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Content

Sandec's research contributes towards developing circular economy solutions to water, sanitation and solid waste challenges.

Photo Linda Strande and Christoph Lüthi.

Sandec has a long research track record in developing and improving circular economy approaches for water, wastewater and solid waste problems. In a world where groundwater levels are sinking, droughts are becoming the norm and landfills are overflowing, intelligent solutions are needed more than ever. Central to the theory of circular economy is the concept of reusing resources and products to achieve a zero waste model by turning waste into a valued resource, such as 'new' water, nutrients or energy. Energy capture and nutrient recovery are key drivers for sustainability in waste management and circular economy solutions of the future.

Let me highlight some current examples of how our research contributes to the transition towards circular systems and resource recovery:

In **Uganda** and **Malawi**, the SWIFT project (Sustainable waste-based insect farming technologies) aims to find sustainable waste management solutions using insect-based farming. Waste-based Black Soldier Fly insect farming can offer a sustainable closed-loop solution by transforming biowaste into high-quality insect protein and fat for animal feed. Interestingly, the residual byproduct can also serve as a fertilizer to improve soil fertility. See pages 16–17 for an update on the SWIFT project.

In **India**, we are investigating off-site reuse of domestic wastewater and greywater and fit-for-purpose water quality standards. The Water Reuse project is a multi-department research project at Eawag, focusing on studying water reuse in Bangalore, India. As India is experiencing increasing water stress, new approaches to water reuse for its booming economy and cities are crucial. Page 36 shows how evidence-based research can make a direct impact on water reuse policy.

Resource recovery from wastewater is a promising avenue for the sustainable management of sanitation and can reduce pressure on local resources and offset operation costs. In an ongoing PhD research project conducted with the University of Geneva, the potential of vermifiltration to treat wastewater, while producing an effluent rich in agricultural nutrients (nitrogen, phosphorous and potassium), is being optimised for global implementation. See pages 26–27 for news about the vermifiltration research project.

In May, Eawag-Sandec hosted the Annual Global WASH Cluster Meeting and the 20th Emergency Environmental Health Forum. More than 200 participants from multiple countries, attending in presence and online, came to learn about emergency WASH practices and policies. On page 59, you will find an article with photos of both events.

I wish you a stimulating read with this issue of Sandec News, which will also be my last issue. After nine years as head of the Sandec department, it is time to hand over responsibilities to my successor, Dr. Linda Strande, and to wish her all the best in charting the future of Sandec.

Best regards –
Christoph Lüthi, Director Sandec

Photographer: Paul Donahue

Municipal Solid Waste Management

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

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

Photo Colorful composting bins in a park used for recycling of organic waste after effective separate waste collection in Bandung, Indonesia.

Photo by Laura Velásquez.

What Drives or Hinders People to Segregate Waste? Answers from Abidjan

The RANAS approach was used to determine what drives people to and hinders them from segregating waste at home. While economic benefits motivate some people, results showed that others saw negative social pressure and perceived risk of illness as barriers. Adeline Mertenat[1], Laura Velásquez[1], Laura Stocco[1], Andrée Marie Kouamé[2], Parfait Kouamé3, Christian Zurbrügg[1]

Introduction

Separating waste at source is key for improving waste management systems, conserving resources, and mitigating environmental pollution. By separating waste at the point of generation, valuable recyclables, as well as organics, can be efficiently processed and reused, reducing the amount of waste to be disposed of and, therefore, prevent harmful environmental impacts. This practice also supports economic development by creating job opportunities in the recycling and waste management sectors. In African cities, uncontrolled dumping and open burning remain the dominant waste disposal methods for waste management and the estimated average municipal solid waste recycling is only at 4% [1]. Therefore, waste segregation at source "should be clearly encouraged […] if the potential of *Waste as Resource* is to be achieved", as stated in the Africa Waste Management Outlook [1]. However, fostering behavioural change among people towards consistent separation of their waste remains a significant challenge worldwide. According to literature, a reason for this is the lack of systematic psychological research on waste segregation determinants by researchers prior to designing behaviour change campaigns [2].

To address this lack, a study was conducted in the Agouéto neighbourhood, located within the Abobo commune of the Autonomous District of Abidjan, Côte d'Ivoire, with the aim of: **1)** identifying current solid waste management (SWM) practices at the household level and **2)** scientifically understanding what drives people to and hinders them from separating recyclable waste at source. The study used RANAS (Figure 1), a systematic behaviour change approach, to identify which key psychological factors – Risk, Attitude, Norm, Ability and Self-regulation – are relevant and need to be considered when designing behaviour change interventions [3].

Method

A household survey was developed based on RANAS that included behavioural questions and RANAS behavioural factors and sub factors. The former comprised three questions to distinguish between those who segregate (Doers) and those who do not (Non-Doers): Behaviour – how frequently they separate recyclables or not, Habit – how often they separate recyclables without thinking after producing them, and Intention – to what extent they intend to always separate recyclables in the future. The latter helped identify

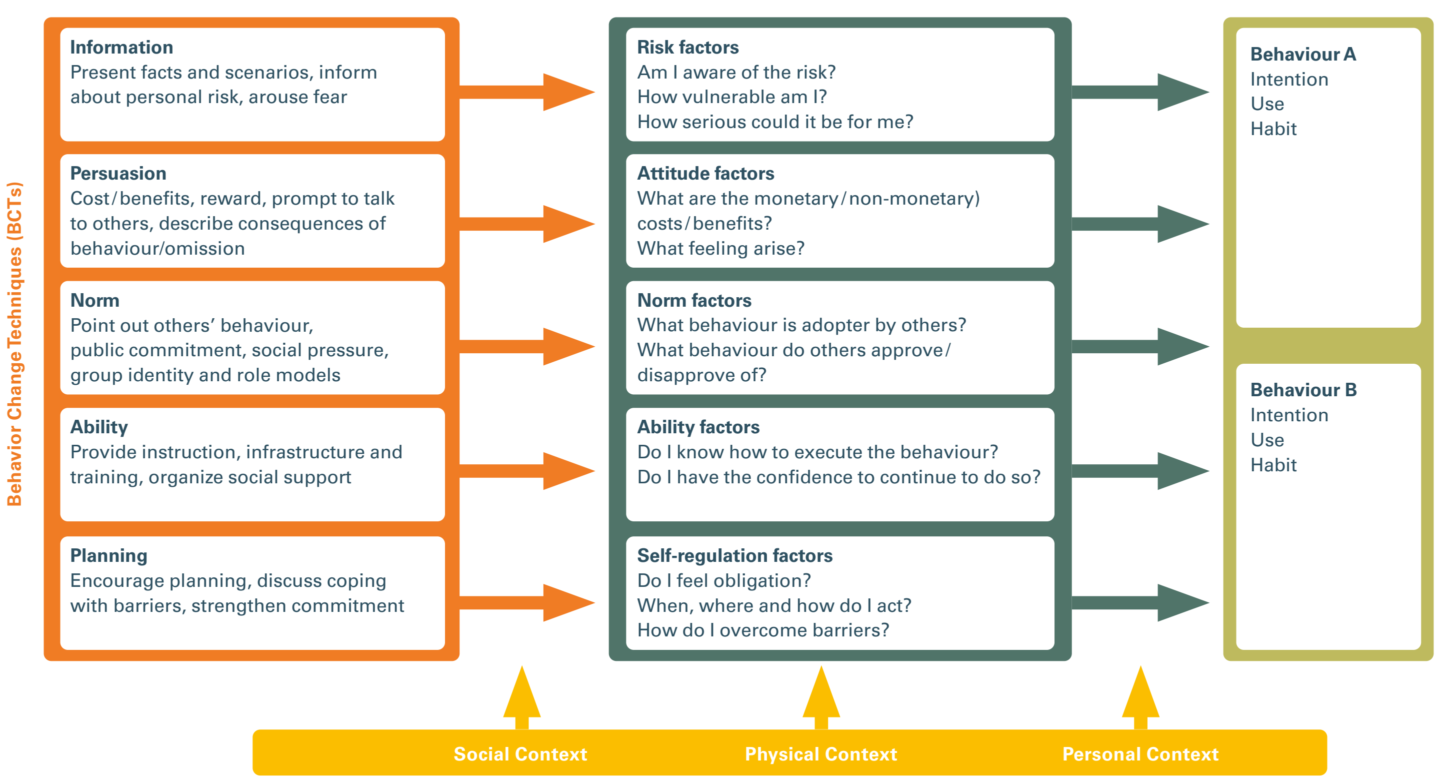

Figure 1: RANAS psychological factors and related behaviour change techniques [3].

the key psychological factors influencing waste segregation behaviour. The survey was conducted at 162 randomly selected households by six trained enumerators organised in groups of two people. Respondents scaled their answers from 1 (never/not at all) to 5 (always/very much). To mitigate bias of self-reported behaviour, only people answering with high scores (3–5) to the three behavioural questions were considered Doers.

Results

Current solid waste management practices

The survey answers showed that women are usually taking care of SWM-related duties at home in the given context (70 %). Waste is usually stored inside the house in reusable material and plastic bags. Every three days on average, someone from the household (63 %) brings the waste to a transfer point. 69 % of the respondents mentioned not knowing what happens to the waste after it leaves their premises.

Separated recyclable items were usually plastic bottles, cans and glass. Recyclables were often kept for personal reuse (mentioned by 77 % of the respondents) or given free to people in need (48 %). While 23 % claimed to sell them to recyclers, they highlighted that the low market price and lack of buyers made it difficult to do so. Organic waste was usually not separated at source (89.5 %). When asked about why waste separation was important, the most common responses were to reduce waste sent to landfills (49 % of occurrence), ease the work of waste collectors (49 %) and make money (20 %).

Psychological drivers and barriers

Results from the RANAS surveys showed that 63 % of the respondents initially declared segregating their recyclables, but only 43 % were defined as Doers. The "Ability" and "Norm" were found to be key factors affecting waste segregation (Figure 2), especially in terms of confidence in performance and personal importance. A more detailed analysis of all the RANAS factors revealed interesting findings. The first one to mention is the Risk aspect. While most of the answers from Doers and Non-Doers were homogenous and scored high, the study revealed that Non-Doers believed that separating waste makes them more prone to contracting a disease. Analysis of the Attitude factor revealed that Non-Doers had a negative stance towards waste segregation, seeing it as time-consuming and requiring much effort. They also did not feel any strong personal obligation to segregate. On the contrary, Doers mentioned feeling proud of segregating and saw the economic benefits as a motivation source. The Norm factor scores were generally low for both Doers and Non-Doers, highlighting the lack of strong social pressure in favour of waste segregation. From the information collected during the interviews, Non-Doers often mentioned that segregating waste was a habit only for very poor people or affluent foreigners. Concerning Ability, Non-Doers mentioned the lack of space and tiredness as reasons for not separating waste, while Doers showed high confidence in being able to organise themselves and execute the necessary actions for waste segregation despite any barriers to doing so. Regarding Self-regulation, Non-Doers showed a higher tendency to forget to segregate and a lower self-commitment towards waste segregation.

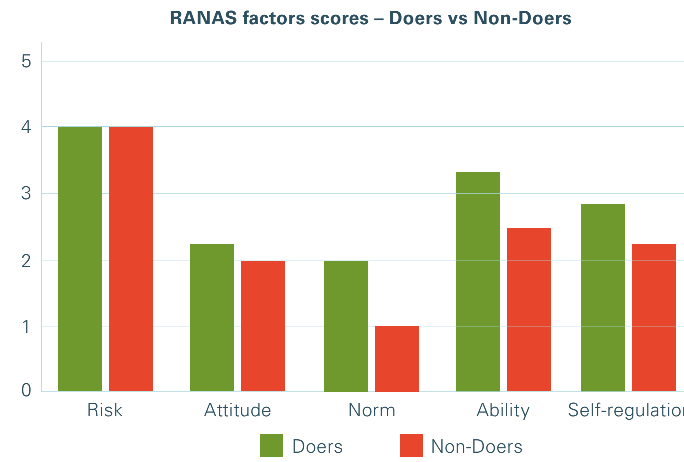

Figure 2: Results of the RANAS analysis.

Conclusion

Besides the economic benefit aspect, our study revealed two interesting unforeseen barriers to waste segregation: negative social pressure and perceived risk of illness. Indeed, contrary to previous studies, which showed social norms being understood as positive drivers for waste segregation, our results show that, in the given context, some specific socio-economic groups feel that waste segregation has a negative connotation, while others consider it an established practice. Some perceive waste segregation as a potential health threat instead of as a sustainable practice aiming at better environmental and human health. These themes would be crucial to tackle in any future interventions in the area, as would working to understand the sources of confidence among Doers. This study highlighted that it is important for researchers to contextualise behaviour change drivers and barriers prior to designing behaviour change campaigns to make sure that local perceptions and (mis)beliefs are taken into consideration. •

References

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Challenges of Flexible Plastics – Lessons from Vietnam

Flexible plastic wastes, are often overlooked in the recycling sector. They are either disposed of or mismanaged, contributing to the global plastic pollution problem. Field research in Vietnam and a literature review reveal significant hurdles in addressing flexible plastic waste. Aravind Edamanakunnel Soman[1], Thi Hanh Tien Nguyen[2], Christian Zurbrügg[1]

Aravind Edamanakunnel Soman

Photo 1: Waste recycler collecting valuables from the landfill, but leaving behind flexible plastic waste.

Aravind Edamanakunnel Soman

Photo 2: Flexible plastic waste in Minh Khai plastic recycling craft village.

Introduction

In 2022, the United Nations Environment Assembly (UNEA) adopted resolution 5/14, aiming to end plastic pollution by 2040. Mismanaged waste is the largest contributor to plastic pollution. Of the approximately 385 million tonnes of plastic waste generated annually (2019), 64 % is disposed of (incinerated or disposed of in engineered landfills), 29 % is mismanaged (disposed of in dumpsites, openly burnt, or leaked into the environment), and only 7 % is recycled. Studies, however, show that implementing a comprehensive set of policies across the entire plastic lifecycle could reduce the annual volume of mismanaged plastic waste by 90 %.

Among the plastic waste collected for recycling, the majority consists of rigid plastics, sometimes referred to as hard or solid plastics (e.g., PET bottles or HDPE bottles). The remaining flexible plastics (FP) (e.g., carry bags or multilayer food packages) are often not preferred for recycling because they are considered difficult to recycle, hard-to-recycle, low-value, or non-recyclable and less than 1% are recycled. Consequently, it is this fraction that remains mismanaged.

In a 2015 study [1], Vietnam was considered the fourth highest contributor to marine plastic pollution. With an annual per capita use of plastics of 81 kg in 2019, coupled with significant challenges in managing plastic waste due to inadequate waste management infrastructure, lack of recycling facilities, and limited public awareness about plastic pollution, Vietnam is facing a nationwide plastic pollution crisis. Like most countries in the world, Vietnam does not have policies focused specifically on flexible plastic pollution, nor are there studies addressing this issue.

Plastic Waste Management in Vietnam

In Vietnam, there are 1,322 municipal solid waste (MSW) treatment facilities nationwide, comprising 381 solid waste incinerators, 37 composting plants, and 904 landfills. A significant number of these landfills are dumpsites (Photo 1). Compared to the global recycling rate of less than 10 % for plastic waste, the recycling rate in Vietnam is better, with more than 30 % of plastic, predominantly hard plastic, being recycled. The informal sector dominates plastic waste recycling in Vietnam, accounting for more than 90 % of these recycling activities; however, it faces many challenges and is often criticised for its high risk of pollution.

Flexible plastic waste status	Specific challenges in the solid waste management chain	
	Collection and transport	*Sorting and Treatment*
Large plastic production and short lifetimes of flexible plastic (packaging) leads to massive waste volumes	Amounts stress the already limited solid waste management capacity	
Flexible plastic waste has low bulk density	Difficult to collect and increases the transportation cost	Equipment complications and process disruptions
Flexible plastic types vary in chemical composition and density leading to a highly heterogeneous material		Difficult to sort, which impacts on economic viability and/or low quality of recyclate if not sorted
Flexible plastic may have multilayered and/or multi-material composition often without Resin Identification Code (RIC)	Difficult to detect and identify	Difficult to detect and identify
Flexible plastic often remains mixed with other waste materials and is therefore contaminated	Awareness and behaviour of segregation from mixed waste is lacking. With segregation at source this would require separate collection. Contaminated plastic waste is unappealing and unhygienic.	Pre-treatment is required to clean the plastics from contamination, increasing costs and decreasing financial feasibility of recycling.

Table: Status and challenges for flexible plastic waste.

The recycling activities of the informal sector include waste collection, separation, shredding, and extrusion, and are carried out in craft villages. Craft villages are a unique feature of rural Vietnam that have evolved over hundreds of years, where artisans have been practicing their skills for generations. However, the recycling activities that have emerged in recent decades in craft villages pose a threat to both health and the environment due to the release of toxic pollutants. Field visits to three informal recycling craft villages (Xa Cau, Minh Khai and Phan Boi), a formal recycling facility, a landfill, scrap shops, and a packaging production unit in Vietnam were conducted to try to capture the challenges and future opportunities for plastic recycling (Photo 2).

Recycling activities in the craft villages are small-scale, often confined to household levels. This restricts their ability to expand due to space and location constraints. There is a significant lack of awareness about the long-term impacts of plastic pollution, with most workers or enterprises prioritising short-term profits over sustainable practices. The use of outdated technology, and unskilled labour often results in the release of toxic chemicals into the environment, overconsumption of materials and fuel, and substandard output quality of the recyclables. Health and safety measures for labourers in the craft villages are often compromised, increasing the risk of accidents and health issues. Additionally, recyclers are unaware of global market dynamics, newly emerging recycling technologies, and investment opportunities, limiting their business development and chances for expansion.

Specific Challenges of Flexible Plastics

Flexible plastics (FP) are commonly identified as "plastics that can be easily scrunched in your hand". FPs are commonly used in the packaging, agricultural and construction sectors. When plastics are made thinner without losing their essential properties, they become lighter, more efficient, flexible, and cost-effective compared to thicker counterparts; however, the end-of-life management of FP becomes more complex. Scientific research, technological advances and available information on flexible plastic recycling is scarce, scattered or hidden. The Table summarises the status and specific challenges of FPs in Vietnam.

Conclusion

Currently, only industrial flexible plastic waste is viable for recycling as they are mostly clean and segregated and easily available from point sources in larger amounts. Capturing and processing the high volumes of post-consumer household and commercial plastic waste will necessitate increasing public awareness to improve segregation and build separate collection systems to facilitate financial viability. The recent introduction of the Extended Producer Responsibility (EPR) policy can give leverage to the recycling of low value plastic waste, but it requires clear communication and stakeholder involvement. Recycling craft villages are vital, but they operate with outdated technologies and inadequate safety measures, requiring modernisation and formalisation. Mechanical recycling remains the most feasible option, but greater awareness and access to advanced technologies are needed. Although emerging players in Vietnam's recycling sector show promise, driven by access to global markets and technology, they face a shortage of technical expertise. Encouraging local production of recycled products can add value and reduce dependency on exports. By addressing these aspects, Vietnam can enhance its plastic waste management, reduce environmental impact, and promote sustainable practices.

A global momentum for improved plastic waste management is reflected in the ongoing plastic treaty negotiations at the international level. Nevertheless, even in these negotiations, there is no specific focus on the challenges of flexible plastics. Furthermore, Vietnam weakened the efforts for an ambitious plastic treaty during the fourth session of the International Negotiating Committee (INC-4) by aligning with countries resistant to upstream measures for addressing plastic pollution. Vietnam should further investigate the long-term trade-offs in sustainable development and align its stance accordingly for a more robust and effective plastic pollution strategy that addresses the entire life cycle of plastic. •

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Is Biogas a Feasible Option for Humanitarian Contexts?

A new publication provides a comprehensive guide for practitioners to assess the feasibility of anaerobic digestion in humanitarian contexts. It includes a tool to help estimate gas and digestate output based on the waste feedstock fed into the reactor. Dorian Tosi Robinson[1], Sara Ubbiali[1], Christian Zurbrügg[1]

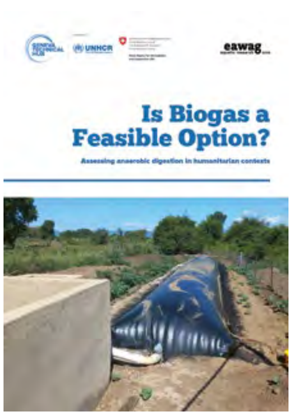

Figure 1: Cover page of the new publication: 'Is Biogas a Feasible Option? Assessing anaerobic digestion in humanitarian contexts'.

Introduction

In humanitarian contexts, solid waste management remains a critical challenge with significant implications for human health and the environment. In these complex settings, there is increased interest in using waste as a resource, which provides new opportunities for sustainable management. The use of anaerobic digestion for biogas production offers numerous benefits for the environment, livelihoods, and human health. Biogas, a renewable energy source, is generated from waste that might otherwise be disposed of unsafely, potentially causing pollution, vector proliferation, and greenhouse gas emissions. Therefore, the implementation of biogas systems can improve solid waste management. The digestate from anaerobic digestion is nutrient rich and can be used as fertilizer, thereby positively impacting soil quality, food production and security. Furthermore, biogas systems can create livelihood opportunities and jobs. The use of biogas also reduces reliance on wood for fuel and, therefore, contributes to the prevention of deforestation. Substituting biogas for wood also reduces health threats of respiratory disease, as biogas is non-harmful when compared to exposure to smoke and small particulates from firewood or other solid and liquid fuels.

However, the success of biogas projects depends on careful feasibility assessments. Regrettably, incomplete or poor assessments have led to the failure of many biogas projects. The appropriateness of biogas solutions must be carefully evaluated based on the specific local context and conditions prior to any decision regarding its implementation. The lack of a guidance document to support practitioners in assessing biogas as an option for waste management and energy production led to requests from the Geneva Technical Hub to produce such guidelines. Primarily authored by Eawag Sandec, the guide outlines all critical aspects to consider when evaluating the feasibility of anaerobic digestion for humanitarian contexts. This includes the guidance document: *Is Biogas a Feasible Option? Assessing anaerobic digestion in humanitarian contexts* (Figure 1) and an Excel-based tool, the Technology Evaluation Tool Biogas (TET – Biogas).

Is biogas a feasible option?

The biogas feasibility assessment package provides practitioners with tools, key considerations to address, checklists and guiding questions to determine the feasibility of biogas systems. Figure 3 shows the navigation tool of the biogas package with its four main parts:

- *Motivation and expectations* outlines how to define the purpose of the project, who the beneficiaries are and who would operate, maintain and ensure that the system performs as desired to ensure sustainable performance.
- *Feedstock identification* details how to evaluate the types, amounts and availability of feedstock. For instance, some questions it addresses are: are suitable feedstocks available? Can they be collected easily?
- *Scale, technology, treatment and operation* addresses the types of technology and treatment and key questions, such as the location of the treatment unit, how and where the biogas will be distributed and used, etc. Key concepts about biogas technology and how to operate such systems are also explained in this section.

Inputs

	Lower value	Higher value	
Water [L/day]	110		*Amount added in your feedstock*
Manpower	1	1	*For operation and maintenance of the system*

Products		Potential outputs	
Potential biogas production [m³/day]	17.5	**Hours of cooking on a household burner per day [h/day]**	53.7
Digestate production [L/day]	290	**Number of households using a stove for 5 hours per day**	10.7

Design

	Lower value	Higher value	
Active bioreactor volume [L]	9,300		*Excludes volume for gas storage*
Space requirement [m²]	31	164.3	*Depends on the type of technology available. Flexible bags/balloon digesters have the highest footprint.*

Figure 2: Example of output results from the Technology Evaluation Tool for Biogas (TET – Biogas).

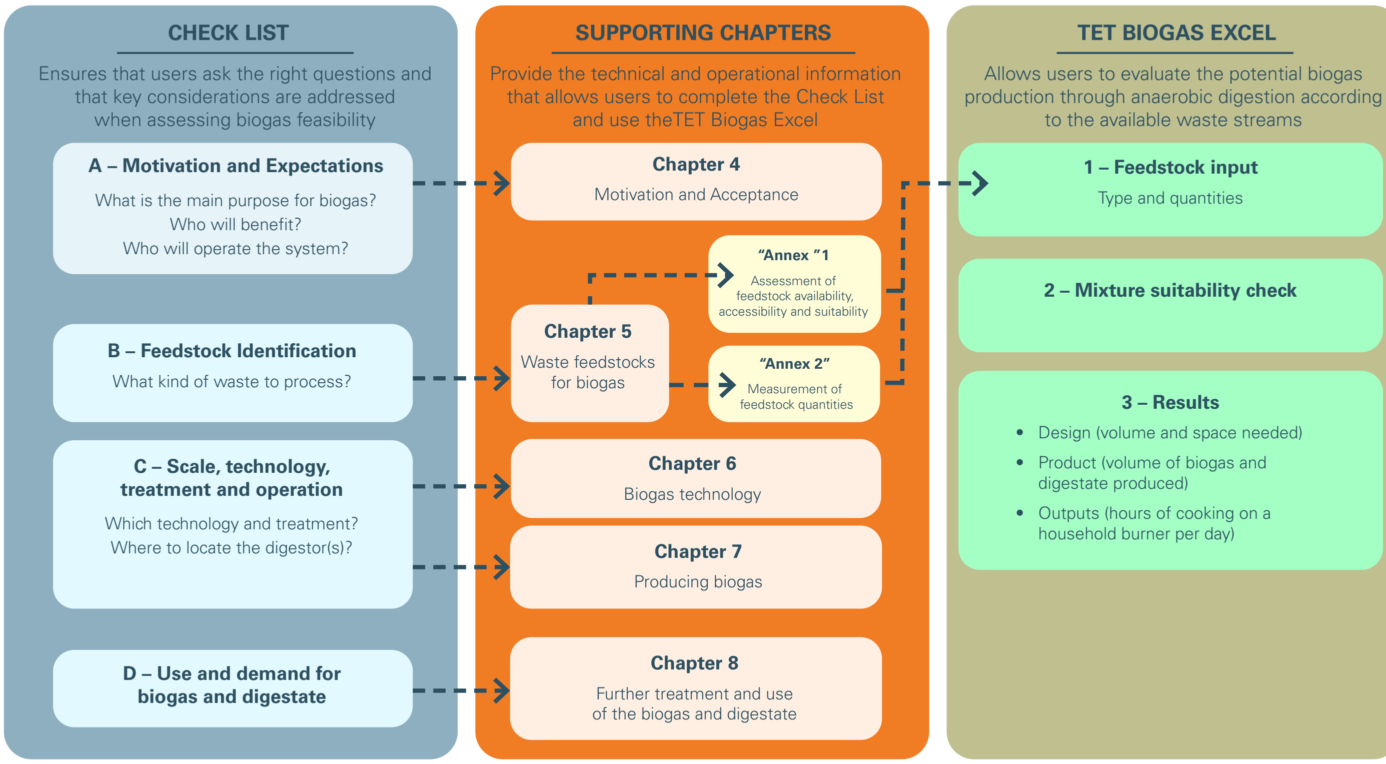

Figure 3: Navigation tool for the "Biogas Package" [1].

- *Use and demand for biogas and digestate* outlines how to address the products produced. Some example questions include: are the products accepted? Will they be used? Is there a market for them?

Technology Evaluation Tool (TET – Biogas)

Along with the guidance document, an Excel-based Technology Evaluation Tool (TET – Biogas) is provided to support practitioners in evaluating the potential biogas production. The user can identify the types and amounts of waste streams (feedstocks) that are available based on an assessment. A default feedstock database to select from includes manures, organic waste, human excreta, straws, leaves and others, but users can also enter their own specific feedstock, if the feedstock properties are known (total and volatile solids, biochemical methane potential, and carbon and nitrogen content). The tool then checks the suitability of the mixture of feedstock in terms of carbon to nitrogen (C/N) ratio and water content, both key parameters for anaerobic digestion. It also suggests if any adjustment is necessary, for example, by adding water. If the waste mix is suitable, the tool depicts a green symbol and shows a first approximation of biogas and digestate production, the manpower required to run the facility, space requirements and how many households could be provided with five hours of biogas for cooking per day. These estimations should be reviewed and evaluated in detail by a biogas expert who can also advise on system design and implementation.

Example of results TET – Biogas

An example of output results from the TET – Biogas is shown in Figure 2 for a small-scale biogas system where 200 kg of organic wastes per day are collected as feedstock. In this case, adding water (110 L) was necessary to balance moisture needs. The tool estimates that one person would be required to run the system, which could potentially produce about 17 m^3 of biogas per day. This amount of gas could be used for the cooking needs of 10 households (using a stove five hours per day). Analysis of this example shows that while 10 households benefit from the gas, the amount of organic waste required to operate the system is more than can be supplied by the 10 households. This example shows the importance of considering where the waste can be generated and where the biogas will be produced and used. Is it more efficient to use the biogas in a community canteen or restaurant instead of in individual households? This is one of the many questions practitioners must think about and the guidelines and the TET – Biogas allow for this assessment.

Conclusion

Selecting appropriate technologies for solid waste management is crucial for sustainable and safe waste management. These guidelines and the TET – Biogas can support field practitioners to quickly assess whether biogas could be a good technology to implement based on their context and specific needs. By understanding the key concepts and steps outlined in the guidelines, practitioners are also able to effectively communicate with biogas professionals on how to set up new anaerobic digestion projects. •

'Is Biogas a Feasible Option? Assessing anaerobic digestion in humanitarian contexts'

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Can Smaller Biowaste Particles Boost Black Soldier Fly Larvae Performance?

Improving performance of Black Soldier Fly Larvae on fibre-rich grass clippings and spent grain by reducing the particle size. Daniela A. Peguero[1,2], Moritz Gold[2], Laura Velasquez[1], Alexander Mathys[2], Christian Zurbrügg[1]

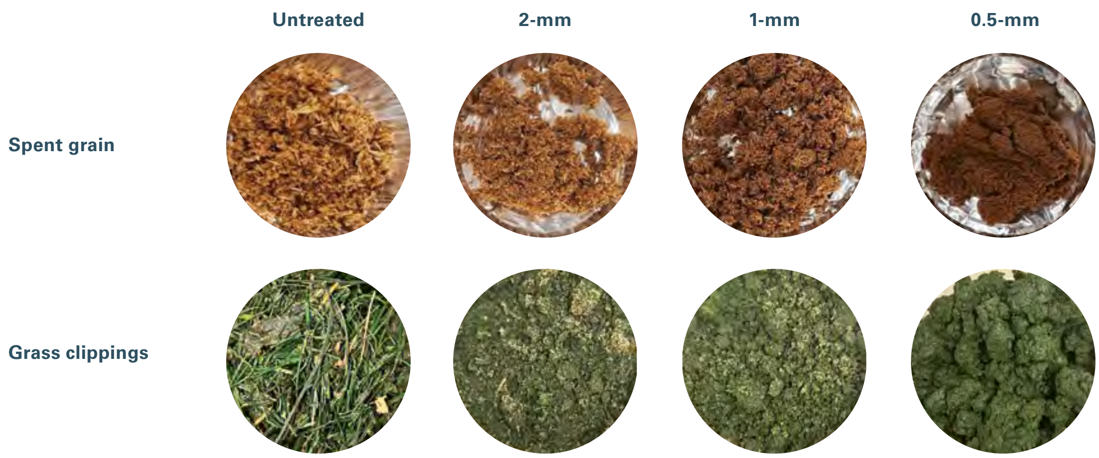

Figure 1: Images of the different reduced particle sizes for spent grain and grass clippings [1].

Background

Black Soldier Fly Larvae (BSFL) are increasingly recognised for their ability to treat waste effectively, reducing the volume of biowaste by up to 75 % dry mass (DM). They transform biowaste into a nutrient-rich insect biomass high in protein and fat, ideal for pet food, aquaculture and animal feed. As population growth continues to rise and meat demand increases, the need for alternative animal feed becomes more important. In addition to the larvae serving as a feed protein source, the residual material from this process, known as frass, can serve as a soil conditioner to enhance soil quality. While BSFL can feed on a diverse range of biowastes, they have difficulty breaking down biowastes containing high fibre contents (> 50% DM), i.e. grass clippings and brewery spent grains [1]. This can impede bioconversion and waste reduction efficiency, prolong larval development times, and affect the overall output quality. The larvaes' ability to transform grass clippings and brewery spent grain could be improved by reducing the particle size through physical pretreatment. Physical pretreatments are widely used for other biowaste management technologies, such as anaerobic digestion, to increase the conversion of fibrous biowastes and byproducts into biogas. This study evaluated if reducing the particle size through physical pretreatment could increase larval performance (e.g., bioconversion rate, waste reduction and fresh larval mass). The full article is available open access at:
https://doi.org/10.1016/j.wasman.2024.02.012.

Reduction of biowaste particle size

The study tested the effect of mechanical pretreatments in two separate experiments using grass clippings and spent grain. In the first, the substrates (3–4 kg wet mass) were milled through screens of 0.5, 1 and 2 mm and compared to untreated substrates (i.e., without pretreatment). After observing that smaller particle sizes improved the BSFL bioconversion rate, the second experiment used only a 0.5 mm screen size for untreated substrates, which prior to milling, were first frozen by dry ice. The ratio of dry ice to substrate was 2:1 for spent grain and 3:1 for grass clippings. Images of the substrates before and after mechanical pretreatment, using screen sizes of 0.5, 1 and 2 mm, are shown in Figure 1.

Larval feeding experiments

Larval feeding experiments were done with untreated and mechanically pretreated substrates with three to four replicates per treatment. In the first experiments, larvae were reared in 7.5 cm diameter by 11 cm high plastic containers and received 35 mg DM substrate / larvae / day for nine days under controlled climate conditions of 28°C and 70% relative humidity. In the second mechanical pretreatment experiment, larvae were given 35 mg DM / larvae / day (spent grain), and 23 mg DM / larvae / day (grass clippings) in slightly larger containers (21 cm x 15 cm x 12 cm). Given the container size and larval density, the days of the experiment had to be reduced from nine days to six days and the ambient temperature and humidity were 30 °C and 50–70%. Typical larval rearing performance metrics, such as bioconversion rate, larval fresh weight and waste reduction, were determined. All experiments maintained a larval density of 2.5 larvae / cm^2 and all containers were covered with a mosquito net to prevent escapes.

Larval feeding experiment results

Mechanical pretreatment of spent grain and grass clippings improved larval performance (Figure 2). Initial experiments demonstrated that reducing the particle size using a 0.5-mm screen, resulted in a 44–53% increase in fresh larval weight (wet mass WM). There was a 13–32% increase in the bioconversion rate of grass clippings compared to untreated substrate.

Contrary to expectations, the results of the second experiment varied. While grass clippings mechanically pretreated with the 0.5-mm screen continued to show improvements in larval fresh weight and waste reduction compared to untreated substrate (Table), it was less pronounced than in the first experiment. Conversely, larval performance on mechanically pretreated spent grain was not improved, in contrast to the first experiment where 0.5-mm milled spent grain had resulted in a 53 % increase in bioconversion rate.

Interestingly, the dynamics of larval weight gain highlighted the impact of rearing conditions. For example, increasing the larval rearing container size increased the volume-based larval density from 0.06 larvae/cm^3 to 0.2 larvae/cm^3 and also necessitated a reduction in the rearing duration from nine to six days. Both changes are critical factors that can impact larval growth outcomes.

Conclusion

Reducing biowaste particle size through mechanical pretreatment has proven promising for boosting larval growth and waste reduction efficiency. Improved larval performance increases growth and enhances larval protein conversion, making the waste a more valuable resource for animal feed due to the higher protein output per unit of biowaste. Although results varied for spent grain – showing improvements in smaller containers, but not in larger ones with shortened feeding time – mechanical pretreatment is still worth exploring. Conversely, grass clippings consistently showed a positive increase in larval performance after mechanical pretreatment.

A next step should investigate the impact of larval density on a volume basis and examine the physical properties of biowaste, i.e. bulk density and air space, to optimise the conditions for larval growth and waste reduction. Optimising these factors could improve bioconversion methods and enhance the sustainability of using larvae in biowaste management. •

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Substrate	Treatment	Fresh larval weight (mg wet mass/ individual larva)	Bioconversion rate (% DM)	Waste reduction (% DM)
Spent grain	Untreated	88.5 ± 4.6	10.5 ± 0.6	47.1 ± 1.2
	0.5-mm	100.8 ± 3.8	10.9 ± 0.7	37.3 ± 0.8
Grass clippings	Untreated	50.4 ± 3.4	5.6 ± 0.3	17.0 ± 3.2
	0.5-mm	62.1 ± 3.5	7. 0 ± 0.4	36.6 ± 1.3

Table: Second mechanical pretreatment larval feeding experiment for spent grain and grass clippings and treatments (untreated and 0.5-mm). Data displayed are mean ± standard deviation (n = 3) [1].

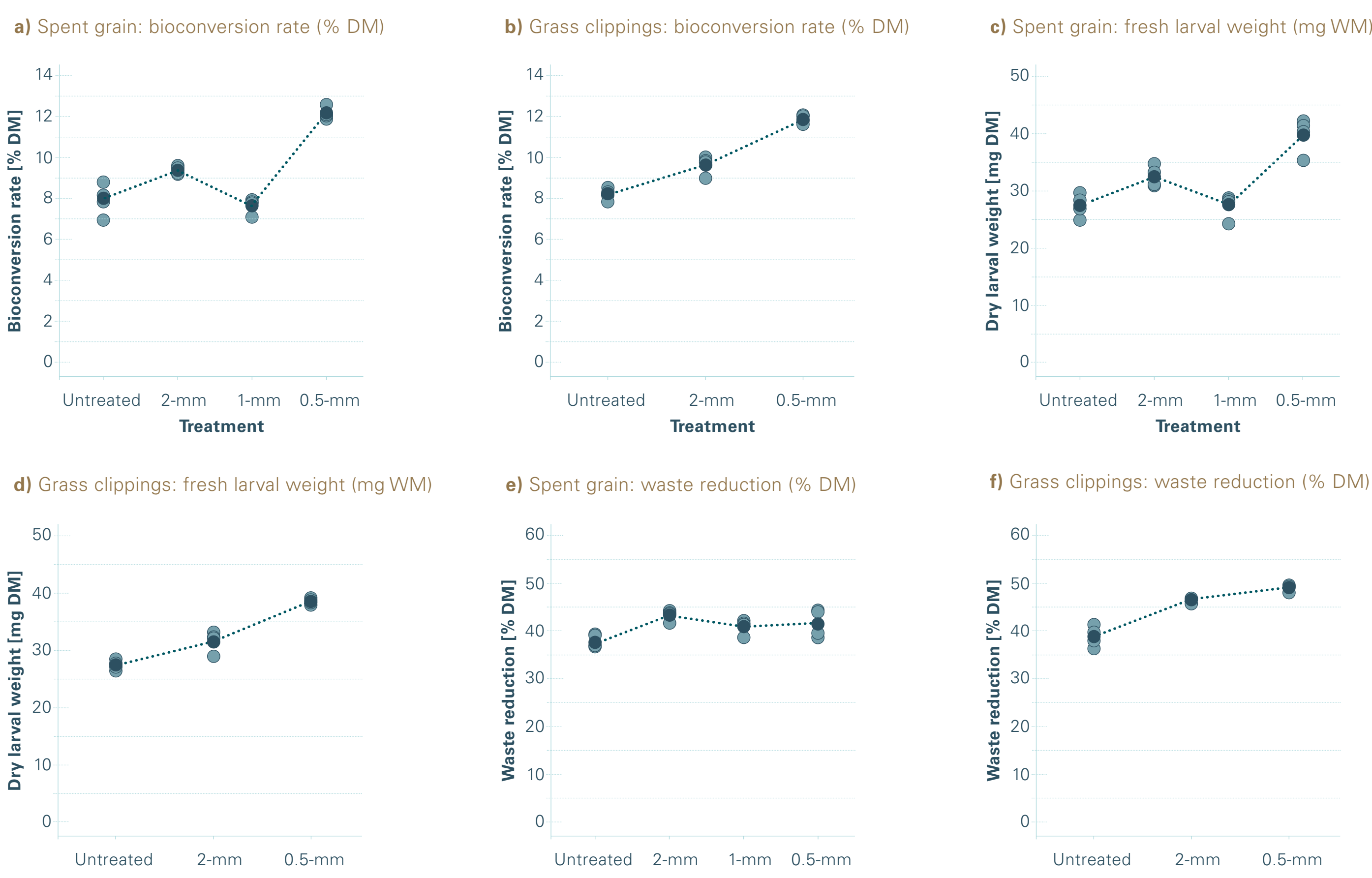

Figure 2: For experiment 1: bioconversion rate, fresh larval weight, and waste reduction on (a,c,e) spent grain and (b,d,f) grass clippings and treatments (i.e., untreated and treatments: 2-mm, 1-mm, and 0.5-mm). Data displayed for experiment 1 are mean (bold) and replicates (grey) (n = 4) [1].

[1] Eawag / Sandec, Switzerland
[2] ETH Zurich, D-HEST, Sustainable Food Processing, Switzerland
Funding: European Union's Horizon 2020 Research and Innovation Program under grant agreement no. 861976 project SUStainable INsect CHAIN (SUSINCHAIN). https://susinchain.eu/
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BSFL Substrate Navigator Online Tool and Pilot Facilities

The Sustainable Waste-based Insect Farming Technologies (SWIFT) project began in May 2023 on Black Soldier Fly farming in Uganda and Malawi. One year later, the project has made significant progress with three sites and the development of an online tool for practitioners. Daniela A. Peguero[1], Marc Reusser[1], Christian Zurbrügg[1]

Bram Dortmans

Photo 1: SFHC staff showing smallholder farmers the Black Soldier Fly room in Malawi.

Bram Dortmans

Photo 2: SWIFT partners Burton Gama, Haswell Nelson and Laifolo Dakishoni, Black Soldier Fly operators from SFHC in Malawi are training smallholder farmers on how to harvest BSFL.

Background

The Sustainable Waste-based Insect Farming Technologies (SWIFT) project, which runs from May 2023 to April 2026, promotes the adoption of waste-based Black Soldier Fly (BSF) farming among smallholder farmers and small- to medium-scale enterprises in Uganda and Malawi. BSF farming is crucial for waste management, transforming biowaste into high-quality insect protein and fat for animal feed, with frass, the residual byproduct, serving as a valuable fertilizer. This approach helps manage waste sustainably, increases the resilience of smallholder farmers and strengthens local food production in the face of growing food insecurity and population growth. One year into the project, significant developments include the establishment of three Black Soldier Fly Larvae (BSFL) sites and the creation of an online tool to support BSF practitioners.

Updates on pilot facilities in Uganda and Malawi:

Uganda:

In Jinja, Uganda, Bioconvision, a small-scale enterprise, operates the BSFL facility. It processes one ton of organic waste per day, with the goal to increase this to 10–15 tons of organic waste per day. It is also a demonstration, communication and training site, facilitating cross-country learning and knowledge sharing. A notable highlight was the two-week workshop attended by Malawian operators who trained at the Jinja facility, followed by the Bioconvision site manager visiting Malawi to provide follow-up training to the operators of the Malawi pilot units.

Malawi:

In Malawi, there are two BSFL facilities, using the Simplified BSF Approach (SIMBA) developed by the SWIFT project team, at Mzuzu University and Soil Food Healthy Communities (SFHC). They function primarily as demonstration and training centres (Photo 1). As part of the project goal, three smallholder farmers were identified and trained to operate a "part-time BSF unit" with pig manure as a substrate (Photo 2). The larvae grown are used as feed for pigs on the same farm. These model farmers will serve as early adopters and their farms as demonstration units for other farmers. The two SIMBA guidelines, published to assist smallholder farmers, outline how to maintain the BSFL reproduction cycle and the waste processing unit, equipment needs and standard operational procedures. They are being tested by practitioners for feedback, and once validated, will be made freely available.

BSFL Substrate Navigator: An online tool

To assist current and prospective BSF practitioners, the project team developed an online tool, the BSFL Substrate Navigator (scan the QR code below to access the tool). It provides comprehensive information on BSF larval performance on various substrates and the corresponding nutrient composition of each substrate (Figure). An in-depth literature review of available substrates and their performance

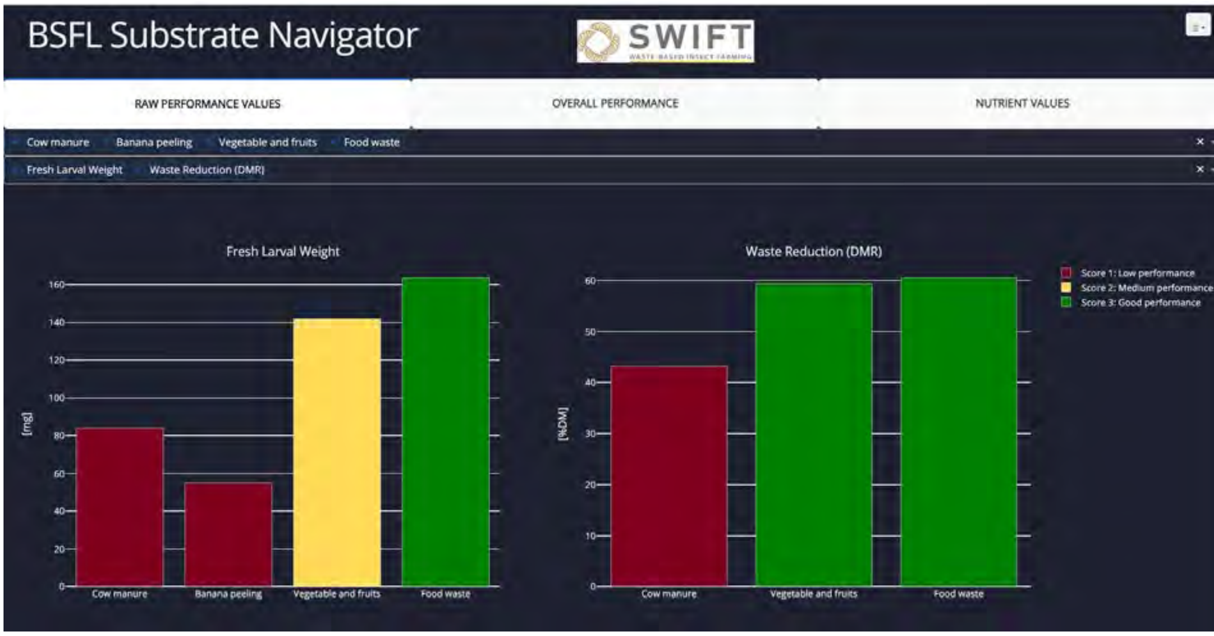

Figure: An overview of the output you will receive when analysing, for example, four different substrates for fresh larval weight and three different substrates for waste reduction. The scores are colour-coded: score 1 indicating low performance, shown in red; score 2 indicating medium performance in yellow; and score 3 representing good performance, shown in green.

comprises the content of the Navigator, which is structured into three main sections:

1. Overall Performance Score

This section allows users to explore larval performance on various substrates (e.g. cow manure, vegetable and fruits, food waste, etc.). An overall aggregated score is determined based on the following key larval performance indicators: fresh larval weight, dry larval weight, bioconversion rate, waste reduction, and survival rate. Each larval performance indicator is equally weighted, with scores ranging from 1 to 3 (1 the lowest, 3 the highest), which are then averaged to produce a mean value. The score provides a generalised assessment of how well the larvae perform on a specific substrate. For more detailed insights, users are encouraged to refer to the raw performance values.

2. Raw Performance Values

In this section, users can explore the desired larval performance indicator on specific substrates, as well as a comparative analysis of multiple substrates and larval performance indicators that offer detailed insights into the performance metrics. For instance, practitioners interested in the amount of insect biomass produced from a specific substrate would look at the bioconversion rate. Those wanting to estimate the residue remaining for frass production would consider the waste reduction for that substrate and then roughly estimate how much would be leftover. The ability to select multiple substrates allows for direct comparison, which is useful for people with diverse wastes available in their region. Hovering over the bars reveals the mean and median values, the variability among different studies, and the number of studies (n) used to create each specific bar. Clicking on a bar displays the precise reference of the relevant studies at the bottom of the tab.

3. Nutrient Values

This section enables practitioners to assess the nutrient composition of substrates, such as protein, fat, non-fibrous carbohydrates, fibre and moisture content. The Navigator does not yet allow for evaluating mixtures of substrates; however, by understanding the nutrient content of each substrate and their nutrient values, practitioners can explore the potential of mixing combinations to optimise larval performance values. Similar to the Raw Performance Values section, users can hover over bars to view more detailed information, such as mean and median values, variability, and the number of studies (n) utilised for the assessment. Clicking on a bar reveals the reference of the corresponding study, providing access to detailed research data.

Menu Button

With the menu button on the top right corner, you can gain more information about the statistical analysis used in this application, find our contact details, and see the recommended citation for this application, if you wish to use some of the data.

Outlook

Project results to date show that the SWIFT project is laying the groundwork for organic waste management and protein production using BSFL in Uganda and Malawi. The expansion of the BSFL facility in Uganda and the growing network of trained smallholder farmers in Malawi indicate strong potential for broader adoption, improved food security and enhanced environmental sustainability in the region. Follow us on our website and social media to get the latest updates on our newest publications and project outcomes.

Acknowledgement

SWIFT project team members: Cyril Studach, Lucas Palumbo, Bram Dortmans, Stefan Diener, Allan John Komakech, Isaac Rubagumya, Simon Kizito, Florence Lwiza, Frank Mnthambala, Gift Chawanda, Esther Lupafya; Laifolo Dakishoni, Konstantin von Hoerner, and Sheila von Hoerner. •

BSFL Substrate Navigator

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Planning for Zero-Waste at Schools – Presenting a "How-to" Toolkit

In close collaboration with schools in Nepal and Peru, a three year project tackled waste management and recycling at school level. The aim was to help schools plan for a Zero-Waste approach. A comprehensive Toolkit was recently published to support these waste management efforts. Adeline Mertenat[1], Christian Zurbrügg[1]

Figure: Planning steps – adapted from UN-Habitat [3].

Introduction

Education has long been a critical factor in addressing environmental and sustainability issues to ensure human and environmental well-being. UNESCO's Education for Sustainable Development (EDS) programme recommends that education "empower and equip current and future generations to meet their needs using a balanced and integrated approach to the economic, social and environmental dimensions of sustainable development" [1]. These are also the precepts of the Zero-Waste Toolkit. It provides step-by-step guidance and a set of tools to help develop and implement Action Plans to minimise waste and maximise recycling of materials and resources in educational institutions with low-tech solutions appropriate for low- and middle-income settings. The Toolkit builds on proven methodologies and technologies from the sanitation and solid waste management (SWM) sectors [2, 3].

Toolkit audience

The Toolkit, available for download below, targets individuals and organisations:

- School community members (teachers, students, non-teaching staff, etc.) motivated to improve SWM in their own institution;
- Non-Governmental Organisations (NGOs) and civil society organisations wanting to support educational institutions in developing their Zero-Waste approach.

Toolkit content

The guidebook outlines a seven step approach, adapted from the planning process documented by UN-Habitat [3] and explains activities to become a Zero-Waste School (Figure), e.g. how to perform a waste audit or a recycling market assessment. Eleven factsheets present best practices for organic and non-organic waste recycling, i.e. vermicomposting, biogas production, ecobricks and plastic extrusion. Technical resources cover SWM issues, e.g. worldwide waste generation, impacts of inappropriate waste management, (bio) degradable plastic, and benchmark indicators on frequency of waste collection services. The Toolkit has a list of resources specifically for schools, such as accessible SWM online courses, and is in English. French and Spanish versions are in development.

Conclusion

This Toolkit is just the start. Through its use and the sharing of experiences, we hope to continue improving it. Our aim is that it fosters Zero-Waste learning, application and practice among students who can become agents of change for a circular economy. •

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Planning for Zero-Waste at Schools – A Toolkit

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Assessing the Feasibility of Black Soldier Fly Waste Processing

Black Soldier Fly Larvae waste processing produces protein for animal feed and frass for soil amendment. Before investing in this, however, it is essential to do a feasibility study. Our recently published assessment guide will help you through this process. Christian Zurbrügg[1], Stefan Diener[2], Daniela Peguero[1]

Daniela Peguero

Photo: Do customers appreciate roasted larvae? Demand for BSF products is one essential aspect to consider when assessing the feasibility of BSF waste processing.

Introduction

Black Soldier Fly Larvae (BSFL) waste processing is an innovative approach to treat organic waste and there are many commercial facilities worldwide. Local context analysis is required to find out if, for example, the waste substrate availability, animal feed market and legislative landscape are favourable for BSFL farming. To assist those considering a BSFL implementation, we published a feasibility assessment manual, which is available for download below. It outlines how to do a feasibility study and assess opportunities and challenges in the following four thematic fields.

Theme 1: Legislation & Institutional barriers and opportunities

Laws and regulations may affect BSFL operations and markets. These are typically set and enforced by various regulatory bodies depending on their scope (e.g., food safety, building permits and emissions, and veterinary, environment, agriculture and business development authorities). Black Soldier Fly (BSF) farming may fall under the same regulations that apply to other farmed animals bred for animal or human consumption. BSFL waste-processing may also be subject to legislation specific to waste management.

Theme 2: Substrate quality, availability and accessibility

The suitability of waste substrates depends not only on nutritional values. The manual suggests scoring processing and financial attributes for each type of waste substrate. The former characterises quantity, quality (purity and safety) and reliability (seasonality) of the substrate generated. The latter characterises how this waste substrate affects the logistics, management and eventually the financial feasibility of the facility. This includes aspects of competition with livestock farmers for the same substrate, price, ease of procurement, required pre-treatment and potential environmental benefit compensation.

Theme 3: Management and operational aspects

This section covers aspects of climate, land availability and suitability, and past and current experiences with BSF waste processing. BSF facilities are best suited in climate zones with average monthly ambient temperatures between 25–30 °C and average relative humidity of 60–90 %. If ambient climatic conditions are not met, they can be controlled through infrastructure and/or climate controlled equipment, but this impacts capital and running costs, and decreases the feasibility depending on energy and substrate costs, and product prices. Learning from people's experiences with BSF waste processing is also important. If past projects failed, what led to failure? It is also important to evaluate if and how BSF enterprises access and share knowledge. Easily accessible knowledge hubs and knowledge sharing platforms facilitate the exchange and learning process around BSF operations and, therefore, their feasibility. Having some expert knowledge in the area allows for a nice head-start.

Theme 4: Market barriers and opportunities

The last section covers aspects of market demand, competitors and competing products, potential market volume and possible market supporting mechanisms. As BSF products are typically new on the market, customer perception and willingness to switch from conventional products to BSF products needs to be evaluated (Photo).

Outlook

This feasibility assessment approach is currently being applied and validated in studies in Uganda, Malawi, Ethiopia and Côte d'Ivoire in the BUGS-AFRICA and SWIFT projects. The main objective is to assess BSF feasibility in selected locations and to explore how and if people without a high level of BSF-expertise can use this manual to conduct a feasibility assessment.

Acknowledgement

The manual was developed as a collaborative effort of different partners in the framework of the SWIFT project (SOR4D grant # 400440_213241/1), as well as the BUGS-Africa project (funded by GIZ and by CCAC). We would like to thank the following people for their help with this guide either during its development or by critical review and/or funding support: Bram Dortmans, Allan John Komakech, Isaac Rubagumya, Florence Lwiza, Frank Mnthambala, Gift Chawanda, Esther Lupafya; Laifolo Dakishoni, Konstantin von Hoerner, Sheila von Hoerner, Moritz Gold, Piotr Barczak, Sarah Elsaid, and Martin Kerres. •

BSF Feasibility Assessment Guide

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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 climate change and rapidly growing cities, with integrated combinations of sewered and non-sewered, and onsite, decentralised, and centralised technologies. Sandec's Management of Excreta, Wastewater and Sludge (MEWS) 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 Operators of the Kingtom faecal sludge treatment plant operated by GOAL and the Freetown City Council in Freetown, Sierra Leone. Transport by truck is the only means for delivery of wastewater to the treatment plant. The operators from left to right are:

1. Momodu Conteh
2. Sheku Amara Sesay
3. Mark Julius Korgay
4. Joseph Patrick Lamboi

Photo by Linda Strande.

Faecal Sludge Management, Beginning or End of an Era in Terminology?

The words we choose to use matter, and have significant impacts on dignity, sanitation service provision, and scientific integrity. You may notice a mix of terminology in this edition of Sandec News. We hope you will engage in our ongoing discussions on this topic! Linda Strande[1]

"Faecal sludge" is a term that Sandec and others in the sanitation field have been using since the 1990s to bring attention to the urgent need for improved sanitation in urban areas of Asia, Africa and Latin America [1]. This cumulative effort has succeeded in raising awareness and sanitation provision, with the concept of faecal sludge management (FSM) now being widely used, and the term incorporated into policies. Despite the success, the term is implicitly reserved for the context of non-sewered sanitation in urban areas of lower- or middle-countries. It is not used in higher-income contexts. This is problematic since terminology stemming from historical power imbalance relationships resulting from aid, colonialism or racism, can perpetuate falsely constructed ideas of the worth or abilities of regions, nations, people or cultures [2]. We are rethinking some terms at Sandec and would like to involve you in the process. Some of the questions we would like to discuss are: What do you think about the term faecal/faecal sludge? Is it too institutionally embedded and here to stay? Will dropping it only result in confusion? Is it time to transition to globally relevant terminology for non-sewered sanitation? Should just the American spelling be used?

Evidently, the term "faecal sludge" does not convey that what is managed in urban areas is mostly dilute wastewater, typically less than 5 % total solids [3]. FSM is often inaccurately referred to as "onsite" sanitation, and storage containments as "pit latrines" or "septic tanks". This is misleading, as treatment does not occur during storage, and in urban areas there is not adequate land available for soil-based treatment. The management of the service chain is also much more complicated than sewer-based approaches (Figure). Owing to complexities of containment and transport, the majority of faecal sludge is not yet safely managed, often resulting in leakage and spillage of dilute wastewater, or it being directly dumped into the urban environment, causing significant harm to public health. Questions for discussion are: Do you think "stored wastewater" would more accurately convey complexities of the service chain? Or could we rebrand FSM to mean the storage of dilute wastewater in fully sealed containments, followed by road-based transport to treatment?

In addition to FSM, many special terms have been coined for service delivery models or strategies for treatment technologies, including RTTC (the reinvent the toilet challenge), CBS (container based sanitation), and dewats (decentralised wastewater treatment systems). If you are not immersed in these areas, it is not always clear whether they are managing "excreta", "black- or brownwater", "greywater", "wastewater" or "faecal sludge". This is at a time when despite rapid advances in scientific knowledge, the focus on individual solutions, research agendas, and funding mandates hinders the transfer of scientific learnings from one to another. An important example is the resulting levels of degradation between treatment at source, storage for < 1 – 2 weeks, or longer-term storage, and the impacts on greenhouse gas emissions and downstream treatment processes and resource recovery [1]. Two discussion questions are: Do we need separate terminology for service provision models and scientific learnings? Or can we find one that meets all needs?

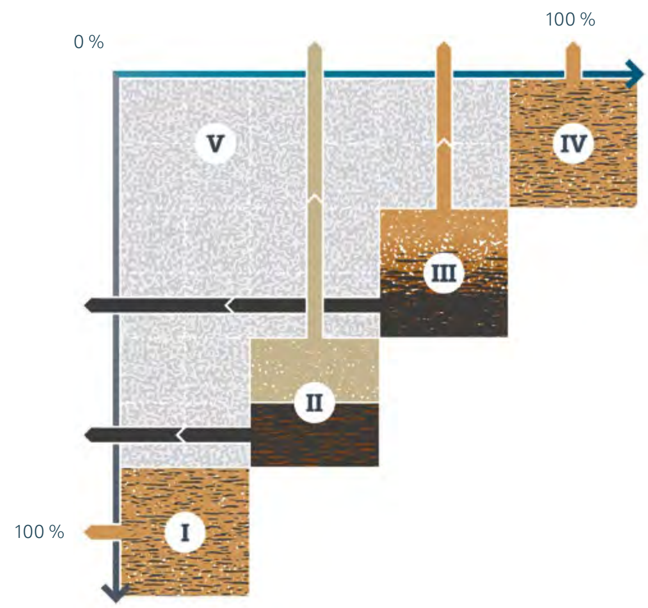

Figure: The ramifications of terminology on the sanitation service chain are further discussed in Strande et al. 2023. Shown here are four categories of storage and transport from the point of production of wastewater to delivery to treatment: (I) fully road transported, (II) source-separated mixed transport, (III) mixed transport, and (IV) fully pipe transported. Unsafely managed excreta, which is not safely contained and conveyed to treatment, falls in category V.

We hope you will join us in an active dialogue on the reasons behind and potential impacts of terminology choice. Sign up with the QR Code to participate in our virtual coffee breaks. •

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Discussion on Changes in Terminology Sign-up Form

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Guidelines for Lime Treatment of Faecal Sludge in Humanitarian Settings

In humanitarian settings, using hydrated lime to treat faecal sludge is an effective way to inactivate pathogens and protect public health. Eawag, Oxfam and UNHCR have published new guidelines for onsite and centralised lime treatment.

Nienke Andriessen[1], Sara Ubbiali[1], Linda Strande[1]

Lime treatment of faecal sludge for humanitarian contexts – Guidelines for onsite to centralised treatment

Introduction

Treatment of faecal sludge is essential for the protection of public health, but, unfortunately, it is often not happening adequately in humanitarian settings. Lime treatment is one of the most used treatment technologies in emergencies, and has been successfully implemented in various locations, for example, Cox's Bazar (Bangladesh), Sittwe (Myanmar), and Bentiu (South Sudan). However, clear guidelines specific to its use in humanitarian settings have been lacking. Therefore, Eawag, Oxfam and Geneva Technical Hub (GTH, part of UNHCR), with contributions from Solidarités International, Austrian Red Cross and Netherlands Red Cross, have developed practical guidelines based on global field-experience [1]. This interagency collaboration was funded through the backstopping mandate between Eawag and GTH. The guidelines are now available open access.

What is lime treatment?

Hydrated lime (also called 'slaked lime') is calcium hydroxide ($Ca(OH)_2$), a white, caustic, alkaline powder that is produced by heating limestone. Lime treatment requires mixing dissolved hydrated lime into faecal sludge, which raises the pH, and then keeping the pH >11 for a minimum of two hours. Lime treatment should use hydrated lime, not other forms of lime, such as quick lime (CaO) or calcium carbonate ($CaCO_3$). Quick lime can be dangerous, as it reacts violently with water, and calcium carbonate does not raise the pH. Lime treatment has multiple benefits: **1)** inactivation of pathogenic bacteria and viruses, **2)** improved solid-liquid separation, **3)** reduction of bad odours from the faecal sludge, and **4)** prevention of insect infestation. It is a low-cost, rapid, internationally recognised treatment technology that is recommended as a short-term emergency solution (mostly for acute and/or stabilising response phases).

Guideline contents

The guidelines cover two treatment scenarios: **1)** in-barrel treatment, where faecal sludge is emptied from onsite sanitation containments into barrels, and lime slurry is added directly to the barrels before they are transported to further treatment, and **2)** lime treatment at a centralised faecal sludge treatment plant. For both scenarios, the following topics are explained:

- For which situations lime treatment is appropriate, and when it is not. Lime treatment is useful in certain situations, but not always. For example, when a constant and affordable supply of hydrated lime or water cannot be guaranteed, pH cannot be monitored, or if there is no viable option for disposing the alkaline sludge and effluent, lime treatment should not be used.
- The requirements for setting up a lime treatment station.
- How to determine the quality of the hydrated lime.
- Health and safety precautions for workers, including a list of appropriate personal protective equipment.
- The lime treatment steps:
  1. Removal of solid waste.
  2. How to determine the required lime dosage.
  3. How to prepare a lime slurry. To maximise treatment efficiency, it is best to first dissolve the lime in water and make a 'lime slurry', which is then added to the faecal sludge.
  4. Mixing options. Mixing is crucial for treatment performance and should not be neglected.
  5. Process monitoring requirements. Measuring pH is key to ensure effective treatment performance.
  6. Solid-liquid separation options.
  7. Cleaning procedures.
- How to treat and dispose of the liquids and solids after lime treatment. Both the liquid and solid fractions are still highly alkaline, and the disposal or resource recovery options need to be carefully considered at each location.
- Challenges, risks and mitigation measures.
- Case studies from applications in Bangladesh and South Sudan.

Where to find the guidelines?

The guidelines are freely accessible from the GTH website [1], where you can also find further guidelines co-produced by Sandec on biogas, solid waste disposal (including sanitary landfill design), and soak pit design. Please share them within your network! •

References

[1] Geneva Technical Hub, 'Lime treatment of faecal sludge for humanitarian contexts – Guidelines for onsite to centralised treatment' [web page] (2024) < https://www.unhcr.org/what-we-do/build-better-futures/climate-change-and-displacement/geneva-technical-hub>; accessed 18 July 2024.

[1] Eawag / Sandec, Switzerland

Funding: The Geneva Technical Hub and the backstopping mandate by Eawag are funded by the Swiss Agency for Cooperation and Development (SDC).

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Sensor-based Conditioner Dosing for Dewatering Stored Wastewater

Real-time monitoring of suspended solids opens possibilities for robust, low-footprint technologies. This project piloted optical sensors to monitor and automate the dewatering of stored wastewater. Michael Vogel[1], Charbel Hankache[2], Rabea Touma[2], Rita Al JahJah[2], Linda Strande[1]

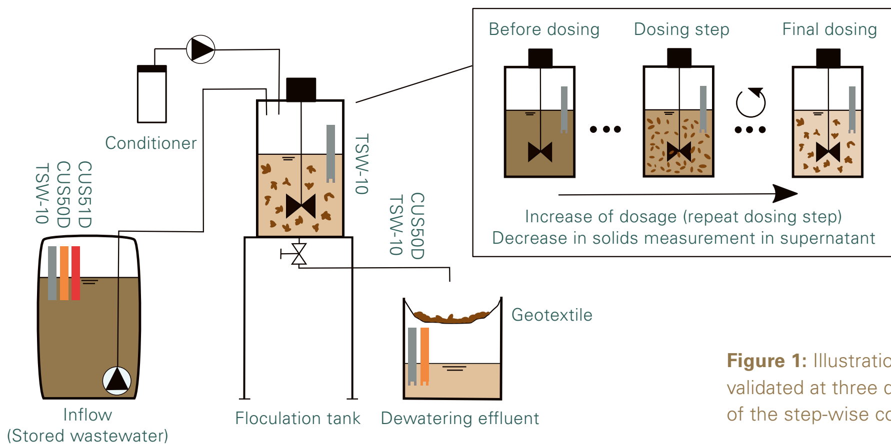

Figure 1: Illustration of the dewatering pilot plant with the sensors validated at three different locations. The small box shows the process of the step-wise conditioner dosing procedure.

Introduction

The characteristics of wastewater from non-sewered sanitation are highly variable, causing difficulties in operating low-footprint, robust sanitation systems. Sensors to monitor treatment performance and mitigate operational problems can alleviate these problems as they allow for real-time control of treatment technologies. For example, an important parameter in wastewater treatment is total suspended solids (TSS), which is measured to monitor the performance of dewatering (solid-liquid separation).

Dewatering is a challenge for non-sewered sanitation technologies due to the variable dewatering behaviour of the incoming wastewater. Therefore, dewatering often relies on passive, large footprint technologies, such as drying beds, making wastewater treatment difficult where land is limited. Dewatering with the use of conditioners (i.e. coagulants and flocculants) can decrease large footprints because they increase settling performance and/or enable the use of mechanical dewatering processes. However, conditioners need to be dosed according to the wastewater characteristics, as under- and overdosing reduces the floc formation and, consequently, the performance of the treatment processes. TSS can be used as a predictor for conditioner dosing and, if measured in real-time, allow for automated conditioner dosing [1].

The project first compared six commercially available sensors to predict TSS in blackwater and stored wastewater. These sensors used the methods of optical light-attenuation, optical light-scattering, Coriolis flow, ultra-sonic dispersion and micro-waves. It was found that the optical light-attenuation and light-scattering methods, commonly referred to as turbidity measurement, more accurately measured the TSS concentrations in wastewater even when there were varying salts, fat, oil and grease and inorganics content. The other methods were strongly influenced by at least one of these parameters [2]. Validation of the three sensors using optical light-attenuation and light-scattering methods for the automation of conditioner dosing was done at a dewatering pilot plant in Beirut, Lebanon.

Approach

Three optical sensors, Endress+Hauser CUS50D, Endress+Hauser CUS51D and Amphenol TSW-10, using optical light-attenuation and light-scattering methods for the automation of conditioner dosing, were chosen to validate at a dewatering pilot plant in Beirut, Lebanon. They were installed at three different locations (influent, flocculation tank, and dewatering effluent) of the dewatering pilot plant, as indicated in Figure 1. The Endress+Hauser sensors cost more than 1000 USD, while the TSW-10 sensor, the low-cost option, was less than 100 USD. The pilot process was operated 13 times in batches. The stored wastewater was first flocculated in a flocculation tank by the addition of conditioners, and then dewatered by being drained through a geotextile. Stored wastewater was collected from nine household containments in Antoura, Lebanon.

Sensor readings were taken from both the influent and effluent and TSS was measured in the lab to determine a correlation between the two. The data from the influent can be used to predict conditioner dosage, while the effluent data shows the dewatering performance.

In the flocculation tank, the sensors were used to identify the optimal conditioner dosing. As the conditioner was dosed in small steps, the sensors identified the optimal dosage, i.e. when the sensor reading reached a pre-defined threshold of low TSS (0.5 g/L), as illustrated in the small box of Figure 1. In addition, laboratory-based jar-tests were conducted to determine the optimum dosage for validation.

Results

Measurement location 1: Influent

The correlation between the laboratory TSS data of the nine different stored wastewater and the three optical sensors are illustrated in Figure 2. The optical sensors CUS50D and CUS51D both had a strong linear correlation to the laboratory measurements ($R^2 > 0.9$). The low-cost option, TSW-10, had a weaker, but still good correlation ($R^2 = 0.87$) up to a detection limit of 5 gTSS/L.

Figure 2: Laboratory TSS measurement and sensor readings of the inflow stored wastewater, with linear regression for CUS50D and CUS51D, and exponential regression for TSW-10.

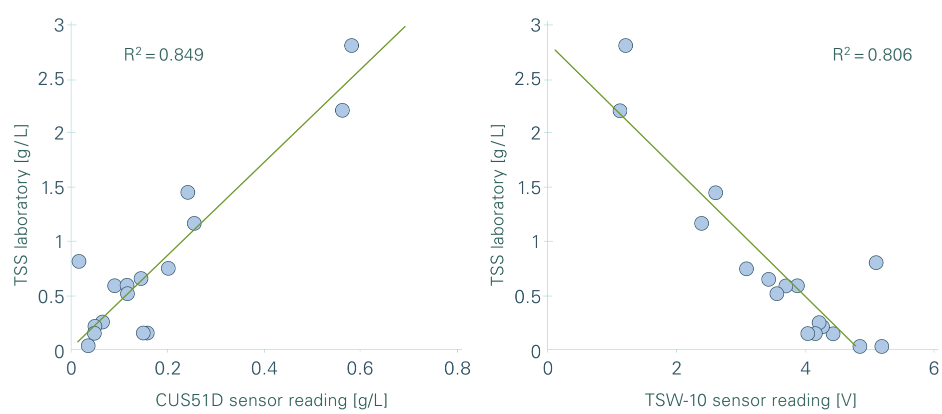

Figure 3: Laboratory total suspended solids (TSS) measurement and sensor reading of the effluent after geotextile, with linear regression for CUS50D and TSW-10.

Sensor modifications, such as better electrical components, could increase the detection limit. The TSS of the stored wastewater used for these tests was up to 16 g/L. In semi-centralised treatment plants (e.g., faecal sludge treatment plants), values of more than 50 gTSS/L are common. Tests within a larger treatment plant are needed to validate the results for higher TSS concentrations.

Measurement location 2: Flocculation tank

MTSS was measured with TSW-10 in the supernatant in the flocculation tank during step-wise conditioner addition. Overall, a clear decrease in TSS was observed, which allowed for the identification of the optimal dosage when the TSS fell under 0.5 g/L. Subsequent dewatering with a geotextile removed 77 % of TSS. This is in the range of what was obtained after predicting the dosage with the standard method jar-test (82 % TSS removal), indicating that a low-cost optical sensor (TSW-10) can be used to control conditioner dosage in a dewatering process. However, in a full-scale system, fouling of the sensor could hinder long-term operation, as conditioners are sticky and adhere to the sensor surface, disrupting the sensor reading.

Measurement location 3: Effluent after geotextile

Inflow sensor measurements and laboratory TSS are illustrated in Figure 3. For both CUS50D and TSW-10, there was a linear trend between the sensor readings and the laboratory measurements ($R^2 > 0.8$). Even though, there was a variability in the readings, both sensors detected effluents with high TSS (> 2 gTSS/L). These results can be relevant for effluent monitoring of small-scale wastewater treatment plants, for example, to identify a performance decrease of the dewatering steps.

Conclusion

The detailed results of this sensor application study will be published this year in a scientific journal article [2]. It will include a comparison of the six state-of-the-art sensors and how effective they were at predicting solids in blackwater. The project SEDUP (Scaling Efficient Dewatering for Urban Practitioners) has recently started with our Sierra Leone partner GOAL and its aim is to upscale the sensor application in a larger faecal sludge treatment plant in Freetown, Sierra Leone. Follow us on our website and social media to get the latest updates on our newest publications and project outcomes. •

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Nitrogen Removal in a Vermifilter Treating Urban Domestic Wastewater

Understanding nitrogen removal processes throughout vermifiltration is a crucial step in creating an optimised treatment model that can help close both water and nutrient cycles via effluent reuse. Kayla Coppens[1], Serge Stoll[1], Linda Strande[2]

Kayla Coppens

Photo: To better understand the mechanisms effecting the nitrogen cycle throughout vermifiltration, the six lab-scale reactors seen in this photo have been installed at Eawag and tests are ongoing. Three of the six filters are currently receiving blackwater (flush water, urine, faeces and toilet paper) and the other three are receiving brown water (flush water, faeces and toilet paper).

Introduction

The United Nations's Sustainable Development Goal 6 (SDG 6) aims to assure the availability and sustainable management of water and sanitation for all. Global challenges inciting researchers and practitioners to search for more sustainable strategies for wastewater management include rapid densification of urban areas, aging of treatment infrastructures and the increasing occurrence and intensity of extreme weather events, such as floods and droughts due to climate change [1]. Additionally, increasing water demand and consumption have led to greater interest in the reuse of treated wastewater for both agricultural and domestic purposes.

Due to its low operational and investment costs and non-waste generation, vermifiltration has been gaining attention as a sustainable wastewater treatment solution. Vermifiltration is a nature-based, non-sewered sanitation technology, which uses earthworms and microorganisms to aerobically treat and stabilise wastewater [2]. One challenge facing vermifiltration is balancing its ability to remove nutrients that cause eutrophication in natural water bodies with the need to retain these nutrients for agriculture and food security. Considering that the effluent of vermifiltration is rich in nutrients, its reuse for irrigation and agricultural practices is an opportunity that needs further study.

To better understand the treatment of nitrogen and potential reuse of the effluent in vermifiltration for agricultural practices, we studied the pilot-scale vermifiltration installation at the building Soubeyran in Geneva, Switzerland. It has been in use since 2017 and treats an average of 6.87 ± 1.43 m^3 of wastewater from an apartment building with 100 residents per day [3]. This study is unique as it focuses on a full-scale setting. The presented results are, therefore, a crucial part in creating an optimised treatment model for vermifiltration as a global and circular sanitation solution.

Methods

The pilot-scale installation includes two separate vermifilters, one for greywater, which is pumped from the bottom of a degreaser, and another for blackwater from toilets. Each vermifilter is made up of three layers: 0.2 m of compost (top), 0.2 m of fine biochar (middle), and 0.5 m of coarse biochar (bottom). The water quality of the influent, the compost layer, and the effluent was characterised six times from November 2022 to August 2023 for both the grey and blackwater vermifilters (Table). Throughout the study time, operational parameters, such as the hydraulic loading rate and temperature, were also recorded.

	Greywater VF	Blackwater VF
Hydraulic Loading Rate ($m^3/m^2/day$)	0.071 ± 0.05	0.057 ± 0.01
Organic Loading Rate (g COD/m^2/day)	59.3 ± 29.1	148.5 ± 53.0
Nitrogen Loading Rate (g TN/m^2/day)	1.3 ± 0.5	18.6 ± 5.1
Influent pH	7.1 ± 0.6	9.0 ± 0.1
Influent DO (mg/L)	1.37 ± 0.58	1.08 ± 0.85
Influent Conductivity (us/cm)	648 ± 72	2660 ± 491
COD RR (%)	77.7 ± 23.7	83.8 ± 3.4
TSS RR (%)	93.9 ± 4.6	95.2 ± 3.4
TN RR (%)	38.7 ± 26.1	17.3 ± 9.1
NH4-N RR (%)	74.3 ± 50.1	50.0 ± 14.7

Table: Operational parameters, influent water quality and summarised removal rates (RR) for the Greywater and Blackwater vermifilters at Soubeyran.

Results

This study used the unique opportunity of having two full-scale vermifilters with the same design to better understand how operating parameters affect the fate of nitrogen throughout vermifiltration. Despite having a similar design, the two vermifilters treat two distinct waters: grey water, which has lower nitrogen loading, and blackwater, which has a higher nitrogen content due to the presence of urine. The Table summarises the distinct operating parameters observed, as well as the removal rates for the basic wastewater components of each vermifilter. The greywater vermifilter (GW.VF) observed higher nitrogen removal than did the blackwater vermifilter (BW.VF). Despite the lower removal rate, the amount of total nitrogen (TN) removed was higher in the BW.VF, with154.9 ± 97.1 g of TN removed daily, compared to only 1.4 ± 1.9 g of TN in the GW.VF. Similarly, removal rates of NH4-N were also higher in the GW.VF, though the total grams of NH4-N removed per day by the BW.VF was over 100-times larger. These results propose that the nitrogen loading rate impacts the removal of nitrogen throughout the vermifilter, where lower loading rates have higher removals.

By looking at the different forms of nitrogen present after different layers in the vermifilter, the predominant treatment mechanisms in each step can be hypothesised. The evolution of nitrogen throughout the two vermifilters varies, indicating that distinct mechanisms are likely occurring. Nitrate was absent in the effluent of the compost layer (top) of the BW.VF, though it makes up 46% of the nitrogen in the final effluent, insinuating that nitrification is occurring only in the biochar layer (bottom) of the BW.VF. As the majority (79.5 ± 15.3 %) of the TN removed in the BW.VF is occurring in the compost layer, it can be assumed that the predominant mechanisms for nitrogen removal is volatilisation of NH3-N. In the GW.VF, the concentration of nitrogen actually increases throughout the compost layer, which is likely due to the leaching of nitrogen found in the compost and vermicasts. It can, therefore, be hypothesised that at higher nitrogen loading rates, more volatilisation of nitrogen in the form of ammonia occurs. If the goal is to reuse the effluent for agricultural purposes, the loss of nitrogen through volatilisation could possibly be lowered by decreasing the daily nitrogen loading rate.

Finally, the effects of temperature on the nitrogen fate throughout the vermifilters were observed by studying the system in both winter (average temperature 5.9 ± 4.13 °C) and summer (average temperature 21.84 ± 5.22 °C). As nitrifying bacteria, which stabilise nitrogen for agricultural reuse, are known to be negatively impacted at lower temperatures, it was hypothesised that nitrification would be less during the winter months. However, our findings did not confirm this hypothesis. For the BW.VF, the nitrification rate remained stable throughout the year. This may be due to the large temperature buffer capacity (temperature in BW.VF in winter is 13.45 ± 1.34 °C) observed by the filter, which is likely because of the fact that the filter is located underground and straw is added to insulate the filter during colder seasons.

Conclusion

These findings are important to optimise either nitrogen reduction, if the effluent is destined to natural water bodies, or nitrogen retention and stabilisation via nitrification in the case that the effluent is to be used for agricultural purposes. The effects of temperature on vermifiltration were not as drastic as found in other studies, which implies that vermifiltration is a promising treatment technology even in cold climates. The nitrogen loading rate may impact the overall fate of nitrogen throughout vermifiltration and, therefore, should be investigated further. This will be done using lab-scale vermifilters with real wastewater simulating both blackwater (with urine) and urine separated water (brown-water) (Photo). Additionally, a study looking into other parameters which may impact effluent reuse in agriculture, such as pathogens, heavy metals, and micropollutants, is ongoing. •

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Impact of Stabilisation on Dewatering and Treatment of Supernatant

Despite increased characterisation of faecal sludge, little is known about the different organic fractions and their treatability. This study will evaluate if metrics of stabilisation can predict dewatering performance and biodegradability of organics in the supernatant. Ednah Kemboi[1, 2], Eberhard Morgenroth[1, 2], Linda Strande[1]

Nearly half (46 %) of the world's population is currently being served by non-sewered sanitation, and in urban areas of low- and middle-income countries (LMICs), it is up to 60–90 % of the population. Wastewater from non-sewered urban areas in LMICs is commonly referred to as faecal sludge, and is typically more than 90 % water. In dense urban areas, there is not enough land available for soil-based treatment, so faecal sludge must be stored onsite in containments (commonly referred to as 'pit latrines', 'cess pits', 'septic tanks' or 'storage tanks'), and then collected and transported to treatment. The first step at treatment facilities is often screening followed by settling tanks and/or drying beds for dewatering in order to remove unbound water. The supernatant following dewatering then requires treatment prior to discharge, as it has concentrations of organics, nutrients, and pathogens that are as high as what are found in the influent at municipal sewer-based treatment facilities [1]. However, passive treatment technologies for dewatering and supernatant treatment have large footprints, making their implementation impractical in dense urban areas. In order to reduce the footprints required and increase treatment efficiency, Ednah Kemboi began a PhD research project, studying the relationship of pools of organic matter in faecal sludge delivered to treatment plants, and how the stabilisation of faecal sludge affects dewatering and supernatant treatment.

Stabilisation refers to the level of readily biodegradable organic matter in a material, and its potential for biodegradation. When organic matter is stabilised, it no longer undergoes rapid changes in organic matter (e.g. finished compost). Further, stabilisation can be context specific and can change with different environmental conditions, though more complex forms of organic matter (e.g. lignin from woody material) tend to be more stable. Faecal sludge is highly variable due to differences in inputs into containments, containment technologies and construction quality, household usage patterns, storage times, and collection practices [1]. Although there is increasing data available on the characteristics of faecal sludge, there remains a knowledge gap about the organic matter that is commonly quantified with aggregate metrics, such as chemical oxygen demand (COD) or volatile solids (VS) that are in the faecal sludge. The variability of faecal sludge, which is delivered batchwise to treatment, makes these metrics unreliable for comparing stabilisation levels. Instead, metrics indicative of bioavailability, such as biochemical oxygen demand (BOD), biomethane potential (BMP), specific oxygen uptake rate (SOUR), and chemical properties, e.g., polysaccharide concentrations and soluble COD (sCOD), are thought to be better indicators of stabilisation [2].

Based on learnings from our previous research, we know that faecal sludge that is 'fresh' or stored for less than one week is more difficult to dewater than more stabilised sludge. During stabilisation there are also changes in the physical properties of faecal sludge, including reductions in extracellular polymeric substances (EPS), a gel-like, high molecular weight polymer secreted by microorganisms, and fibres, which hold water and reduce the dewatering performance as measured by cake solids [2]. As such, 'fresh' faecal sludge contain a higher concentration of EPS and fibres compared to more stabilised faecal sludge. Although the degradation of EPS releases small particles that block filters, overall, it increases the filtration rate as quantified by the laboratory-based metric of capillary suction time.

Another aspect of this study is to look at how the level of stabilisation affects the overall biodegradability and treatment of supernatant. Attached growth biofilm treatment processes will be evaluated (i.e., rotating biological contactor, moving bed biofilm reactor, and trickling filter), as we expect them to be more resilient to fluctuations, and require a smaller footprint. However, some pools of organic matter, such as fats, oils and greases, can limit oxygen transfer to microorganisms in biofilm treatment. More stabilised fractions of organic matter could also explain why faecal sludge treatment plants easily meet BOD effluent requirements, yet have difficulties to meet effluent COD requirements. Therefore, the composition of the pools of organic matter in supernatant and effluent after treatment based on degradability and functional group will be evaluated to explain the observed treatment performance. Degradable fractions will be evaluated using short term batch experiments and chemical assays, while functional groups will be quantified using nuclear magnetic resonance (NMR) spectroscopy.

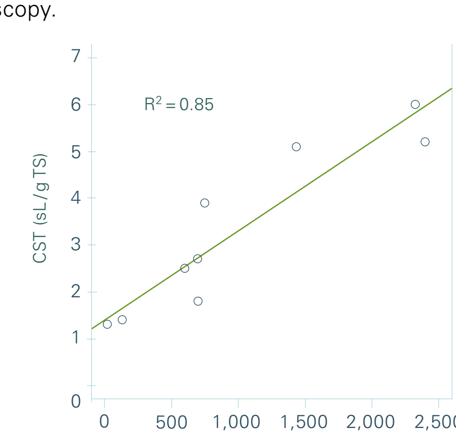

Figure: Dewatering rate measured as capillary suction time (CST) vs. biological oxygen demand (BOD) concentration in faecal sludge samples from Eldoret, Kenya.

Erick B.

Photo 1: Ednah Kemboi collecting faecal sludge samples at the Quarry Wastewater Treatment Plant. The faecal sludge was analysed for dewatering performance and stabilisation level in the laboratory at Eawag.

Paul Donahue

Photo 2: Ednah Kemboi analysing faecal sludges in the laboratory at Eawag.

First Steps

As a first step, nine samples collected from trucks delivering faecal sludge to the Quarry Wastewater Treatment Plant operated by Eldoret Water and Sanitation Company (ELDOWAS) in Eldoret, Kenya, have been collected and analysed (Photo 1). The preliminary results indicate that the metrics of dewatering performance strongly correlate with BOD concentrations (R^2=0.85), as shown in the Figure. Future planned research includes sampling at faecal sludge treatment plants (FSTPs) in Kampala, Uganda, where properties of faecal sludge, dewatering and stabilisation metrics will be quantified and evaluated to determine the role of stabilisation in dewatering performance. After determining the properties of supernatant, treatment with attached growth biofilm reactors will be evaluated at Eawag in Switzerland (Photo 2). The objective is to find out if attached growth reactors are resilient for fluctuations observed in faecal sludge, whether reliable models can be developed for the design and operation of FSTPs, and if effluent guidelines should be modified to account for the non-biodegradable fractions of COD in effluent.

Expected Outcomes

Developing reliable and agreed upon metrics of stabilisation will be useful for optimising process control at faecal sludge treatment plants by improving predictions of dewatering performance, and the understanding of the kinetics of the removal of organic matter. An improved understanding of the pools of organic matter and their fate in the environment will also be useful for the development of realistic discharge standards that provide adequate environmental protection. Stay tuned here for research results! •

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Improving Emission Estimates of Greenhouse Gas Emissions from Containments

As countries strive for net zero emissions, managing greenhouse gases from non-sewered sanitation is becoming a pivotal focus, emphasising the need for detailed emission studies and the inclusion of climate-smart strategies.

Kelsey Shaw[1,2], Caetano Dorea[2], Linda Strande[1]

Left: Kelsey Shaw, Right: Davis Majara

Photos: Field measurement in action: A gas flux chamber in use, capturing headspace gas for analysis. This technique involves syringe extraction of gases, which are then analysed on a gas chromatography mass spectrophotometer (GC-MS) to determine per capita flux and calculate accurate emission rates. Such in situ methods are integral to our research, enhancing our understanding of GHG emissions from NSS.

Introduction

Globally, almost half (46 %) of the population relies on non-sewered sanitation systems (NSS), which are increasingly recognised for their environmental implications – especially in terms of greenhouse gas (GHG) emissions [1]. As the world strives towards net zero emissions, the need to develop climate-smart sanitation solutions that are also financially accessible, especially in low-income regions, becomes more urgent [2]. However, measuring GHG emissions from NSS presents complex challenges due to the highly variable nature of stored effluent in containment, as well as its distinctive characteristics as compared to sewer-based municipal wastewater [3]. Addressing the need for globally relevant data, this study uniquely measures point-source GHG emissions directly from containment systems in contrasting settings. This dual-site approach not only addresses a critical gap in the literature, which shows sparse reporting of direct GHG estimates from non-sewered systems [2], but also sets the stage for a broader understanding of emissions dynamics across diverse economic and environmental landscapes.

Similar to what we have learned from evaluating characteristics of stored wastewater, point source emissions data also prove insufficient unless they are integrated with the existing body of scientific knowledge. For example, degradation processes tend to level off after one – two weeks of storage when the readily degradable organic matter is consumed, and this level of stabilisation is directly linked to the amount of gas produced [3].

The *Quantities and Qualities* (Q&Q) approach for city-wide estimations can be employed to create more accurate and scalable projections of methane emissions [3]. Moreover, addressing the potential overestimation prevalent in previous studies is crucial [2]. Field-based studies indicate that the Intergovernmental Panel on Climate Change (IPCC) guidelines might overestimate emissions, therefore, enhancing the precision of emission estimates through refined methodologies will aid in the formulation of effective sanitation-borne GHG management strategies.

The objective of this study is to utilise advanced microbial methods to evaluate the pathways of degradation of organic matter during storage in containment and subsequent GHG emissions. This includes insights from the study of microbial processes within containment systems, where molecular microbiology techniques, such as paired metagenomics and metatranscriptonomics, elucidate how organic matter is degraded and contributes to GHG emissions.

Methods

The study's methodology involves a dual-site analysis to capture GHG emission dynamics in two economically and environmentally diverse locations: the rural higher-income environment of Vancouver Island, Canada, and the urban lower- to middle-income context of Kampala, Uganda. It was specifically designed to consider the influence of temperature on GHG emissions, investigating common assumptions that tropical climates might inherently produce higher emissions due to elevated temperatures. Preliminary findings indicate that while temperature does influence the rate of organic matter degradation, its effect is minor compared to other factors, such as the availability of organic matter, system operation, and inhibitory conditions. Further, it is expected that the insulating effects of soils will mean that temperatures within containment systems do not vary substantially, thus, moderating the direct impact of ambient temperature extremes.

The flux chamber method – originally developed by Leverenz et al., 2010 from the University of California Davis – was adapted for our study [4]. This method uses a floating chamber constructed from PVC, coupled with manual sampling, to ensure precise and reliable

Location	Flux (g/cap-day)	Influent/Configuration	Sources
Vancouver Island, Canada	Range: 0–14 n = 22	Mixed wastewater, connected to a leech field	Unpublished, preliminary results
Kampala, Uganda	Range: 0–11 n = 19	Blackwater and mixed wastewater, connected to soak pits	Unpublished, preliminary results
Hanoi, Vietnam	11.9 (±4.5)	Blackwater, connected to open drains	Huynh et al., 2021
North Carolina, USA	11.0 (±2.2)	Mixed wastewater, connected to leech fields	Diaz-Valbuena et al., 2011
New York, USA	11.0 (±12)	Mixed wastewater, connected to leech fields	Truhlar et al., 2016
NA	25.5 ($p < 0.001$) 27.1 ($p < 0.001$)	Guideline	IPCC USEPA

Table: Preliminary CH_4 Flux Measurements Compared to Recent previous CH_4 emission measurements taken from the liquid surface of NSS containments.

gas capture (Photos). The captured gases are analysed using gas chromatography, employing both an Electron Capture Detector (ECD) and a Flame Ionization Detector (FID). This setup precisely quantifies the concentrations of methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O), which are crucial for understanding their environmental impact.

To calculate the emission rates, the linear plot method was used, consistent with established studies. This technique allows for accurate estimation of GHG emissions over time, providing a dependable basis for projecting these emissions on a citywide scale.

Results

By examining parameters crucial to anaerobic digestion – such as temperature, pH, carbon-to-nitrogen (C/N) ratio, organic loading rates, and toxicity – we are able to assess how these factors correlate with GHG outputs. Additional measurable factors, such as oxidation-reduction potential (ORP), along with operational variables, including scum layer presence, emptying intervals, and user numbers, are also considered to provide a comprehensive view of system performance.

The Table presents preliminary CH_4 flux measurements from both Canada and Uganda, juxtaposed with IPCC guidelines, USEPA guidelines, and findings from recent published literature. This comparison aims to highlight the diversity in emission factors across different locations and how such variability can inform city-wide planning and mitigation strategies.

Current and Future Work

A central element of our investigation is the hypothesised acetoclastic methanogenesis pathway. This pathway, primarily responsible for methane production via the breakdown of acetate, will be studied both *in situ* and through controlled lab-based specific methanogenic activity (SMA) tests using field-sourced inoculum. By determining the operational conditions that favour acetoclastic methanogenesis, we can devise targeted strategies to manage methane production. For instance, determining the operational conditions that favour or inhibit acetoclastic methanogenesis, such as pH, temperature, and ammonia concentrations, could inform how to predict and, therefore, better manage methane emissions significantly. Ammonia, in particular, is known to be inhibitory at high concentrations, affecting microbial pathways and potentially redirecting or halting methanogenic processes.

Furthermore, the integration of operational parameters with microbial genomic data enhances our understanding of the resilience and stability of microbial communities within these systems. By overlaying this information with gas emission data, we can identify whether systems are merely taxonomically diverse or also functionally resilient –meaning they can maintain function despite shifts in microbial composition due to environmental stresses. Understanding these dynamics is crucial for developing management strategies that ensure system efficiency and robustness against climate variability. For example, by identifying microbial communities and understanding their roles in the degradation of organic matter, we can more accurately predict the pathways of GHG production. This knowledge enables us to make informed operational adjustments to better manage the GHG emissions, such as changing the emptying frequency or substrate composition (i.e. blackwater only, mixed wastewater).

Looking ahead, the findings from this detailed investigation will be incorporated into a projection model designed to estimate volumes of GHG emissions on a city-wide scale. Utilising the developed Q&Q approach, we aim to scale these projections effectively, enhancing city-wide sanitation management strategies and contributing to more sustainable urban environments. •

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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. Sandec's Strategic Environmental Sanitation Planning (SESP) research aims 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 Onsite reuse of treated wastewater in a large apartment complex in Bengaluru, India.

Photo by Abishek S. Narayan.

Integrated Baseline Assessment of Water, Sanitation and Solid Waste Management

An integrated baseline assessment of water supply, sanitation and solid waste was conducted in two small towns in Uganda. This article presents highlights from the novel methodology, key results and ways forward. Abishek S. Narayan[1], Charles B. Niwagaba[2], Ronald Sakaya[2], Abubakar Batte[2], Christoph Lüthi[1]

Introduction

Water, sanitation, and solid waste are intricately connected, yet a comprehensive approach to their provision is often absent [1]. In many small towns across Sub-Saharan Africa, rapid urbanisation and limited resources have led to poor access to these essential services. An integrated approach could significantly improve access to these basic services, thereby contributing to progress in SDGs 1, 6, and 11. The WABES programme, led by Eawag-Sandec, is investigating this hypothesis in two small towns in Uganda. The first step in this integrated approach is to conduct an integrated baseline assessment (IBA) in these Ugandan towns to understand the current service levels of water, sanitation, and solid waste, as well as to identify the interlinkages between them (Photo). This approach has the potential to reduce costs and efforts by conducting a single assessment instead of separate ones, which could also mitigate stakeholder fatigue. Importantly, it will allow for the identification of interlinkages between these sectors, which are often overlooked in conventional baseline assessments.

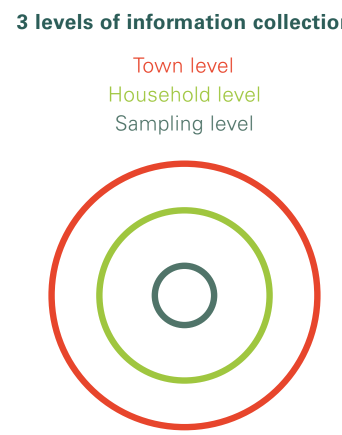

Figure 1: The three levels of data collection as part of the Integrated Baseline Assessment.

IBA Approach

Since an integrated approach to conducting baseline assessments, particularly in the water, sanitation, and solid waste sectors, has not been previously undertaken, a novel transdisciplinary process was employed by the project team through a series of research design seminars, where the methodology was co-created [2]. This approach involved three levels of information collection (Figure 1): **(i)** town level (infrastructure observations, policy analysis, and key informant interviews), **(ii)** the household level (survey and microbial water quality, etc.) and **(iii)** a detailed sampling at a system level (waste characterisation, sludge accumulation, water quality tests from source to distribution points, etc.).

Abishek S. Narayan

Photo: Detailed assessment of sanitation facilities underway as part of the IBA in Uganda.

The data collection campaign took place in July–August 2023, during which information was gathered from 650 household surveys and 30 interviews, and detailed sampling in approximately 50 houses took place. The collected data will be made openly available at the Eawag Research Data Institutional Repository and the Open WASH Data Repository at ETH Zurich. Additionally, the exact methodology used for the integrated baseline assessment (IBA) approach will be available as a package on the WABES project webpage, allowing for its potential application in other contexts.

IBA Highlights

The IBA results revealed several key insights into the water, sanitation, and solid waste sectors. In the water sector, notably, over 80% of the water samples tested at the point of consumption indicated faecal contamination, highlighting the severity of recontamination issues. Furthermore, the intermittency of water supply, seasonality, and low affordability of formal services resulted in households using other potentially unsafe water sources for drinking. Additionally, heightened levels of fluoride and heavy metals, such as Zinc and Manganese, were found in certain locations, requiring further investigation to determine the causes of these contaminations. A more detailed assessment of the water sector can be found in the article "Insights about Water Supply and Quality in Ugandan Small Towns" on pp. 40–41. In the sanitation sector, a surprising 95 % of the households lacked lined pit latrines, leading to issues, such as potential groundwater contamination, lack of emptiabilty, and underutilisation of the newly built Faecal Sludge Treatment Plant. In addition, the depth of the pits well exceeded the WHO Guideline of three metres. Public toilets in one town were also found to be non-functional due to low willingness to pay and questionable location choices.

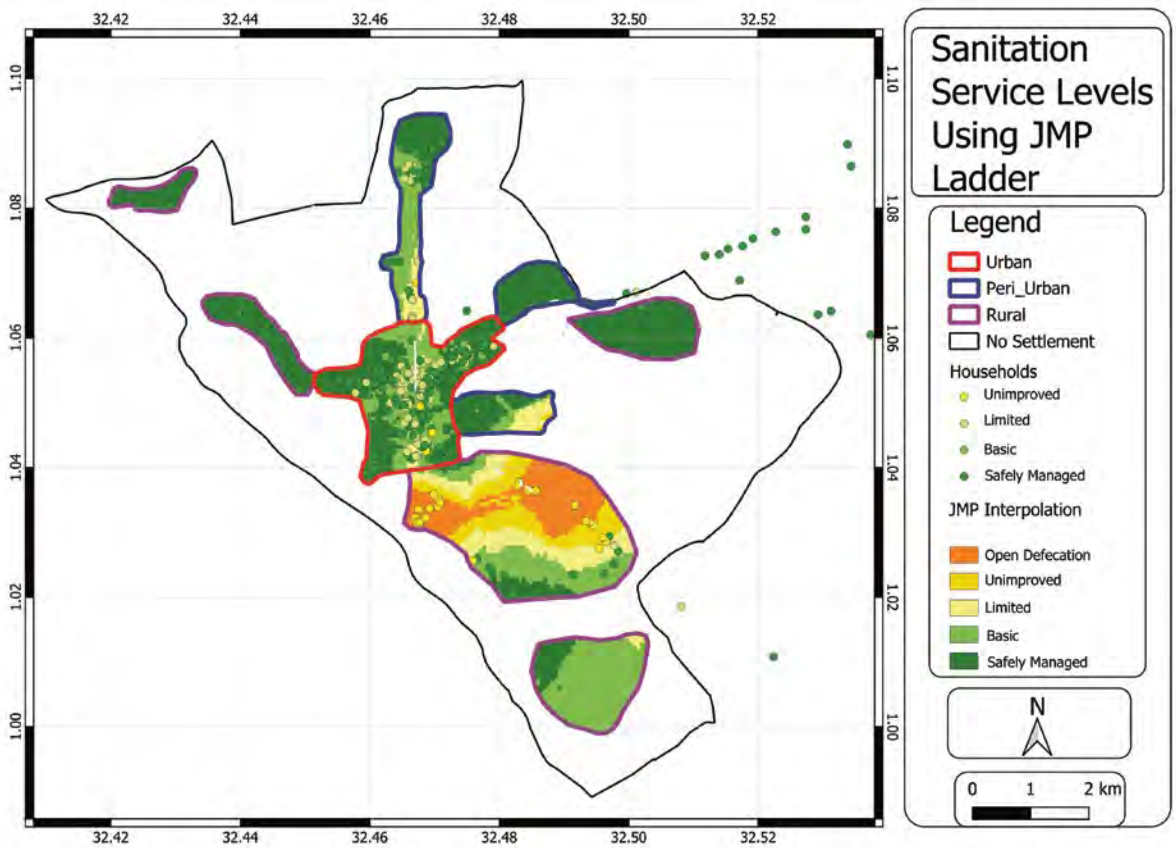

Figure 2: Map of service provision across urban, peri-urban, and rural areas in one of the small towns.

The solid waste management sector faced significant challenges, including poor collection, which resulted in litter throughout the towns. This was attributed to the lack of functional collection vehicles or contracts with private companies. As a result, nearly 50 % of the households reported burning waste at least once a week on or outside their premises. On the other hand, over 60 % of the households segregated kitchen waste, and almost 70 % segregated recyclables, such as PET and Glass, indicating a developed informal recycling sector.

The IBA also uncovered interlinkages between the sectors. For instance, faecal contamination from unlined pits was found to contaminate groundwater, and nearby residents reported issues with groundwater contamination near the solid waste dumpsite. Litter regularly ended up in stormwater channels, leading to pollution in wetlands and water bodies. Furthermore, a dominant practice of throwing menstrual hygiene products in pit latrines was observed in the sanitation and solid waste sectors. Some positive interlinkages observed were the segregation of recyclables at source and reuse of greywater.

Mapping interlinkages

A spatial analysis of the service levels of water, sanitation and hygiene, using the Joint Monitoring Programme's (JMP) service ladder approach, to spatially identify the areas that are better served and those underserved needing urgent attention, was also done. The household service levels from the survey were interpolated at unsampled locations, using a geostatistical autocorrelation technique called spatial kriging. Results were categorised along urban, peri-urban and rural typologies. A sanitation example shows that service levels in urban and peri-urban areas are higher than in rural areas (Figure 2).

Conclusion

The findings from the integrated baseline assessment were presented to stakeholders at the Uganda Water and Environmental Week, hosted by the Ministry of Water and Environment. This workshop provided an opportunity for participants to synthesise a list of priority solutions, including integrated behaviour change campaigns, chlorination, and modular pit liners, which will be considered by the towns. The results have also been shared with officials at the town, district, and national levels in practice-friendly formats, ensuring effective dissemination of the findings. •

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Governance of Water Reuse in Bengaluru, India

Wastewater reuse from decentralised sources enhances Bengaluru's water security, yet its governance mechanisms have not been adequately studied. This research presents the current policies, institutions and regulations that support innovation on the city, state and national levels. Abishek S Narayan[1], Francine van den Brandeler[2], Rebecca Humborg[1,2], Christoph Lüthi[1]

Eawag and WELL Labs

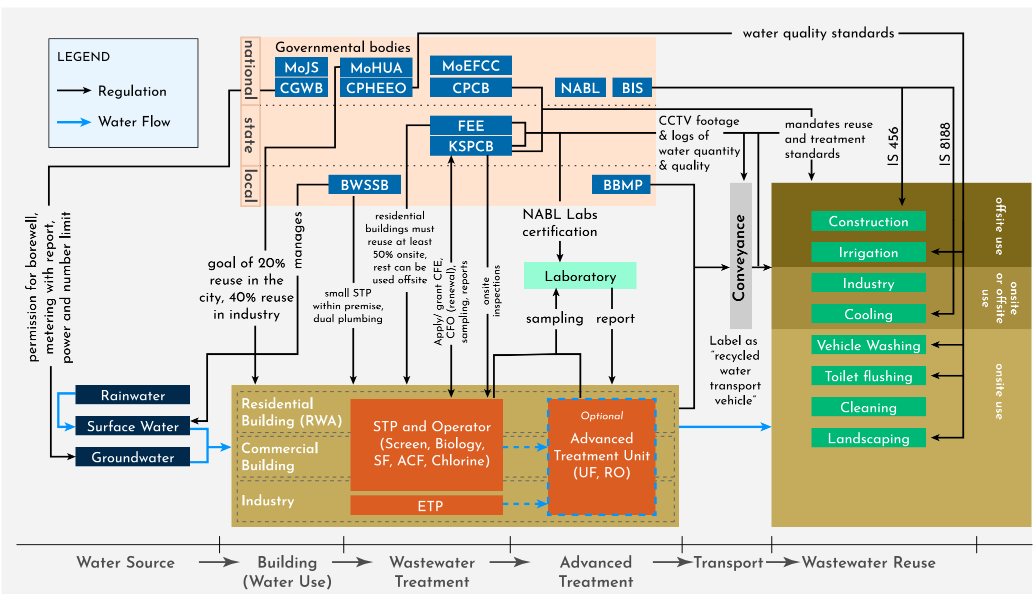

Figure: A flowchart of the governance mechanisms in place across the water reuse value chain leading to different on-site and off-site reuse scenarios.

Introduction

Bengaluru is in the midst of a severe water crisis. Conventional centralised water and wastewater transport and treatment approaches have proven ineffective in addressing the growing environmental and public health, water and sanitation concerns. Treated wastewater from decentralised sources could become an important water resource. Over 15% of the city's wastewater treatment infrastructure, i.e. 250 Million Litres Per Day (MLD) – is decentralised. The latest government policy encourages reuse from decentralised sewage treatment plants for both onsite and off-site applications. The stages are: the building complex, the decentralised Sewage Treatment Plant (STP), additional treatment units (often used for advanced treatment), collection and transport (by pipeline or tanker), and reuse, including onsite or off-site reuse and discharge. Sustainably managing a functional reuse value chain in the city beyond ad hoc and pilot cases requires an enabling governance regime with clear policies and regulations that give certainty to technology developers, suppliers, operators, users, government officials, etc. To develop an enabling environment, it is important to understand the current governance regime. This research is based on key informant interviews, workshops and policy and institutional analysis. The aim is to provide a comprehensive understanding of the policy, institutional and regulatory landscapes (Figure).

Current Governance Regime

The governance mechanisms dictating decentralised reuse are complex, involving numerous national, state, and city governmental bodies. National bodies set policy visions and standards, state bodies establish operational mandates and regulations, while city-level authorities implement regulations. Governance also varies across the reuse value chain, with different regulations from different bodies active in different segments.

Decentralised STPs have multiplied rapidly, to around 3000 in the city. Calculations estimate that roughly 47 MLD of 250 MLD treated wastewater from these systems is currently reused. Although reusing all treated wastewater may not be realistic, a significant potential remains untapped. However, different reuse applications require different levels of treatment. Because the Zero Liquid Discharge (ZLD) mandate was withdrawn in 2024 off-site reuse for selective purposes, e.g. construction and cooling, became officially allowed, and a wastewater economy is set to emerge in the city. Sellers and buyers of such treated wastewater will need further guidance on how to safely manage this wastewater.

Conclusion

While the current governance regime covers many aspects of the reuse chain, for both onsite and offsite reuse, there are several overarching governance reforms still necessary to create a sustainable decentralised wastewater treatment and reuse model in the city. These include: fit-for-purpose reuse standards and developing a comprehensive and coherent governance framework that accounts for the entire reuse value chain. •

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This research is part of the Water Reuse Lab project at Eawag between Sandec, Process Engineering and the Environmental Social Sciences departments, in collaboration with WELL Labs in India.

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Integration of Artificial Intelligence in WASH and Solid Waste Services

The work of the five research groups of Sandec was analysed using Artificial Intelligence (AI). The aim was to find how AI could improve and further their applied research objectives and goals. Prasil Adhikari[1,2], Christoph Lüthi[1]

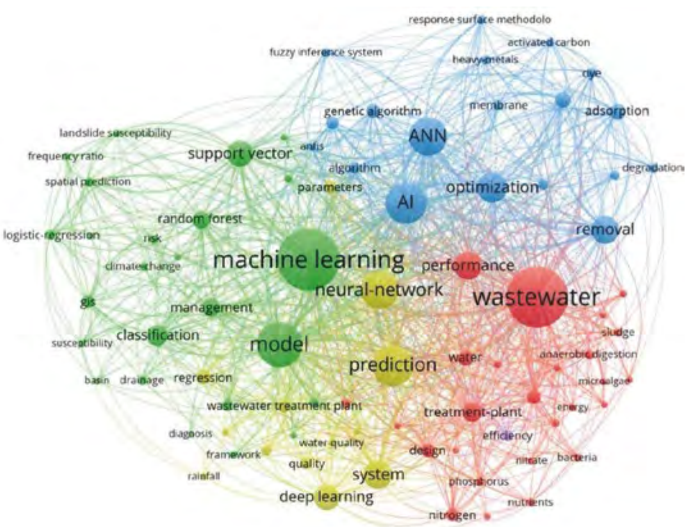

Figure: Network depiction of the use of ML and AI terminology in recent wastewater publications [1].

Introduction

Artificial Intelligence (AI) has the potential to transform, develop and enhance Water, Sanitation and Hygiene (WASH), as well as Solid Waste services. It can be used to address current challenges in these sectors through the development of data-driven solutions, thus, helping to achieve the Sustainable Development Goals, particularly SDG 6 [2]. AI, with its learning, reasoning, and self-correction capabilities, provides enhanced data evaluation, pattern recognition, and predictive analysis, which can be leveraged by the Department of Sanitation, Water, and Solid Waste for Development (Sandec) to aid its existing projects and future targets.

Results

For the five distinct research groups of Sandec, some of the potential AI implementations can be summarised as:

1. Data driven planning and decision support
2. Optimisation of infrastructure layout
3. AI-driven simulation of urban sanitation scenarios
4. Development of smart monitoring, waste sorting, and recycling systems
5. Optimised biowaste processing
6. Pattern recognition and anomaly detection in water quality
7. Estimating quantities and qualities (Q&Q) in faecal sludge
8. Enhancing water safety and health outcomes predictions
9. Custom tool development by user needs analysis
10. Capacity building in WASH and Solid Waste and the MOOC series

Sandec can go forward in the path of integrating AI in its work by further extending the research and model development. The Machine Learning (ML) and AI models can be optimised with data collection and organisation, and there can be continuous improvement made to them to cater to project objectives and community needs. Moreover, the already existing tools and applications can be incorporated to aid research and development. For instance, large language models (LLMs), such as GPT4, Gemini, Perplexity, and such domain specific models as WASH AI [3], can be synergised to gather tailored solutions to the WASH and Solid Waste research needs of the department.

Conclusion

The integration of AI in the WASH and Solid Waste sectors comes with its own set of challenges and ethical considerations. Sandec should prioritise data privacy and safety as sensitive data, such as health statistics, private information and community-specific information, are at the core of WASH and Solid Waste data collection and analysis. Bias mitigation can be achieved by developing solutions that are context-aware and inclusive, thus, promoting equitable access to WASH and Solid Waste services. Ethical AI solutions adhere to transparency, robustness, and resilience, which should be followed by Sandec researchers when developing and incorporating AI systems in their work [4] [5]. •

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Water Supply and Treatment

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

- Implementing passive chlorination technologies at scale.
- Strengthening operational water quality testing laboratories in remote rural areas.
- Evaluating integrated approaches for water supply, sanitation and solid waste planning.
- Developing experiential measures for assessing institutional WASH.

Photo Piped water connection in Wobulenzi, Uganda, linked to an overhead tank for continuous water storage and usage, ensuring a reliable supply despite the intermittency of the main water supply system.

Photo by Marisa Boller.

Insights about Water Supply and Quality in Ugandan Small Towns

An integrated approach was used to assess the water sector and its interconnection with sanitation and solid waste management. Key challenges identified included intermittent water supply, microbial contamination of drinking water and solid waste obstructing drainage channels. Marisa Boller[1], Abishek Narayan[1], Loïc Fache[1], Regula Meierhofer[1], Sara Marks[1]

Marisa Boller

Photo: Solid waste obstructing drainage channels.

Introduction

Access to safe water remains a critical challenge in many communities worldwide, including in Uganda [1]. Small towns, being at the rural-urban transition, often face unique challenges in water service provision, as they combine urbanised centres and surrounding rural settings. As part of the Water, Behavior Change and Environmental Sanitation (WABES) project, water service provision in two small towns in Uganda was assessed and specific challenges identified.

The WABES project proposes adopting a transdisciplinary approach for water, sanitation and solid waste services because these sectors are closely interconnected in their service chains [2]. Understanding their interconnections can lead to more efficient integrated planning. Doing an Integrated Baseline Assessment (IBA) is the first step. It provided comprehensive insights into the water sector and its interlinkages with sanitation and solid waste management. While this article focuses mainly on the assessment of the water sector, a more detailed overview of the IBA results can be found on pp. 34–35.

Research context and methodology

Data collection was conducted in two small towns in Uganda, Kakooge and Wobulenzi, in collaboration with Makerere University during summer 2023. The methodology involved key stakeholder interviews, household surveys (N = 640), and system analysis, including water quality testing and waste characterisation. The microbial water quality of drinking water at the household level (point of use) was tested for *E.coli*, using presence-absence tests. For a subset of households (n=41), samples were taken at the tap and at the storage levels (point of collection and point of use) and were analysed for *E.coli* concentrations, free residual chlorine, pH, and turbidity. Chemical water quality analyses were also conducted to provide a comprehensive understanding of the water quality situation.

Results

Drinking water sources

Piped water in the two towns is provided by governmental water utilities. Residents in their urban cores typically access these services through private piped connections (individual households) and public standpipes (shared). In contrast, people in the rural areas mostly rely on boreholes or other sources, such as rainwater or unimproved sources, for their drinking water (Figure 1).

Throughout the year, the main drinking water source of the households is prone to change. 75 % of the respondents said that they had to use different drinking water sources due to intermittency of the water supply, how the seasons and/or weather influence water availability, breakdowns in the main water source, and affordability issues. The residents are forced to sometimes seek alternative, potentially unsafe water sources, such as surface water or other unimproved sources. Additionally, intermittent water supply can result in low pressure in the piped systems, which increases the possibility of contamination entering the pipes if they are leaky.

Microbial water quality

E.coli presence-absence tests at the point of use revealed that 83% of all samples tested were contaminated with faecal bacteria, despite 76 % of the households reporting to boiling water before storage and consumption (Figure 2). This discloses that there are poor storage practices and unhygienic water handling in the households. Although efforts are made to ensure safe drinking water in the piped supply systems through chlorination, inconsistent chlorine dosing leads to inadequate disinfection due to underdosing. And overdosing makes the water unacceptable for the people to drink. During the field visits, the recommended WHO free residual chlorine levels (0.2 – 0.5 mg/L) were found in only two of the 14 taps tested, making the water susceptible to microbial contamination.

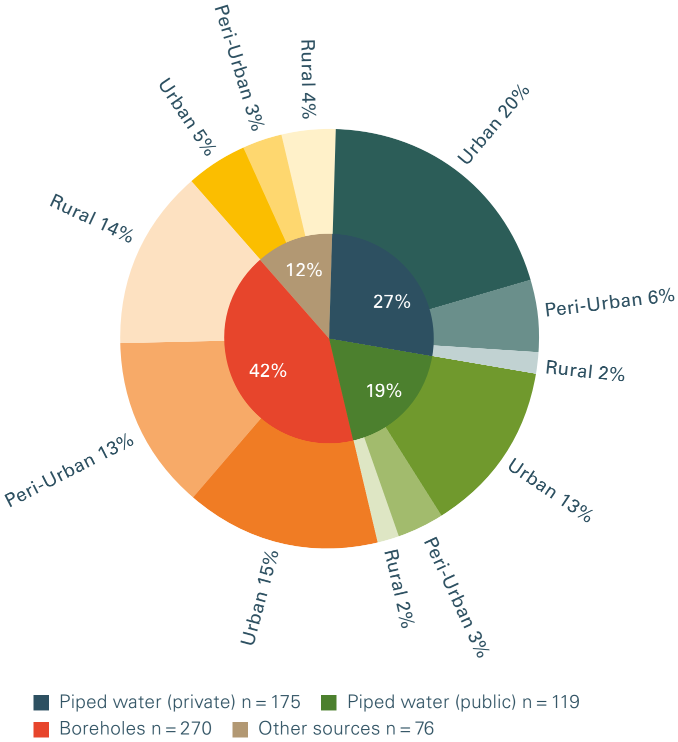

Figure 1: Main drinking water sources, categorised for urban, peri-urban and rural areas in Kakooge and Wobulenzi.

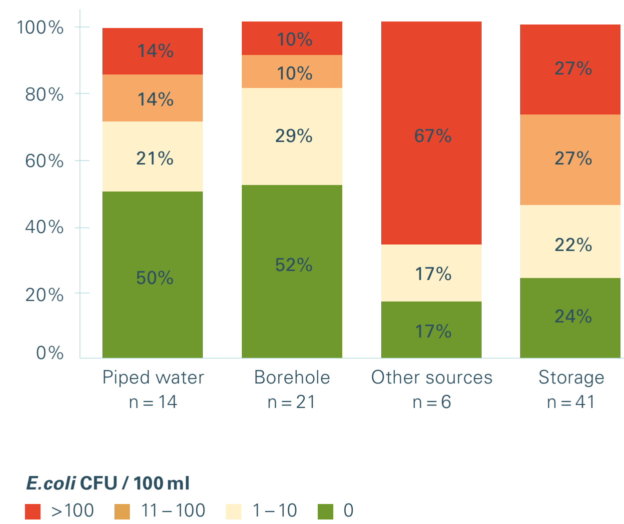

Figure 2: Faecal contamination at tap level (point of collection) and at storage level (point of use) in Kakooge and Wobulenzi.

Piped water supply

Chemical water quality analyses revealed that the piped water of Kakooge had a slightly elevated fluoride concentration (approximately 2 mg/L), compared to the WHO recommended limit of 1.5 mg/L. This fluoride in the groundwater source of the piped supply, likely of natural origin, can cause adverse health effects including dental or skeletal fluorosis [3]. Other chemicals of concern found in the borehole water of both towns included manganese and zinc.

A significant number of respondents (approximately 20%) expressed concern about the chlorine taste of the piped water. This indicates that chlorine overdosing in the piped supply systems sometimes occurs, leading to a negative perception of piped water among some consumers. Furthermore, the willingness to pay for piped water is relatively low, posing challenges to the sustainable operation of the supply systems.

Observed interlinkages

Greywater reuse is a common practice, mentioned by 74 % of the respondents in the two towns. Used water is repurposed for cleaning, garden irrigation, or toilet flushing. This represents a sustainable approach to water management in these communities.

Unmanaged solid waste dumpsites contaminate nearby water sources through leachate release (Photo). This was confirmed by elevated concentrations of various pollutants, including heavy metals, such as lead, arsenic, and iron, in a pond near the main dumpsite in Kakooge. Furthermore, solid waste dumped in the drainage channels sometimes obstructs water flow, leading to increased flooding risks, and degradation of nearby swamps and wetlands.

These interlinked issues underscore the importance of having an integrated approach to water, sanitation, and solid waste management. This allows for better understanding of the underlying mechanisms of water contamination. It also assists in the development of effective solutions.

Way forward

To address the identified challenges and to design potential solutions for improving services, local stakeholders from the two towns (including the town clerk, physical planner, health inspector, and water utility manager) were convened to identify the towns' priorities and to co-create possible interventions. Proposed solutions included improving the chlorination systems of the piped water supplies, managing the solid waste in the drainage channels, sensitising the local population about water handling and safe storage practices, and instructing them in hygiene and waste management practices. These measures will be developed in collaboration with local stakeholders and supported by Sandec staff in the coming years. •

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An Assessment Tool for Rural Water Quality Testing Laboratories

'Fit-for-purpose' rural laboratories support regular monitoring of drinking water quality. A digital tool is being developed to assess the standard benchmarks of laboratory installation and operation. Bal Mukunda Kunwar[1], Marisa Boller[2], Jackline Muturi[2] and the REACHLab Team[3], Sara Marks[2]


Marisa Boller

Photo: 'Fit-for-purpose' water quality testing laboratory in Kenya.

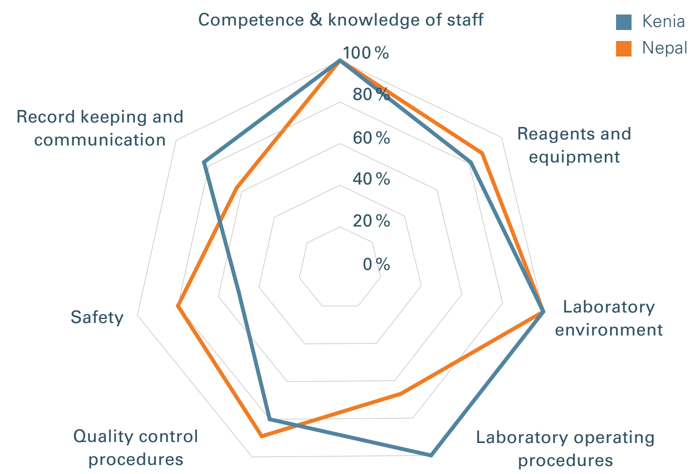

Figure: Pilot test results of the laboratory assessment tool in Kenya and Nepal.

Introduction

The SDGs prioritise universal access to safe drinking water, particularly for rural populations facing water quality challenges. Field-based laboratories help to identify water risks and treatment solutions. 'Fit-for-purpose' (FFP) rural labs support local operational monitoring efforts [1], and test basic water quality parameters (pH, turbidity, free residual chlorine, and *E.coli*) and additional contaminants as needed [2]. To support their effectivity, a digital assessment tool is being developed by the REACHLabs team (Eawag/Sandec, FundiFix, Helvetas Nepal, SafePani, and University of Oxford).

Aims and Objectives

The tool's aim is to evaluate strengths and weaknesses of existing labs, provide recommendations for improving lab equipment and management processes, and explore opportunities and challenges prior to putting new labs in place. The evaluation criteria align with the ISO guidelines for laboratory operations and are: **(1)** competence and knowledge of staff, **(2)** availability and quality of reagents and equipment, **(3)** environment conducive to good working conditions and effective monitoring (e.g. cleanliness, availability and accessibility of space), **(4)** operating procedures, **(5)** quality control measures, **(6)** safety measures and protocols (e.g. risk mitigation, waste handling, and availability of safety protocols), and **(7)** record-keeping procedures.

Methodology

Development of the tool

The digital tool was developed in Kobo Toolbox and includes approximately 50 quantitative and qualitative questions. First, interviews with the responsible lab managers are conducted, followed by direct observations of the lab. A full assessment requires about one hour to complete, and basic training on the tool is required prior to using it.

Pilot Test

Pilot testing of the digital tool took place in February 2024 at two laboratories in Kenya and Nepal. Results showed that both labs have competent staff, clear quality control procedures and conducive laboratory environments. While the lab operating procedures in Kenya were clear and strongly adhered to, there were deficiencies identified in Nepal. Conversely, fewer dedicated safety protocols were documented in Kenya and there were no procedures for microbial lab waste handling (Figure 2). Interview questions were well-understood by lab managers and overall, the tool was suitable for the local contexts. The pilot test provided useful insights for the further development of the digital tool, and have already contributed to improvements in the labs. For example, the lab in Kenya prepared and printed dedicated safety protocols visible to all lab operators.

Upscaling and Way Forward

The research team will further refine the digital tool and eventually disseminate it as an open access resource to water sector stakeholders. Uptake of the tool will contribute to both the strengthening of existing FPP labs and the establishment of new ones, and support improved regulatory oversight of drinking water quality in rural areas [3]. •

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Measuring Student and Staff Experiences with WASH in Ugandan Schools

Current water, sanitation, and hygiene (WASH) indicators focus on service quality and availability. Eawag researchers and global partners piloted an experiential survey to capture users' needs. Marisa Boller[1], Joshua D. Miller[2], Christina Barstow[3], John Brogan[3], Charles B. Niwagaba[4], Sera L. Young[5], Sara Marks[1]

Marisa Boller

Figure: From left-right: Sanitation, water, hygiene, and solid waste facilities at a school in Wobulenzi, Uganda.

Introduction

Tracking progress towards improved WASH services in schools mainly relies on direct observations, i.e. proximity to taps and latrines, to assess resource availability and functionality. Although useful, it does not inform about accessibility or satisfaction. Experiential measures of domestic water insecurity with resource-based indicators give insights into how water issues manifest and impact daily living. More than 100 organisations have used the Water Insecurity Experiences (WISE) Scales to quantify water insecurity, evaluate impact, and develop effective WASH policies and programmes [1]. Analogous tools for schools and healthcare facilities could also transform WASH interventions. Researchers from Eawag and Makerere University, in partnership with Helvetas, Northwestern University, UNC Chapel Hill, and the Swiss Water and Sanitation Consortium, piloted an experiential survey among students and staff in 10 primary and secondary schools in Uganda. The Institutional WISE (INWISE) project's aim is to develop a scale that comparably measures the adequacy of WASH, waste management, and menstrual hygiene management services across diverse contexts.

Methodology

The study took place in Wobulenzi and Kakooge, small towns with approximately 36,000 and 11,000 inhabitants, respectively. The ongoing WABES Integrate Study (see pp. 34–35) takes place in these towns. The main water sources in both are piped networks and boreholes, while non-sewered sanitation systems consist of unlined and lined pit latrines. Solid waste collection takes place daily in Wobulenzi and weekly in Kakooge. Open burning of solid waste is commonly practiced in both towns (Figure).

The schools ranged from 80 to 1,700 students. Cognitive interviews were done with a subset of students and staff (48 students and 20 staff) in two schools in Wobulenzi to determine if the survey questions were easy to understand or needed revising.

Preliminary Results

Most survey questions were well understood. Several had to be adapted and new questions added to capture local WASH realities. For example, "dirty" replaced "disgusting or unacceptable to use" in a question on school toilet facilities, and feedback led to a question about smell.

All available teachers and staff (161), and about 10 % of the students (613) completed the revised surveys, and WASH and solid waste management practices at the schools were directly observed. Many school sanitation facilities were in poor condition. Nine out of 10 students reported the latrines as dirty and smelly, 64 % stated there was not enough toilet paper available and 49 % said the absence of school toilet bins made it difficult to dispose of menstrual hygiene products. Handwashing stations were available in all schools, yet 83 % of the students reported a lack of soap. Solid waste collection was described as unreliable and eight schools burn their waste on a daily to weekly basis. Despite seven of the 10 schools treating their drinking water, 40 % of the students said the water was unsafe and 59 % were concerned about not enough drinking water available at school.

Next Steps

Results revealed that combining resource-based and experiential measures can provide a comprehensive understanding of WASH conditions of schools. Data showed that students experienced considerable challenges with unsanitary latrines, disposal of menstrual hygiene products, and hand washing. The factors influencing students' and staff members' lived experiences with WASH and solid waste, including service integration and seasonality, will be further analysed. This study will be repeated at healthcare facilities in the two towns to further support the development of the INWISE scale. •

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[4] Makerere University
[5] Northwestern University
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Characterising and Strengthening Rural Water Quality Labs

Rural water quality monitoring requires laboratories that are tailored to local needs and technical capacities. Effective monitoring strategies prioritise translation of data to decisions through stakeholder collaboration and sensitivity to communities' social-cultural diversities. Jackline Muturi[1], Sara Marks[1] and the ReachLabs Team[2]

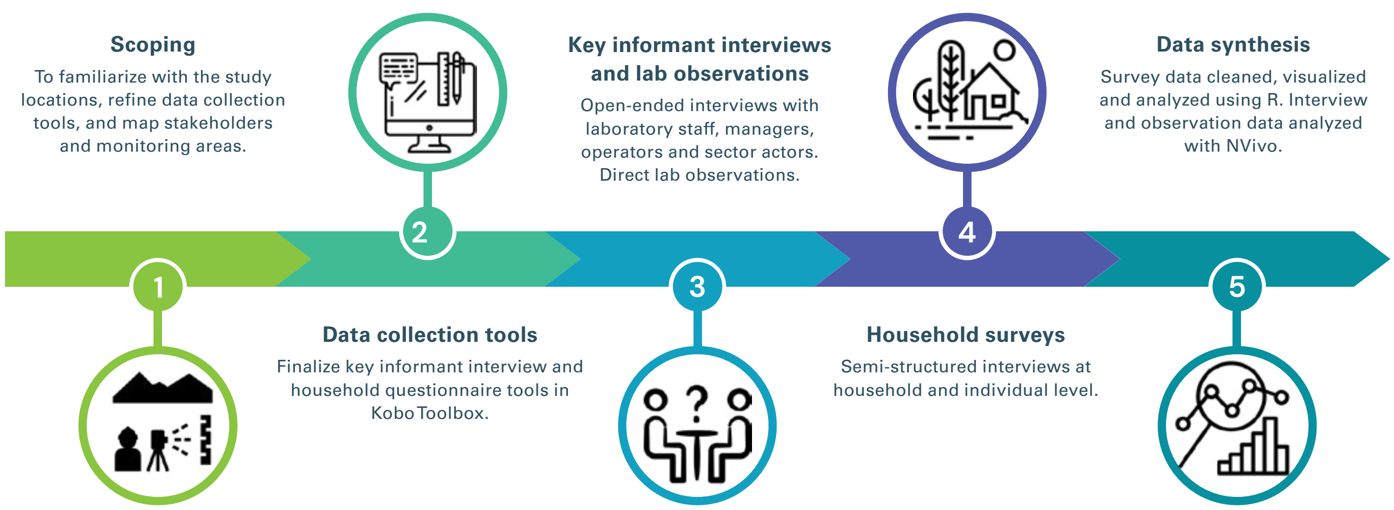

Figure: Study chronology and methodology.

Introduction

One of the key challenges to water safety management in rural areas of low- and middle-income countries is effectively collecting and using water quality data. In response, water sector regulators and service providers are showing increasing interest in applicable water quality monitoring solutions [1]. Eawag is collaborating with a team of global researchers and water service providers on the REACHLabs project, which will document learnings from fit-for-purpose laboratories aimed at supporting operational water quality monitoring of rural water supplies.

Research context and methodology

Between 2017 and 2022, the REACH project installed rural water testing laboratories in Nepal, Kenya and Bangladesh to monitor microbial and physicochemical water quality parameters of concern in their respective geographical locations (Photo). The labs had varying testing capacities, power supplies, management arrangements, and institutional settings.

The study was carried out across rural communities served by eight laboratories in Nepal (in partnership with Helvetas-Nepal), one laboratory in Kenya (with FundiFix) and one laboratory in Bangladesh (with SafePani). It was aimed at characterising how the rural labs' monitoring arrangements were adapted to local contexts to deliver useful and useable operational data to improve the performance of water systems. A comparative mixed-methods study design was conducted, consisting of 57 key informant interviews, direct observations of the lab arrangements, and 175 surveys with water users (Figure).

Preliminary results

Early analysis of interview, lab observation, and survey data revealed several initial insights:

Diverse arrangements: There was wide variability in the system types, monitoring arrangements, and level of community involvement across the three study sites. For instance, in Nepal, households had gravity-fed piped water supplies from spring sources. Management of these schemes consisted of a supported community management model, with water users themselves often engaging in monitoring activities, such as sample collection and delivery. In Kenya, communities were served by boreholes with hand pumps and small-piped systems, and a professional service provider was contracted to deliver water supply and monitoring services as a bundled package. Finally, in Bangladesh, households accessed deep tube wells with hand pumps and small-piped supplies. These schemes were managed and monitored by a local service provider.

Translating data to action: For each lab, the decision to adopt a monitoring approach was shaped by local contamination issues and operational needs. Testing methods were also chosen based on the availability of local energy sources. Due to long shipping times, all labs used simplified, locally made equipment when possible and gave preference to the use of locally sourced materials. In Nepal, the electrical grid remained largely unavailable to the surrounding rural communities. Labs were, therefore, limited to a basic set of parameters (microbial, pH, and turbidity) and made use of off-grid solutions, such as the DelAgua filtration unit paired with a solar-powered incubator [2]. In Kenya, salinity and fluoride were known water

Guillaume Clair-Caliot

Photo: Water quality testing labs serving rural communities in Surkhet, Nepal.

quality issues and, therefore, labs were equipped to regularly test for these contaminants. As some communities in Kenya and Nepal had adopted passive inline chlorination, labs in these countries were equipped to conduct regular free residual chlorine testing. In Bangladesh, where grid electricity was available and local contaminants of concern included arsenic, iron and manganese, the labs were equipped to test for a wider range of monitoring parameters.

Sustainability at scale: Innovative financing arrangements were harnessed to overcome the notion that water quality monitoring is expensive and unaffordable. A blended finance model was used in Bangladesh to reform existing institutional design and move towards greater professionalisation of water services [3]. In Kenya, water quality monitoring was financed through a private sector player. The fit-for-purpose labs have been an effective mechanism for establishing a water quality information system, with verified performance metrics unlocking results-based funding. In Nepal, effective water quality monitoring was achieved through the integration of the lab activities into the wider integrated water resource management programme, with complementary long-term goals and existing networks at the local, regional and national level [4].

Conclusion

Initial results revealed a wide diversity of arrangements for rural water quality monitoring across the three study sites. Differences in laboratory set-ups were driven by pragmatic concerns, such as local contamination, system management models, availability of material supplies, local technical capacities, and energy availability. Yet, the laboratories had in common the aim to support system operators in proactive management and decision making. These cases provide insights on how tailoring operational monitoring to local realities can effectively contribute to water safety aims. The REACHLabs project will conclude at the end of this year, with final results to be published in a forthcoming scientific article. •

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Water Safety Management

About 1.8 billion people use a source of water that is unsafe and large disparities in access to water exist between rural and urban areas and among different regions worldwide. Sandec's Water Safety Management (WSM) research is developing and evaluating appropriate solutions to strengthen the access to and enhance the consumption of safe drinking water in vulnerable households in low-income countries and improve water management. 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 programmes.
- Impact evaluations of improved access to safe drinking water.
- Assessment of water management and climate resilience of WASH.

Photo Assessing the impact of safe drinking water on improving child health.

Photo by Regula Meierhofer.

Association of WASH and Nutrition with Stunting of Children in Rural Ethiopia

Poor water supply, difficult hygiene conditions, contaminated water and nutritional challenges pose a threat to the health of children in the Sidama region of Ethiopia. The situation before the installation of solar powered electro-chlorinators was alarming. Loïc Fache[1], Anna Wettlauffer[1], Moa Kenea Abate[2], Daniel Abera[2], Regula Meierhofer[1]

Anna Wettlauffer

Photo: Water distribution point, Shebedino.

Introduction

Poor water, sanitation and hygiene (WASH) conditions pose a significant public health threat, especially to children under the age of five. The consequences of exposure to poor WASH conditions can include diarrhoea and chronic malnutrition, inhibiting the child from growing and healthy development. Poor WASH conditions are also associated with environmental enteropathy, a poorly defined state of intestinal inflammation without overt diarrhoea caused by repetitive exposure to environmental pathogens [1, 2]. Poor-quality water is a transmission vector for diseases, such as diarrhoea, typhoid, cholera or polio [3]. Diseases and environmental enteropathy can lead to or increase malnutrition by lowering the absorption of nutrients in the intestine [4].

The goal of this study was to assess water quality at collection and at the point of consumption, sanitation and hygiene infrastructure and practices, and nutrition and their association with child health. The survey was conducted prior to a safe water intervention consisting of the installation of an automated chlorination system using electrolysis for the production of chlorine at the water collection point.

Methodology

This cross-sectional survey was conducted from May to June 2023 in six rural Kebele (villages) in the Sidama region of Ethiopia. In each community, 100 households were randomly selected, making a total of 600 households. The criteria to include households in the study were that the household had to have at least one child under the age of five and they had to collect their drinking water from the main supply scheme (Photo). The interview consisted of a questionnaire that consisted of questions to the main caregiver of the child about the wealth of the household, use of water sources, water handling and hygiene practices, sanitation infrastructure, information on WASH promotion activities received, nutrition provided to children and the children's history of illness in the past week. These questions were complemented by the interviewers doing structured observations of the WASH infrastructure and the condition of the house. The questionnaire was pre-tested in a real setting and corrected according to the comments received. To assess children's nutritional status, the following indicators were measured: height, weight and middle-upper arm circumference. From that, Height-to-age (HAZ) and Weight-to-age (WAZ) scores were computed to assess malnutrition. In addition, clinical signs of malnutrition were observed.

Water quality tests were conducted at household level, i.e. after storage and potential treatment, and at the point of water collection. The tests were conducted using membrane filtration of 100 ml water samples and subsequent incubation on Nissui compact dry plates to measure colony forming units (cfu) of *E.coli* and total coliforms. Also, pH and free residual chlorine were measured. Frequency statistics and logistic regression models were used for analysis to identify the factors associated with the stunting of children and water quality.

Results

General data, WASH practices and infrastructures

In this rural setting, three quarters of the household heads were farmers. 83 % of the respondents were women, among them a third were illiterate. The results showed a concerning sanitation and hygiene situation. Access to basic or even limited sanitation was lacking, with 86 % of the households having access only to simple pit latrines. 12 % reported practicing open defecation and 95 % of the households did not have handwashing facilities. Animals were present inside 34 % of the surveyed households, and animal faeces were found inside 41 % of the homes, and outside 56 % of the houses.

Water supply and quality

The water supply system, which consisted of reservoirs filled with groundwater and supplying standpipes, was prone to interruptions and 23 % of the standpipes were not functioning properly. Almost 90 % of the respondents relied on public standpipes. Very few households treated their water (3 %). The storage containers, predominantly plastic jerrycans (99 %), were not clean in 85 % of the cases. Although 99.5 % of the respondents cleaned their jerrycans, the methods used were inefficient, due to the lack of proper cleaning materials and difficulty to reach the inside of the jerrycans. At the point of water collection, 97 % of the samples were contaminated with total coliforms and 71 % with *E.coli*. At the point of consumption (household), all samples were contaminated with total coliforms, and 95 % with *E.coli*. The median contamination was 32 cfu / 100 mL (Figure).

Children's health

The child health indicators were also concerning: 45 % of the caretakers reported that their child had had fever in the last week, and 44 % cough. Diarrhoea was the third most reported illness, with 26 % of the children having suffered from it in the week preceding the interview. Some children showed clinical signs of malnutrition: 14.5 % had a swollen abdomen, and 8.5 % a loss of hair pigment. The analysis of HAZ and WAZ revealed that 37 % of the children were stunted and 13 % underweight.

Factors associated with stunting

Logistic regression models with HAZ-scores as outcome revealed that higher HAZ scores (indicating children who were a normal size for their age) were significantly ($p \leq 0.05$) associated with: higher wealth (OR = 1.42, 95 % CI [1.13 – 1.78]), hygiene knowledge and risk awareness (OR = 1.38, 95 % CI [1.04 – 1.84]), cleaner hands (OR = 2.34, 95 % CI [1.65 – 3.31]), clean jerrycans (OR = 1.97, 95 % CI [1.19 – 3.26]), improved sanitation (OR = 2.70, 95 % CI [1.68 – 4.35]), the presence of a clean cutting board in the house (OR = 2.57, 95 % [1.57 – 4.21]), additional snacks given to the children (OR = 1.9, 95 % CI [1.35 – 2.66]) and better food security (OR = 1.2, 95 % CI [1.01 – 1.43]), as well as the use of soap for handwashing (OR = 1.10, 95 % CI [1.01 – 1.2]). Lower HAZ scores indicating stunted children were associated with the presence of animal faeces outside the house (OR = 0.60, 95 % CI [0.43 – 0.85]), the disposal of children faeces in the open (OR = 0.43, 95 % CI [0.28 – 0.67]), the presence of trash in and outside the house (OR = 0.45, 95 % CI [0.3 – 0.6]) and diarrhoea (OR = 0.66, 95 % CI [0.45 – 0.95]). Having *E.coli* present in the drinking water during the survey was not significantly associated with stunting (p = 0.265, OR = 0.89, 95 % CI [0.73 – 1.09]).

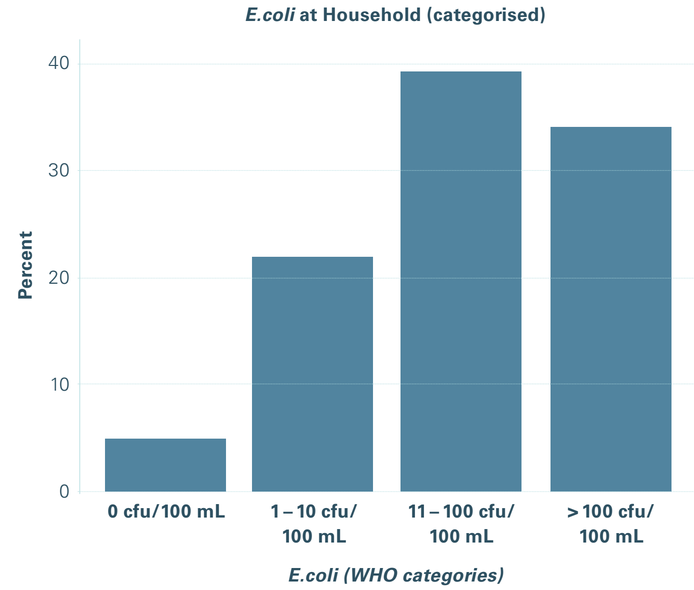

Figure: *E.coli* contamination in the household water samples.

Conclusion

This cross-sectional study shed a light on an alarming WASH situation at the study sites. A significant proportion of the children experienced health issues, including fever and diarrhoea. Chronic malnutrition, indicated by stunted growth, affected a substantial percentage of the children. Moreover, the community exhibited poor hygiene practices. Sanitation conditions were poor, with unclean toilets and no handwashing facilities in most households. The drinking water quality reflected the poor hygienic conditions as it was highly contaminated by bacteria and storage containers were rarely clean. Several factors contributed significantly to childhood stunting, including recent illnesses, nutritional factors and unsanitary practices, such as inadequate hand hygiene and the presence of animal faeces. The poor WASH conditions in Sidama should urgently be addressed to improve children's health in the region. •

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Education and Training

Sandec aims at reducing the global WASH capacity gap by offering a wide range of education and training initiatives. These cover face-to-face, blended and online learning formats, as well as fellowships. Five of our main focus areas are:

- Offering free 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 Master's courses on Sanitary Engineering at EPFL Lausanne and ETH Zürich.
- Hosting Master's and PhD students and visiting scientists from low- and middle-income countries who receive Eawag Partnership Programme Fellowships.

Photo After a one-week training on data collection, students from Makerere University joined the researchers from Eawag and Makerere to collect data in households and schools. In the picture, you see the team after a day of data collection in Kakooge, Uganda.

Photo by Fabian Suter.

Blending Human Expertise and AI to Create Future WASH MOOCs

How can human expertise and artificial intelligence complement each other to better address global challenges? Our first experiences bringing the two together in the WASH MOOC series provide promising examples, but also highlight the need for ethical guardrails. Fabian Suter[1]

Introduction

The debate over whether Artificial Intelligence (AI) should be embraced or feared is reminiscent of the discussions in 2012 when Massive Open Online Courses (MOOCs) burst onto the scene. The promise of free, global access to education created a hype with enthusiasts highlighting the potential "to unlock a billion more brains to solve the world's biggest problems" [1], while sceptics argued that MOOCs could widen educational disparities and pose a threat to academia [2, 3]. In the meantime, MOOCs have become an integral part of the educational landscape. To date, over 1,300 universities from all continents have produced courses. They are hosted on a growing number of platforms (e.g. Coursera and edX in the United States, SWAYAM in India and ThaiMOOC in Thailand), covering topics from the humanities, sciences, technology and business [4].

Today's discussion about AI again revolves around whether it is more of an opportunity or a risk. This time, however, the stakes are higher as AI is posing more fundamental questions, including its potential existential threat to humanity (e.g. the thought experiment "paperclip maximiser" by philosopher Nick Bostrom from Oxford University highlights a scenario in which humanity is outmanoeuvred by a superintelligence) [5]. Our first experiences with AI in work on Eawag's WASH MOOC series (www.eawag.ch/mooc) provide promising examples of how human expertise and AI can complement each other to address the challenges of reducing educational inequalities worldwide.

Rank	Country	World region	Enrolled learners between Jan 2014 and Dec 2023
1	India	Asia	41,600
2	United States	North America	11,926
3	Mexico	North America	4,994
4	Colombia	South America	4,714
5	Philippines	Asia	4,542
6	France	Europe	4,451
7	Nigeria	Africa	4,319
8	Peru	South America	4,046
9	Brazil	South America	3,318
10	Pakistan	Asia	3,292

Table: Countries with the most enrolled learners in the WASH MOOC series between 2014 and 2023. Source: Coursera

Enhancing equal access to WASH MOOCs globally

Facts now show that MOOCs are being widely used by learners in all regions of the world. Our WASH MOOC series has reached learners in 195 countries. India is by far the country with the most enrolled learners, and countries in all the world's regions, except Oceania, rank among the top ten (Table).

Over the past decade, two main activities have been pursued to improve equal access to the courses. Firstly, producing subtitles in multiple languages has expanded the reach of the MOOCs to non-English speakers. The impact on enrolment of this time-intensive work shows clearly in the top ten countries, among them three are Spanish-speaking, one is Portuguese-speaking and one is French-speaking. Secondly, collaborations with universities, ministries and NGOs have been instrumental in reaching new learners in countries with lower enrolment numbers (Photo 1). Successful collaborations include those with Prof. Elizabeth Tilley at the Polytechnic in Blantyre, Malawi, in 2017 and Dr. Abdisalam Ibrahim Hussein at the Ministry of Health, Somalia, in 2023. Both have nearly doubled enrolments for the WASH MOOCs in their countries. AI is complementing these efforts by contributing machine learning-powered subtitles in over 20 languages, such as Arabic, Ukrainian or Indonesian, and by improving accessibility for learners with disabilities by providing features, such as speech-to-text, text-to-speech, and other assistive technologies. In this way, the combination of targeted collaborations with strategic use of AI has accelerated the uptake of the WASH MOOC series, while also significantly reducing the time and effort required to produce subtitles.

Will we learn from avatars in the near future?

Advances in cognitive psychology have enhanced our understanding of how multimedia technology can foster student learning, more concretely, of how it can be used best to move concepts through learners' limited working memories into their long-term memory, enabling them to use what they have learned in a variety of circumstances [6]. Mayer's learning principles, such as the segmenting principle (break lessons into user-paced parts) or the modality principle (combine graphics and narration rather than graphics and printed text) [7], have proven effective for creating engaging learning videos. In our experience, they can be best applied when green-screen recording technology is used in a collaborative process involving instructors, learning experts, and multimedia professionals (Photo 2). In the near future, AI will streamline and considerably shorten the production process with automated scripts and visuals, as well as real-looking avatars that can be fed with texts. However, this increase in efficiency comes with risks. Quality control of AI-created components and prevention of the misuse of avatars will be essential to maintain the reputation of the WASH MOOC series.

Najma Ali Farah

Photo 1: Students in Somalia are joining the WASH MOOCs thanks to a new partnership established in 2024 between the Somali National University and Eawag.

Laura Baquedano

Photo 2: A recording session in the Eawag video studio using green-screen technology.

Conclusion

The examples provided only scratch the surface of AI's enormous possibilities. In the near future, MOOC learners will, for example, have access to personalised learning paths dynamically adjusted to their learning behaviour and prior knowledge. AI-powered coaches will provide personalised support and feedback, and AI-powered predictions will help reduce people dropping out by enabling timely interventions. In addition, current unpredicted AI-driven innovations promise to further enrich the educational landscape. Therefore, research is required not only to explore AI's full potential for MOOCs, but also to establish ethical guardrails that minimise the associated risks. •

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The MOOC series "Sanitation, Water and Solid Waste for Development" was developed by Eawag in collaboration with EPFL. It is co-funded by the Swiss Agency for Development and Cooperation. The courses are continuously running and available for free on the learning platform Coursera. More information can be found at: www.eawag.ch/mooc

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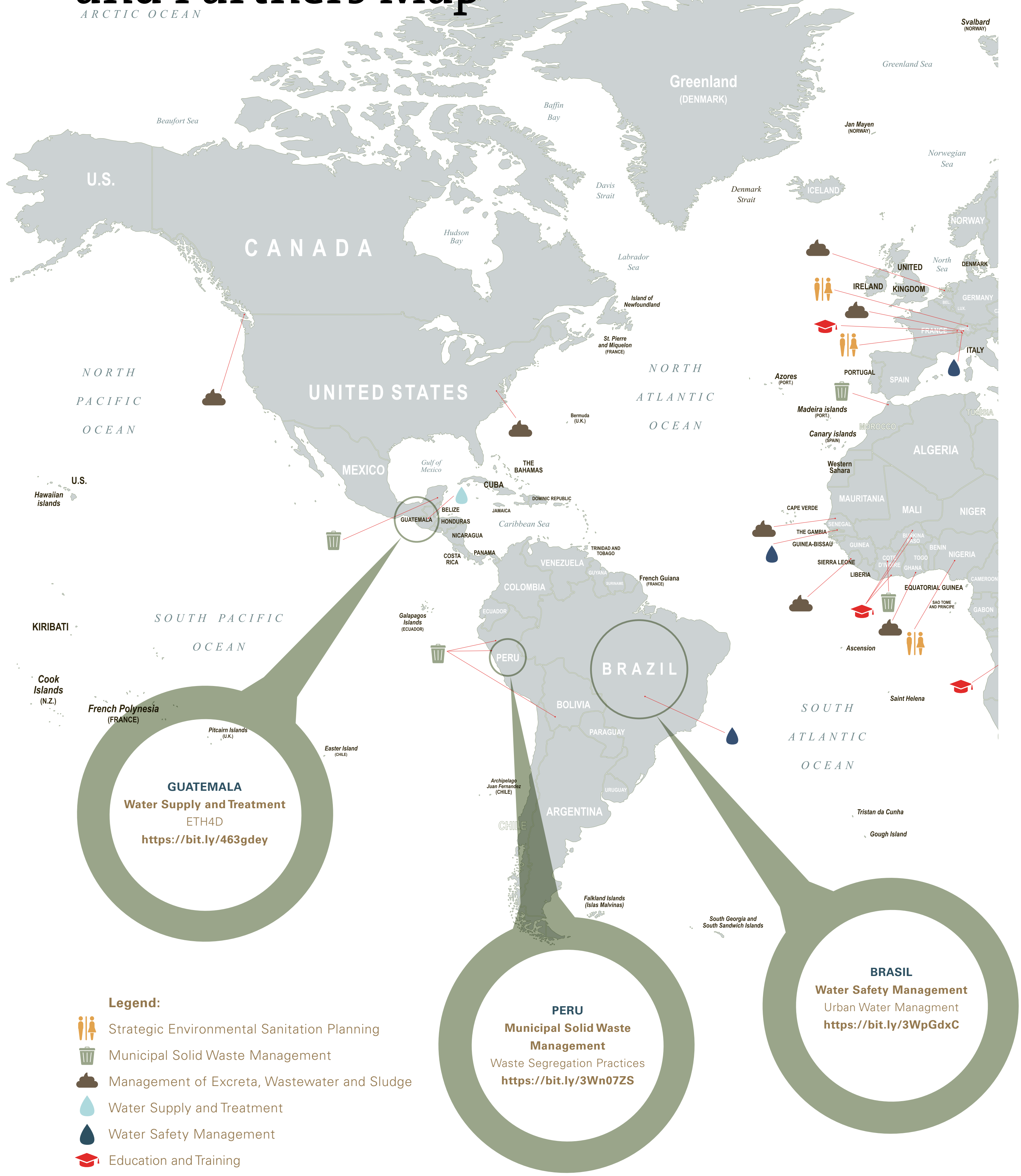
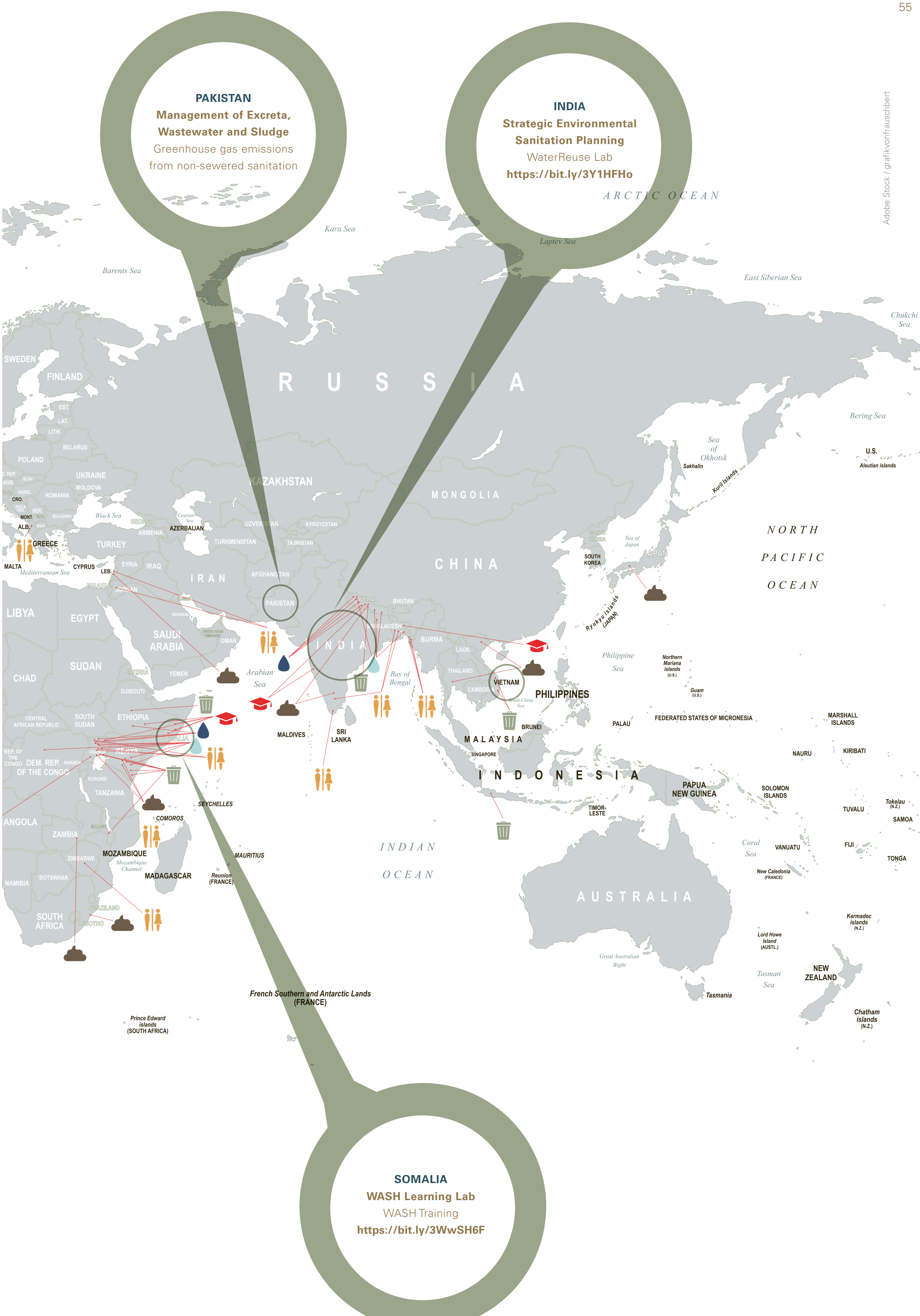
Global Research Projects and Partners Map



Legend:

- Strategic Environmental Sanitation Planning
- Municipal Solid Waste Management
- Management of Excreta, Wastewater and Sludge
- Water Supply and Treatment
- Water Safety Management
- Education and Training



Adobe Stock / grafikvonfrauschbert

Rick Johnston

Freya MILLS

Rick Johnston is from Chicago, Illinois, and is a Co-lead of the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).

Photo: Visiting a municipal faecal sludge emptying service in Nepal to improve monitoring of safely managed onsite sanitation.

What did you study and where did you do your university degrees?

I first got a Bachelor's degree in Liberal Arts, studying French language and history! After, I became interested in the natural sciences. I started a Master's degree in hydrogeology at University of Wisconsin-Madison, but transferred and ended up getting an MSc in Environmental Engineering from Johns Hopkins University. Finally, I developed an interest in arsenic contamination and did a PhD at the University of North Carolina-Chapel Hill, looking at subsurface oxidation and removal of iron and arsenic.

How did you find out about Eawag-Sandec?

When I did my graduate studies, I learned about Eawag's important place in the history of aquatic chemistry (not least from reading Stumm and Morgan's Aquatic Chemistry). Then, when I worked with UNICEF in Bangladesh I learned about Sandec's work in developing countries. My PhD supervisor, Phil Singer, had done a sabbatical at Eawag and always spoke highly of it. When Martin Wegelin retired from Sandec, Phil encouraged me to apply for the Drinking Water Group Leader position.

What did you do at Eawag-Sandec?

I brought with me my strong interest in arsenic contamination, and broadened this to work in addition on fluoride and manganese contamination, as well as microbiological contamination. I also developed the new Water Supply and Treatment group.

How was Eawag-Sandec beneficial to your career?

I worked to develop a module for testing water quality in household surveys, which led me to partner more and more with UNICEF and the WHO/UNICEF JMP. Also, I worked on developing targets and indicators for water quality and integrating these data into global monitoring mechanisms. Both of these were helpful in my being hired at my present job.

What are you presently doing?

I have been at WHO headquarters since 2013, and I lead the WHO side of the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), which tracks WASH services in households, schools and health care facilities. I also work on monitoring wastewater treatment, and calculating the burden of disease caused by unsafe WASH. In recent years, I have been working with a variety of partners to develop or promote enhanced monitoring of gender and WASH, and now am trying to work on indicators of climate resilient WASH services.

What do you most appreciate about your connection to Eawag?

Since leaving Eawag, I really appreciate staying in touch with the Eawag-Sandec network. Everywhere I go, be it conferences, workshops or WASH events, I meet people who took courses at Eawag or the MOOCs, did internships, Master's degrees or PhDs, etc. Our alumni network is really powerful and the people in it are really special •

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Changes in Knowledge Exchange Among WASH Scientists and Practitioners

WASH practitioners are essential for achieving SDG 6. However, they struggle to access current scientific information to inform their decisions and this impairs their efforts. Science communication aims to accelerate access, but is not without its own challenges. George Wainaina[1], Christoph Lüthi[1]

Introduction

Science communication is the use of appropriate skills, media, activities, and dialogue to produce either awareness, enjoyment, interest, opinion, and or understanding of scientific knowledge and information [1]. However, this is only the supply side necessary for knowledge transfer.

Research about the demand side shows that information-seeking behaviours of audiences of science communication are either passive, active or ongoing. Passive implies the incidental acquisition of information, for instance, discovering it on social media, while active is intentional searching for new information. Ongoing describes when the searcher updates findings of a previous search [2]. The demand side is also necessary for knowledge transfer.

Besides the demand and supply sides, there are the intermediaries [3]. As one, I am a knowledge broker for Sandec, where I translate and transfer knowledge flows between practitioners and scientists.

Research study

I am conducting a study at Sandec to inform knowledge brokers of the mismatches of science communication and the information-seeking behaviours of WASH practitioners. The study focuses on how practitioners acquire information from social media in contrast to how knowledge producers provide the knowledge in a bid to communicate science. Social media is selected as a medium due to the increasing potential of such platforms for knowledge sharing, as recent studies have demonstrated [4].

Early findings from a literature review demonstrate that the media for science communication has evolved from traditional media, such as science television and newspapers (science journalism). New user-centred forms of media, including blogs, knowledge portals and social media, make science easily accessible [5]. Currently, over five billion people are on social media and its use as a science communication medium is very prevalent [4].

Despite this evolution, mismatches between knowledge provision and access persist. The demand side highlights such challenges as limited search skills. There are also limited studies about information-seeking behaviours among people from non-high-income countries and sectors beyond health. Knowledge brokers can encourage critical engagement, advocate for broader studies, and promote the contextualisation of science (Photo). Leveraging social media, the knowledge brokers can target audiences by focusing on relationshipbuilding, dynamic presentation, and storytelling to increase engagement. Additionally, categorising audiences by mutual interest can help to address their unawareness of available sources through targeted outreach and engagement.

Marisa Boller

Photo: Facilitating a knowledge co-creation workshop in Uganda March 2024.

Conclusion

Reflecting on the findings, WASH practitioners are a diverse group. Therefore, how can we subcategorise them meaningfully? This would improve our knowledge of their information-seeking behaviours. Additionally, collaborations in the context of new media and AI could revolutionise their practices. How, is yet unclear. Lastly, science communication and information-seeking behaviours studied together can offer practical insights for enhancing knowledge transfer. •

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[1] Eawag / Sandec, Switzerland

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New Capacity Development Collaborations in Uganda, Somalia and Ethiopia

Together with partners in Uganda (Makerere University), Somalia (Ministry of Health and Somali National University) and Ethiopia (Jigjiga University), the WASH Learning Lab has initiated a series of new collaborative capacity development projects for students and practitioners. The projects blend online learning, classroom teaching, site visits, and interactions with WASH experts in the respective countries and Sandec. The goal is to foster both theoretical WASH knowledge and practical WASH skills.

Please visit this webpage for more information: https://www.eawag.ch/en/department/sandec/digital-learning/collaboration/ and get in touch with Fabian Suter (fabian.suter@eawag.ch), if you are interested in starting a WASH capacity development collaboration.

Capacity Development Collaboration Information

Abdisalam Ibrahim Hussein

Photo 1: WASH training session facilitated by the Ministry of Health in Somalia.

Najma Ali Farah

Photo 2: Practical introduction to the WASH MOOC series at the Somali National University.

Here is Your Chance to Advise on How to Improve Sandec News

Dear Sandec News Reader, Thank you for annually reading the most recent highlights of our water, sanitation and solid waste research. We would like your input on how to make your reading experience more fulfilling. Therefore, we welcome your advice on how we can improve – through the website link or QR code below. The survey will take less than five minutes to complete. Your valuable insights will guide how we present and deliver future publications.

Any data you share will only be used at Sandec and stored for a maximum of one year. Thank you in advance for your advice.

Sandec News Feedback Form

Eawag Hosts Two Major International Humanitarian WASH Conferences

Eawag hosted the 20th Emergency Environmental Health Forum (EEHF) and the 28th Global WASH Cluster (GWC) Annual Meeting in spring 2024. Both provided excellent platforms for meaningful exchanges, and the fostering of collaborations and innovations in the field of water, sanitation, and hygiene (WASH) in Humanitarian Contexts. Over 250 participants from various organisations and countries gathered to discuss critical topics, such as Nexus, Climate Change, and Localisation, as well as to share new WASH research, learning and approaches. Eawag Director Prof. Martin Ackermann welcomed both events and emphasised how important collaboration and innovation are for the development of sustainable solutions and the building of resilience in communities facing crises. Through these collaborative efforts, Eawag aims to act as a central hub for international efforts to mitigate global water-related challenges.

Laura Baquedano

Photo 1: Eawag Director Martin Ackermann welcomes guests from all over the world to the Emergency Environmental Health Forum.

Leonardo Biasio

Photo 2: 28th Global WASH Cluster Annual Meeting.

Laura Baquedano

Photo 3: 28th Global WASH Cluster Annual Meeting.

Laura Baquedano

Photo 4: Lauren D'Mello-Guyett from the LSHTM and Andy Bastable from Oxfam closing the 20th EEHF.

Peter Penicka

Photo 5: Sandec representatives with key WASH Humanitarian actors at the EEHF.

The Sandec Team

From left to right – Front row: Christoph Lüthi, Adeline Mertenat, Elizabeth Tilley, Vasco Schelbert, Dorian Tosi Robinson, Laura Baquedano, Isolde Wackernagel, Emma Ossola, Marisa Boller, Daniela Peguero
2nd row: Abishek Narayan, Sara Ubbiali, Chris Zurbrügg, Linda Strande, Laura Velasquez, Maja Schøn, Kayla Coppens, Regula Meierhofer, Celestine Uwanyirigira, Ednah Kemboi, Caterina Dalla Torre
3rd row: Cyril Studach, Kelsey Shaw, Philippe Reymond, Michael Vogel, Nienke Andriessen, Fabian Suter, Fatema Sebti, Sara Marks
Missing in photo: George Wainaina, Paul Donahue, Loïc Fache, Jasmin Hänni, Mariève Dallaire-Lamontagne, Sejal Dangi

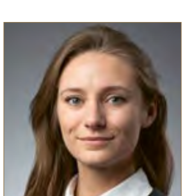
New Faces at Sandec

Laura Nelly Velásquez Arenas holds an MSc in Environmental Engineering from ETH Zürich, with a specialisation in hydraulic engineering alongside waste management and ecological system design. She has gained experience in various projects, spanning across Latin America, Europe, and Asia. Her current role is Project Officer in the MSWM group.

Loïc Fache holds an MSc in Environmental Science and Engineering from EPFL, with a focus on hydrology and water management in low- and middle-income countries. After completing his Master's thesis on in-line chlorination using electrolysis in Ethiopia with the WSM group last year, he is now a Project Officer in the same group.

Philippe Reymond returns after six years working for the private sector (Vuna) and UNHCR as a Sanitation Specialist. He has much experience in WASH for development and humanitarian contexts, and governance is at the core of his work. His main task will be to manage the new SECO-funded project in Tirana, Albania, in the SESP group.

Natalia Montoya holds an MSc in Environmental Sciences and Engineering from EPFL. She has three years of experience on the assessment of greenhouse gas emissions from waste management and sanitation in low- and middle-income countries, and has worked in projects related to non-sewered sanitation. Currently, she is a PhD student in Sandec's MEWS group.



Maja Schøn, BSc and MSc in Biology from Aarhus University, Denmark, has previously worked with microbiome characteristics, behaviour, nutrient requirements and metabolism in invertebrates. Doing her PhD at ETH Zurich and Sandec, she works with Black Soldier Flies for bioconversion to understand how different physical parameters influence the process outcomes.

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.

Sanitation in Humanitarian Settings

This comprehensive manual provides guidance on how to design, construct and operate sanitation facilities in humanitarian settings. The book concentrates on the acute response and stabilisation phases of an emergency and features more than 130 illustrations, 50 tables and 20 design examples.
By: Robert Reed
Practical Action Publishing, 2024, 314 pages
ISBN: 9781788532655

Guidelines for drinking-water quality: Small water supplies

These guidelines, specifically tailored to small water supplies, build on more than 60 years of guidance by the World Health Organization (WHO) on drinking-water quality. They focus on establishing drinking-water quality regulations and standards that are health-based and context appropriate.
By: World Health Organization, 2024, 220 pages
ISBN: 9789240088740

Water for All: Global Solutions for a Changing Climate

A fresh look at the world's water crises, and the existing and emerging solutions that can be used to solve them. Sedlak highlights the many solutions available, and charts a realistic, practical course of action for tackling the world's water crises, offering an approach for rethinking our assumptions about the way that water is managed.
By: David Sedlak
Yale University Press, 2023, 440 pages
ISBN: 9780300274776

Beyond an age of waste: Turning rubbish into a resource

Jointly published with the ISWA, the report provides an update on global waste generation and the cost of waste and its management. It presents the approach of addressing waste as a resource opportunity and a vital circular economy feature to reverse waste costs and damages and create a more sustainable future.
By: United Nations Environment Programme, 2024, 116 pages
ISBN: 9789280741292

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.

Operating the Volaser

This video shows you how to operate the Volaser, a measuring device developed to measure in situ volumes (quantities) of faecal sludge. Understanding both quantities and qualities of faecal sludge is essential when designing treatment facilities and emptying programmes, and for sound faecal sludge management planning.

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Operating the Volaser Video at Sandec Eawag YouTube Channel

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