POLICY BRIEF | NOVEMBER 2025

Science-based policy recommendations for non-sewered sanitation in urban areas

Why non-sewered sanitation (NSS)?

Nearly half of the world's population relies on non-sewered sanitation. This is more pronounced in rapidly urbanizing areas with limited planning. As a result, NSS is an increasingly prevalent urban sanitation strategy and is projected to become the default in many parts of the world.

However, NSS is often neglected in urban sanitation planning, which has tended to prioritize centralized, sewer-based approaches. This has left millions of urban residents dependent on informal or poorly managed systems that pose significant health and environmental risks. NSS is a legitimate and essential component of sustainable urban sanitation and is critical to achieving universal access to safe sanitation.

Why this brief?

This brief builds on a Nature Water Review article by Dr. Linda Strande, highlighting new scientific insights for improving non-sewered sanitation. It highlights the relevance of the insights to policy for improving NSS services.

Who is this brief for?

The brief is intended for policymakers in low- and middle-income countries, particularly those working within ministries responsible for sanitation, and linked sectors including water, health, environment, planning, climate, urban development, housing, or infrastructure.

What does this brief cover?

The brief defines NSS and explains the need for better scientific evidence for processes and systems. Building on the review paper, it then presents two recent research insights, highlights four key policy recommendations, and outlines three strategic approaches relevant to the improvement of NSS for policymakers.

eawag
aquatic research

Part 1 **Background**

What is NSS?

NSS services refer to onsite and offsite management of wastewater from source to enduse without a centralized sewer network. Wastewater includes blackwater (a liquid or slurry that originates from toilets and contains human excreta, including urine, feces, flushing and cleansing water, and toilet paper) and greywater (wastewater from cleaning, bathing and kitchen water, that does not contain human excreta). In NSS it is important to distinguish between storage (**Figure 1)** and treatment. Within NSS systems in urban contexts, wastewater may be:

- Treated **onsite**, directly at the source. This can include strategies such as biodigester toilets, tiger worm toilets, or combined treatment within a larger building.
- Treated **offsite**, collected and stored onsite before being transported and processed at designated treatment facilities before enduse or disposal. This includes road-based transport to semi-centralized treatment facilities and can also include short-term storage and short-travel distance (container-based sanitation) with more frequent collection and decentralized treatment.

Why is NSS important?

Effective understanding and planning for NSS systems is crucial for protecting both public and environmental health. Poorly managed systems can contaminate ground and surface water, contribute to disease outbreaks, and undermine broader efforts toward urban resilience and environmental protection. In contrast, well-designed and well-regulated NSS solutions can recover valuable resources such as water, nutrients, and energy (as indicated in **Figure 2**), transforming waste into an asset.

Why now?

Recent years have seen a surge in scientific knowledge related to NSS. However, significant knowledge gaps remain, and many research groups are actively exploring NSS-related topics as highlighted by the magnifying glasses in **Figure 2.** Strengthening partnerships among municipalities, utilities, and research institutions will be essential to translate emerging science into more effective NSS systems that meet the needs of communities while protecting public and environmental health.

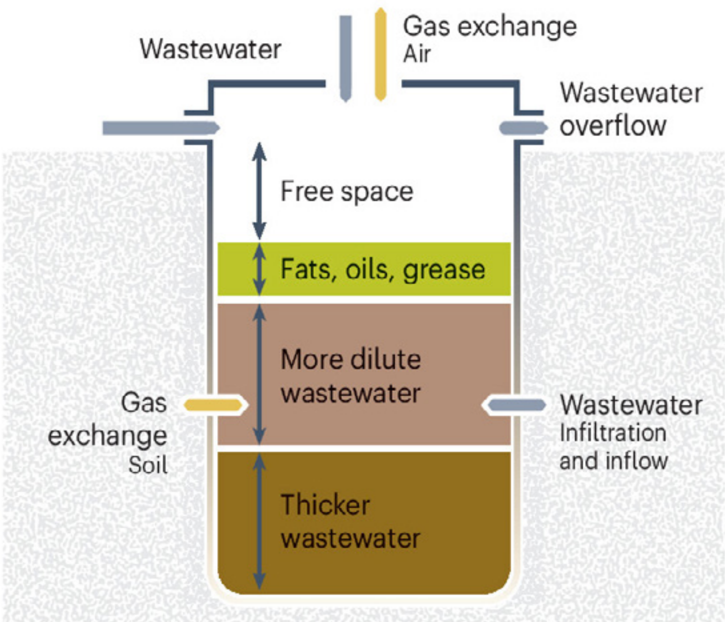

Figure 1. Illustrative onsite containment of stored wastewater. (Strande 2024).

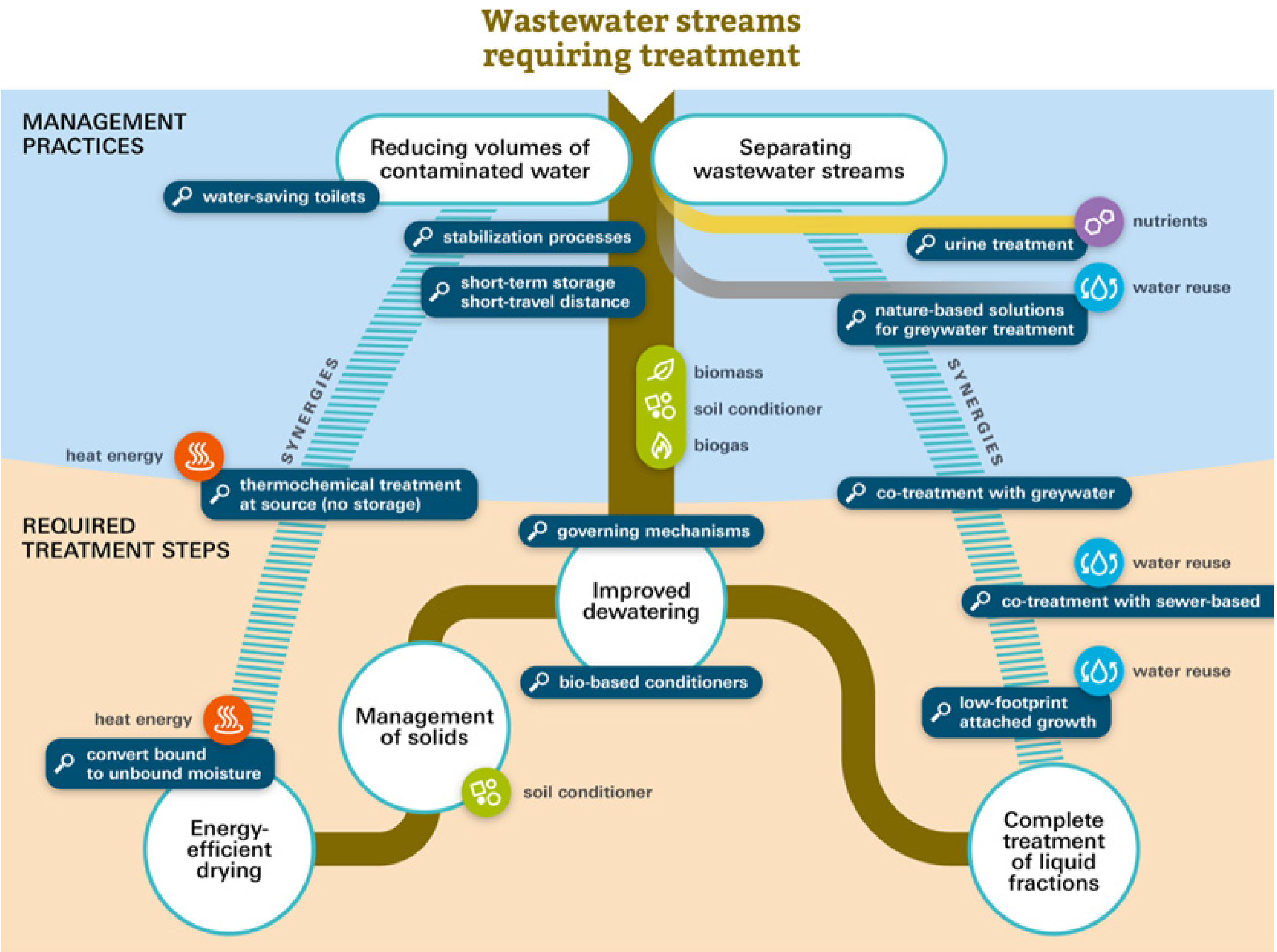

Figure 2 . Illustration of interconnected NSS bringing research to practice (Strande 2024).

- This illustration highlights **key ongoing research topics** (magnifying glasses) related to both the **management decisions** and **treatment steps** for wastewater. Importantly, management practices (top half of diagram focused on the management choices about the flows of wastewater) are interlinked with required treatment technologies (bottom half of diagram).
- Key **wastewater streams** (illustrated in yellow, grey, and brown) and **resource recovery potential** (nutrients, water reuse, heat energy icons) are illustrated alongside **priority practices** (white shapes with colored border).
- For example, the separation of wastewater streams (upper right side of diagram) paves the way for nutrient recovery and water reuse, promoting the complete treatment of liquid fractions; or short-term storage with short-travel distances (upper left side of diagram; container-based sanitation) leads to better heat recovery and more efficient drying**.**

Part 2 **Recent Scientific Insights**

This brief clarifies two recent scientific insights that shape how NSS can be promoted and applied in urban contexts, as outlined in the review paper.

→ In NSS, the quantities and qualities of wastewater are highly variable.

There is high variability in quantities and qualities within wastewater in NSS in urban settings.

- **Quantities** - The total amount of wastewater streams, including blackwater and greywater.
- **Qualities** - The composition and characteristics of wastewater.

Variability means unpredictable concentrations of liquids, solids, organic matter, and nutrient contents in the wastewater. Subsequently, the level of degradation or biological breakdown of organic matter in wastewater over time is also unpredictable. Variability is due to differences in water use, containment design, and building use (e.g., household, commercial, or public toilets). This variability makes it difficult to design and operate effective treatment processes (onsite and offsite), often resulting in poor treatment, health risks, and environmental pollution.

→ In NSS, wastewater storage does not imply treatment.

In urban contexts, it is a common misconception that wastewater stored in pits or tanks is being passively treated, or that wastewater "breaks down over time" while stored. However, recent research shows that biological degradation slows down significantly after 1-2 weeks of storage in tanks and pits as illustrated in **Figure 3**. In addition, new wastewater is continually coming into tanks and pits. In other terms, the processes of how organic matter in wastewater breaks down during storage are still relatively opaque, with incomplete understanding of microbial communities, organic matter degradation, and limits of stabilization. This is an open area for research.

As such, the storage of wastewater does not imply treatment. In urban contexts, pits and tanks are not designed for treatment processes. Instead, true treatment is a strategic and designed process which occurs at a treatment plant and includes four objectives: solid-liquid separation, pathogen inactivation, stabilization, and nutrient management (see **Figure 3**, treatment objectives).

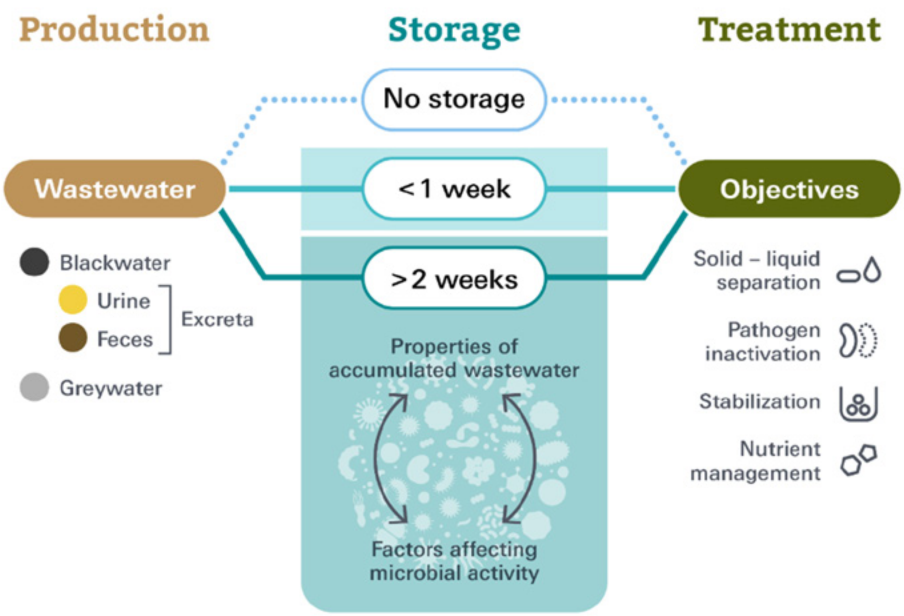

Figure 3. Overview of wastewater flows, importance of storage time, and treatment objectives in NSS (Strande 2024)

Part 3 **Policy Recommendations**

Based on the insights, the following four recommendations are curated for policy makers to support regulation, policy and strategy about NSS.

1 Ensure clear and precise language related to NSS in policies and guidance.

Policy makers are encouraged to adopt unified, scientifically robust, and descriptive terminology for all aspects of NSS to avoid misconceptions and improve communication (see **Table 1**). This includes moving away from uninformative or misleading labels (for example: "*fecal sludge management,*" "*septic tank*") and requiring clear definitions based on actual containment and management practices. Improved language is encouraged within policies, regulations, guidelines, strategies, multi-year plans, and even terms of reference.

Policy makers can:

- Consistently use terms that have clear definitions (for example: blackwater, greywater, features of containments) in policies and regulations.
- Distinguish between storage, treatment, and transport processes and not assume that treatment happens in storage tanks and pits.
- Avoid misleading or technically inaccurate assumptions due to terms (for example: storage to imply treatment).

Table 1. Recommended Terminology for Urban Environments

Terms to avoid	Terms to use instead
• **Fecal Sludge Management (FSM)** – Describes a service chain from storage through disposal or enduse. The term is being phased out because it is predominantly associated with low- and middle-income countries and reinforces inequalities in sanitation options.	• **Non-sewered Sanitation (NSS)** – Describes sanitation systems operating without a centralized sewer network. Still imperfect as it frames sanitation by what is lacking rather than what exists.
• **Onsite Sanitation** – Describes a process that implies wastewater is safe, contained and treated, which is often not true in urban contexts where tanks and pits mainly store wastewater.	• **Onsite Storage** – Describes tanks and pits as storage points, avoiding the false assumption of treatment during storage within urban contexts.
• **Pit Latrine and Septic Tanks** – In the urban context, in-ground pits do not have the appropriate space to safely leach wastewater, and lined pits and tanks do not have adequate land for leach fields. These terms are still relevant in rural contexts, where there is adequate land available for soil-based treatment of leached wastewater.	• **Pits and Tanks –** Describes structures where wastewater is stored before transfer to treatment facilities, with descriptors such as fully sealed, partially lined, and with or without overflow. Avoids implying onsite treatment.
• **Fecal Sludge –** Implies a semi-solid waste typical of dry toilets in rural areas, but urban wastewater is typically very liquid, including flush water and greywater.	**Municipal Wastewater –** Globally relevant term for liquid waste streams that are produced in urban areas. • **Blackwater** – Wastewater that originates from toilets and contains human excreta, including urine, feces, flushing and cleansing water, and toilet paper. • **Greywater** – Wastewater from household sources such as water used in kitchens, and for cleaning or bathing, that does not contain human excreta. • **Excreta** – Human bodily waste, specifically urine and feces, which are primary components of blackwater.

For a more detailed discussion on terminology for urban sanitation please see Strande et al. (2023).

2 Endorse the use of modular, integrated and tested NSS technologies from storage to enduse and disposal.

Combinations of modular and context-specific technical solutions for urban sanitation are essential from storage to enduse. This includes the treatment steps of dewatering, stabilization, pathogen removal, and nutrient recovery. For example, in a dense urban area where there is less physical space, it is appropriate to use a small-footprint dewatering step (e.g., mechanical dewatering with conditioners), whereas for settings with more land available drying beds may be more appropriate. Additionally, modular-based approaches have the potential for increased resilience to extreme weather events due to faster recovery times.

With the emergence and use of a variety of modular storage, treatment, and resource recovery technologies (see **Figure 1**), policy makers can promote and allow for the use of these technologies through flexible regulation, guidelines, and monitoring. Partnering with research institutes in such applications could allow for experimentation while minimizing public health risks.

Policy makers can:

- Craft more flexible regulations that allow for context-relevant modular technologies along the NSS service chain.

3 Promote monitoring of pathogens and treatment performance.

Knowledge of what is happening in treatment systems is critical to ensuring treatment efficacy and safeguarding communities. Policy makers can promote the monitoring of pathogen removal and treatment performance indicators through monitoring frameworks, pilots, and guidelines.

Policy makers can:

- Promote use of rapidly advancing open-source microcontrollers, sensor technology, and machine learning models, to provide inexpensive and faster monitoring of wastewater treatment.
    - Sensors can monitor the effluent of treatment processes, at any scale from in-building to decentralized to centralized. Treatment performance data could also be shared in dashboards.
    - Free machine learning tools such as the Sludge Snap App which uses color and texture data from smartphone photographs, could be developed to estimate characteristics and dewatering performance of stored wastewater.
- Sponsor environmental surveillance pilots that evaluate water in surface water runoff drains for pathogens, to identify hotspots with high pathogen loads for priority improvements for safely managed sanitation.
- Develop and implement evidence-based standards and guidelines for the design, operation, and monitoring of both onsite and offsite treatment, with a focus on pathogen monitoring and treatment efficacy.

4 Support scientific examination of assumptions used in planning and reporting.

Across the sector, many estimations and assumptions used in planning and strategy development, are not based on evidence. These assumptions and estimations are also rarely questioned as scientific knowledge grows and shifts. For example, greenhouse gas emissions and population equivalents. As such, policy makers can support better science and actively question these assumptions.

Policy makers can:

- Avoid estimating greenhouse gas (GHG) emissions using emission factors with limited scientific consensus, and rather encourage approaches that align with emerging science. Existing emission factors for GHG overestimate and further research is required to determine more accurate estimates for NSS.
- Avoid basing sanitation planning and emissions on incorrect estimates such as ‘population equivalents’ for individual tanks and pits (estimated average pollution loads produced by one resident in a day). In urban contexts, daily toilet use is distributed across several locations, and wastewater comes from many non-household sources such as schools, businesses and markets which are typically not accounted for in estimations.
- Partner with research institutions to develop and pilot evidence-based estimations and assumptions such as GHG emission estimates and population equivalents for NSS.

Underpinning Strategies

To support these recommendations, the review paper also highlights a set of strategies that policy makers can promote to foster and strengthen evidence-based decision making. These strategies can dismantle entrenched barriers while staying realistic about implementation challenges.

Policy makers can:

- Ensure clear governance, institutional support, community engagement, and adequate resources for operation and maintenance across the whole NSS service chain from storage to collection and transport, treatment and final disposal or enduse.
- Promote the equitable involvement of in-country researchers and practitioners in knowledge generation, application and policy development to ensure context relevance of research insights.
- Integrate sanitation policy with broader urban aspects such as urban planning, housing rights, solid waste management, and climate resilience strategies which are interconnected.

Part 4 **Conclusions**

With increasing urbanization, especially in places with widespread NSS systems, there is a growing need for flexible, resilient solutions to manage and treat wastewater while ensuring safety for communities and the environment. Together these insights, recommendations and strategies can bridge science and policy for NSS and help support more sustainable, safe and equitable sanitation for urban populations.

About us:

Eawag is Switzerland's leading water research institute, advancing science and solutions for sustainable water management. Eawag's **Sandec** department aims to create a world where everyone has equitable access to safe, resilient, and sustainable sanitation, water, and solid waste services facilitated through innovation, research, and global collaboration that drives progress towards protecting human and environmental health

Hosted in Sandec, the research group **Management of Excreta, Wastewater, and Sludge (MEWS)** addresses solutions for city-wide inclusive sanitation (CWIS) through applied and fundamental research, design and optimization of treatment technologies, development of analytical and monitoring methods, and training and reference materials.

Explore the review article:

Strande, L. (2024). Integrating recent scientific advances to enhance non-sewered sanitation in urban areas. *Nature Water*, 2, 405–418. https://doi.org/10.1038/s44221-024-00240-7

See also:

Strande, L., Evans, B., von Sperling, M., Bartram, J., Harada, H., Nakagiri, A., & Nguyen, V. A. (2023). Urban Sanitation: New Terminology for Globally Relevant Solutions? *Environmental science & technology,* 57(42), 15771–15779. https://doi.org/10.1021/acs.est.3c04431.

Recommended citation for this brief:

MacArthur, J., Wainaina, G., Strande, L. (2025) Science-based policy recommendations for non-sewered sanitation in urban areas. Policy Brief. Sandec-Eawag.

Further information:

www.sandec.ch

www.sandec.ch/mews

Funding:

This development of this brief was supported through SDC as part of the WABES program.

The research was funded by the Swiss National Science Foundation.

WABES sanitation

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

Swiss National Science Foundation