

## Mini Review

# Innovative sanitation approaches could address multiple development challenges

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### ABSTRACT

Globally, more than 60% of the human population live without safely managed sanitation services or even lack access to basic sanitation facilities. In addition, most of the wastewater produced in the world is discharged without proper treatment. Integrated approaches are needed to address these issues and curb the resulting adverse impacts on public health and the environment, and associated societal economic losses. The United Nations 2030 Agenda for Sustainable Development provides an important framework towards more sustainable sanitation development, in terms of both safe sanitation access and wastewater management. Innovative solutions that treat and enable productive safe use of water, and facilitate recovery of nutrients and organic matter from waste resources are booming. Some examples of trends are decentralized solutions, separation of waste flows, low-or no-flushing toilets, and converting faecal sludge to energy. These alternative technologies show huge potential to address many development challenges, contributing to multiple sustainable development goals but achieving upscaling has proved to be a major challenge. A paradigm shift to 'treatment for reuse' instead of 'treatment for disposal' is already taking place in the wastewater sector. Nevertheless, a better understanding of driving forces and enabling environments, new organizational models based on more service-oriented sanitation provision, and highlighting potential multiple societal benefits to attract investments from new sectors are identified areas that need further attention.

**Key words** | innovation, resource recovery, SDGs, sustainable sanitation, wastewater management

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Our society is facing an overwhelming sanitation challenge, where the issues and challenges differ across the world. More than 4.5 billion people live without safely managed sanitation services (WHO & UNICEF 2017). About 1 billion people even lack basic access to a sanitation facility. The absence of wastewater treatment is also an immense problem, where only 10–20 per cent of the globally produced wastewater receives any kind of treatment (Corcoran *et al.* 2010). The economic costs for these shortcomings are massive given the significant negative impacts on public health and the environment. Monetarily, the global economic losses due to inadequate water and sanitation access have been estimated at US\$260 billion annually, with major impacts in Africa, Asia and Latin America (Hutton 2012). An example is the South-east Asian country of Cambodia, where the annual economic loss of US\$448 million could be attributable to poor sanitation.

This translated into a per capita loss of approximately US\$32 and a total of 7.2% of the country's gross domestic product (WSP 2012; Van Minh & Nguyen-Viet 2011). In Latin America, universal access to sanitation is also far from being reached. For instance, in Brazil, a country with over 200 million inhabitants, a recent study shows that only 43% of the population has sewage collection and treatment (ANA 2017). The estimated annual investment of US\$50 billion in Brazil is necessary to reach the universal access goal in 2030, as globally envisioned.

Another widespread challenge is how to achieve sustained use of new sanitation facilities, especially in projects aiming to achieve open-defecation-free communities (Tyndale-Biscoe *et al.* 2013; WSP 2012). This may be due to problems such as odours, poor user experience, safety concerns, and environmental contamination. Underlying factors are the lack of financing available for on-site or decentralized systems, and

service provision not well developed as in other sectors. In addition, there may be external factors impacting system functionality, such as water scarcity and floods.

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## NEW STRATEGIES FOR IMPLEMENTATION – BEYOND PURE HEALTH OBJECTIVES

The 2030 Agenda on Sustainable Development is providing an important global framework for working towards more sustainable sanitation development. In the preceding agenda, the Millennium Development Goals, the focus was on increasing the access to basic sanitation. The Sustainable Development Goal (SDG) 6, *Clean water and sanitation*, has raised the ambition level adding both social and environmental dimensions, the latter expressed in terms of, for example, protecting water quality, wastewater treatment, recycling and reuse. The 2030 Agenda is meant to be an integrated framing to achieve a sustainable development; hence, it is critical to promote sanitation development that can provide benefits to other SDGs. The linkages between SDG 6 and *Good health and wellbeing* (3), *No poverty* (1), and *Sustainable cities and communities* (11) may be obvious, but there are also other possible sanitation SDG interconnections that need further consideration, e.g. *Zero hunger* (2), *Affordable and clean energy* (7), and *Climate Action* (11). Solutions that treat waste and enable productive safe use of water, nutrients and organic matter in the sanitation flow-streams, e.g. for agricultural or energy purpose, have shown great potential to contribute to multiple SDGs (Andersson *et al.* 2016). There is an increasing number of promising sanitation approaches and technologies emerging that can provide cross-sectoral benefits and attract new investments, to increase service levels and long-term functionality.

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## INNOVATIVE SANITATION APPROACHES

The number of initiatives around the world that research or implement new and innovative sanitation solutions is booming. Different trends can be distinguished. On-site sanitation is one area that has received lots of attention. The reasons for this are manifold, e.g. low viability for sewer system; extensive distribution of on-site system – but without access to adequate maintenance; and unreliable water supply. The extensive lack of services, e.g. faecal sludge management (FSM), has motivated major efforts to be invested in finding more efficient and productive management of waste resources, to also create opportunities and

incentives for business and recovering waste resources. A diverse set of onsite sanitation approaches are being explored including: waterborne or low/no-flushing toilets, and source separation of waste flows. There is growing experience linked to resource recovery with numerous innovative solutions for waste processing now being scaled-up in different parts of the world, e.g. black soldier fly larvae producing protein feed or hydro-thermal carbonization making biochar; wet composting; urea treatment; bio-electrochemical processing producing direct electricity or hydrogen; and dry combustion. The private sector has a key role to play in this space by providing the much-needed capital for resource recovery and reuse initiatives and the sanitation and water sector more broadly. However, issues related to enabling environments, risk and uncertainty, financial mechanisms, project bankability, and matching projects with appropriate investors in terms of objectives, scale, and timelines represent obstacles to attracting finance. Naturally, the private sector tends to engage in the sector when a business case exists. Innovative business models and financing mechanisms, such as blended, green and climate finance, will be needed to address shortfalls. Grasping how to use innovations in partnerships (public-private, public-public, private-private), and business models to turn economically beneficial projects into bankable ones will be critical.

A considerable number of emerging technologies have been developed in recent years for on-site wastewater treatment aiming to recover resources from wastewater, especially phosphorus and nitrogen. Nevertheless, to scale up is still a challenge. Solutions that are adopting toilets with source separation (urine and faeces) without or with very little water consumption are non-grid settings conceptually promising for low cost solutions while recovering nutrients to be used as fertilizer (Chrispim *et al.* 2017) and do not consume water or energy. In spite of the strong interconnectedness among water, energy, food and the environment, policy makers have continued to address and formulate policies in silos that do not guarantee simultaneous attainment of food, energy and water security as well as environmental sustainability. Governments often design agricultural policies and subsidy programmes, such as those for fertilizer, without taking into account the complexity of linkages with energy and water, forgoing opportunities to maximize positive results and minimize harmful impacts (Bhaduri *et al.* 2015).

Decentralization is another trend, where sanitation flow-streams are still managed off-site but on a neighbourhood or urban sector level. Decentralization offers a greater opportunity to extend sanitation services to all segments of society, particularly poorer households in peri-urban and

marginalized areas, than do centralized alternatives. Decentralized technologies tend to be more suited to specific local conditions. Furthermore, implementation timelines are shorter and related capital investment and operating costs are comparatively lower with decentralized technologies. The financing of these technologies can, however, still be challenging. By contrast, centralized systems benefit from economies of scale; so trade-offs, and specific objectives of implementing entities need to be considered. When planning and implementing decentralized systems, more emphasis needs to be placed on local stakeholder engagement, community acceptance and buy-in to ensure acceptance and sustainability. Governance is about co-creation; so by allowing people to co-create, local ownership is created.

### What is needed?

- Service-oriented sanitation is needed to address issues with maintenance, sustained use and function of on-site sanitation systems. Households with on-site systems should be able to have the same level of comfort and service as people with a flush toilet connected to sewerage. Other key aspects to increase acceptance and ownership are accomplishing the same level of aspiration for alternative systems (no flush toilets), which require investing in design, high-end examples, and awareness raising.
- Driving forces and an enabling environment are needed for change. In rural smallholder communities, reuse-oriented sanitation has provided additional motivation for sustained toilet use (Dickin *et al.* 2018).
- New technical solutions are available. The key question that remains is how to take these encouraging examples to scale. How does the sanitation (and waste resource recovery) sector make use of innovation in financing and business models to ensure sustainable delivery of products and services?
- Attract investments from new sectors. There is a need to further explore and highlight the cross-sectoral benefits, where sanitation can contribute to multiple SDGs, e.g. inter-sectoral water exchange between urban water (fresh water), farmers and industry (treated used water).

### CONCLUSIONS

In emerging and developing economies, as well as in urban expansions in general, there are opportunities for leapfrogging

the technological trajectories of conventional linear systems and facing up to the sanitation (and wastewater) problems, by implementing alternative solutions that are more eco-socio-economically sustainable. A more integrated approach, for example a bio-based circular economy approach, represents a paradigm shift that can address multiple challenges and produce local and regional benefits for the population, e.g. new 'green' jobs. The private and public sectors, international organizations and research-funding institutions have engaged in supporting research on new approaches and innovative solutions for sanitation. Still, the successful upscaling of resource recovery solutions in sanitation requires exploration of new drivers and enabling environments, such as efficient service and market-oriented mechanisms, and comprehensive assessments of social, financial, health and environmental impacts. Comparing the potential cost-benefit impacts between new integrated approaches based on 'circular economy' and 'business-as-usual' approaches will also be crucial. These outcomes can support decision making and new sustainable sanitation business models.

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### REFERENCES

- ANA (Agência Nacional de Águas de Brasil; Brazilian National Water Agency) 2017 *Atlas Esgotos: Despoluição de Bacias Hidrográficas*. ANA, Secretaria Nacional de Saneamento Ambiental, Brasília, Brazil. <http://atlasesgotos.ana.gov.br/> (accessed 8 October 2017).
- Andersson, K., Rosemarin, A., Lamizana, B., Kvarnström, E., McConville, J., Seidu, R., Dickin, S. & Trimmer, C. 2016 *Sanitation, Wastewater Management and Sustainability: from Waste Disposal to Resource Recovery*. United Nations Environment Programme, Nairobi, Kenya and Stockholm Environment Institute, Stockholm, Sweden.
- Bhaduri, A., Ringler, C., Dombrowski, I., Mohtar, R. & Scheumann, W. 2015 *Sustainability in the water-energy-food nexus*. *Water International* **40** (5-6), 723-732. DOI: 10.1080/02508060.2015.1096110.
- Chripim, M., Tarpeh, W., Salinas, D. & Nolasco, M. 2017 *The sanitation and urban agriculture nexus: urine collection and application as fertilizer in São Paulo, Brazil*. *Journal of*

- Water, Sanitation and Hygiene for Development* 7 (2017), 455–465.
- Corcoran, E., Nellesmann, C., Baker, E., Bos, R., Osborn, D. & Savelli, H. (eds) 2010 *Sick Water? The Central Role of Wastewater Management in Sustainable Development. A Rapid Response Assessment*. UN Environment Programme, UN-HABITAT, GRID-Arendal, Nairobi, Kenya.
- Dickin, S., Dagerskog, L., Jiménez, A., Andersson, K. & Savadogo, K. 2018 [Understanding sustained use of ecological sanitation in rural Burkina Faso](#). *Science of the Total Environment* 613–614 (2018), 140–148.
- Hutton, G. 2012 *Global Costs and Benefits of Drinking-Water Supply and Sanitation Interventions to Reach the MDG Target and Universal Coverage*. WHO, Geneva, Switzerland.
- Tyndale-Biscoe, P., Bond, M. & Kidd, R. 2013 *OSF Sustainability Study*. FH Designs. [http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/Plan\\_International\\_ODF\\_Sustainability\\_Study.pdf](http://www.communityledtotalsanitation.org/sites/communityledtotalsanitation.org/files/Plan_International_ODF_Sustainability_Study.pdf) (accessed 27 November 2017).
- Van Minh, H. & Nguyen-Viet, H. 2011 Economic aspects of sanitation in developing countries. *Environmental Health Insights* 5 (2011), 63–70.
- WHO and UNICEF 2017 *Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines*. World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), Geneva, Switzerland.
- WSP – World Bank's Water and Sanitation Program 2012 *Economic Assessment of Sanitation Interventions in Cambodia: A Six-Country Study Conducted in Cambodia, China, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI)*.

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