How to Sustainably Scale up Small-Scale Sanitation in India?

The project "Small-Scale Sanitation Scaling-up (4S)" reaches completion after 2.5 years and provides a systematic assessment of small-scale sanitation in South Asia. This article highlights our research findings with a focus on India, and presents the main recommendations. Lukas Ulrich[1], Marius Klinger[1], Christoph Lüthi[1], Philippe Reymond[2]

Introduction

Since 2006, there has been a remarkable growth in the number of small sewage treatment plants (SSTPs) in India's rapidly expanding urban areas, typically serving 10–1 000 households. This is mostly due to policies that require on-site wastewater treatment and reuse for new, large buildings. More than 20 000 such small-scale sanitation (SSS) systems are estimated to be in operation in India today, providing an alternative to conventional, large-scale systems and an opportunity for water reuse. However, a majority of these systems are underperforming due to poor design, operation and maintenance (O&M), and monitoring. The 4S study was initiated with the endorsement of the Indian government in order to find out what can be done to ensure sustainable use of SSS systems.

Due to increasing demand for SSTPs, hundreds of private companies operate across the country (300+ were found). They offer consultancy, design, turnkey solutions, as well as O&M services. A wide variety of technologies are available on the market, ranging from energy-saving anaerobic and soil-based systems to common activated sludge and even membrane bioreactors.

There is no comprehensive database of SSTPs, their capacity, operational status and performance. As part of 4S, 9 500 systems in India were catalogued from various sources and 279 were visited for qualitative assessments.

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Photo 1: Basic assessment visit of a small-scale sewage treatment plant in Chennai, India.

Detailed water quality analyses were undertaken for 40 (35 in India, 5 in Nepal). These formed the basis for detailed studies on technical aspects. In parallel, interviews, policy review and data collation with stakeholders allowed for the analysis of governance and financial aspects.

Results

Technical performance

Performance analysis (Figure 1) shows that for biochemical parameters and solids (BOD, COD and TSS), any technology, if combined with the right post-treatment units and operated correctly, has the potential to achieve the stringent discharge standards set by the Central Pollution Control Board (CPCB). The rest of the parameters subject to CPCB standards (e.g. nitrogen), however, are systematically not met. It appears that nutrient removal is more a side-effect than a goal by itself in the assessed SSTPs, as most systems lack nutrient removal processes. Microbial quality is also consistently not met in almost all systems analysed. Systems with disinfection steps (usually chlorination) do not ensure a better removal of faecal coliforms than those without. This indicates low pre-disinfection water quality (e.g. high organic content), as well as poorly operated and/or designed disinfection units.

The management of solids (sludge, screenings and scum) is another major issue observed. A majority of the systems studied do not treat and safely dispose of the sludge they produce. With a lack of alternatives, sludge is often disposed of in nearby storm drains, water bodies or land, neutralising the benefits obtained from treating the wastewater.

The analysis of the water reuse practices highlights the good impact of the reuse policies established in the wake of increasing water stress. Reclaimed water from SSTPs is commonly used for toilet flushing and gardening. Unfortunately, a significant fraction of the treated water (typically in the range of 25–70 %) cannot be reused due to the lack of local reuse opportunities.

Sustainability of systems

The factors that influence a system's successful long-term performance were analysed. Such success factors can be found in five different performance-enabling domains (Figure 2). Among them, the following areas of concern are highlighted here:

i. System start-up and hand-over: The period in which ownership and/or responsibility are transferred from the designer/builder to the management entity is crucial, but, unfortunately, often not getting sufficient attention.
ii. Skills and knowledge: Operators and managers often do not sufficiently understand the functioning of SSTPs and the requirements for good performance. Troubleshooting skills are, therefore, generally weak.
iii. Supervision of O&M activities: Operators are often not clearly instructed and supervised, leading to unclear or neglected responsibility and lack of information exchange.
iv. Documentation of O&M activities and financial flows: The absence of systematic archiving of information makes it difficult to monitor, understand and optimise the systems' performance over time.
v. Anticipation of maintenance works: Clear responsibility for organising spare parts, as well as for planning and budgeting scheduled maintenance, is often lacking. As a consequence, there are risks of lasting system failures.

Governance of small-scale sanitation

At the national level, current sanitation policies focus on large-scale centralised systems and faecal sludge management (FSM), without defining the role and scope for SSS. SSS is also not explicitly mentioned in the State Sanitation Strategies and only rarely in City Sanitation Plans (CSPs). Today, SSS systems are driven and funded by the private sector/citizens who have to build and operate them to fulfil building regulations. As such, SSS is not under the responsibility of the government agencies in charge of wastewater management, although it plays a growing role in terms of sanitation coverage.

The capacity of monitoring agencies has not kept up with the rapid expansion of the sector in recent years. Lack of coordination, expertise, human resources and financial means for SSS hamper monitoring processes. Re-

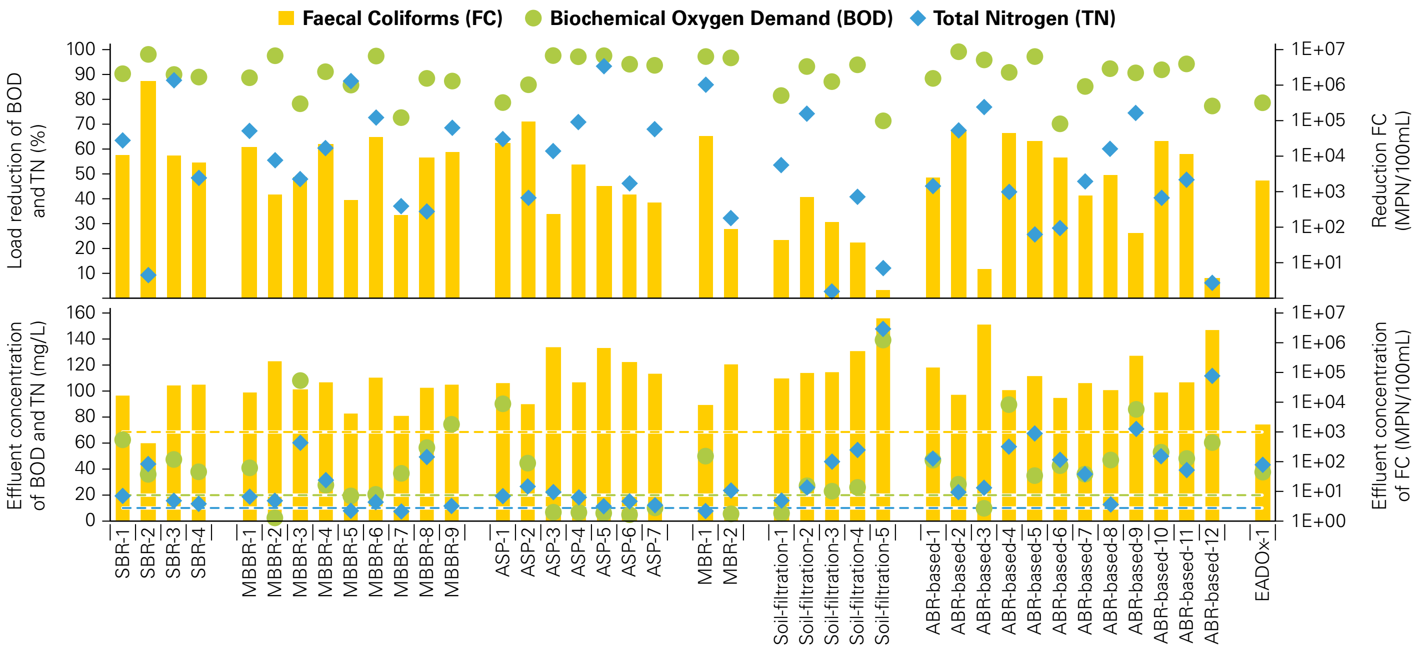

Figure 1: Average removal performance and effluent concentration for key water quality parameters of 40 sampled SSTPs, grouped by technology families. The dashed lines indicate the 2017 CPCB discharge standards for metropolitan cities.

lated loopholes lead to poorly designed and operated plants.

Even where good water reuse policies exist (e.g. requiring the use of treated wastewater on construction sites), there is presently insufficient coordination and regulation to link producers and potential users of reclaimed water. Therefore, much of the water, which cannot be reused onsite, is wasted.

Costs and financial issues

As part of 4S, life-cycle costs (capital, operational and capital maintenance costs) were analysed for different common SSS technologies. The findings show that operational expenditures have a cumulative impact on life-cycle costs, which outstrip the initial investment manifold (2–12 times). Costs vary greatly depending on technology, system size and level of O&M. Hence, an approach to financial sustainability would need to consider entire life-cycle costs at the moment of technology choice. Today, however, technology selection is largely vendor-driven and dominated by the investment and area required, as well as preferences of consultants. Real estate developers seek to minimise their capital expenditures, often leading to high O&M costs on the part of the future users who are not included in the system selection. Therefore, owners and users commonly see SSTPs as financial burdens rather than assets that create value for them. This drives their thinking towards cost reduction rather than system optimisation, unless further incentives are provided.

Main recommendations

Reaching adequate treatment performance

Good effluent quality regarding organic constituents can be achieved by combining measures to ensure proper O&M of systems with efficient monitoring. However, it is not realistic to expect compliance with stringent nutrient standards from most systems. If current standards for nitrogen parameters are to be fulfilled, systems must account for this in their process design. While this could be implemented for newly planned units in the higher capacity size range, it will be necessary to lower the bar for existing and smaller systems. Concerning microbial quality, measures ensuring the correct design and operation of disinfection units, as well as reuse-specific standards, are required for safe reuse.

Arranging for sludge management

The issue of solids management should be addressed strategically by either ensuring appropriate on-site treatment or by providing (semi-) centralised off-site sludge treatment units. Any newly planned treatment infrastructure for sewage sludge, faecal sludge or septage should account for capacity to receive the sludge from existing and future SSTPs nearby.

Standardising handover, operator training and documentation

A clear procedure for the handover of plants from technology providers to long-term owners and operators is required. Systematic transfer of information, including design details, user-friendly and comprehensive manuals and other technology-specific knowledge, should take place to ensure proper operation. Mandatory training and licencing of operators should be established and complemented with technology, design and context-specific requirements. Mandatory documentation of financial and O&M details would allow for the traceability of the systems' operation and upkeep. Analysis of such information should become part of the monitoring procedure. In the long term, online logbooks should be established for all systems.

Improving monitoring through a centralised database

A collated, unified database would foster coordination and harmonisation between agencies, standardise data collection, allow for automated analyses and facilitate SSS progress monitoring at national, state and city levels. First, an online data platform should be created, ideally under the auspices of the Ministry of Environment, Forest and Climate Change or Ministry of Housing and Urban Affairs (MoHUA). State and city authorities must then upload records on locations, system specifications and performance. There needs to be agreement on the merging of existing databases to create a national (or state-based) repository. It is essential that each SSS system can be tagged and given a unique ID. Geo-referencing of all units is necessary to facilitate follow-up and to eventually bring SSS into sanitation plans. There needs to be a clear allocation of the responsibilities for data collection and analysis at the various government levels.

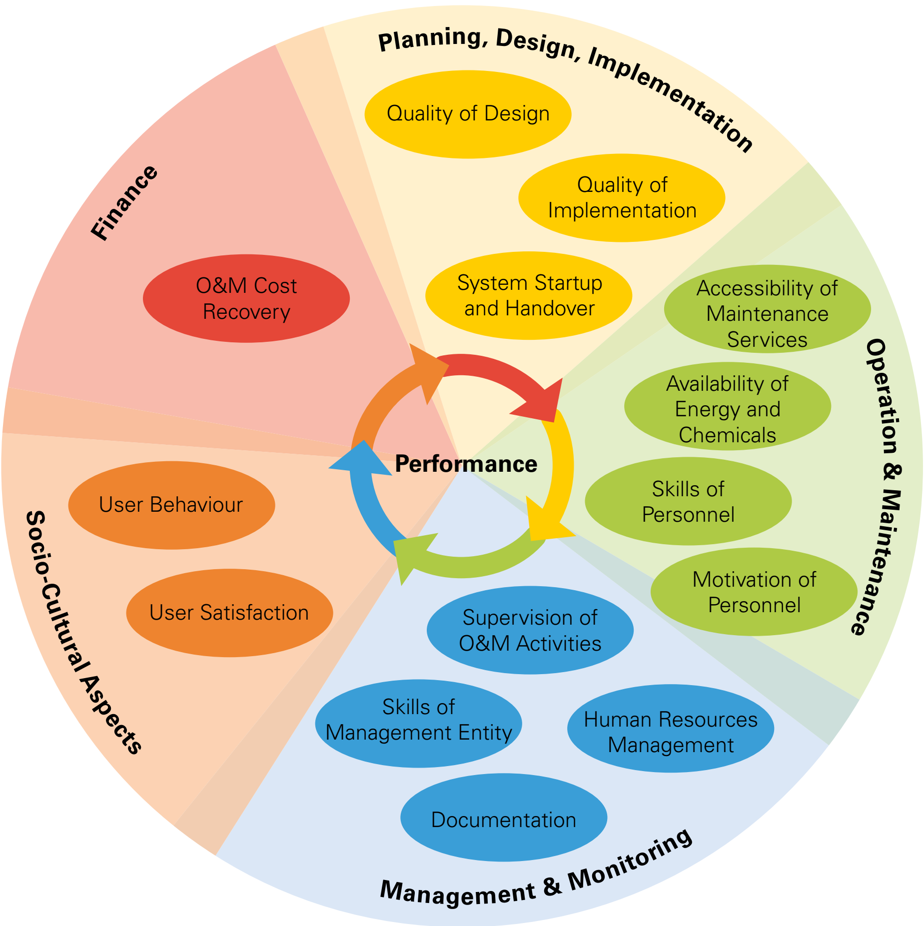

Figure 2: Critical success factors for well-performing SSS systems.

Creating SSS management units

While long-term monitoring should remain with the PCBs, agencies in charge of wastewater management must be given more responsibility. City water utilities and urban local bodies need to create a dedicated SSS planning and management division, consisting of trained professionals. These are the government bodies closest to implementation, with the required technical expertise. In cities with staff shortages, delegating the monitoring to a private company could also be considered as a medium-term measure.

Developing clear policies and design standards

At the national level, the MoHUA should lead the development of a clear policy framework for SSS. Technical specifications and design standards need to be developed, so that funds can be channelled from the national level down to cities. Guidelines for the design and implementation of SSTPs are needed, considering the SSS specificities and the wide variety of technologies now on the market.

Integrating SSS in strategic planning

The role of SSS should be explicitly stated in the State Sanitation Strategies and every CSP. This together with the online database will allow for the making of informed decisions about future investments for sanitation and water usage improvements. Cities should produce and maintain sanitation maps of sewers, SSTPs and FSM infrastructure. This will promote the zoning of areas to be served by SSS, which should be based on the optimal scale of sanitation systems. The latter is a function of availability of funds and space, life-cycle costs, management constraints and the reuse strategy.

Encouraging water reuse

Reuse policies need careful planning based on a good understanding of the situation. Reuse opportunities, space for SSTPs, the feasibility of retrofitting dual plumbing and cost implications are crucial aspects to consider when drafting effective and realistic policies.

The current gap between supply and demand for treated water opens up a potential market opportunity for an Uber-like service, allowing users of treated water to identify suppliers. Also, as users require a certain water quality, operators would be incentivised to maintain a consistent treatment performance.

Incentivising affordable quality systems

Purchasing decisions should be made based on life-cycle costs, not just capital costs. To improve O&M, special funds should be earmarked by developers to cover all costs over a defined period (e.g. 10 years). More sustainable systems could also be achieved by giving builders and technology providers more responsibility in O&M (e.g. build-operate modalities), and through performance-based contracts between owners and operators. Governments should provide incentives for sound SSS systems. Tax incentives would encourage developers to invest in robust premium systems. Well-operated SSTPs should benefit from lower development charges, property taxes or water rates as they save substantial money and work for the government.

Conclusion

Distributed SSS systems offer the opportunity to simultaneously address public health, environmental pollution and water scarcity issues in a targeted way. Current policies in India have enabled the establishment of a capable private sector with technical solutions ready to be scaled up. To cope with increasing water stress, the concerned authorities will be obliged to introduce a systematic and coordinated management approach for the strategic and efficient planning, design, implementation, O&M and monitoring of SSS.

The full potential of SSS can only be successfully tapped if an institutionalised process of continuous analysis, learning and optimisation is established. By studying the current scenarios and experiences on the ground, 4S aimed to start this learning process. Another objective was to provide guidance for decision-makers so that they can devise concrete steps towards creating an ecosystem conducive to a thriving and scaled-up SSS sector. The outputs of this project include policy briefs, factsheets, reports and a technology guide. They will be available at: www.sandec.ch/4S.

[1] Eawag/Sandec, Switzerland

[2] Vuna Ltd., Switzerland

Funding: Bill & Melinda Gates Foundation, German Federal Ministry for Economic Cooperation and Development

Project Partners: IIT Madras, BORDA (Germany), CDD Society (India) and ENPHO (Nepal)

We would like to thank all the numerous individuals who have voluntarily contributed their valuable knowledge, opinions, feedback and data throughout the project period.

Contact: christoph.luethi@eawag.ch