland

Partner: FundiFix Limited in Kenya and University of Oxford.

Acknowledgement: We would like to thank Lisa Appavou for her efforts and commitment during her thesis work and our partners for their enthusiasm and great collaboration during the experiment.

Enabling a More Holistic Urban Water Management

Eawag and partners are developing an easy to understand and to use Urban Water Flow Diagram to illustrate urban water flows. The objective is to facilitate the understanding of the urban water cycle and the identification of challenges and opportunities. Lukas Bouman[1], Marta Grave[2], Amadou Gueye[2], Marc-André Bünzli[3], Dorothee Spuhler[1]

Background

Urbanisation and rapid industrialisation are current trends altering the natural water cycle, i.e. increased use of groundwater and surface waters and the reduction of infiltration and evapotranspiration. Furthermore, surface water runoff and the lack of wastewater treatment create chemical and biological pollution leading to public health risks and environmental degradation. Poor urban areas, where most population growth worldwide is taking place, face particular challenges because of the lack of infrastructure and high population density. Although the more frequent occurrence of droughts, floods and changes in resource availability due to climate change can intensify these problems, addressing them with innovative sustainable urban water management approaches can also be an opportunity for researchers and practitioners.

Sustainable urban water management is inclusive and integrates different sectors and actors, making it necessary to find a common language and the joint identification of problems and opportunities. But, where to start? There is a need for a simple tool that allows for initiating this process.

Eawag-Sandec together with SDC, HEKS-EPER, Helvetas Swiss Intercooperation and the Swiss Water Partnership have started to develop such a tool: the urban Water Flow Diagram (uWFD). The uWFD is an easy to understand and to use diagram visualising all water flows within a city from source to discharge, including reuse. It shows the interactions between the human and natural water cycles by illustrating groundwater and surface water use and recharge, evapotranspiration, and the discharge and reuse of wastewater. It also shows the interactions of different uses and users. It makes visible the problems related to overuse, pollution and inequalities, as well as opportunities for improvement. The initial idea for the uWFD occurred at the meeting of the Swiss community of practice for water and sanitation (Aguasan) in autumn 2020. From there, a larger alliance comprising experts from the Stockholm Environment Institute and UNICEF joined the core team of Aguasan members to develop the concept.

A Design Thinking Approach

The project started with case studies in three locations that represented different environmental and institutional settings: Bern (Switzerland), Rio Pardo de Minas (Brazil), and Bangalore (India). The case studies tested two types of representation: the block flow diagram and the Sankey flow diagram. For the case study in Bangalore, a block flow diagram illustrating the groundwater balance for the entire city was developed. For the case studies in Bern and Rio Pardo de Minas, Sankey flow diagrams were generated. Sankey diagrams are flow diagrams in which the width of the arrows is proportional to the flow.

Presentations about the case studies took place in 2021 at the World Water Week in two interactive sessions. The audience confirmed the usefulness of the tool, but stressed the need for a standardised and well-defined approach to guarantee its reproducibility. Sankey diagrams were found to be better suited to represent what needs to be illustrated and easier to understand than the alternative block flow diagram approach. Therefore, a subgroup of the initial partners decided to continue and standardise the methodology, using the Sankey flow diagram (Figure).

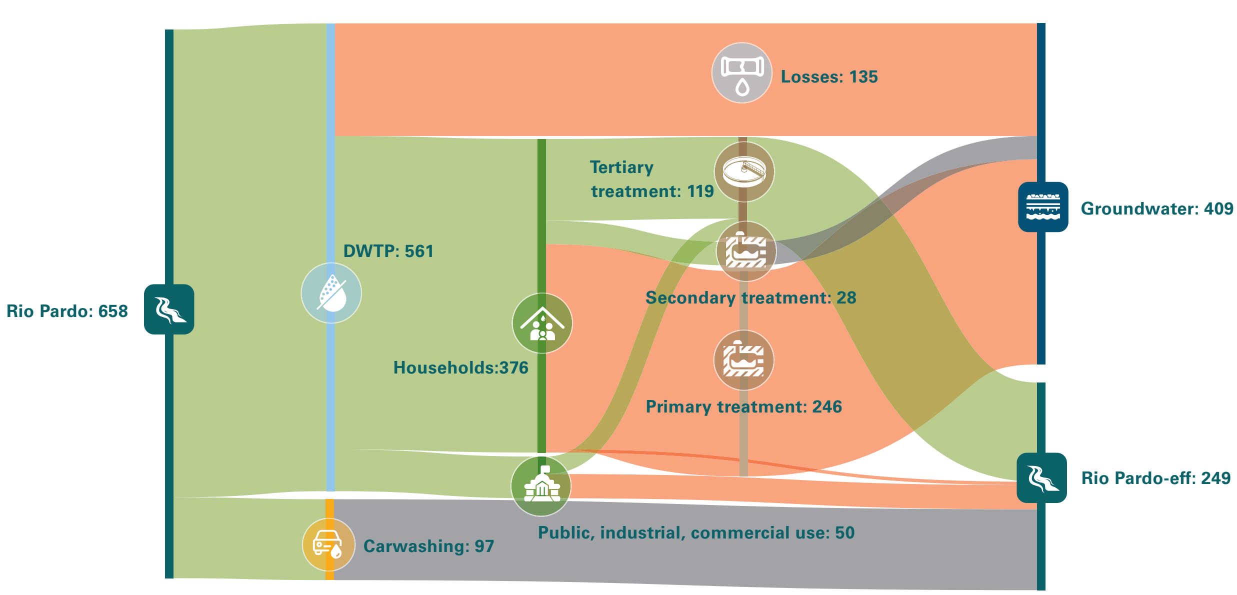

Figure: Draft of the Sankey Diagram methodology (green = appropriate practices, red = problematic practices, grey = unknown) for Rio Pardo de Minas. The diagram reveals high water losses, problematic disposal of wastewater and a high water demand for car washing.

Christopher Friedrich

Photo: Group discussion about the methodology of the Urban Water Flow Diagram at the World Water Forum 2022 in Dakar.

The Standardised Methodology

The first step is to define the system map, i.e. the system boundaries, functional groups, nodes and flows. The system boundaries are usually determined by the political boundaries of the city or the service area of utilities. The functional groups are water sources, drinking water treatment, different water uses, wastewater treatment, and reuse and discharge. The nodes are the different building blocks in each of these functional groups, such as rainwater harvesting, turbidity treatment, irrigation or surface water discharge. There are four categories of flows: source water, drinking water, used water/wastewater, and effluent. With these definitions, the methodology was standardised and is reproducible.

Building on the system map, relevant information is compiled in three additional layers, illustrating issues related to quantity (water volumes), quality (level of pollution) and the data accuracy (the reliability of the used data). The thickness of the flow provides information about the quantity, and every flow shows one of the four water quality categories: **1)** uncontaminated, **2)** microbiologically contaminated, **3)** chemically (and maybe microbiologically) contaminated and **4)** unknown. Combining the given quality of a flow with a node allows for analysis of "appropriate" and "problematic" practices. For instance, "chemically contaminated" water flowing into "wastewater treatment" can be highlighted in green, as this is an appropriate practice. The same "chemically contaminated" water flowing into "surface water disposal" would be highlighted in red and rated as a problematic practice.

In addition, a quantitative analysis of water use provides evidence to answer the question, whether the amount of water used by each sector is "appropriate" or "problematic". As opposed to the qualitative judgement, the answer to this question is highly dependent on the context (how much water is available in total) and the distribution (fair allocation). For instance, the quantity of water available to households could meet the United Nations "human right to water" (50 – 100 L/day/person) and, therefore, be rated as "appropriate". Alternatively, when not enough water is available, the rating would be not sufficient or "problematic". A data accuracy layer was also introduced, which allows for an overview of the reliability of the data used for the diagram. The categories "high", "medium" and "low" were defined based on the quality of the data source and the level of difficulty to quantify a given type of flow.

The draft methodology was presented during the Water Summit in Delft, the World Water Forum (Photo) and the alternative forum (FAME) in Dakar, as well at a webinar with a selected expert panel. The expert panel consisted of researchers, practitioners, and policy makers from Eawag, the German Society for International Cooperation (GIZ), the Swiss Federal Institute of Technology Zurich (ETHZ), SDC and UN-Habitat. The methodology integrates feedback from these discussions and the current version constitutes a step-by-step guide. The guide also comes with an Excel sheet that helps the collection and structuring of the data required to produce the uWFD.

Conclusion

As a next step, five more case studies will take place to test the standardised methodology in the Philippines, Honduras, Uganda, Brazil and Senegal. Sandec will provide technical and conceptual support for the local teams. After these tests, the goal is to finalise the methodology and publish an open source user guide. If relevant, the guide will be complemented with a web-based platform for interactive guidance through the process of data collection and compilation, and the generation of the uWFD. •

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Acknowledgments: We would like to thank all the participants of our presentations, sessions and workshops for their valuable contributions. With your creativity and feedback, the Urban Water Flow Diagram has developed into what it is today! Two case study videos can be accessed via the QR codes.

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Education and Training

With its Education and Training Programme, Sandec 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 Sandec's Nienke Andriessen is teaching staff from the University of Zambia how to use a Volaser measuring device during a sampling campaign in Lusaka, Zambia. The Volaser can measure volumes of faecal sludge and onsite sanitation systems in situ, and was used in a study, measuring quantities and qualities of faecal sludge in Lusaka in 2019.

Photo by Barbara Riedler.

Easing Access to Scientific Publications

Sandec has developed a new video series, called "Spotlight on WASH Publications" to increase MOOC learners' exposure to WASH publications. In addition, their launch on social media can be used as a trigger to start a dialogue between researchers and learners. Laura Baquedano[1], Fabian Suter[1]

Introduction

Researchers around the globe are continuously producing a wealth of scientific articles. However, their findings often remain in the academic sphere and do not reach current and future practitioners, because articles are locked behind expensive paywalls, are hard to find or difficult to understand for readers without an academic background in the same field [1]. The request from learners of our MOOC series "Sanitation, Water and Solid Waste for Development" to get more exposure to scientific literature, led to the idea to produce so-called Spotlight videos.

What are "Spotlight videos"?

Spotlight videos are short videos introducing recent open-source WASH publications. They were initially developed to increase MOOC learners' interest in scientific publications, show learners how to find and access the publications, and to foster reading and understanding skills. The initial approach of integrating the Spotlight videos in our MOOCs and using them as a vehicle of one-way transmission of information from experts to learners, has been expanded during the production of the first four Spotlight videos for the articles and books "Methods for Faecal Sludge Analysis", "Advancements In and Integration of Water, Sanitation and Solid Waste", "Black Soldier Fly Biowaste Processing" (Photo 1) and "A Sanitation Journey". Today, Spotlight videos are also launched on Sandec's social media channels (YouTube, Facebook and LinkedIn) with the objective to trigger a dialogue between experts and the public about the publications and their research findings [2].

The characteristics of Spotlight videos are:
- The **short duration** (~2 minutes) aims at motivating viewers to watch the whole video and allows viewers to easily identify and retain the main message.
- A **pre-defined structure** helps to clearly convey the main message and allows viewers to become familiar with the series. It also eases the production process and reduces the required time investment for researchers and the production team.
- The integration of **creative ideas** is key to make the production process and the video itself attractive (for example, Stefan Diener getting ready for a bath with Black Soldier Fly Larvae (Photo 2) or Roland Schertenleib showing slides from the 1970/80 ies to illustrate early innovations in the sanitation sector).
- Use of **jargon-free language** is key to reaching a wider audience and to making the message easily understandable.

Conclusion

Although it is still early to assess if the initial objectives have been achieved, the increasing interest in the series are driving the production of new Spotlight videos. Preliminary feedback has led to the conclusion that the combination of the predefined structure with a lot of room for creative ideas is well suited for the creation of attractive short videos, which can be versatilely used on different platforms, such as the MOOC-platform Coursera or social media channels, such as LinkedIn. To increase their potential in the future, it will be crucial to fine-tune the Spotlight initiative based on viewers' feedback and explore the potential for synergies with other Sandec initiatives. A particular focus will be put on finding ways how to best use the videos on social media to create a dialogue between researchers and learners. •

Photo 1: Still image from the Spotlight video.

Laura Baquedano

Photo 2: Making of the Spotlight video with Dr. Stefan Diener for the Step-by-Step Guide on "Black Soldier Fly Biowaste Processing".

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[1] Eawag/Sandec, Switzerland

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YouTube-Playlist with all Spotlight videos: https://bit.ly/3pkXPJk

Special thanks to our intern Cyril Favre for the production of the first Spotlight videos.

How to Run a GDM system – A Cross-border Video Production

The Covid19 pandemic has accelerated the digital transformation and reshaped the way organisations team up, and tackle and solve problems together. This article looks back at the remote production of a video series conducted with our local partner NGO Get Water Uganda. Lukas Bouman[1], Cyril Favre[1], Henry Ouma[2], Regula Meierhofer[1], Fabian Suter[1]

Henry Ouma

Photo: Our partner organisation Get Water Uganda & Richards Studio in action.

Introduction

In 2016, Sandec's Safe Water Promotion Group and members of local NGOs in Uganda joined forces to construct five water kiosks at the shore of Lake Victoria in Eastern Uganda. The kiosks provide safe drinking water to the local communities, using gravity-driven membrane (GDM) filtration [1]. To develop the capacity of local and international water experts in installing and operating a community-scale GDM filtration system, a user guide and a video series were produced. Due to the pandemic, traveling to Uganda was not possible and the video project had to be done remotely. The remote collaboration started with a joint meeting between Eawag and Get Water Uganda (GWU) to define the scope of the production and clarify responsibilities. The team at Eawag drafted the scripts, which were then revised by GWU and adapted to the local context. Together with a Ugandan filming company, GWU recorded the onsite footage and voice-overs in several sessions (Photo). The Eawag team recorded the narrator voice-over and edited the videos. During the project, information exchange took place via regular video calls and group chats, especially during the days of onsite recording. A final review round by Eawag and GWU approved the video series and it has been uploaded to the Sandec YouTube channel.

Ups and downs of a remote video collaboration

One main challenge in the collaboration were long feedback loops. As the team at Eawag was not onsite, it could only review the footage after it had been uploaded to a cloud server. Consequently, some parts had to be re-filmed on another day. Filming at different times led to divergent recording outputs because the natural light, background noise, distances to the microphone and the types of microphones used were different. Due to the slow internet connection, uploading the footage of one day could take hours, which caused extra workload for GWU and delayed the review process. Occasionally, the unstable internet connection also hindered the virtual communication between the teams.

The principal advantage of the remote video collaboration was that our partner NGO had more responsibility and ownership of the project. It resulted in a highly authentic final product. Furthermore, the remote video collaboration created local employment for the filming company and enhanced a knowledge exchange in both directions. It also saved travel expenses for the team at Eawag and reduced CO_2 emissions of air travels.

Conclusion

The past two years have furthered the transfer of responsibilities for the execution of activities to local partners. The added constraints have led to rethinking workflows and allocation of terms of references.

Remote collaborations require patience from all collaborators in order to succeed. For similar projects, it is recommended to establish a reliable data sharing mechanism upfront and to carefully discuss the policies of the parties concerning the online publication of the video material. Additionally, the recording equipment should be aligned, enabling the video editor to smoothly combine sequences recorded at different locations and times. In view of the climate crisis, remote collaborations are also recommended as avoiding air travel saves a considerable amount of CO_2 emissions. Even though it would have sometimes been easier to jointly work together onsite, the advantages of the remote collaboration outweighed the challenges as shown by the local ownership and authenticity of this video series. •

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[1] Eawag/Sandec, Switzerland
[2] Get Water Uganda
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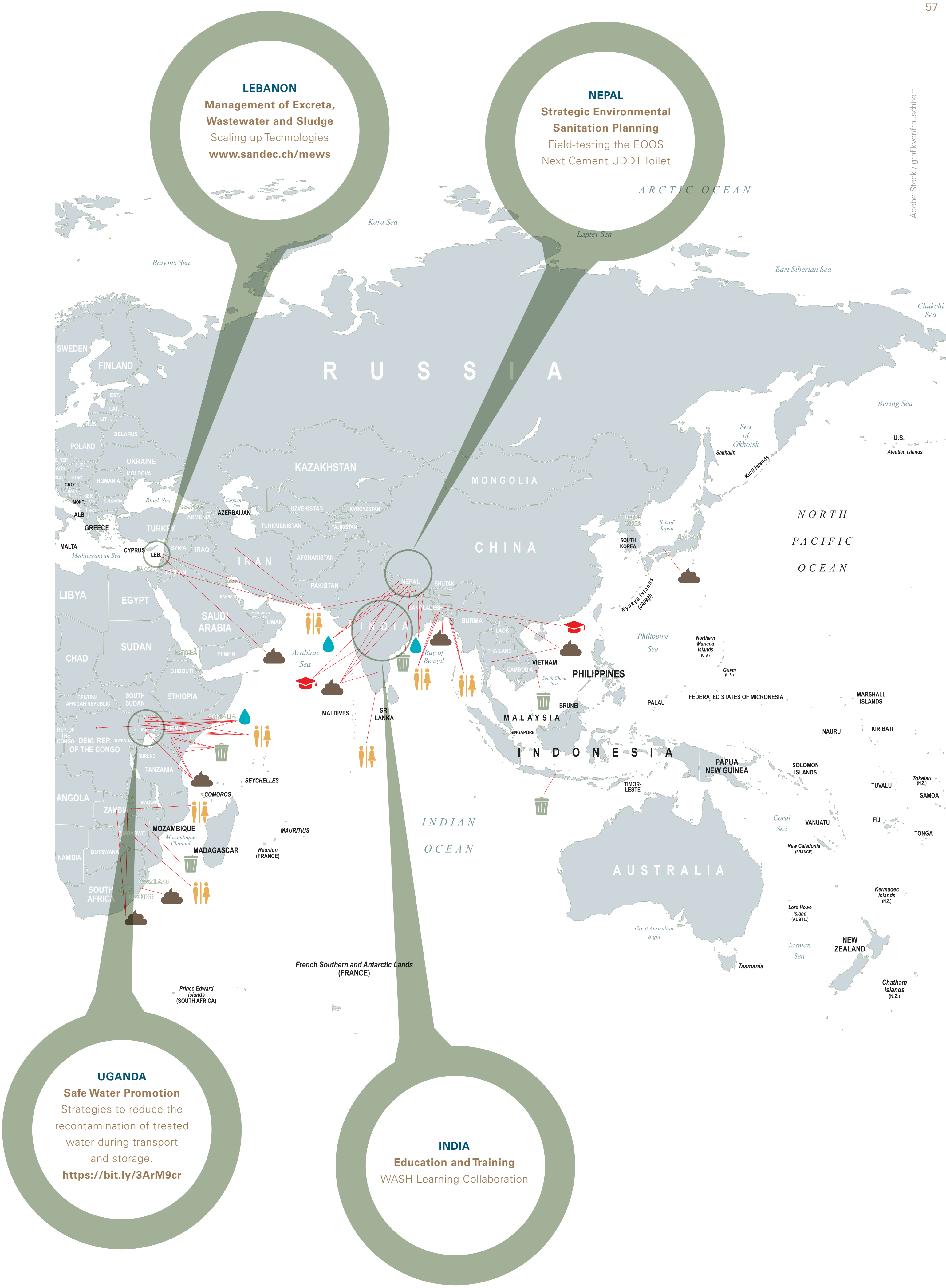
We would like to thank our partners in Uganda (Get Water Uganda & Richard's Studio) for the high level of commitment and flexibility throughout the collaboration.

The video series and user guide can be found here: www.sandec.ch/gdm-manual

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
- Education and Training



Adobe Stock / grafikvonfrauschbert

In Memory of Pierre-Henri Dodane

Agnès Montangero

Photo: Pierre-Henri Dodane.

Sandec would like to dedicate this Alumni Page to the memory of Pierre-Henri Dodane, who died in June 2022 at the age of 48. Pierre-Henri was a discreet, but instrumental player in the Faecal Sludge Management sector, whose high competence, humility and diverse interests marked those who had the chance to collaborate with him.

He started his career at the water and environment engineering school in Strasbourg (ENGEES), specialising in the research, development and implementation of constructed wetlands for wastewater treatment. After a few years at CEMAGREF, Pierre-Henri became a Project Officer at Eawag Sandec with the mission to adapt his field engineering expertise to faecal sludge treatment in low-income countries. He was part of the pioneering FSM research team, working especially on the development of the service chain and the design of planted filters, with a focus on the collaborations in Dakar, Yaoundé and Bangkok. He supervised and mentored a number of students who are now pushing the sector forward in their respective regions.

When Pierre-Henri left Sandec in 2009, he established a consulting career, building and/or contributing to multiple faecal sludge treatment plants and nature-based wastewater treatment plants from Cameroon to Cambodia and Laos, via Madagascar and Kosovo. He was a co-author of the FSM book and led the translation and production of the French language edition.

At FSM5 in Cape Town, a colleague titled him "FSM Hero" with these words: "Because he supported me in doing so many things, impacting my FSM surroundings with vision, and keeping doors open". Pierre-Henri was always interested in the human being, in the people he was meeting through his work. His human qualities made him an exceptional engineer, a true development professional and a citizen of the world. The loss of Pierre-Henri will be regretted. May his soul rest in peace. •

Sandec's Participation at the World Water Forum

Sandec had a significant presence at this year's World Water Forum, which took place in Dakar, Senegal, from 21 – 26 March 2022. Our experts gave presentations at the Swiss Pavilion on the Volaser, the urban Water Flow Diagram and dewatering of faecal sludge, and set up a Virtual Reality exhibit of a faecal sludge management lab in the Sanitation Village. Invaluable exchanges took place with sector experts and development partners. Here are some of the highlights from WWF!

Photo 1: Setting up the water wall of the Autarky toilet at the Swiss Pavilion.

All Sandec

Photo 2: Entrance of the International Exhibition.

Photo 3: Sara Ubbiali assisting two visitors at the Virtual Reality exhibit.

Photo 4: Stanley Sam explains the Volaser to Sandec alum Doulaye Koné of the Bill & Melinda Gates Foundation.

Photo 5: Sandec's Philippe Reymond, Christoph Lüthi and Sital Uprety at the Eawag exhibit.

Photo 6: Sandec staff with four of Sandec's African PhDs. From left to right: Sital Uprety, Parfait Kouame, Stanley Sam, Jean Birane, Amadou Gueye and Elhadji Sonko.

The Sandec Team

From left to right – Front row: Anik Dutta, Frank Mnthambala, Nala, Sital Uprety, Jasmine Segginger, Daniela Peguero, Elizabeth Tilley, Laura Baquedano, Adeline Mertenat, Vasco Schelbert, Paul Donahue
2nd row: Cyril Favre, Abishek Narayan, Regula Meierhofer, Eugene Appiah-Effah, Stanley Sam, Christoph Lüthi, Nienke Andriessen, Caterina Dalla Torre, Sudeshna Kumar, Maria Isabel Amorin Cabrera, Jessica MacArthur
Last row: Kelsey Shaw, Lukas Bouman, Michael Vogel, Philippe Reymond, Fabian Suter, Benjamin Ambühl, Dorian Tosi Robinson, Margot Plassard, Fabian Massa, Chris Zurbrügg
Missing in photo: Sara Marks, Dorothee Spuhler, Linda Strande, Ariane Schertenleib, Christopher Friedrich

New Faces at Sandec

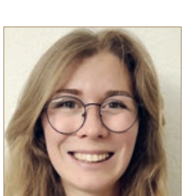
Dorian Tosi Robinson holds an MSc in Environmental Engineering from EPFL, specialising in WASH and waste management in low- and middle-income countries. He has five years of professional work experience in Switzerland, Nepal and Central America with Helvetas and Eawag. Currently, he is a Project Officer in the MSWM and WST groups at Sandec.

Julian Fritzsche completed his BSc in Environmental Engineering at ETH Zurich. After an internship at Sandec working on the SaniChoice tool, he started his Master's in Urban Water Management at ETH Zurich and also works in the SESP group on the evaluation of the implementation of countries on the UNECE Protocol on Water and Health.

Kelsey Shaw is a PhD student in Civil Engineering at the University of Victoria (Canada) in the Public Health and Environmental Engineering Lab (PH2E) and the MEWS group. Her interests are at the intersection of public health, environmental engineering, and sustainability science. The overarching goal of her research is to increase scientific knowledge for the application of sustainable sanitation and wastewater management technologies in resource constrained settings.

Sara Ubbiali completed a Master's degree in Water Resource Management in International Cooperation in 2015 and started working in the WASH sector. She has managed humanitarian projects in Nicaragua, during the Syrian crisis, in Palestinian refugee camps in Lebanon and for the protracted Rohingya emergency responses in Bangladesh and in Myanmar. In October 2021, she joined the SESP group to technically support the humanitarian backstopping mandates.

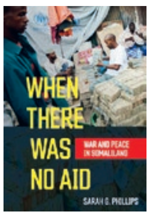
Jackline Muturi is a hydro-science professional with a MSc in Integrated Water Resources Management from the University of Queensland, Australia, and a BS in Earth Sciences (Hydrology) from Maseno University, Kenya. Jackline has worked in water resources management, agriculture development, environmental management and climate change adaptation. Currently, she is a WST group Project Manager of the REACHLab project being implemented in Kenya, Nepal and Bangladesh.



Laura Stocco completed her MSc in Environmental Engineering at EPFL, focusing on environmental and chemical bioprocesses. She was an intern in contaminated sites remediation in Denmark and in wastewater treatment in Vietnam, before co-founding Openversum. Openversum develops household-level drinking water filters with nanotechnology, reaching rural areas in Latin America through a microfranchising distribution system. She works as a Project Officer on biowaste segregation in the MSWM Group.

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.



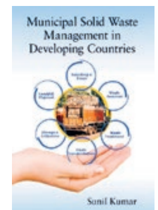
When There Was No Aid: War and Peace in Somali-land

This book explores the reasons for Somaliland's relative peace and stability. It explores how international aid organisations work to justify their own interventions in the global South and whether the quality of a country's governance institutions influence the level of peace and civil order.
By: S. Phillips
Cornell University Press, 2020
256 pages
ISBN: 9781501747175

Water Supply and Treatment

Clean Water for Developing Countries

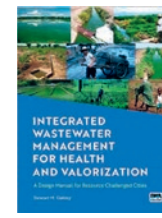
The main purpose of this book is to assist the reader in choosing the best method for providing clean and safe water in a developing country. The author brings more than 50 years of university research and teaching to this subject.
By: J. Dracup
Clean Water Press, 2020
302 pages
ISBN: 9781734352405



Municipal Solid Waste Management

Municipal Solid Waste Management in Developing Countries

Written in view of actual scenarios in developing countries, this book contains detailed and structured approaches to tackling practical decision-making in municipal solid waste management. It provides knowledge on how to develop solutions for solid waste problems in these nations.
By: S. Kunar
CRC Press, 2020
178 pages
ISBN: 9780367574284



Management of Excreta, Wastewater and Sludge

Integrated Wastewater Management for Health and Valorization: A Design Manual for Resource Challenged Cities

This book incorporates the new paradigm of integrated wastewater management for valorisation without surface water discharge using waste stabilisation pond systems and wastewater reservoirs. Emphasis is on sustainable engineering solutions for low- to middle-income cities worldwide.
By: S. Oakley
IWA Publishing, 2022
370 pages
ISBN: 9781789061529

On the YouTube Channel

We would like to recommend this new video produced by Sandec/Eawag that deals with issues in our areas of research.

How to Run a GDM Water Filtration System Teaser Video
This video introduces our series "How to run a GDM water filtration system". This 10-part series teaches about Gravity Driven Membrane (GDM) technology, key concepts about the GDM water filtration system, how to install the ultrafiltration membrane modules, operation & maintenance procedures and more.

Produced by: Sandec/Eawag and Get Water Uganda
Filmed by: Richards Studio Uganda with Get Water Uganda
Edited: Sandec/Eawag 2022, 2:43
It can be seen at: https://bit.ly/3Mvw2PV

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Cover Photo: Two employees of the Ugandan Red Cross are preparing dishes for Total Solids analysis in the Faecal Sludge Field Laboratory located at the newly constructed Faecal Sludge Treatment Plant in Imvepi refugee settlement in Northern Uganda. Ibrahim Mukiza (left), Derrick Muhumuza (right).

Cover Photo by Nienke Andriessen.

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