DEPARTMENT OF HUMAN SETTLEMENTS

a world class African city

Innovative
SANITATION SOLUTIONS
For Sustainable Development

Research Publication 2025/26 - Issue 5

New chemical toilets being delivered in an informal settlement in 2026. Photo credit: Asivikelane.

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Innovative Sanitation Solutions for Sustainable Development

CITY OF JOHANNESBURG
Human Settlements Research Publication 2025/26
Issue 5

MMC
Foreword

Access to dignified sanitation is a constitutional responsibility and a fundamental component of human dignity. In advancing this mandate, the City of Johannesburg remains committed to ensuring that all residents, irrespective of where they live, have access to safe and sustainable sanitation services.

Through the work of Johannesburg Water, the City manages more than 10,000 kilometres of sewer infrastructure and six wastewater treatment works with a combined capacity of 960 megalitres per day. Census 2022 indicates that approximately 94.9% of households in Johannesburg have access to improved sanitation, with 93% connected to the sewer network. These achievements reflect focused political oversight and administrative coordination.

However, meaningful leadership requires that we prioritise communities that remain underserved. The City has over 300 informal settlements where sanitation provision remains complex due to unsuitable land, environmental constraints, and historical infrastructure backlogs. In many instances, chemical toilets have been used as temporary measures. While necessary under certain conditions, they are not a permanent solution and have presented challenges relating to dignity, health, maintenance costs, and environmental impact.

Under my tenure as MMC, we have intensified efforts to implement alternative and innovative sanitation solutions that are both practical and sustainable. In areas such as Drieziek, new sanitation technologies are being introduced following community engagement and site assessments. This approach ensures that solutions are informed by both technical feasibility and community acceptance.

We have also drawn lessons from innovation emerging from institutions such as the University of the Witwatersrand, where research has demonstrated the potential for significantly reduced water usage, per flush, through modern sanitation systems. Such advancements present opportunities to conserve water, reduce strain on existing infrastructure, and improve long-term financial sustainability.

Importantly, governance requires a balance between technical compliance and responsiveness to lived realities. While regulations and engineering standards guide our work, being present on the ground allows for informed decision-making. Direct engagement with communities assists in identifying practical interventions, accelerating permissible processes, strengthening interdepartmental coordination, and ensuring that policy implementation advances community interests.

This community-oriented and hands-on leadership approach contributes to reduced delays, improved accountability, and stronger trust between residents and the City. It ensures that sanitation interventions are not only technically sound, but also socially responsive and sustainable.

This progress reflects a collective institutional effort aimed at restoring dignity, protecting public health, conserving water resources, and strengthening confidence in local government. The City of Johannesburg will continue to pursue innovative, inclusive, and responsible sanitation solutions to ensure that no community is left behind.

Cllr Mlungisi Mabaso
MMC for Human Settlements
City of Johannesburg

Message from the

Executive Director

The City of Johannesburg remains firmly committed to advancing the constitutional imperative of providing dignified, safe, and sustainable sanitation for all residents. While the City has made notable progress, persistent inequalities - particularly in informal settlements - continue to challenge conventional service delivery approaches. Rapid urbanisation, infrastructure backlogs, land constraints and climate pressures, require a shift beyond traditional waterborne systems towards more innovative, context-responsive solutions.

This research publication on innovative sanitation solutions for sustainable development marks an important step in this transition. It includes a desktop study that presents a diverse suite of technologies, including water efficient systems, non-sewered systems, decentralised wastewater treatment systems and nature-based solutions. These are not merely technical alternatives but form part of a broader shift towards sustainable, resilient, and inclusive service delivery systems. Crucially, these solutions are adaptable and can be implemented across both informal and urbanised settings, responding to varying infrastructure, density, and resource conditions.

The publication is grounded in national best practice and strengthened by evidence from multiple municipalities. The inclusion of the Asivikelane Sanitation Learning Paper provides critical, community-driven insights, highlighting the lived realities of residents in informal settlements. Its findings underscore that temporary sanitation often becomes permanent, maintenance systems are frequently inadequate, and meaningful community engagement is essential. These lessons reinforce key principles such as lifecycle costing, effective maintenance, and clear transition pathways to permanent, dignified solutions.

In advancing this agenda, the City continues to prioritise collaboration and knowledge exchange. Through partnerships with the Department of Water and Sanitation, the Water Research Commission, the Water Partnership Office, the Development Bank of Southern Africa, and Planact, the City plans to host a symposium on advancing water-efficient sanitation solutions under the theme "Creating an Enabling Environment for Scaling and Application." This platform will bring together key stakeholders to explore pathways for scaling innovative and sustainable sanitation systems.

As the Human Settlements Department, we recognise that the future of sanitation lies in integrated, adaptive, and people-centred solutions. This requires not only technological innovation but also strengthened institutional capacity, improved governance and sustained community partnerships.

We trust that this publication will contribute meaningfully to ongoing sanitation reform and serve as a catalyst for practical, scalable solutions that advance dignity, equity, and sustainability for the residents of Johannesburg and across South Africa.

Lungile Mtshali
Acting Executive Director: Human Settlements

Message from the Editorial Team

Editorial Team (in the picture, from left to right): Thabo Molaba, Londeka Thanjekwayo, Mathung Sekonyela; Human Settlements Policy, Planning & Research.

This fifth issue of the City of Johannesburg's research publication brings into focus a critical and evolving area of urban service delivery: The need to rethink sanitation systems in response to rapid urbanisation, unequal access, resource constraints and climate pressures. As cities grapple with the limitations of conventional sanitation approaches, this publication seeks to contribute to a growing body of knowledge on innovative, inclusive, and sustainable options.

The featured desktop study provides an overview of a range of sanitation system innovations. Rather than presenting these as isolated technical fixes, the study situates them within a broader sanitation service chain perspective - one that recognises the importance of context, lifecycle management, institutional readiness and long term sustainability.

Importantly, this issue also emphasises the lived experiences of residents through the inclusion of the *Asivikelane Sanitation Learning Paper*. These community generated insights remind us that infrastructure alone is insufficient. Issues of maintenance, service continuity, accountability and meaningful engagement, remain central to whether sanitation solutions ultimately deliver dignity and safety. The lessons shared challenge practitioners and decision makers to move beyond temporary interventions and to plan deliberately for transition pathways that are realistic, well resourced, and people centred.

This publication is further enriched by the inclusion of the PhD research study titled "*A Critical Evaluation of Sanitation Infrastructure Challenges in Informal Settlements in South Africa (1995–2020)*." Drawing on fieldwork conducted in the municipalities of Johannesburg and Ekurhuleni, it highlights how inadequate sanitation perpetuates public health risks, inequality, and cycles of exclusion. Importantly, it proposes a forward-looking framework that integrates technical innovation, community participation, and policy reform, grounded in a rights-based and participatory approach.

We hope that the insights presented here will support ongoing reflection, encourage cross sector collaboration, and help advance practical, scalable sanitation solutions that respond to Johannesburg's diverse urban realities.

More importantly, we trust that this work will contribute to strengthen approaches that place dignity, equity, and sustainability at the centre of sanitation planning and delivery.

An Asivikelane community plumber in Cape Town replaces a missing tap on a standpipe in their settlement during a site visit. Photo: Asivikelane.

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Next Generation Sanitation Technologies, a Solution for Informal Settlements

A Communal waterborne flush toilet in the Hani Park informal settlement in Buffalo City in 2024. The toilet has a wheelchair ramp and one of the toilets is suitable for use by persons with disabilities. The toilets can lock from the inside and is well-maintained. There is a basin with a tap, and an additional communal standpipe which is installed with the toilets. Photo Credit: Asivikelane.

Acronyms and Abbreviations Table

ACRONYM	FULL TERM	DESCRIPTION
DEWATS	Decentralised Wastewater Treatment Systems	Localised systems that treat wastewater near the point of generation rather than at central plants.
FSM	Faecal Sludge Management	The collection, transport, treatment, and safe disposal or reuse of sludge from on-site sanitation systems.
NSP	National Sanitation Policy	South Africa's policy guiding sanitation service delivery and standards.
NSS	Non-Sewered Sanitation	Sanitation systems that operate without connection to a central sewer network, including on-site and off-site waste management.
NW&SMP	National Water and Sanitation Master Plan	Strategic framework addressing infrastructure, capacity, and sustainability challenges in the sector.
SDG	Sustainable Development Goal	Global development targets set by the United Nations, including SDG 6 for sanitation and water.
UDDT	Urine-Diverting Dry Toilet	A waterless sanitation system that separates urine and faeces for treatment, reuse, or safe disposal.
VIP	Ventilated Improved Pit Latrine	An improved pit latrine designed with ventilation to reduce odours and flies.
WSA	Water Services Authority	Municipal entity responsible for water and sanitation service provision.

Sanitation Conditions and Practices (Terminology)

TERM	DESCRIPTION	CONTEXT / IMPLICATIONS
Open defecation	The practice of defecating in open spaces such as fields, bushes, or water bodies due to lack of access to toilets.	Indicates severe sanitation service gaps; linked to disease transmission, environmental contamination, and loss of dignity.
Flying toilets	The use of plastic bags for defecation, which are then discarded in the environment.	Common in dense informal settlements where toilets are unsafe or inaccessible; poses serious public health and environmental risks.
Bucket toilets	A system where human waste is collected in buckets and manually removed.	Considered undignified and a legacy of apartheid-era service inequities; targeted for eradication in policy.
Shared sanitation	Toilet facilities used by multiple households.	Can improve access but often leads to overcrowding, poor maintenance, and safety concerns.
Communal sanitation	Public or community-managed toilet facilities serving a settlement.	Dependent on maintenance and management; often unsafe or inaccessible at night.
On-site sanitation	Systems where waste is stored and treated at or near the point of generation (e.g., pit latrines, septic tanks).	Common in informal or peri-urban areas; risks include groundwater contamination if poorly managed.
Off-site sanitation	Systems where waste is transported away from the source for treatment (e.g., sewer systems, CBS).	Requires infrastructure and service chains; generally safer when well managed.
Interim sanitation	Temporary sanitation solutions provided where permanent infrastructure is not yet available.	Often becomes long-term due to delays in upgrading; may entrench inequality.
Unsafe sanitation practices	Behaviours such as open defecation or improper waste disposal due to lack of adequate services.	Reflect systemic service delivery failure and increase public health risks.
Sanitation backlog	The gap between existing sanitation services and the population requiring access.	Driven by rapid urbanisation, infrastructure limits, and financial constraints.

A Ventilated Improved Pit Toilet in the Meriteng informal settlement with a broken door. One of the key issues residents experience is not having easy access to replacement parts when something breaks with the VIP top structure. Photo credit: Asivikelane.

Exploring Innovative Sanitation Systems: A Desktop Study for the City of Johannesburg

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1. Introduction and background

South Africa has one of the most progressive legislative and policy frameworks for water and sanitation services globally. This framework includes the constitutional right to access sufficient water and sanitation, as well as the national Free Basic Water policy, which seeks to ensure a minimum level of service for all citizens (COHRE, 2008). These commitments reflect the country's strong policy intent to address historical inequalities and promote equitable access to basic services. Sanitation is a cornerstone of public health, involving access to safe drinking water, effective sewage treatment, and environmental cleanliness (Abrahams & Everatt, 2019). It mitigates diseases such as roundworm infections, ensures hygienic conditions through waste and wastewater management, and addresses global health challenges. Despite sanitation initiatives, millions worldwide lack access to basic sanitation services (Hewitt et al., 2020).

Regardless of progressive policy framework, sanitation remains a persistent and unresolved challenge, particularly in urban informal settlements. Global assessments continue to highlight the scale of the problem. A joint report by the World Health Organisation (WHO) and UNICEF indicates that while 64% of the world's population relies on improved sanitation facilities, approximately 15% still practice open defecation, underscoring the magnitude of sanitation deficits worldwide (WHO and UNICEF, 2013).

In South Africa, access to safe and hygienic sanitation is a constitutional right, enshrined in Section 24 of the Constitution (Act 108 of 1996). This right contributes to public health, human dignity, and environmental sustainability. The National Development Plan (NDP) aims to ensure universal access to reliable and affordable sanitation by 2030, aligning with Sustainable Development Goal 6.2, which seeks equitable access to sanitation and hygiene for all, prioritising women, girls, and vulnerable populations (National Planning Commission, 2012).

South Africa has made significant strides in access to sanitation, with improved facilities reaching 84.1% of households in 2021, up from 61.7% in 2022 (STATSSA, 2022). The National Sanitation Integrated Plan 2021(NSIP) offers a 10-year roadmap to address sanitation backlogs, eliminate substandard systems (including bucket toilets, open defecation, and all sanitation systems below the basic level of service), and foster innovative solutions while creating economic opportunities. Yet, rapid urbanisation and population growth in informal settlements strain existing infrastructure, contributing to overcrowding, unsanitary conditions, and public health risks. For cities like Johannesburg, these challenges highlight the urgent need for sustainable sanitation strategies.

In Johannesburg, the provision of conventional waterborne sanitation is often constrained by settlement density, land tenure insecurity, old infrastructure, and water scarcity. As a result, achieving universal access to sanitation will require the provision and implementation of alternative sanitation technologies in informal settlements and other underserved areas where waterborne systems are not feasible. This process should be undertaken in partnership with residents, ensuring that solutions are responsive to community needs and preferences. Addressing these challenges calls for a refreshed and pragmatic mindset—one that balances technical feasibility with social acceptability, while recognising that sustainable sanitation solutions must be adaptable to diverse urban conditions.

This desktop study focuses on identifying sanitation alternatives for the City of Johannesburg, specifically targeting informal settlements that lack proper sanitation infrastructure. These areas face significant socio-economic and infrastructural challenges, leading to environmental degradation, health risks, and compromised quality of life. By exploring alternative sanitation solutions, this study aims to support the city's efforts in addressing sanitation infrastructure.

1.1 Problem Statement

The City of Johannesburg continues to face difficulties in providing sanitation services, especially in peri-urban areas, inner city neighbourhoods, and informal settlements. Even with the city's current vast sewer infrastructure, many residents still lack access to sanitary facilities that are respectable, safe, and dependable. The interim solutions that have been put in place, such as poorly maintained pit latrines, communal toilets, or chemical toilets, are common features of sanitation facilities in many informal settlements. These facilities are frequently insufficient for the population size and settlement density.

Rapid urbanisation, population growth, infrastructure backlogs, and a lack of institutional and financial capacity all exacerbate these issues. Multiple homes share sanitary facilities in some places, increasing the risk of overuse, hygiene issues, and public health problems. In others, failing or vandalised infrastructure results in sewage spills, groundwater contamination, and pollution of urban watercourses.

Climate change is a significant contributing factor to these conditions. Increased flooding damages on-site sanitation infrastructure, while growing water scarcity places strain on waterborne sanitation systems. As a result, certain areas of the City of Johannesburg can no longer rely solely on conventional sewer-based sanitation systems. This underscores the need to investigate alternative sanitation solutions that are suited to specific contexts, environmentally sustainable, and capable of extending equitable access to marginalised populations.

2. Research Question and Objectives

2.1 Research Question

What innovative sanitation solutions are potentially suitable for addressing sanitation challenges in the City of Johannesburg, particularly in informal settlements, peri-urban areas, and other contexts where conventional waterborne sanitation is not feasible?

2.2 Research Objectives

- Assess the current sanitation context and key challenges in the City of Johannesburg.
- Review global experiences and best practices related to innovative sanitation systems.
- Examine the policy, global, and institutional frameworks guiding sanitation provision in South Africa.
- Identify and assess innovative sanitation solutions that could apply to different settlement typologies within the City of Johannesburg.

3. Understanding Sanitation Value-Chain

To comprehend various sanitation options, one must consider factors beyond the physical design of a toilet. In public health and environmental engineering, sanitation is characterized as a continuous, interconnected value chain system that manages human waste from its generation to its ultimate reintegration into the environment. This system is referred to as Faecal Sludge Management (FSM). When any link in this chain is compromised, the entire system collapses, resulting in groundwater pollution and the proliferation of waterborne illnesses.

Figure 1: Steps of Faecal Sludge Management-Sanitation Value-chain

a) Capture and Confinement

The chain commences with the user interface. Options include basic pit latrines, advanced pour-flush toilets, and waterless "dry" toilets. The "containment" portion pertains to the onsite storage of the waste. In several metropolitan locales, this entails a septic tank or a lined pit. The selection of containment represents the initial critical factor for sanitation options; for example, a composting toilet processes waste on-site, but a conventional septic tank necessitates regular maintenance.

b) Emptying

Upon reaching capacity, a containment system must be evacuated. This is a pivotal phase where numerous informal systems collapse, frequently leading to manual scavenging or illicit dumping. Contemporary options encompass mechanized emptying utilizing vacuum trucks or specialised pumps engineered for the management of viscous sludge. The objective is to eliminate trash without human interaction, preserving the "sanitary" integrity of the procedure.

c) Transportation

After emptying process, the faecal sludge must be transported to a facility equipped to manage it. In a sewer system, transfer occurs passively through subterranean pipes. In FSM, transport is operational. This entails the practicalities of navigating vacuum trucks through constricted urban passages to access a centralised or decentralized Transfer Station. These stations serve as "drop-off" locations to minimise travel distance for smaller collectors, hence enhancing the efficiency of the chain.

d) Treatment

This is the locus of the most varied array of technical options. Untreated sludge is toxic and must not be discharged into aquatic environments. Treatment techniques seek to stabilize organic materials and eliminate microorganisms. It involves physical treatment of drying beds to segregate liquids from solids; Biodegradation where it employs anaerobic digesters for waste decomposition; and thermal treatment where it uses elevated temperatures (pyrolysis) to eradicate infections completely.

e) Resource Recovery and Secure Disposal

The ultimate connection converts "waste" into a "resource," so finalising the Circular Economy of sanitation. When the sludge undergoes treatment to elevated standards, it can be repurposed for various benefits such as agriculture where processed solids are converted into organic fertilisers or soil amendments, while others used as energy through the sludge conversion into fuel pellets or biogas for cooking and electricity generation. If recovery is not feasible, the waste is disposed of in a controlled landfill to prevent leaching into the water table.

Figure 2: Circular Economy of Sanitation-Waste to Resource Process

4. Global Sanitation Context

Globally, sanitation challenges are most acute in informal settlements and peri-urban areas, where rapid population growth has far outpaced the development of basic infrastructure. The United Nations estimates that the current rate of progress must increase fivefold for the world to achieve universal access to safely managed sanitation services by 2030, as envisioned under Sustainable Development Goal 6. This shortfall is most visible in densely populated, resource-constrained urban environments, where residents frequently rely on makeshift or inadequate sanitation facilities (UNICEF, 2021). The consequences include recurring public health crises, environmental degradation, and social inequities. These challenges are also intensified by climate change, as flooding, droughts, and water scarcity disrupt already fragile sanitation systems, particularly in low-lying and informal urban areas (World Bank, 2020).

In the Global South, sanitation deficits are closely linked to broader processes of urbanisation. Rapid and often unplanned urban growth has placed enormous pressure on municipal authorities, many of which lack the financial, technical, and institutional capacity to extend waterborne sewerage and wastewater treatment services to expanding urban populations (UNICEF, 2019). While higher population densities can, in theory, create efficiencies in service delivery and economic development (Bernstein, 2012), the reality in many developing-country cities is that infrastructure systems are overwhelmed by the speed and scale of urban expansion. As a result, sanitation provision often lags behind demand, particularly in informal settlements and peri-urban areas that fall outside formal planning frameworks.

The sanitation experiences of countries such as Ghana and India illustrate the structural nature of this global challenge. In Ghana, sanitation coverage remains extremely low, with only 21% of the population having access to hygienic toilet facilities. Municipal sewer systems and wastewater treatment plants are widely inadequate or non-functional, and open defecation remains prevalent, especially in rural and peri-urban areas. These conditions contribute directly to the spread of waterborne diseases such as cholera and diarrhoea. Financial constraints further compound the problem, as households are often expected to finance their own sanitation infrastructure despite widespread poverty. Cultural practices, land availability constraints, and lack of institutional coordination have also limited the uptake of improved sanitation technologies (Baldwin Kan-uge, Kan-uge, & Stwalley, 2024).

In India, the country continues to face severe sanitation challenges, particularly in rural areas and densely populated urban regions. Despite large-scale government initiatives, open defecation remains widespread, contributing to environmental pollution, public health risks, and persistent inequalities. Rapid urbanisation has strained existing sanitation infrastructure, resulting in unsanitary conditions in slums and informal settlements, where marginalised populations are disproportionately exposed to health hazards. In both Ghana and India, the limitations of conventional sewer-based systems in low-income, high-density contexts are evident.

More broadly, the transition of settlements from rural or peri-urban to fully urban environments in the Global South is frequently accompanied by increased environmental contamination due to inadequate sanitation and poor waste management. Governments often lack the capacity to extend centralised waterborne sewerage systems to all neighbourhoods, particularly those characterised by land tenure security, topographical constraints, or informal development patterns. In this context, decentralised and non-sewered sanitation systems, including nature-based and green infrastructure approaches, have emerged as potential alternatives capable of addressing sanitation needs where conventional systems are financially or technically unfeasible.

Urbanisation also has direct implications for water resource management and environmental sustainability. In South Africa, for example, major metropolitan areas are located on watershed divides, meaning that rivers serve both as sources of potable water and as recipients of treated and untreated waste. As urban populations grow, sanitation infrastructure must be upgraded and carefully managed to prevent the degradation of water resources and downstream ecosystems (Oberholster, 2010). Similar dynamics are observed globally, underscoring the interconnectedness of sanitation, urban growth, and environmental protection.

Informal settlements play a particularly significant role in shaping sanitation outcomes. In South Africa, more than 65% of informal settlement residents lack access to adequate sanitation facilities (UN-Habitat, 2014). Although sanitation is recognised as a human right and policies such as Free Basic Sanitation aim to provide minimum service levels, access and usability remain major challenges. Poor maintenance and limited community participation in planning processes often render facilities unsafe or inaccessible, especially for women, children, and the elderly. As a result, residents frequently resort to unsafe practices such as open defecation or the use of bucket toilets, particularly at night (Lagardien & Muanda, 2014; Taing, 2015).

These dynamics highlight that the global sanitation crisis is fundamentally an urban challenge, concentrated in informal settlements and peri-urban areas of the Global South. The persistence of inadequate sanitation is not merely a technical failure but also reflects deeper structural, financial, and governance constraints. Traditional sewer systems, which are built for well-planned, low-density areas, often do not work well in rapidly growing, informal, or resource-limited communities. This recognition has driven a global shift towards alternative sanitation approaches that emphasise decentralisation, flexibility, and context-specific solutions.

However, the adoption of sanitation alternatives also presents new challenges. Without strong institutional frameworks, inclusive planning processes, and sustainable financing mechanisms, alternative systems risk becoming permanent interim solutions that entrench unequal service standards. Effective sanitation reform, therefore, requires not only technological innovation but also strengthened governance, community engagement, and integration of sanitation planning into broader urban development strategies. In this sense, sanitation alternatives are best understood not as a substitute for long-term infrastructure development, but as a critical component of equitable and sustainable urban sanitation systems in rapidly urbanising contexts.

5. Sanitation Context in the City of Johannesburg

Sanitation challenges in South Africa, and particularly in the City of Johannesburg, are deeply rooted by historical spatial inequality, rapid urbanisation growth, and declining municipal resources. Although sanitation is recognised as a constitutional right and supported through policies such as Free Basic Sanitation, access remains highly uneven. Johannesburg continues to exhibit a two-tier system in which affluent suburbs are largely served by functional waterborne sewerage, while townships and informal settlements depend on deteriorating infrastructure or interim solutions (Muanda, Goldin & Haldenwang, 2020; Muller, 2022).

A core challenge is the physical deterioration and overloading of Johannesburg's sewerage network. Large sections of the system are ageing and poorly maintained, resulting in frequent blockages, pipe bursts, and sewer overflows into streets and stormwater systems (Department of Water and Sanitation, 2021). Much of the infrastructure was never designed to accommodate current population densities, particularly in older townships and rapidly densifying informal settlements. High levels of non-revenue water, caused by leaks, illegal connections, and infrastructure failures, further strain Joburg Water's financial and operational capacity, indirectly undermining sanitation service delivery (Muller, 2022; Sheridan, 2024).

Residents of informal settlements experience the most acute sanitation challenges. Johannesburg has over 180 recognised informal settlements and many more unrecognised ones, most of which lack access to waterborne sanitation. In these areas, the municipality has relied heavily on interim sanitation services, primarily ventilated improved pit (VIP), chemical toilets and limited container-based systems (Mkhize et al., 2020).

Empirical studies and community monitoring initiatives show that these facilities are frequently inadequate in number, poorly located, and inconsistently serviced, resulting in unhygienic conditions and rapid deterioration (Mkhize et al., 2020; Asivikelane, 2025). In settlements such as Diepsloot, single toilets may be shared by up to 15 households, while in areas like Zandspruit, Finetown, and Ivory Park, residents report broken or missing toilets, pit latrines linked to groundwater contamination, and delayed servicing.

These conditions often force residents to resort to open defecation or the use of "flying toilets," particularly at night when communal facilities are unsafe or inaccessible. As a result, sanitation has become a persistent trigger for service delivery protests in Johannesburg, reflecting both unmet basic needs and broader struggles over dignity and safety (Dlamini & Ncube, 2023). Governance challenges worsen the situation, including weak coordination within municipal departments, poor contract management for interim services, and limited community engagement, which together prolonged the use of temporary solutions (Mathonsi, Mphambukeli & Mufungizi, 2025).

The environmental impacts of poor sanitation are serious. Sewer overflows, failing pump stations, and illegal connections have caused untreated sewage to be released into Johannesburg's River systems, especially the Jukskei and Klip rivers (Department of Water and Sanitation, 2021). Research in Gauteng's informal settlements shows high levels of microbial contamination in surface water, directly linked to inadequate sanitation and wastewater management (Hlengwa et al., 2025). The sanitation crisis in Johannesburg is thus part of a broader water quality and public health crisis affecting both urban residents and informal settlements.

5.1 Sanitation Statistics in the City of Johannesburg

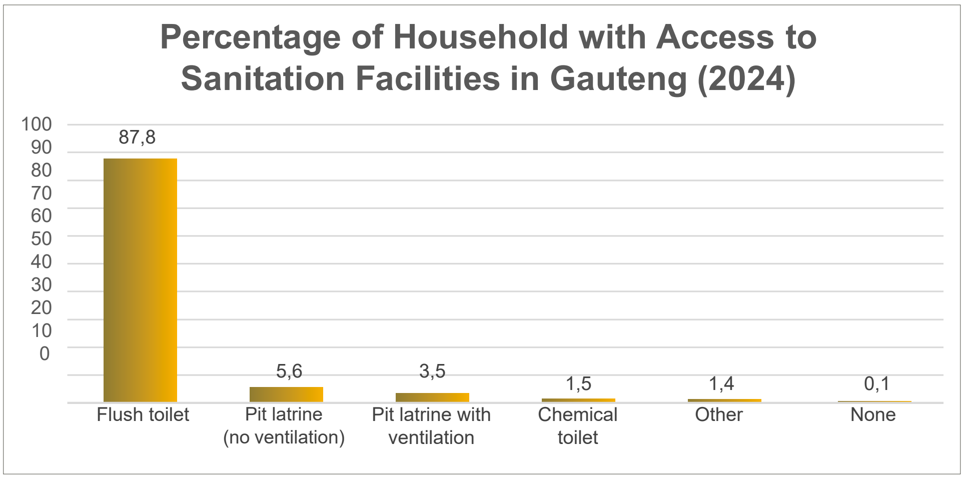


Figure 3: Access to sanitation in Gauteng (Source: Statistics South Africa, 2024)

Figure 3 illustrates the distribution of sanitation facilities in Gauteng. Most households use flush toilets (87.8%), which shows that access to proper sanitation is generally high in the province. However, some households still rely on other options, including pit latrines without ventilation (5.6%) and ventilated pit latrines (3.5%). A small number use chemical toilets (1.5%) or other types (1.4%), while very few households (0.1%) have no access to sanitation at all.

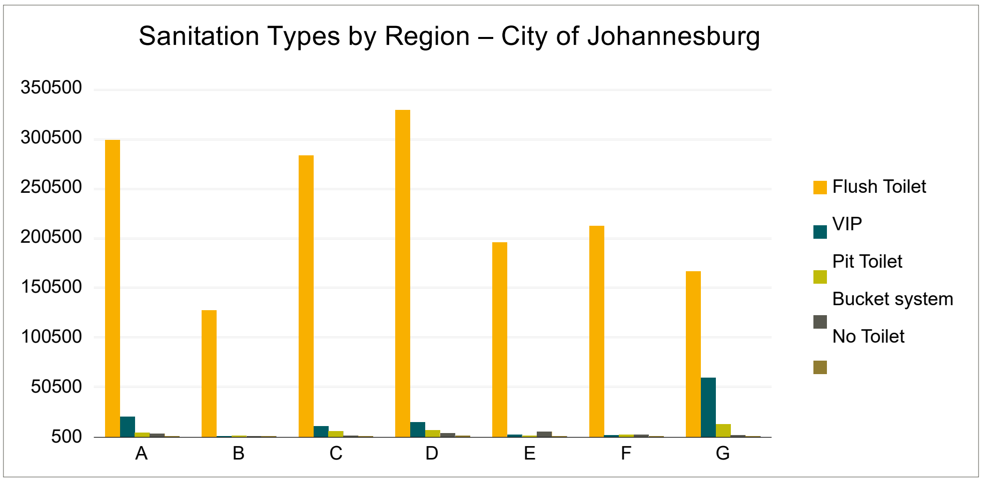


Figure 4: Access to Sanitation Services in the City of Johannesburg (Source: S&P Global, 2024)

Figure 4 illustrates sanitation access across regions in the City of Johannesburg. Overall, most households use flush toilets, accounting for the largest share in every region. However, access varies by region. Region G has a noticeably higher number of households using ventilated improved pit (VIP) latrines and pit toilets compared to other regions. Bucket systems and households without toilets make up a small proportion overall, but are still present in all regions. These patterns indicate that while formal sanitation services are widely available, some areas continue to rely on alternative or limited sanitation options.

Overall, Johannesburg's experience highlights the limitations of traditional centralised sewerage systems in contexts of informality, infrastructure decay, and rapid urban growth. The persistence of interim sanitation solutions, coupled with environmental degradation and governance failures, underscores the need to explore decentralised and non-sewered sanitation alternatives that are context-appropriate, sustainable, and supported by stronger institutional capacity and community participation.

6. Policy, Global and Institutional Context

Sanitation is internationally recognised as a fundamental human right and a cornerstone of public health, environmental protection, and sustainable development. This recognition is embedded in the United Nations Sustainable Development Goals, particularly SDG 6.2, which calls for equitable access to adequate and safely managed sanitation and hygiene for all, with specific emphasis on women, children, and vulnerable populations living in informal and marginalised contexts (UN General Assembly, 2015; WHO & UNICEF, 2021). Importantly, SDG 6 shifts the global focus beyond mere access to facilities towards the safe management of sanitation services across the entire value chain, including containment, emptying, transport, treatment, and final disposal or reuse.

South Africa's sanitation policy framework is closely aligned with these global commitments. The National Sanitation Policy (NSP) of 2016 explicitly acknowledges the diversity of settlement types across the country and promotes a differentiated, context-sensitive approach to sanitation service delivery. The policy moves away from a singular reliance on conventional waterborne sewerage systems and recognises the role of alternative and non-sewered sanitation technologies, particularly in informal settlements, peri-urban areas, and water-scarce regions (Department of Water and Sanitation, 2016). The NSP further emphasises environmental sustainability, user dignity, gender sensitivity, and meaningful community participation as core principles guiding sanitation planning and implementation.

Building on the NSP, the National Water and Sanitation Master Plan (NW&SMP) of 2019 offers a strategic framework to address ongoing infrastructure backlogs, institutional weaknesses, and financial constraints in the water and sanitation sector. The Master Plan emphasises the increasing risks from climate change, rapid urbanisation, and deteriorating infrastructure, and explicitly urges municipalities to explore decentralised, off-grid, and water-efficient sanitation solutions where conventional sewerage is unfeasible or unsustainable (Department of Water and Sanitation, 2019). In this context, sanitation alternatives are regarded not as temporary stopgap measures but as fundamental to a resilient and diverse sanitation system capable of adapting to future urban growth and resource limitations.

The institutional shift towards non-sewered sanitation is further reinforced by South Africa's National Faecal Sludge Management (FSM) Strategy, finalised in 2023. The FSM Strategy responds to the reality that a significant proportion of South African households rely on on-site sanitation systems, including pit latrines, septic tanks, chemical toilets, and container-based sanitation. It emphasises the need for municipalities to plan for – and manage- the full sanitation service chain, ensuring that faecal sludge is safely emptied, transported, treated, and disposed of or beneficially reused (Department of Water and Sanitation, 2023). The strategy aligns directly with SDG 6.2 and serves as a critical institutional mechanism to improve sanitation outcomes in informal settlements and other underserved areas.

Together, these global and national policy frameworks provide a strong enabling environment for municipalities such as the City of Johannesburg to pursue innovative and context-appropriate sanitation solutions. They legitimise the adoption of alternative sanitation technologies, decentralised systems, and service-based models, while also placing clear responsibility on local government to ensure sustainability, environmental protection, and human dignity. However, the effectiveness of these frameworks ultimately depends on municipal capacity, governance, and the ability to translate policy intent into operational practice at the local level.

7. Sanitation Technologies

The following subsection introduces a range of sanitation systems that can operate independently of conventional sewer networks. It outlines practical technologies such as non-sewered sanitation systems, urine-diverting dry toilets, decentralised wastewater treatment, and nature-based solutions. Each option is presented with its core functions, benefits, limitations, and relevant case examples, to support understanding of how the systems can address service gaps in areas where sewer expansion is difficult or impractical.

7.1 Non-Sewered Sanitation Systems

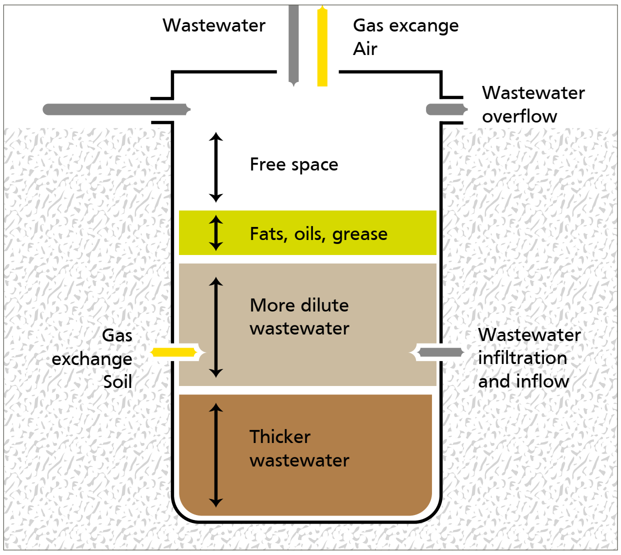


Figure 5: Illustrative onsite containment of stored wastewater.

Non-sewered sanitation (NSS) services refer to the on-site and off-site management of wastewater from the point of generation to final treatment, end use, or disposal without reliance on a centralised sewer network. Wastewater within NSS systems includes blackwater, which originates from toilets and contains human excreta (urine and faeces), flushing and cleansing water, and toilet paper, as well as greywater, which is generated from bathing, washing, and kitchen activities and does not contain human excreta. NSS approaches are particularly relevant in contexts where conventional sewer infrastructure is technically, financially, or environmentally unfeasible.

NSS systems may be treated on-site, directly at or near the source of generation. This includes technologies such as biodigester toilets, tiger worm toilets, urine-diverting dry toilets, or combined treatment systems serving individual households or larger buildings. Alternatively, wastewater may be managed off-site, where it is collected and temporarily stored before being transported to designated treatment facilities. Off-site management typically relies on road-based transport to semi-centralised or decentralised treatment plants. It may include container-based sanitation systems characterised by short storage periods, frequent collection, and relatively short transport distances. These approaches allow for flexible and-, modular sanitation service delivery while enabling safe treatment and resource recovery without dependence on large-scale sewer networks.

An example of off-site NSS with semi-centralised treatment is found in Kumasi, Ghana, where faecal sludge from pit latrines and septic tanks is collected by vacuum trucks and treated at dedicated facilities using co-composting and stabilisation processes. This system has improved environmental protection and reduced uncontrolled dumping, demonstrating the effectiveness of faecal sludge management as part of a citywide non-sewered sanitation approach.

7.1.1 Urine Diverting Dry Toilets

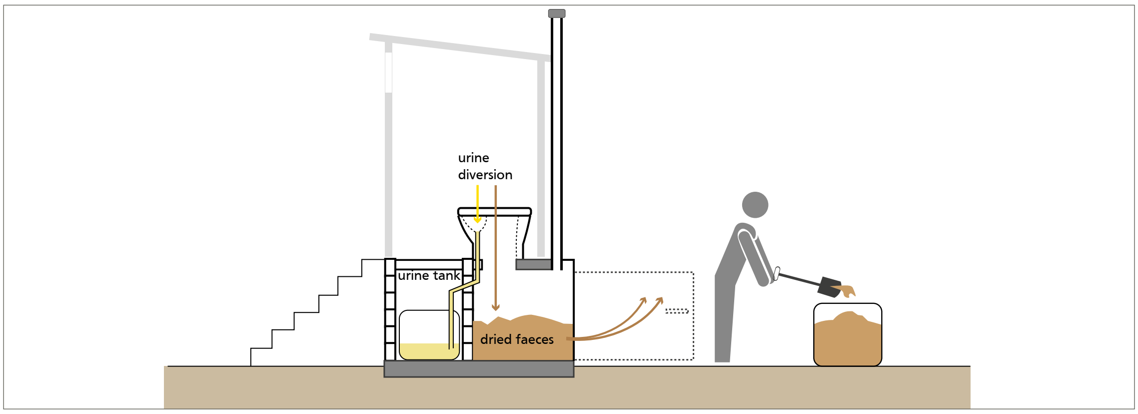


Figure 6: Diagram of a UDDT structure with faecal matter being emptied for potential reuse

Urine-diverting dry toilets (UDDTs) represent one of the most significant advancements in waterless sanitation technologies, particularly in contexts characterised by water scarcity, dispersed settlement patterns, and limited sewer infrastructure. UDDTs function by separating urine and faeces at the source, typically through a specially designed pedestal or squat plate. Urine is diverted into a separate collection or infiltration system, while faecal matter is retained in a dry vault where dehydration and pathogen reduction occur over time. This source separation offers several advantages over conventional composting or mixed-waste on-site systems, including reduced odour, lower moisture content in faecal matter, improved treatment efficiency, and enhanced potential for nutrient recovery (Larsen et al., 2013; Tilley et al., 2014).

From a resource-efficiency perspective, UDDTs significantly reduce water demand by eliminating the need for flushing, making them particularly suitable for water-scarce regions. Studies have shown that urine diversion reduces the overall volume of waste requiring treatment and enables more efficient recovery of nitrogen and phosphorus, as most nutrients are contained in urine rather than faeces (Larsen et al., 2013). When appropriately managed, separated urine can be reused as an agricultural fertiliser, while dried faecal matter poses a lower health risk and is easier to transport and treat compared to sludge from wet sanitation systems (WHO, 2018).

ADVANTAGES	DISADVANTAGES
Do not require water for operation, making them suitable for water-scarce areas.	Require user training and acceptance to ensure correct use.
Low odour and vector (flies) problems when maintained properly.	Can be prone to misuse or clogging if faeces enter the urine area.
Low capital and operational costs; can be built and repaired with local materials.	Prefabricated models are not widely available in all regions.
Environmentally friendly: separates urine and faeces, enabling drying and pathogen reduction.	A visible excreta pile may reduce user comfort or acceptance.
Enables the reuse of urine as fertiliser and dried faeces as soil amendment in agriculture.	Requires regular emptying and proper waste sludge management.
Suitable for locations where sewered systems, pit latrines, or deep excavation are not feasible.	Construction or vault failures (e.g., poor sealing or ventilation) can affect usability and hygiene.
Minimises groundwater pollution due to above-ground vaults and contained storage.	

In South Africa, the most widely cited example of large-scale UDDT implementation is found in the eThekwini Metropolitan Municipality. Faced with water scarcity, challenging topography, high infrastructure costs, and extensive peri-urban and rural settlements, eThekwini adopted UDDTs as a strategic alternative to conventional waterborne sewerage. Beginning in the early 2000s, the municipality installed over 80,000 UDDTs, primarily in areas where sewer connections were technically or financially unfeasible (Roma et al., 2013; Buckley et al., 2016). This programme positioned eThekwini as a national and international pioneer in the use of non-sewered sanitation systems within a metropolitan context.

7.2 Decentralised Wastewater Treatment Systems

Decentralised wastewater treatment refers to a range of systems that collect, treat, and manage wastewater at or near the point where it is generated, rather than conveying it to a distant centralised treatment plant. These systems can serve individual households, clusters of homes or businesses, institutions, or entire communities. The choice of system is informed by site-specific conditions such as soil type, population density, water availability, and environmental sensitivity. Decentralised systems range from simple onsite technologies, such as septic tanks with soil dispersal, to more advanced and mechanised treatment units that serve multiple users and discharge treated effluent to soil or surface water in compliance with regulatory requirements. As permanent infrastructure, these systems can operate independently or be integrated with centralised sewer networks, offering flexible and scalable solutions for rural, peri-urban, and urban contexts.

Decentralised wastewater treatment offers a viable and often preferable alternative to centralised systems, particularly for communities facing financial, spatial, or environmental constraints. These systems can reduce high capital investment costs associated with extensive sewer networks, lower operation and maintenance expenses, and allow for phased implementation aligned with population growth. From a sustainability perspective, decentralised treatment supports efficient use of land and energy, protects water quality, enables water reuse, and mitigates health and environmental risks linked to untreated wastewater. Additionally, decentralised approaches can stimulate local economic development through job creation and support improved public health outcomes by reducing pollution and exposure to contaminants.

The Technology Management (TM) Decentralised Wastewater Treatment System (DEWATS) at IIT Gandhinagar, India, demonstrates the practical application of decentralised wastewater treatment within an institutional setting. Wastewater generated from campus facilities is collected and conveyed to the treatment units through a localised sewer network, enabling treatment close to the source of generation and reducing reliance on centralised municipal infrastructure.

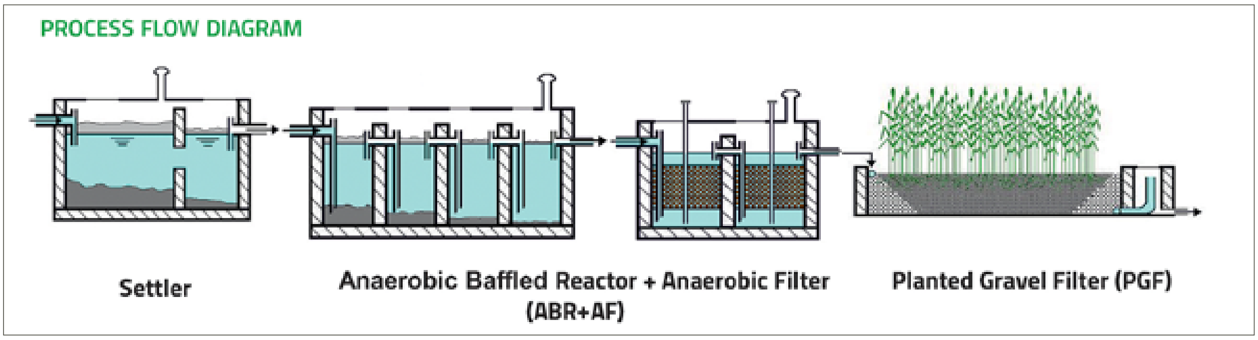


Figure 7: Illustrates the flow diagram of Decentralised Wastewater Treatment Systems

The treatment system consists of four sequential modules designed to progressively improve effluent quality:

Settler	The settler functions as a sedimentation tank where wastewater is retained for a specified period, allowing heavier suspended solids to settle. This primary treatment step reduces the organic load entering subsequent units and enhances overall system efficiency.
Anaerobic Baffle Reactor (ABR)	The ABR promotes anaerobic degradation of suspended and dissolved organic matter by directing wastewater through a series of compartments. In this process, fresh wastewater is mixed with an active sludge blanket, facilitating effective biological treatment and improved breakdown of organic pollutants.
Anaerobic Filter (AF)	The anaerobic filter contains a filter bed that supports the growth of active bacterial biomass. As wastewater flows through the filter media, dissolved organic matter is degraded through contact with anaerobic microorganisms attached to the material, further reducing biochemical oxygen demand (BOD).
Planted Gravel Filter (PGF)	The planted gravel filter serves as a tertiary treatment unit, enabling aerobic and facultative degradation of remaining dissolved organic pollutants. Vegetation and gravel media enhance oxygen transfer, nutrient uptake, and polishing of the effluent before reuse or safe discharge.

ADVANTAGES	DISADVANTAGES
Community-managed DWTS can rapidly improve sanitation in dense, low-income settlements where centralised sewerage is absent or not planned.	On-site sanitation alone is often inappropriate in dense informal settlements, requiring intermediate systems that may still be hard to implement.
DWTS can be installed where conventional WWTPs do not exist or cannot function properly, including slums and labour camps	Limited space and complex settlement patterns make sewer routing, plant siting, and maintenance difficult
Modular DEWATS (e.g., settler + anaerobic baffled reactor + wetlands) have shown high removal efficiencies (>85% COD, NH_4-N, PO_4-P) even under informal settlement type conditions.	Systems may struggle with denitrification due to poor carbon availability and fluctuating loads typical in informal settlements
Provides affordable sanitation for poor households where centralised systems are too costly or slow to implement.	Limited municipal budgets and a lack of long-term financing hinder continuity and scaling.
Community-managed DWTS can empower local groups in informal settlements to maintain systems and ensure sanitation continuity	Requires sustained local engagement, which may be difficult in transient informal settlements
Reduces pollution load on local water sources where untreated wastewater is common, improving overall environmental quality.	Poor wastewater characterisation in informal areas complicates design and sizing, reducing the predictability of outcomes.
Systems can handle variable wastewater qualities common in unplanned settlements due to robust anaerobic and wetland components	

7.2.1 Community-Based Sanitation

Community-based sanitation refers to sanitation systems that are developed and managed with the active participation of communities, rather than being delivered solely through centralised municipal infrastructure. In many rapidly urbanising cities, including Johannesburg, conventional sewer-based sanitation systems are often difficult to extend into informal settlements due to high costs, land constraints, and complex settlement patterns. Community-based sanitation, therefore, offers an alternative approach by emphasising local participation in the planning, management, and maintenance of sanitation facilities. This approach often includes shared sanitation facilities, community-managed ablution blocks, and locally organised maintenance systems that are supported by municipalities. Importantly, involving residents in decision-making can improve the sustainability of sanitation services, as communities are more likely to take ownership of facilities and ensure their proper use and maintenance (Tilley et al., 2014; Water Research Commission, 2017). For Johannesburg, integrating community-based sanitation within broader sanitation strategies could help address service delivery gaps in informal settlements while strengthening collaboration between residents and the municipality.

In South Africa, elements of community-based sanitation have already been implemented in several municipalities, offering practical lessons for other urban areas. For example, Durban, through the eThekwini Municipality, has implemented participatory sanitation programmes in peri-urban and informal settlements, including the introduction of urine-diverting dry toilets accompanied by community education and maintenance support (Roma, Buckley & Jefferson, 2010). Community participation has also been incorporated into sanitation upgrading initiatives in Cape Town, where residents are involved in monitoring and maintaining shared sanitation facilities in informal settlements (South African Local Government Association, 2016). These experiences highlight that when communities are actively involved in sanitation planning and management, the likelihood of long-term functionality and acceptance of sanitation systems improves. Adopting similar participatory approaches in Johannesburg could therefore enhance the effectiveness of alternative sanitation solutions, particularly in areas where conventional infrastructure expansion remains limited.

ADVANTAGES	DISADVANTAGES
Encourages community participation and local ownership of sanitation facilities, which can improve long-term sustainability.	Requires consistent community participation and leadership, which may decline over time.
Generally, more cost-effective than extending conventional sewer infrastructure in informal settlement areas of Johannesburg.	Shared facilities may lead to overcrowding, especially in dense informal settlements.
Can be implemented more quickly than large-scale centralised sanitation systems.	Maintenance responsibilities between communities and municipalities may become unclear.
Flexible and adaptable to spatial constraints in informal settlements and marginalised urban areas.	Concerns around privacy, safety, and hygiene can arise with communal sanitation facilities.
Promotes sanitation awareness and improved hygiene practices within communities.	Some residents may perceive shared sanitation as a temporary or inferior solution compared to household sanitation.

7.3 Nature-Based Waste Treatment: A Sustainable Alternative

Nature-based solutions (NBS) are a cost-effective and eco-friendly alternative to tackle wastewater contamination. When combined, they can provide several advantages, including improving water management, mitigating and adapting to climate change, enhancing biodiversity, improving air quality, increasing stakeholder involvement, urban renewal, recreation, social cohesion, and improvements in public health, green growth, and environmental sustainability. Through the recovery of nutrients, the creation of useful bioresources, and the creation of employment possibilities, the use of NBS may also have positive economic effects.

7.3.1 Constructed Wetlands

Figure 8: Constructed Wetlands Mimicking natural purification processes, these systems require minimal energy input whilst remaining highly adaptable to the unique conditions of informal settlements. Plants and microorganisms work together to break down contaminants.

Wetlands are natural or engineered systems that use plants, soils, and microbial processes to filter and clean wastewater in an environmentally friendly way. As water flows slowly through a wetland, pollutants such as suspended solids, nutrients, and organic matter are trapped, absorbed, or broken down by vegetation and microorganisms. A practical example is the Mikindani Constructed Wetland in Kenya, which uses plants like Typha, Cattail, Flat sedge, and Vetiver grass to remove nitrates, ammonia, and total suspended solids from community wastewater. This approach shows how wetlands can deliver effective treatment while supporting biodiversity and requiring very little energy (Al-Kuwari, 2025).

For a rapidly growing metropolitan area like Johannesburg, constructed wetlands could provide a valuable sanitation alternative by easing pressure on overloaded wastewater treatment plants, especially in informal settlements and peri-urban areas where sewer access is limited. Wetlands can be built near communities, operate with minimal electricity, and continue to function during load-shedding, making them resilient in a city facing energy constraints. They can also help reduce pollution entering rivers such as the Jukskei and Klip, improving downstream water quality and supporting healthier ecosystems. As sustainable, low-cost, and scalable systems, wetlands could complement existing infrastructure and strengthen Johannesburg's long-term water security and sanitation resilience.

ADVANTAGES	DISADVANTAGES
Low-cost and low-energy sanitation option requiring minimal electricity.	Require a large land area, which may be limited in dense informal settlements.
Effective at removing pollutants such as suspended solids, nutrients, ammonia, and nitrates.	Treatment performance can vary with climate, plant species, and maintenance quality.
Supports biodiversity and creates ecosystem benefits.	Risks of clogging if not properly maintained.
Resilient during load-shedding, continues functioning without grid power.	May attract mosquitoes or pests if not well managed.
Reduces pollution into rivers, improving downstream water quality.	Requires community involvement for upkeep to prevent decline in performance.
Suitable for peri-urban and informal settlements lacking sewer infrastructure.	

7.3.2 Natural Filtration Systems

Natural filtration systems depend on the natural cleansing ability of soils, sediments, and underground geological layers to purify water as it seeps into the ground. According to Balke and Zhu (2008), artificial groundwater recharge enhances these natural purification processes by directing rainwater or river water into underground aquifers, where contaminants are reduced through natural attenuation mechanisms such as adsorption by clay minerals, iron hydroxides, and humic substances, and biodegradation by microorganisms. These processes significantly improve water quality while reducing the need for intensive mechanical or chemical treatment. Since filtration occurs gradually as water percolates through sand, gravel, and soil layers, pollutants are trapped or broken down, resulting in cleaner water that is easier and cheaper to treat further if necessary. This method also supports long-term water security by storing excess water underground during high-flow periods and making it accessible during drier months, ensuring a more reliable year-round supply.

For a water-scarce and rapidly urbanising region like Johannesburg, natural filtration systems, especially artificial groundwater recharge, could provide a valuable and sustainable alternative to sanitation. Many wastewater treatment facilities in the city are overwhelmed, and pollution often enters rivers such as the Jukskei and Klip. Introducing natural filtration systems could reduce the pollutant load entering these waterways by diverting treated or partially treated wastewater into controlled infiltration zones, where soils and microbial communities naturally remove contaminants before they reach aquifers or surface waters. Because artificially recharged groundwater is naturally shielded from surface pollution, this approach increases the overall safety and dependability of Johannesburg's water and sanitation network.

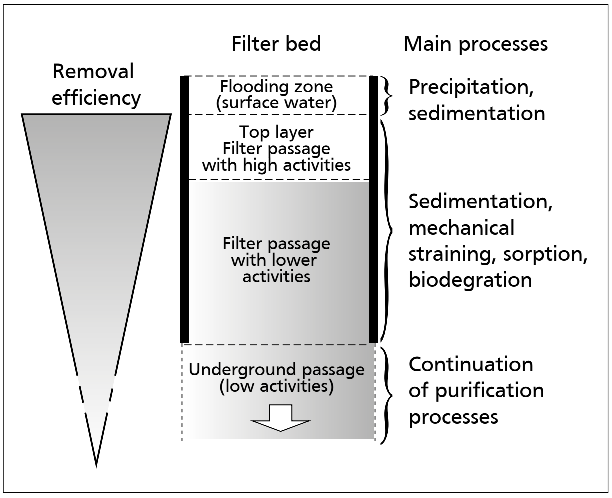


Figure 9: Purification process during vertical infiltration of water (Preuß and Schulte-Ebbert, 2000)

These systems could also enhance Johannesburg's resilience to energy shortages and fluctuating water availability. Natural filtration demands minimal electricity, making it far less susceptible to load-shedding than conventional treatment technologies. Subsurface storage created through artificial recharge would enable the city to manage seasonal variations in rainfall, storing more water during wet periods and retrieving it during dry seasons. Additionally, because much of the purification occurs underground, the final treatment stages become simpler and less costly. This makes natural filtration systems a low-maintenance, climate-resilient, and cost-effective supplement to existing wastewater infrastructure, particularly in informal and peri-urban regions where conventional sewerage systems are limited.

ADVANTAGES	DISADVANTAGES
Uses natural soil, sediments, and geological layers to purify water with minimal energy.	Effectiveness depends on subsurface geology, and unsuitable soils reduce treatment efficiency.
Low operational costs and minimal mechanical equipment needed.	Risk of groundwater contamination if pretreatment is inadequate.
Enhances long-term water security by storing water underground for dry seasons.	Requires careful monitoring to avoid aquifer overloading or rising groundwater levels.
Reduces pollutant load entering rivers like the Jukskei and Klip.	Implementation requires regulatory approvals and detailed hydrogeological assessments.
Provides reliable treatment even during power shortages.	Slow filtration rates may limit suitability for high wastewater volumes.
Improves final water quality, reducing the need for intensive treatment.	Potential land-use conflicts for establishing infiltration zones.

7.3.3 Solar-Powered Small-Scale Wastewater Treatment Systems

Solar-powered small-scale wastewater treatment systems are decentralised units that use renewable solar energy to aerate, ozonate, and filter wastewater, significantly improving water quality without relying on the electricity grid. The system described in the article demonstrated strong purification results, including reducing oil and grease by 94.26%, lowering BOD by 71.93%, and increasing dissolved oxygen from 0.88 mg/L to 3.98 mg/L, showing that clean water can be produced using a low-cost, energy-efficient process powered entirely by sunlight. These systems are compact, community-friendly, and operate independently of complex sewer networks, making them ideal for areas where conventional wastewater infrastructure is insufficient.

For the City of Johannesburg, this technology could provide an effective alternative sanitation solution, especially in informal settlements and high-density areas that lack proper sewer connections. Solar-powered treatment units would help reduce pollution entering the Jukskei and Klip River systems, relieve pressure on overloaded wastewater treatment plants, and ensure continuous sanitation even during load shedding because they do not rely on the national grid. By treating wastewater at the source like the success demonstrated in the study's canal system, Johannesburg could improve public health, restore degraded waterways, and expand sanitation services sustainably and affordably.

ADVANTAGES	DISADVANTAGES
Fully independent of the electricity grid, not affected by load-shedding.	Dependence on sunlight may reduce performance during consecutive cloudy days.
Achieves significant pollutant reduction (oil & grease).	Solar panels require periodic cleaning and protection from vandalism.
Compact and suitable for dense informal settlements.	May have higher initial installation costs compared to wetlands.
Reduces pollution entering major river systems.	Requires technical support for long-term maintenance of pumps, filters, and sensors.
Supports decentralised wastewater management close to the source.	Limited treatment capacity per unit may require scaling for large communities.
Improves public health by preventing raw sewage discharge into waterways.	Batteries (if used for storage) have a limited lifespan.

The sanitation alternatives discussed demonstrate that a mix of non-sewered, decentralised, and nature-based solutions can effectively complement or substitute conventional sewered systems. While each option has specific requirements and constraints, together they offer flexible, affordable, and sustainable pathways for improving sanitation access, especially in the informal settlements and rapidly growing areas. Choosing the right approach depends on local conditions, community needs, and long-term management capacity.

7.4 Water-Efficient Sanitation Alternatives

7.4.1 Vacuum Sewer Systems

Vacuum sewerage systems signify a notable technological shift from traditional gravity-driven sanitation systems. Rather depending on the constant water flow for waste transfer, these systems utilize differential air pressure within a sealed, shallow-depth piping network. This method is especially appropriate for high-density urban neighbourhoods and informal settlements, because current gravity sewers are frequently antiquated, inadequately maintained, or hydraulically burdened. Due to the operation of the system under constant negative pressure, vacuum sewers are intrinsically less prone to leakages, blockages and sewer overflows, which are significant factors in microbiological contamination of receiving water bodies like the Jukskei and Klip rivers (DWS, 2016; Asivikelane, 2025).

Vacuum toilets necessitate significantly lower flush volumes, often ranging from 0.5 to 1.2 litres each use, as contrast to the 6-9 litres required by traditional waterborne systems (DWS, 2019; WHO & UNICEF, 2021). This performance fully aligns with the National Water and Sanitation Master Plan (NW&SMP) objective of advocating for water-efficient technology in areas where traditional sewerage is impractical (DWS, 2019). Moreover, the necessity for merely shallow trenching renders vacuum sewerage a viable solution for intensifying informal settlements, where deep excavations are impeded by settlement density, subterranean utilities, and geotechnical constraints (National Planning Commission, 2012; DWS, 2016).

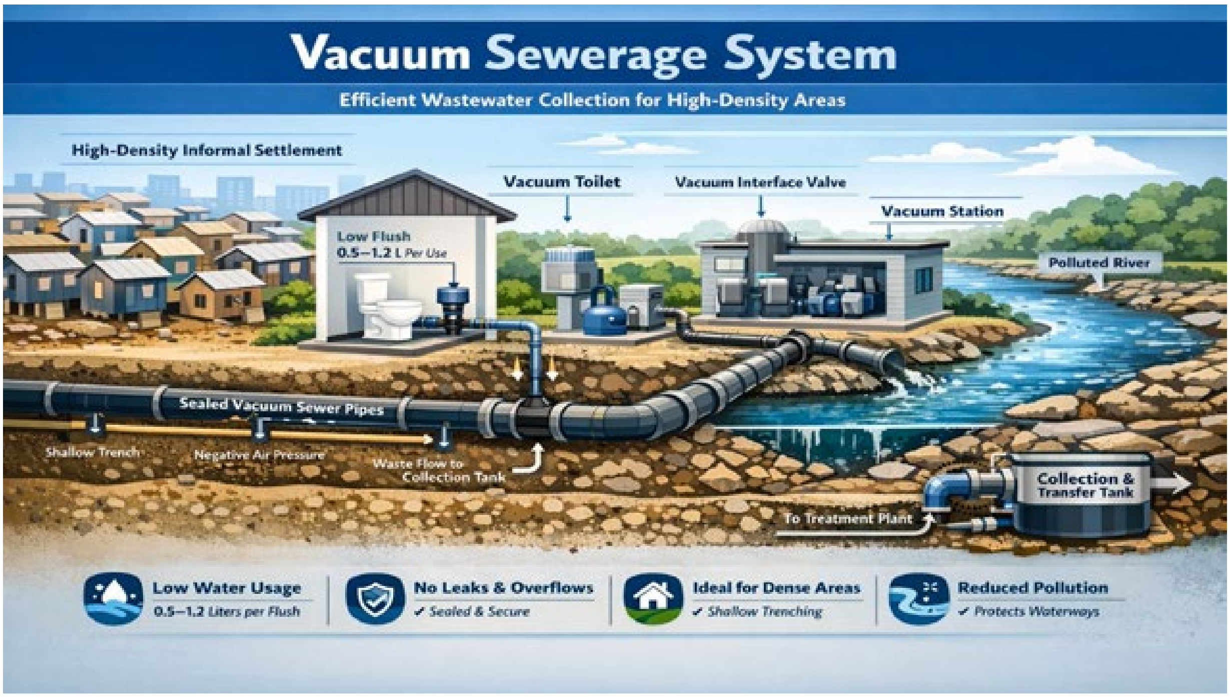


Figure 10: Vacuum Sewer System

Vacuum systems are widely used in Europe and the United States, particularly in areas with high water tables or flat terrain. United States extensively used in Florida (e.g., Key Largo and Jacksonville) to replace failing septic systems in environmentally sensitive coastal zones (Flovac 2024). In New Zealand it was successfully implemented in Kawakawa Bay and Christchurch, where the system was chosen for its resilience in earthquake zones, as the flexible, shallow-trench pipes are less prone to rupture than rigid gravity pipes, as well Poland in Imielin to address specific topographical challenges (Flovac 2024).

The first vacuum sewer in an informal settlement in Cape Town was considered a failure. Despite the technical potential, the system failed shortly after commissioning due to "sociopolitical factors," including dissent from residents and municipal officials, and a lack of community-based management (Taing et al. 2013), which gave a lesson that a technical efficiency does not guarantee success in informal settlements without robust social engagement and maintenance plans.

7.4.2 Tiger Worm Toilets (Vermifiltration)

Tiger Worm Toilets, as an advancement of Non-Sewered Sanitation (NSS) methods, utilize composting worms (Eisenia fetida) to process human waste directly at the source. The worms facilitate swift pathogen reduction and aerobic decomposition of organic matter by ongoing ingestion and aeration, parallel to the treatment methods seen in Planted Gravel Filters (PGFs) (DWS, 2016; DWS, 2023). The resultant stabilized by-product is a nutrient-dense vermicompost, aligning with the National Sanitation Policy's focus on resource recovery and advantageous reuse (DWS, 2016).

From a social and operational standpoint, these systems function as pour-flush units, necessitating merely 1–2 litres of water each use, and offer a safe, dignified, and reliable alternative to communal chemical toilets (WHO & UNICEF, 2021; Asivikelane, 2025). Tiger Worm Toilets mitigate malodours and inhibit fly proliferation by biological digestion, hence improving the unsanitary living conditions commonly observed in areas like Diepsloot and Ivory Park (Asivikelane, 2025; Stats SA, 2022). Significantly, they eradicate dependence on regular collection, vehicular transfer, and external disposal, which continue to be critical shortcomings of container-based sanitation systems (DWS, 2023).

Tiger Worm Toilet (Vermifiltration)

Figure 11: Tiger Worm Toilets

7.4.3 Micro-Flush Bio-Digester Toilets

Micro-flush bio-digester toilets operate as compact Decentralized Wastewater Treatment Systems (DEWATS) by combining low-volume flush technology with onsite anaerobic treatment. Waste is introduced into a primary digestion or settling tank, where an active sludge blanket facilitates the anaerobic decomposition of organic contaminants (DWS, 2016; DWS, 2023). This multi-stage treatment process markedly enhances effluent quality before regulated discharge into soakaways or limited irrigation reuse (DWS, 2023).

Micro-flush mechanisms generally necessitate only 500 ml to 1 litre of water each use, rendering them especially appropriate for Johannesburg neighbourhoods confronting water scarcity and deficiencies in sanitation infrastructure (DWS, 2019; Stats SA, 2022). Bio-digester toilets mitigate the influx of untreated or partially treated sewage into municipal systems by handling waste at or near the place of creation (DWS, 2023). This methodology is in direct accordance with the National Faecal Sludge Management Strategy, which emphasizes containment, treatment, and safe handling along the entire sanitation service chain (DWS, 2023).

Figure 12: Micro-Flush Bio-digested Toilets

The global Implementation of this system includes Ghana through the The Global Social Benefit Institute (GSBI) where they field-tested micro-flush valves combined with bio-digesters in rural and school settings. The technology was successful but faced challenges in scaling up due to initial costs (SuSanA 2023). India Implemented in Agra to treat wastewater from slums before it enters the Yamuna River, improving local health and tourism potential (Gates Foundation 2014).

Success in South Africa includes eThekwini (Durban). A demonstration-scale DEWATS has been operational since 2014. Research indicates it is a practical option for fast-growing cities where waterborne sanitation is desired but central connection is impossible (Sutherland et al. 2023). While technically sound, widespread “biogas” or bio-digester interventions in South African rural areas have historically struggled due to limited technical support and inconsistent maintenance (IEA Bioenergy 2021).

7.4.4 Solar-Powered Dehydration and Evaporation Toilets

Aligned with the National Sanitation Policy's focus on innovation in water-scarce regions, solar-powered sanitation units provide a completely off-grid option for resource-limited peri-urban areas (DWS, 2016). These devices employ solar energy to facilitate dehydration and evaporation processes, resulting in a negligible amount of dry, stable material. Being entirely devoid of water, these systems exhibit remarkable resilience to climate-induced challenges, such as extended droughts that progressively burden Johannesburg's waterborne sanitation facilities (DWS, 2019; WHO & UNICEF, 2021).

From the standpoint of social acceptability and public health, permanent onsite solar units offer a safer and more dignified alternative to behaviours such as flying toilets or the ongoing use of bucket systems in the absence of accessible community facilities (Stats SA, 2022; Asivikelane, 2025). They mitigate the danger of pit collapse and groundwater contamination linked to conventional pit latrines often seen in areas like Zandspruit and Finetown (DWS, 2016; DWS, 2019). Moreover, their above-ground or non-excavated design renders them less susceptible to flood damage, which often undermines subsurface sanitary infrastructure in low-lying informal regions (National Planning Commission, 2012).

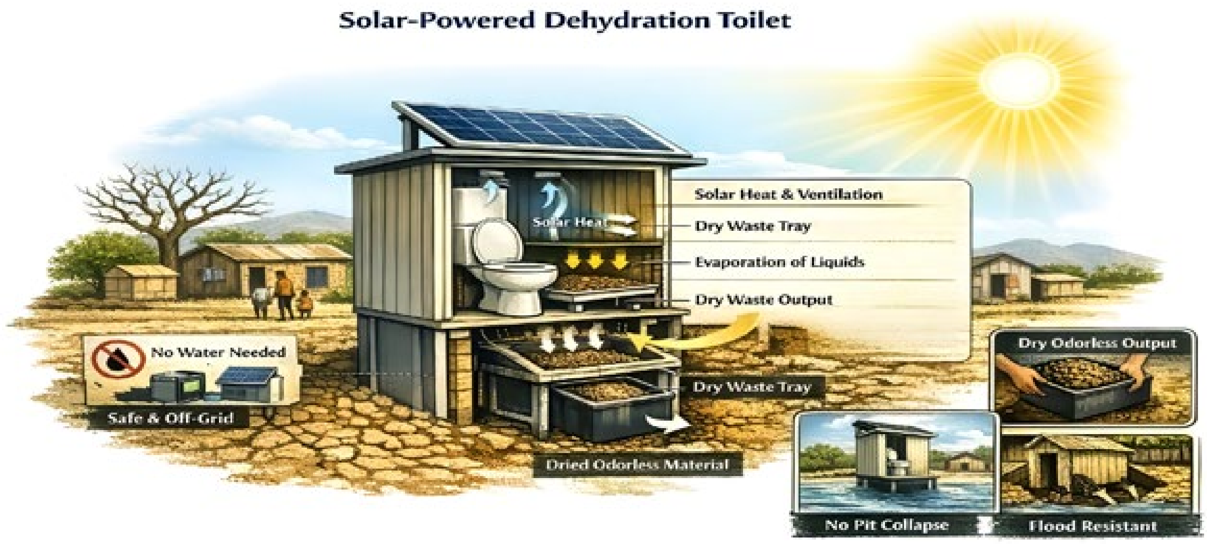
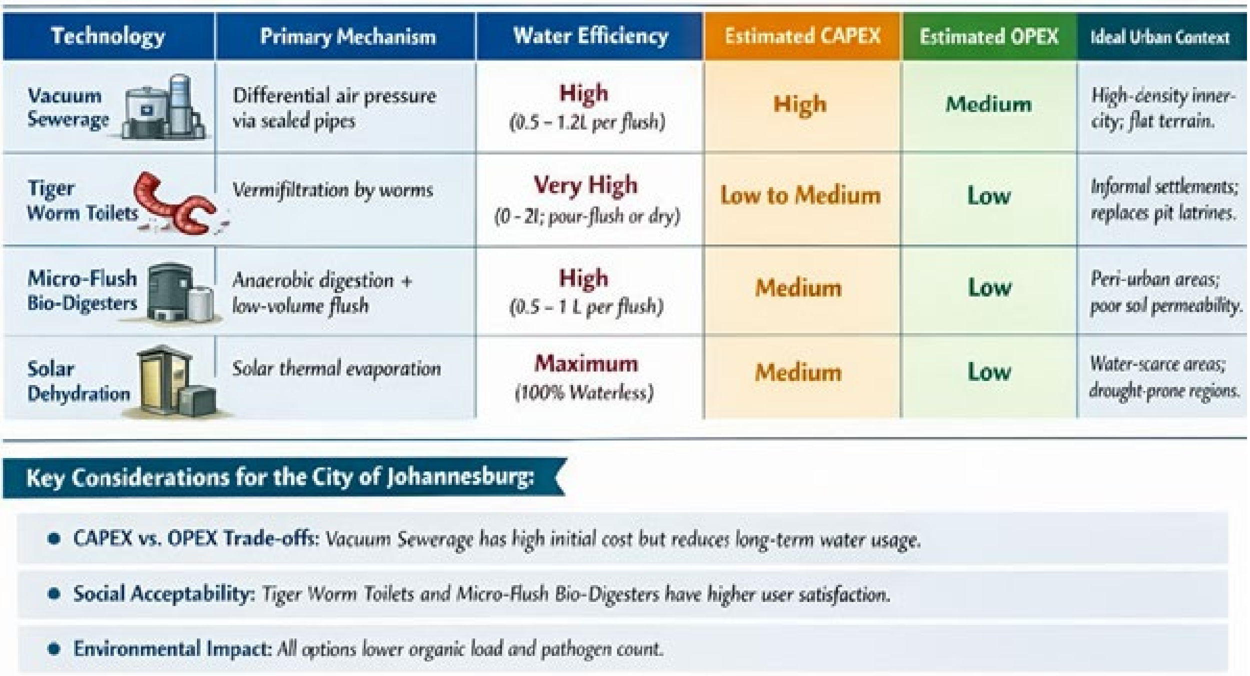


Figure 13: Solar-Powered Dehydration and Evaporation

In Kenya & Peru, Sanivation has successfully deployed "Blue Box" systems that collect household waste and transport it to a central processing plant. Sola thermal energy is used to treat the waste, which is then transformed into high-pressure fuel briquettes for industrial use (Sanivation 2023). Meanwhile the United States through research at the University of Colorado Boulder, funded by the Gates Foundation, developed "Sol-Char" toilets. These use fiber-optic cables and parabolic mirrors to concentrate sunlight, heating waste to over 200°C, effectively creating a sterilized biochar (Fisher et al. 2018).

In south Africa, eThekwini (Durban) developed the LaDePa (Latrine Dehydration and Pasteurization) machine to process sludge from Ventilated Improved Pit (VIP) latrines. It uses infrared radiation (which can be solar-augmented) to dry and pasteurize sludge, turning it into soil conditioner pellets. The system significantly reduces the volume of waste that needs to be transported to landfills. However, the process is energy-intensive if not purely solar-driven, and technical mechanical failures in the conveyor parts of the machinery have been noted in early prototypes (Harrison et al. 2021).

7.4.5 Comparative Analysis of the Water Efficient Alternatives



Technology	Primary Mechanism	Water Efficiency	Estimated CAPEX	Estimated OPEX	Ideal Urban Context
Vacuum Sewerage	Differential air pressure via sealed pipes	High (0.5 – 1.2L per flush)	High	Medium	High-density inner-city; flat terrain.
Tiger Worm Toilets	Vermifiltration by worms	Very High (0 - 2l; pour-flush or dry)	Low to Medium	Low	Informal settlements; replaces pit latrines.
Micro-Flush Bio-Digesters	Anaerobic digestion + low-volume flush	High (0.5 – 1 L per flush)	Medium	Low	Peri-urban areas; poor sol permeability.
Solar Dehydration	Solar thermal evaporation	Maximum (100% Waterless)	Medium	Low	Water-scarce areas; drought-prone regions.

Key Considerations for the City of Johannesburg:

- **CAPEX vs. OPEX Trade-offs:** *Vacuum Sewerage has high initial cost but reduces long-term water usage.*
- **Social Acceptability:** *Tiger Worm Toilets and Micro-Flush Bio-Digesters have higher user satisfaction.*
- **Environmental Impact:** *All options lower organic load and pathogen count.*

Figure 14: Water Efficient Alternatives

8. Conclusion

This desktop study shows that sanitation challenges in Johannesburg cannot be addressed through sewer expansion alone. Rapid urbanisation, infrastructure backlogs, and the growth of informal settlements require more flexible and context-appropriate sanitation solutions. The range of systems reviewed, such as non-sewered systems, decentralised wastewater treatment, community-based approaches, wetlands, natural filtration systems, solar-powered treatment technologies, and water efficient systems demonstrate that using a mix of sanitation options is both practical and necessary.

The study also shows that technology by itself does not ensure sustainable sanitation. Successful implementation depends on municipal capacity, community participation, reliable service systems, and governance structures that respond to the different needs of settlements. Innovative sanitation technologies should therefore not be seen as temporary substitutes for conventional sewerage, but as important components of a resilient sanitation strategy. If properly planned and supported, these systems can expand sanitation access, reduce environmental risks, improve public health, and help the city respond to water scarcity and climate pressures.

9. References

Abrahams, A. and Everatt, D. (2019). Sanitation as a cornerstone of public health.

Al-Kuwari, S.J. (2025). Evaluation of Constructed Wetlands as a Nature-Based Solution for Urban Water Management. Master's thesis, Hamad Bin Khalifa University (Qatar).

Asivikelane. (2025). Community monitoring of sanitation services in informal settlements.

Baldwin Kan-uge, B., Kan-uge, B. and Stwalley, R.M. (2024). Sanitation challenges and infrastructure in Ghana.

Bernstein, A. (2012). Urbanisation and service delivery efficiencies.

Buckley, C.A., et al. (2016). Lessons from large-scale UDDT implementation in eThekwini.

COHRE (Centre on Housing Rights and Evictions). (2008). Water and sanitation as a human right.

Constitution of the Republic of South Africa. (1996). Act 108 of 1996. Pretoria: Government Printer.

Department of Water and Sanitation. (2016). National Sanitation Policy (NSP). Pretoria: Government Printer.

Department of Water and Sanitation. (2019). National Water and Sanitation Master Plan (NW&SMP). Pretoria: Government Printer.

Department of Water and Sanitation. (2021). Assessment of sewerage network deterioration in Johannesburg.

Department of Water and Sanitation. (2023). National Faecal Sludge Management (FSM) Strategy. Pretoria: Government Printer.

Dlamini, S. and Ncube, A. (2023). Service delivery protests and sanitation in Johannesburg.

Fisher, R., et al. (2018) 'Solar thermal treatment of human feces: Pathogen reduction and drying', Journal of Environmental Management, 212, pp. 263-272.

Flovac (2024) Case Studies - Flovac Vacuum Sewerage Systems. [Online]. Available at: https://flovac.com/case-study/ (Accessed: 31 March 2026).

Furlong, C., et al. (2016) 'The development of the Tiger Toilet for use in India', Waterlines, 35(1), pp. 41-55.

Gates Foundation (2014) Reinvent the Toilet Fair: India | Technical Guides. Seattle: Bill & Melinda Gates Foundation.

Gauteng Sanitation Access statistics. (n.d.). Statistics on sanitation access in Gauteng province.

Harrison, J., et al. (2021) 'A review of the LaDePa process: Lessons learned from sludge pasteurisation in Durban, South Africa', Water SA, 47(2), pp. 185-194.

Hewitt, J., et al. (2020). Global access to basic sanitation services.

Hlengwa, N., et al. (2025). Microbial contamination in surface water of Gauteng's informal settlements.

IEA Bioenergy (2021) Decentralised Micro-biodigester Systems for rural South Africa. [Online]. Available at: https://www.ieabioenergy.com/ (Accessed: 31 March 2026).

Lagardien, A. and Muanda, C. (2014). Challenges of sanitation access in informal settlements.

Larsen, T.A., et al. (2013). Source separation and nutrient recovery in sanitation.

Mathonsi, M., Mphambukeli, N. and Mufungizi, A. (2025). Governance and sanitation challenges in municipal departments.

Mkhize, N., et al. (2020). Interim sanitation services in Johannesburg's informal settlements.

Muanda, C., Goldin, J. and Haldenwang, R. (2020). Inequality in Johannesburg's sanitation systems.

Muller, M. (2022). Infrastructure failure and water delivery in Johannesburg.

National Planning Commission. (2012). National Development Plan (NDP) 2030. Pretoria: Government Printer.

Oberholster, P.J. (2010). Impact of urban growth on water resources and ecosystems.

Oxfam WASH (2021) Tiger Worm Toilets: A Manual for Implementation. [Online]. Available at: https://www.oxfamwash.org/ (Accessed: 31 March 2026).

Preuß, V. and Schulte-Ebbert, U. (2000). Purification processes in vertical water infiltration.

Roma, E., Buckley, C.A. and Jefferson, B. (2010). Participatory sanitation programmes in eThekwini.

Roma, E., et al. (2013). User perceptions of UDDTs in eThekwini.

Sanivation (2023) Impact Report: Circular Economy in Kenya. [Online]. Available at: https://www.sanivation.com/ (Accessed: 31 March 2026).

Sheridan, C. (2024). Impact of non-revenue water on sanitation delivery.

South African Local Government Association (SALGA). (2016). Community monitoring of shared sanitation facilities.

STATSSA (Statistics South Africa). (2022). General Household Survey 2021. Pretoria: Statistics South Africa.

SuSanA (2023) Project Database: Prototype microflush-biofil toilet facilities in Ghana. [Online]. Available at: https://www.susana.org/ (Accessed: 31 March 2026).

Sutherland, C., et al. (2023) 'The potential of decentralised wastewater treatment in urban and rural sanitation in South Africa', Water SA, 49(1), pp. 1-12.

Taing, L. (2015). Unsafe sanitation practices in urban informal settlements.

Taing, L., et al. (2013) 'How sociopolitical factors affected the implementation of Cape Town's vacuum sewer', Journal of Water, Sanitation and Hygiene for Development, 3(2), pp. 101-110.

Tilley, E., et al. (2014). Compendium of sanitation systems and technologies. 2nd edn. Dübendorf: Eawag.

UN General Assembly. (2015). Transforming our world: the 2030 Agenda for Sustainable Development.

UN-Habitat. (2014). Sanitation access in South African informal settlements.

UNICEF. (2019). Sanitation deficits and urban expansion in the Global South.

UNICEF. (2021). Progress on household drinking water, sanitation and hygiene.

Water Research Commission. (2017). Sustainable management of community-based sanitation.

WHO (World Health Organisation). (2018). Guidelines on sanitation and health. Geneva: WHO.

WHO and UNICEF. (2013). Progress on sanitation and drinking water.

WHO and UNICEF. (2021). Progress on household drinking water, sanitation and hygiene: Five years into the SDGs.

World Bank. (2020). Climate change and its impact on urban sanitation.

10. Annexure A: Summary of Innovative Sanitation Systems

System Category	Technology	Key Features	Primary Advantages	Main Disadvantages
Non-Sewered (NSS)	**Urine Diverting Dry Toilets (UDDT)**	Separates urine and faeces at the source using a special pedestal.	No water required for operation; low odour and minimal groundwater pollution.	Requires specific user training to ensure correct use and prevent clogging.
Decentralized (DEWATS)	**Modular DEWATS**	Localised modules (Settlers, Anaerobic Baffle Reactors, Filters).	High treatment efficiency (>85%); can be installed where centralized plants are absent.	Difficult to site and maintain in dense informal settlements with limited space.
Nature-Based	**Constructed Wetlands**	Mimics natural purification using plants and microorganisms to break down contaminants.	Highly adaptable to informal settlements; requires minimal energy input.	Systems may struggle with nutrient removal (denitrifaction) due to fluctuating organic loads.
Nature-Based	**Natural Filtration Systems**	Utilizes vertical infiltration through soil or gravel media to purify water.	Low-tech and sustainable; protects local water sources by reducing pollution loads.	Poor wastewater characterization in unplanned areas can make design and sizing unpredictable.
Technology-Driven	**Solar-Powered Small-Scale Treatment**	Independent, off-grid units that use solar energy for mechanical treatment processes.	Provides a resilient, off-grid solution suitable for water-scarce or energy-constrained regions.	Requires higher technical capacity for maintenance and initial capital investment.
Water-Efficient	**Tiger Worm Toilets**	Uses vermifiltration (composting worms) to treat waste.	High-quality compost production; low maintenance and water-efficient.	Not suitable for all climates; requires specific conditions for worm survival.
	Micro-Flush Bio-Digesters	Small-scale anaerobic digestion using very low water volumes.	High reduction of organic waste; produces biogas potential for household use.	Higher initial capital cost compared to basic pit latrines.

Communal flush toilets in the city of Cape Town. Photo: Asivikelane.

Sanitation Inequality in South Africa's Informal Settlements and the Path Toward Sustainable Solutions

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Across South Africa's rapidly expanding urban centres, informal settlements continue to grow as a result of sustained rural–urban migration, housing shortages, and persistent socio-economic inequality. While these settlements provide critical access to urban opportunity, they remain characterised by limited infrastructure and inadequate service delivery. Among the most pressing challenges is access to safe and reliable sanitation.

This issue extends beyond infrastructure provision. It intersects with public health, environmental sustainability, governance, and human dignity, making it a critical concern within broader debates on urban development and social equity.

1. Sanitation as a Structural Challenge

The findings of this study indicate that sanitation challenges in informal settlements are not isolated technical failures but are embedded within complex structural conditions. Overcrowding, limited infrastructure investment, and weak institutional coordination have resulted in sanitation systems that are both insufficient and unsustainable.

A key observation highlights the scale of the challenge:

"10 families sharing one toilet, which leads to spread of disease."

Such conditions reflect not only inadequate provision but also the inability of existing systems to accommodate rapid population growth in informal settlements. Facilities, where available, are frequently overburdened, poorly maintained, and vulnerable to vandalism.

2. Impacts on Living Conditions and Well-being

The consequences of inadequate sanitation are multifaceted and extend across social, economic, and environmental dimensions. The study identifies a strong relationship between poor sanitation infrastructure and deteriorating living conditions.

Residents often experience:

- Reduced productivity due to time spent managing sanitation challenges
- Increased household vulnerability linked to health-related costs
- Environmental degradation, including waste accumulation and water contamination

In addition, access to sanitation facilities is frequently associated with safety risks, particularly for women and children:

"Long distances to access sanitation facilities have risked the lives of women and girls."

These conditions highlight the extent to which sanitation influences not only physical environments but also social dynamics and quality of life.

3. Public Health Implications

The study confirms a direct and significant link between inadequate sanitation and adverse public health outcomes. Waterborne diseases such as cholera, diarrhoea, and typhoid remain prevalent, alongside respiratory infections and skin conditions associated with poor hygiene and environmental exposure.

These health risks disproportionately affect vulnerable populations, including children and the elderly, thereby reinforcing existing inequalities. Furthermore, the cumulative impact of recurring illness places additional pressure on already constrained healthcare systems.

Importantly, the findings also recognise the psychological dimensions of sanitation insecurity. The lack of safe, private, and accessible facilities contributes to stress, anxiety, and diminished well-being, particularly among women and caregivers.

4. Governance and Policy Constraints

Despite the existence of multiple policy frameworks aimed at improving sanitation access, the study identifies significant challenges in implementation. Weak enforcement mechanisms, fragmented institutional arrangements, and limited inter-sectoral coordination continue to undermine policy effectiveness.

Additionally, the exclusion of informal settlement residents from planning and decision-making processes has resulted in interventions that are often misaligned with local needs and conditions.

As reflected in the findings:

“Residents see poor sanitation as a failure of service delivery and a sign of neglect.”

This perception underscores the importance of addressing governance deficits alongside infrastructural improvements.

5. Community Agency and Localised Responses

Notwithstanding these challenges, the study highlights the active role played by communities in responding to sanitation constraints. Community-led initiatives—including the management of shared sanitation facilities, waste recycling programmes, and local monitoring mechanisms—demonstrate the potential of participatory approaches.

These initiatives contribute to improved service delivery, local employment, and enhanced social cohesion. However, their long-term sustainability remains contingent on institutional support, financial resources, and effective collaboration with government stakeholders.

6. Reframing the Sanitation Discourse

A central contribution of this research is the reframing of sanitation as a multi-dimensional issue requiring integrated solutions. Rather than treating sanitation as a purely technical concern, the study situates it within broader socio-political and environmental contexts.

Sanitation challenges in informal settlements are closely linked to:

- Urban inequality and spatial exclusion
- Inadequate investment in marginalised communities
- Weak governance and accountability structures

Addressing these challenges therefore requires a shift toward more inclusive and systemic approaches.

7. Toward Sustainable and Inclusive Solutions

The study proposes a framework that emphasises the need for coordinated and long-term interventions. Key priorities include:

- **Inclusive governance:** Strengthening community participation in planning and decision-making
- **Infrastructure investment:** Expanding access to reliable and context-appropriate sanitation systems
- **Policy implementation:** Enhancing coordination, accountability, and enforcement mechanisms
- **Innovation:** Leveraging technology to improve monitoring, efficiency, and service delivery

These elements are mutually reinforcing and essential for achieving sustainable sanitation outcomes.

8. Conclusion: A Question of Equity and Dignity

The evidence presented in this study underscores that sanitation in informal settlements is not merely an infrastructural issue but a matter of equity, dignity, and social justice.

Ensuring access to safe sanitation requires more than technical solutions. It demands institutional reform, inclusive planning, and sustained investment in communities that have historically been marginalised.

Ultimately, improving sanitation is integral to building more equitable, resilient, and inclusive urban environments in South Africa.

Author Note

This article is based on doctoral research conducted by **George Okezie Nkere**, submitted in fulfilment of the requirements for the **Degree of Doctor of Philosophy in Urban and Regional Planning**, Faculty of Engineering and the Built Environment.

The full dissertation can be accessed on the University of Johannesburg Institutional Repository (UJ IR) under: Open Access → Dissertations. The URL is: https://ujcontent.uj.ac.za/esploro/.

A demolished legacy VIP Toilet in Johannesburg where the pit was not fully decommissioned at the time the picture was taken in 2024. This poses significant health and safety risks. Picture: Asivikelane.

Next Generation Sanitation Technologies, a Solution for Informal Settlements

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1. Abstract

The South African government has been focusing on eliminating service delivery backlogs since 1994, mostly through the employment of conventional solutions. However, indigent communities remain marginalized because most conventional solutions are not easy to implement due to the settlement topography and density. Furthermore, rapid urbanization means municipalities and water service agencies, who are responsible for service delivery are always playing catch-up.

Municipalities continually face challenges in meeting the costs and logistics of delivering free basic sanitation services, as informal settlements, which, by definition, are expected to be transient with no long-term CAPEX investment. As such only temporary or ad-hoc solutions such as chemical toilets and other container-based sanitation solutions are provided, which are expensive, unsustainable, potentially have adverse effect on the environment and have poor user acceptance. A shift in the current paradigm is long overdue if the SDG target for 2030 is to be achieved. In South Africa, approximately 13% (7.27 million) of the population live in informal settlements (Danti, 2018). According to StatsSA, 68% of households living in informal dwellings are forced to share toilet facilities and approximately 6.8% rely on the ‘bucket system’, which speaks to the scale of the problem. The emergence of next generation sanitation (NGS) technologies such as non-sewered sanitation systems (NSSS) and other innovative sanitation offers a viable solution to meeting current sanitation challenges including in informal settlements.

This paper uses case studies where NSSS were successfully implemented in informal settlements in South Africa and provides lessons for governments and development agencies to prioritize the implementation of non-sewered sanitation systems in informal settlements to improve public health and hygiene in these communities.

Keywords: next generation, sanitation, informal settlement

2. Introduction

The South African government has made efforts to address service delivery backlogs and improve access to basic services since the advent of democracy in 1994. However, the implementation of conventional solutions has faced challenges in meeting the needs of marginalized communities, particularly those living in indigent areas. The topography and density of settlements in these communities often make it difficult to deploy traditional service delivery approaches. As a result, many indigent communities continue to face inadequate access to essential services.

According to a report by the United Nations Human Settlements Programme (UN-Habitat), rapid urbanization poses significant challenges for municipalities and water service agencies in delivering basic sanitation services. The report highlights that municipalities are often overwhelmed by the increasing demands resulting from rapid urbanization. The costs and logistical difficulties associated with providing free basic sanitation services become particularly pronounced in informal settlements, which are expected to be temporary and lack long-term capital expenditure (CAPEX) investments. Consequently, temporary, or ad-hoc solutions such as chemical toilets and container-based sanitation systems are commonly deployed.

These solutions, while providing immediate relief, come with various drawbacks. They are expensive to maintain, lack sustainability in the long term, potentially harm the environment due to inadequate waste treatment, and often face poor acceptance by users due to limited functionality and hygiene concerns (UN-Habitat, 2020).

In South Africa, approximately 13% (7.27 million) of the population live in informal settlements (Danti, 2018). According to StatsSA, 68% of households living in informal dwellings are forced to share toilet facilities and approximately 6.8% rely on the 'bucket system', which speaks to the scale of the problem. The emergence of next generation sanitation (NGS) technologies such as non-sewered sanitation systems (NSSS) and other innovative sanitation offers a viable solution to meeting current sanitation challenges including in informal settlements.

A study conducted by Smit and Pieterse (2019) explored the complexities of service delivery in South Africa, highlighting the limitations of conventional approaches in effectively reaching marginalized communities.

The research highlights the importance of context-specific interventions that account for the unique settlement characteristics and challenges faced by indigent communities. Additionally, a report by the Development Bank of Southern Africa (DBSA) (2020) acknowledges the need for innovative and adaptive approaches in overcoming service delivery challenges, particularly in areas with complex settlement patterns and limited resources.

Site Selection

This study is part of the Water Research Commission's South African Sanitation Technology Enterprise Programme (SASTEP), whose aim is to fast track the adoption of NGS technologies capable of addressing sanitation challenges. The programme prioritizes the demonstration of appropriate technologies to ensure their appropriateness within local context and works with capable local commercial partners to early adopters such as municipalities and water service providers to ensure uptake and adoption of these innovative solutions.

SASTEP is funded by the Bill and Melinda Gates Foundation (BMGF) and the Department of Science and Innovation (DSI) and, has partnered with Johannesburg Water to demonstrate two (2) NSSS technologies at informal settlement sites that are not currently serviced by the city's sewer reticulation system. Two informal settlements (Mofolo North and Timehouse in Slovoville) were selected by Johannesburg water.

The location of the sites is indicated on figure 1. Both sites were depending on the chemical toilets for their sanitation needs.

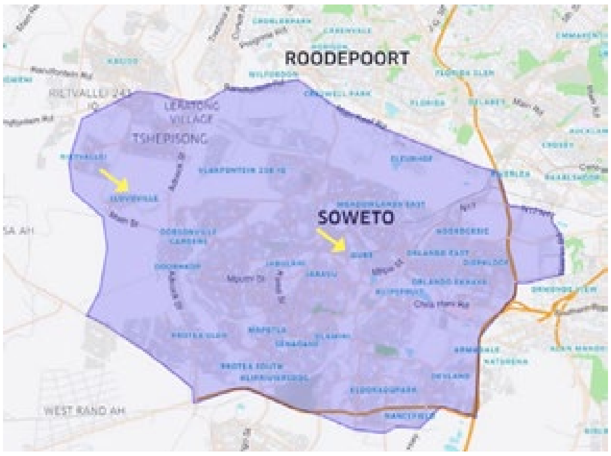

Figure 1: Location of the informal settlements

Summary of site demographics

The sites are characterized by high rates of unemployment and poverty. Table 1 summarizes key demographics of each site.

Table 1: Key demographics within the selected sites

Name	WSA/WSP	Population (households)	Average hh size
Slovoville	Johannesburg water	25	4
Mofolo North	Johannesburg water	75	4

3. Research objectives

The primary aim of the demonstration projects is to evaluate the technical performance and the community acceptance of the innovative sanitation technologies, NEWgenerator technology and Clear recirculating toilet in South African informal settlements which are currently not serviced by formal sanitation reticulation systems.

Objectives of the demonstration projects are:

- To evaluate the technology performance
- To assess social/user acceptability of the systems
- To use the experience gained from the demonstration projects to assess the technologies for local manufacturing.

4. Approach and methodology

Stakeholder Engagements

Widespread consultations were conducted with the active role players ranging from community leadership (political), community representatives, water service provider (JW), local NGOs and forums. The municipality served as an entry point to the community due to its role of a Water Service Provider (WSP) and the project sites fall within its jurisdiction.

Field testing

The technologies were field tested from November 2021 to date to obtain data on functionality and performance of the technologies. Field testing is a research method that entails carrying out tests or collecting data in real-world settings, outside of laboratory circumstances. It enables researchers to observe and study occurrences in natural or applied settings, providing insights into the practicability and efficacy of interventions or hypotheses (Yin, 2017).

System design and configuration

Both systems consist of a community toilet block, the treatment systems, ancillary water and sewage storage tanks, a mechanical screen in the case of new generator, and interconnecting pipework.

User Surveys

User surveys was conducted to measure the satisfaction of the users with the technologies and get insights about the technologies. According to Sheffield & McClanahan (2017) user surveys are critical for getting important feedback and insights from people who interact directly with products, services, or experiences. These surveys enable researchers and businesses to better understand user preferences, needs, and levels of satisfaction. User surveys provide numerous important advantages in terms of informing decision-making and encouraging improvements.

Sample collection and analysis

Monthly samples of the raw water and product water from the clear system and new generator system are taken and submitted to an accredited laboratory for analyses.

5. Results and discussion

Two informal settlements were provided with NGS technologies to demonstrate and evaluate their technical performance and the user acceptance of the innovative sanitation technologies.

Mofolo North – Clear Recirculating Toilet System

The Clear Recirculating Toilet System, installed at the Mofolo North informal settlement, The Clear toilet uses a full water recycling process for treatment of the sewage. An advanced unique“ Biofilm MBR” treatment process is employed as the core technology for treatment, producing a stable and clean effluent that is further disinfected through ozone to ensure safety of the effluent for reuse. The system is modular and can be moved should the need arise.

The installation at Mofolo North informal settlement service 75 households. The community was trained on the safe use of system as well as the benefits.

User acceptance in Mofolo North

A total of 26 respondents were interviewed (10 males, 13 females and 3 janitors). The survey was conducted in December 2021. The users have indicated their satisfaction with the system and have agreed that the Clear system is an upgrade from the chemical toilets that they were using.

There is also community ownership of the system, where cleaners and security are from the area, and they all assist each other to look after the system.

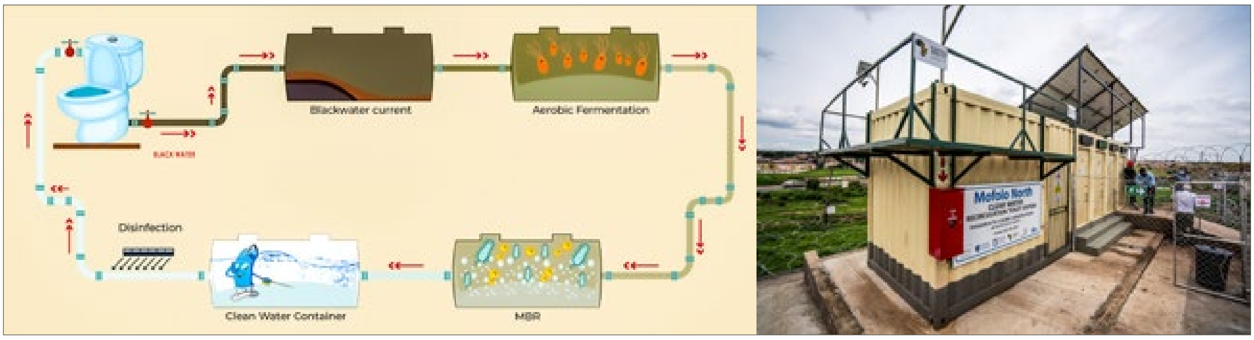

Figure 2: Clear recirculating system process (Left) and demonstration (Right)

Operation and maintenance of the Clear system

The system does not require constant water supply. Only the first fill water needs to be secured for the startup of the system, thereafter it continues to treat and recycle with no need for top up. This water can be secured from a potable water supply line, rainwater harvesting tanks or nearby springs or rivers or even stormwater drains. The water for handwashing needs to be provided via municipal supply line, borehole, or rainwater tanks. To run optimally, the system needs minor maintenance, which entails cleaning the membrane every 6 to 8 months and desludging (major service) is required every 18 months. Effluent quality results for the Clear Recirculating Toilets are presented in Table 2.

According to the results some parameters tested are within specification and comply with the DWS general discharge limits. Nitrate has a high reduction removal rate (>90%), and total phosphate has a reduction removal rate between 0% and 69%. Pathogen removal is in accordance with SANS limits and observed to be above the required limits. COD, TSS, pH and E coli complied with the performance requirements of SANS 30500. The salinity of the water and electrical conductivity are elevated due to accumulation of salts.

Slovoville – NewGenerator

The NEWgenerator, installed at Time-house Informal Settlement, Soweto is a compact, portable, and modular resource recovery machine that eliminates waste while recovering fertilizer nutrients, renewable energy, and clean water. The system uses an anaerobic baffled reactor design followed by a nanomembrane filter operated at subcritical water flux to extend the longevity of the membrane. Permeate from the filter is treated by electrochemical chlorine production from table salt for toilet flushing. The unit is equipped with solar panels to generate sustainable energy for the operation of the NEWgenerator system. The system services 25 households.

Table 2: Effluent quality result raw vs product vs DWS limits

Parameters	DWS Limits General	Special	Units of measure	Raw	Product
pH				4,3	6,8
Electrical conductivity	70 - 150mS/m	50 - 100 mS/m	mS/m	285	208
Salinity			mg/l	1909,5	1313
Total dissolved solids			mg/l	1270	830
TSS [Total Suspended solids]	25	10	mg/l	99	4,7
Colour			Pt-Co	19	10
Turbidity			NTU	14	2,8
COD [Chemical Oxygen Demand]	75*	30*	mg/l	88	60
Dissolved oxygen			mg/l	8,5	8,4
Nitrates as NO3	15	1,5	mg/l	73	6,9
Phosphate as P Ortho			mg/l	0,3	<0.1
Saline Ammonia as N free	3	2	mg/l	78	191
E. coli	1000	0	MPN per100ml	820	<1

User acceptance in Slovoville

The first survey was conducted after commissioning in November 2021 and the second survey was conducted in August 2022, the surveys were conducted to assess the community's satisfaction with the use of the toilet block. The first survey had 40 participants and the second survey had 39 participants. The surveys were conducted to identify any areas where improvements could be made and to assess the satisfaction of the users with the new toilets. The survey's results showed that the community is pleased with the NEWgenerator system and that the toilets are still preferred to the previous chemical toilets. The NEWgenerator system is a significant improvement over the previous chemical toilets and is providing a much-needed service to the community.

Operation and maintenance of the NEWgenerator

The NEWgenerator also require water for startup and then it recycles the water for flushing. The system is Off Grid and Modular Design which can be moved easily. There is also remote monitoring & operation. The screen must be cleaned twice daily and major maintenance (desludging) is required every 12-18 months. Effluent quality results for the NEWgenerator Toilets are presented in Table 3.

According to the results all parameters examined are within specification and comply with the DWS general discharge limits. Total nitrogen has a high reduction rate (>95%), but total phosphate has a reduction removal rate ranging between 0% and 69%. This is because the NEWgenerator system was not designed for phosphorus removal, which can be linked to the system's low phosphorus reduction. The phosphorus removal performance was improved by treating the zeolite bed with calcium chloride. Pathogen removal in accordance with SANS limits is observed to be above the required limits. COD, TSS, TN, pH and E coli complied with the performance requirements of SANS 30500.

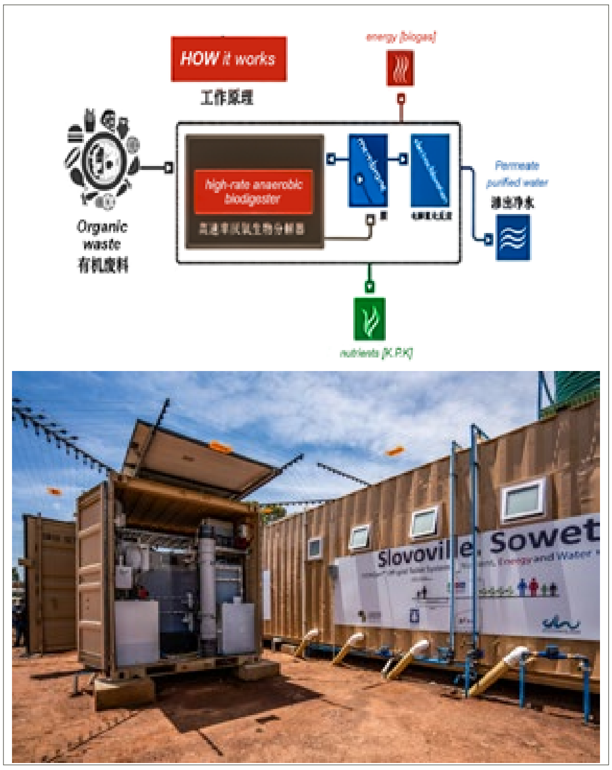

Figure 3: NEWgenerator system process (Top) and Slovoville demonstration (Bottom)

6. Lessons learnt from the demonstrations

1. **Stakeholder engagements are key to ensure understanding and ownership.**

2. **Access to electricity**
   - The next generation sanitation technologies are being designed to try and reduce energy needs and these systems can be installed with solar panels but there are more sustainable options explored.
   - Risk of vandalism or theft and hence, for the demo itself security is provided but this remains a massive collective burden for South Africa. Thorough community engagements is required for the community to be

3. **Access to water**
   - Only the first fill water needs to be secured for the startup of the system, thereafter it continues to treat and recycle with no need for top up. This water can be secured from a potable water supply line, rainwater harvesting tanks or nearby springs or rivers or even stormwater drains.
   - Water for handwashing will need to be provided via municipal supply line, borehole, or rainwater tanks.

4. **Cleaning and Upkeep of toilets**
   - Janitorial services are a requirement for the upkeep of the systems, training on hygiene and use of the toilets was done but there is no guarantee of ownership and proper use.
   - Hence, constant engagement has shown some benefits but it's challenging as it is linked to practice, behaviours, and values.

5. **Operations and Maintenance**
   - Ideally a contract /SLA needs to be put in place to operate and maintain the whole system (inclusive of any energy supply system).
   - The current suppliers of these NSSS technologies are being asked to look at innovative models to ensure O&M can be done correctly.
   - At a sector level we are trying to encourage certification of O&M companies to ensure quality of service.

6. **Social Engagement**
   - Expectations need to be understood at start of project demo.
   - During a testing and O&M phase it is useful to continue to collect social data on use, smell, cleanliness, and acceptance of the technology.

7. Conclusion

It is concluded that the water treated by the NEWgenerator system meets the DWS general discharge standard limits and is safe for re-use in the multi-use toilet block and for irrigation purposes. The nutrient rich liquid fertiliser will be used to water the new community garden, The results indicate that the NEWgenerator system is performing as anticipated. The *E coli* and faecal coliforms also indicate that the water is free from any disease-causing bacteria. The effluent treated with Clear recirculating toilet is also free from disease causing bacteria, therefore safe to re-use, however, the water has elevated salinity.

From the user acceptance surveys conducted, both communities are pleased with the next generation sanitation technologies and that the new toilets are still preferred to the previous chemical toilets they used.

Table 3: Effluent quality results for the NEWgenerator

Parameters	DWS Limits		Units of mea-sure	NewGen Slovoville	
	General	Special		Raw	Product
Faecal coliforms	1000	0	MPN per100ml	>100000	<1
COD	75*	30*	mg/l	418	44
Free and saline Ammonia as N	3	2	mg/l	10	<0.1
Nitrate as N	15	1,5	mg/l	<0.1	14
Free chlorine	0,25	0	mg/l	0	<0.1
TSS	25	10	mg/l	154	1,3
Electrical conductivity	70 - 150mS/m	50 - 100 mS/m	mS/m	45,3	52
Total phosphorus	10	1 (Median) and 2.5 (maximum)	mg/l	4,8	3,4
E-coli	1000	0	MPN/100ml	>100000	<1
Turbidity			NTU	100	0,6
Colour			Pt-Co	180	60
BOD			mg/l	<10	<10
TKN			mg/l	36	2,8

8. References

Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approach. Sage Publications.

Danti, N., 2018. Critical assessment of right to safe water and sanitation in a South African informal settlement: A Case Study of Marikana, Cape Town, University of Cape town accessed here chrome-extension: //efaidnbmnnnibpcajpcglclefindmkaj/https://open.uct.ac.za/bitstream/handle/11427/27876/thesis_ebe_2018_danti_ntomboxolo%20%281%29.pdf?sequence=1&isAllowed=y

Bank of Southern Africa. (2020). Infrastructure Barometer 2020/2021. Retrieved from https://www.dbsa.org/Research/Publications/Infrastructure-Barometer

Ntshangase, N., & Ndlovu, R. (2015). Water and sanitation challenges in informal settlements: A case study of KwaMashu Township in South Africa. Journal of Public Administration and Governance, 5(3), 131-148.

Smit, W., & Pieterse, E. (2019). Reframing Informal Settlements in South Africa: From Problem to Potential. Development Southern Africa, 36(2), 149-164.

Sheffield, C. A., & McClanahan, P. (2017, August 3). BHL's Feedback Tools and User Surveys: Investigating User Needs for Data in Digital Libraries. Proceedings of TDWG, 1, e20003. https://doi.org/10.3897/tdwgproceedings.1.20003

United Nations Human Settlements Programme (UN-Habitat). (2020). The State of African Cities 2020: The Geography of African Investment.

Retrieved from https://unhabitat.org/sites/default/files/2020/12/the_state_ of_african_cities_2020_-_the_geography_of_african_investment.pdf

Yin, R. K. (2017). Case study research and applications: Design and methods. Sage Publications.

An unusable toilet communal waterborne flush in the Slovo Park informal settlement in Buffalo City in 2024. The toilet door is broken, the toilet seat is missing, and the toilet is dirty and unusable. A lack of repairs and maintenance, and too many households using the same toilets has a massive impact on the useability of a communal flush toilet. Photo credit: Asivikelane.

Managing Temporary Sanitation in Informal Settlements: Lessons from Asivikelane

By Claudi Mailovich and Chumile Sali, International Budget Partnership South Africa
[February 2026]

'Temporary' toilets that last for years. Residents who don't know if better sanitation is even coming. Billions of rands spent on solutions that cost more than permanent infrastructure.

This is the reality of sanitation in South Africa's informal settlements - and municipalities can change this trajectory.

For the past six years, Asivikelane[1] has been documenting what's really happening with sanitation provision in informal settlements across the country. The evidence gathered has assisted with identifying trends and recommendations which could assist municipal officials responsible for service delivery.

Urban municipalities face genuine challenges; informal settlements grow rapidly, boundaries shift constantly, and the delivery of permanent infrastructure struggles to keep pace. In response, cities rely on temporary measures: chemical toilets, ventilated improved pit (VIP) latrines, and communal flush toilets. These are meant to be short-term solutions while permanent infrastructure is planned and installed.

But 'temporary' has become permanent.

In March 2025, 74% of residents surveyed by Asivikelane had been using their temporary toilets for over three years. Only 6% were aware of any municipal plans to replace these with full flush toilets. This reveals a critical gap: the absence of permanent solutions for the majority of informal settlement residents.

These temporary solutions come with serious problems. Residents reject facilities that don't meet their needs. Maintenance is poor or non-existent. Fault reporting systems fail informal settlement residents. Costs spiral out of control. And residents often lack basic information on how to use and maintain the facilities provided to them.

The result? Public money wasted, service delivery goals unmet, and communities left without clear timelines for improvement.

But change is possible. Based on years of systematic evidence collection and community engagement, Asivikelane has identified six practical, evidence-based recommendations that can transform how municipalities manage temporary sanitation.

Six Evidence-Based Recommendations:

1. **Consult with communities**
   Engage residents meaningfully before installing temporary sanitation to ensure solutions are acceptable, dignified and meet community needs. When residents are involved in designing solutions, acceptance and proper use improve dramatically.
2. **Provide user education**
   Share clear, step-by-step usage instructions through multiple channels when installing new toilets. Don't assume residents know how to properly use VIPs or chemical toilets - many temporary sanitation products require specific behaviors that differ from flush toilets.
3. **Undertake lifecycle budgeting**
   Compare total costs over time, not just upfront costs. Our evidence shows that when they are provided for many years, temporary solutions often cost more than permanent infrastructure. That 'affordable' chemical toilet becomes extremely expensive after three years of monthly servicing.
4. **Plan and fund maintenance of both temporary and permanent solutions**
   Develop maintenance plans with dedicated, ring-fenced funding for repairing informal settlement sanitation infrastructure. Ensure regular monitoring and timely repairs. Broken toilets that remain broken for months leave residents without the basic sanitation they need.
5. **Build functional fault reporting systems**
   Create systems specifically designed for informal settlements; systems that also use geographical location rather than just formal addresses, allow photo sharing, offer simple fault categories, require minimal data and provide reference numbers for follow-up. Current systems fail because they are not designed with informal settlement realities in mind.
6. **Plan the transition from day one**
   Communicate clearly how long temporary toilets will be in use. Develop and fund actionable plans to transition to permanent solutions. Define resident roles throughout the process. Temporary should mean temporary and not a decade-long placeholder with no exit strategy.

1 **Asivikelane** is a coalition of eight grassroots organisations that monitors and documents basic service delivery in South Africa's informal settlements. Since 2020, trained community facilitators have collected evidence on water, sanitation and refuse removal, using this data to hold municipalities accountable and advocate for improved service delivery. Asivikelane is an initiative of the International Budget Partnership South Africa. Learn more at www.asivikelane.org

This paper shares the evidence behind these recommendations and provides practical guidance on implementing them in your municipality. The detailed lessons that follow draw on systematic monitoring, community feedback, and municipal case studies from across South Africa.

1. Communities know their needs and are willing to compromise if government engages them

One of the most significant lessons is that residents will accept interim toilet solutions if government involves them meaningfully in designing those solutions, but only if these solutions ensure dignity, safety and meet their needs.

While all residents ideally want their own full flush toilet, they acknowledge this won't happen immediately given massive infrastructure backlogs. The critical insight; residents are willing to compromise and use alternative solutions, including communal facilities, as long as they have access to clean, dignified, and safe toilets.

The lesson is clear: Municipalities must consult communities about what they need before installing sanitation.

1.1 Evidence from Mangaung

In April 2024, Asivikelane[2] explicitly asked residents living in informal settlements in Bloemfontein, Mangaung, whether they were willing to use communal sanitation if it meant access to municipally provided toilets. At the time, there were no municipally provided sanitation facilities in Mangaung's informal settlements, forcing residents to dig their own pit toilets.

The responses[3] revealed three critical lessons:

- **First**, residents expressed willingness to clean and fix their *own* toilets if they could have their own flush toilets. This demonstrates a genuine willingness to take ownership of their infrastructure.
- **Second**, residents were willing to share toilets if it meant having proper sanitation facilities. This illustrates a pragmatic willingness to compromise on the ideal individual solution, providing it is safe, healthy and dignified.
- **Third**, residents articulated clear standards for communal toilets. They wanted facilities separated by gender, and they required that shared toilets be cleaned, repaired and maintained by the municipality. This shows that residents know exactly what they need from their sanitation services.

Recommendation: Municipalities must consult meaningfully with communities before installing temporary sanitation. Residents should be involved in designing solutions that comply with national standards while ensuring dignity and safety. This consultation process should identify community-specific needs and preferences to maximise acceptance and proper use.

2. Temporary sanitation requires comprehensive user education

There is a critical need for end-user education to ensure that residents in informal settlements understand how to properly use and care for their toilets. Because many temporary solutions function differently than full flush toilets, residents require specific guidance that is currently rarely provided.

2.1 The case of VIP Toilets in Johannesburg

The City of Johannesburg provides Ventilated Improved Pit (VIP) toilets as one of its main sanitation interventions in informal settlements. These dry toilets work differently from flush toilets: users shouldn't throw anything except toilet paper into the pit, and water needs to be added before desludging so contractors can empty them effectively. Education is therefore needed to ensure the toilet functions properly.

The City itself acknowledges the importance of user education in its own 2021 Sanitation policy[4], emphasising that education should go hand-in-hand with sanitation provision.

Yet when Asivikelane mapped VIP toilets in early 2024 63%[5] of users reported receiving no user education whatsoever when their toilets were installed. That's a critical gap especially when residents are expected to maintain these facilities themselves.

2 St James Apostolic Faith Mission is the Asivikelane partner organisation in Mangaung.
3 https://asivikelane.org/wp-content/uploads/2024/12/2024-12-Mangaung-sanitation-summary.pdf
4 The City of Johannesburg Sanitation Policy (2021)
5 https://asivikelane.org/wp-content/uploads/2024/12/2024-12-Joburg-summary-of-VIPs.pdf

2.1.1 The impact of missing education

The consequences of inadequate user education are straightforward but severe:

- Residents don't know how to properly maintain their toilets, leading to faster deterioration
- Toilets fall below acceptable standards, denying residents the dignified sanitation they need
- Municipalities face increased repair and maintenance costs, or must replace toilets entirely
- Public health risks escalate when toilets are not properly maintained

2.2 Recommendation: Make user education mandatory from day one

When installing temporary toilets, municipalities must share step-by-step instructions on proper use, what to do and what to avoid, cleaning and maintenance responsibilities, and who to contact when things go wrong.

Use multiple channels: posters on or inside toilets, community meetings, SMS messages, and door-to-door visits. Provide information in local languages with visual demonstrations where possible.

3. Temporary sanitation becomes extremely expensive in the long-term

While temporary sanitation solutions are critical for ensuring residents have access to basic facilities when permanent infrastructure is not yet available, they are far from being a 'cheap' option when extended over time. The upfront bulk infrastructure costs for permanent flush toilets may seem daunting, but the long-term cost of providing temporary sanitation such as chemical toilets becomes astronomically expensive and ultimately unsustainable.

3.1 The cost of chemical toilets in Gauteng

Ekurhuleni Metropolitan Municipality provides a stark illustration. In 2024/25, the municipality budgeted R500 million[6] for chemical toilets alone - 85% of its entire R590 million capital budget for water and sanitation infrastructure.[7]

When examining multi-year trends, the numbers add up. Between 2018 and 2023, five Gauteng municipalities collectively spent R3.36 billion on chemical toilets.[8] Ekurhuleni accounted for R2.38 billion of this total - enough to have built permanent infrastructure for thousands of households.

Instead, that money bought temporary toilets that require servicing every month, indefinitely.

3.2 Permanent solutions are more cost-effective

Research commissioned by the International Budget Partnership South Africa and the Social Justice Coalition in 2016 proved what many suspected: full flush toilets are the most cost-effective option over their full lifecycle.[9]

The crucial shift is moving beyond a narrow focus on upfront capital costs to evaluating the total lifecycle cost of a sanitation solution. Chemical toilets require minimal upfront investment, but the ongoing cost of collection, transport, treatment and disposal accumulate rapidly. Flush toilets require significant upfront infrastructure investment but cost far less to operate over decades.

3.3 Recommendation: Calculate the real costs before deciding

Municipalities must undertake comprehensive lifecycle budgeting that accounts for acquisition, operation, maintenance and eventual disposal or replacement. They should compare total lifecycle costs of temporary versus permanent solutions and not just the upfront costs.

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6 Annexure 1 - Ekurhuleni City Wide SDBIP 2024/25 page 342; Annexure 1- City Wide SDBIP 2023/24 page 100
7 Ekurhuleni medium Term Revenue and Expenditure Framework 2024/25 -2026/27 Annexure C, Capital Budget per ward and authors' own calculations.
8 https://www.politicsweb.co.za/politics/over-r33-billion-spent-on-chemical-toilets--solly- (accessed 6 December 2024)
9 Cornerstone Economic Research, *Estimating the cost of sanitation infrastructure for selected sites in Khayelitsha in City of Cape Town* (2016) (On file with IBPSA)

This analysis will reinforce what the evidence already makes clear: short-term savings from temporary solutions ultimately lead to substantially higher long-term costs. Municipalities should therefore develop multi-year capital plans that prioritise the transition to permanent solutions, while clearly demonstrating to elected officials and communities the strong financial case for investing in durable, long-term infrastructure.

4. Maintenance must be planned, and budgeted for

One of the most consistent trends Asivikelane has observed is that temporary sanitation fails when municipalities don't repair and maintain the facilities. Across South Africa's metros, inadequate maintenance budgets lead to rapid deterioration, compromising the safety and dignity of residents who depend on these facilities.

4.1 Johannesburg: The VIP maintenance gap

Between May and June 2024, Asivikelane[10] mapped more than 800 VIP toilets in Johannesburg's informal settlements. The findings[11] were alarming:

- Half of all toilets mapped had broken doors or couldn't lock, compromising user safety and dignity
- One-third of toilets were missing the cover at the back, creating health and safety hazards
- One third of toilets did not have functioning ventilation pipes, creating unpleasant smells and potentially hazardous conditions.[12]

These statistics reveal toilets that are generally below standard and are unsafe for residents to use.

The root problem? Johannesburg Water only desludges VIP toilets. The City provides no maintenance or repairs for the structure or pit chamber.

Residents are expected to maintain the toilets themselves but they're ill-equipped to do so. They lack access to materials, and the repair work is often technical. Without training or spare parts, toilets quickly fall into disrepair.[13] The result: toilets deteriorate below the City's own standards, requiring complete replacement.

4.2 Knysna and Cape Town community plumbers do their own maintenance and repairs

Initiatives by Asivikelane in Knysna Local Municipality and the City of Cape Town demonstrate the substantial value of equipping community members to help maintain their own infrastructure.

In both municipalities, communities supported by Asivikelane rely on communal flush toilets that frequently break, with repairs by local authorities often taking a long time. Following physical inspections of the damaged infrastructure, Asivikelane found that most faults were minor and could be addressed by residents with basic plumbing training. After receiving this training, some community members were able to fix simple issues with taps and toilets, while escalating more complex faults to the municipality.

Although these examples relate specifically to communal flush toilets, they highlight a broader lesson: involving community members in repairs and maintenance transforms them from passive end-users into active participants in sustaining essential services.

4.3 Buffalo City: No ring-fenced maintenance budget

In Buffalo City Metropolitan Municipality the primary sanitation intervention is communal flush toilets. Unlike Johannesburg, Buffalo City Metro is responsible for repairing and maintaining the toilets yet many remain broken, leaving residents without access to working sanitation.

10 In Johannesburg, 1to1 Agency of Engagement, Planact and the International Budget Partnership SA represent the Asivikelane Initiative. The mapping was done by community members and community facilitators representing 1to1 Agency of Engagement and Planact.
11 https://asivikelane.org/wp-content/uploads/2024/12/2024-12-Joburg-summary-of-VIPs.pdf
12 https://asivikelane.org/wp-content/uploads/2024/12/2024-12-Joburg-summary-of-VIPs.pdf
13 https://asivikelane.org/wp-content/uploads/2024/05/2024-04-budget-submission_buffalo-city.pdf page 6.

When Asivikelane asked whether there was a ring-fenced budget for repairs and maintenance in informal settlements, the Metro indicated that this was not possible. They explained that ring-fencing is “impossible” because the services don’t generate revenue and the equitable share allocation is inadequate.[14]

However, the overall budget reveals a gap in repairs and maintenance funding. National Treasury requires that metros budget 8% of the total value of Property, Plant and Equipment (PPE) for repairs and maintenance. Buffalo City only budgeted 2.8% of the value of PPE in the 2024/25 draft budget. When asked to increase this, the Metro revealed their already inadequate budget runs out early each financial year, primarily due to infrastructure vandalism.[15]

Buffalo City is not unique. Many municipalities fall short of the 8% norm. The consequences are particularly acute in informal settlements: when broken toilets can’t be fixed due to budget constraints, residents go without sanitation for extended periods.

4.4 Recommendation: Plan and fund maintenance from the start

Municipalities must:

(1) Consider and plan for repairs and maintenance needed when choosing a sanitation type provided in a settlement, including education for residents to prevent repairs needed because of incorrect use of facilities.
(2) Set aside adequate repairs and maintenance budget allocations that meet or exceed National Treasury guidelines (8% of PPE value)
(3) Ring-fence a portion of these funds specifically for informal settlement sanitation maintenance
(4) Adequate budgeting alone is not sufficient. Municipalities must ensure:
   a. Regular monitoring so problems are identified before they become critical
   b. Response time targets for different types of faults
   c. Training dedicated maintenance teams who understand the specific challenges of informal settlements
   d. Consider training community members to fix minor faults in the settlements in which they live.

5. Fault reporting systems must work for informal settlement residents

An effective fault-reporting system can be the deciding factor in whether a toilet is repaired promptly or remains broken for months—or even permanently. However, many municipal fault reporting systems struggle to serve informal settlement residents effectively.

In September 2022[16], Asivikelane asked residents whether they report faults when a tap or toilet breaks, and whether the municipality fixes them. The findings revealed significant challenges:

- 78% of residents said they report faults when infrastructure breaks
- 89% of those faults were not fixed within a week
- 72% of faults were still not fixed after a month of being reported

5.1 Why fault reporting systems struggle in informal settlements

Asivikelane’s research identified key barriers that prevent fault reporting systems from working effectively for informal settlement residents

- User requirements don’t match reality: Systems require formal addresses, account numbers, ID numbers, or ratepayer information that many informal settlement residents do not have. Without this information, municipalities cannot locate the broken toilet.
- Data costs: Apps and web portals require significant mobile data that many residents cannot afford.
- Complexity: Systems are difficult to navigate or use complicated language.
- No visual evidence: Residents can’t easily attach photos showing the problem.
- No tracking: Residents are unable to check the status of their report.
- Resource constraints: Metros often lack sufficient staff to handle the volume of faults reported and follow up on contractors’ work.

14 Annexure AC under 2024/25 Final IDP and MTREF Budget. Available for download from: https://www.buffalocity.gov.za/folder.php?id=8CFB733 . Pages 12 and 13 of PDF document.
15 Annexure AC under 2024/25 Final IDP and MTREF Budget. Available for download from: https://www.buffalocity.gov.za/folder.php?id=8CFB733 . Pages 12 and 13 of PDF document.
16 https://asivikelane.org/wp-content/uploads/2022/09/asivikelane-number-31_final.pdf

5.2 Buffalo City: Understanding alternative reporting patterns

Buffalo City Metropolitan Municipality provides insight into what happens when official fault reporting systems don't align with informal settlement realities.

When Asivikelane community facilitators[17] investigated how residents report broken taps and toilets in 2024, they found a significant gap between the use of the official fault reporting system and actual reporting patterns: while 98% of broken toilets, standpipes, and taps were reported by residents, only 15% went through official channels like the call centers.[18]

Where did the other 83% of faults go? Directly to ward councillors, ward committee members, or municipal officials whom residents happened to know personally.

This reliance on informal channels creates unintended consequences. Faults aren't logged, making it difficult to track response times or measure performance. Residents get no reference numbers to follow up on their reports. Repairs happen ad hoc rather than systematically. And critically: areas with strong political connections may receive attention while other areas with equal or greater needs have to wait longer.

The outcome: residents who lack personal connections experience longer waiting times for repairs, while those with established contacts may get faster service. **This pattern makes it challenging to ensure equitable service delivery based on need.**

This is a widespread country-wide challenge. Across South Africa's metros, informal settlement residents often find that official fault reporting channels do not accommodate their needs and circumstances and then develop alternative approaches. The challenge is that these workarounds, while understandable, make systematic maintenance planning difficult and can lead to uneven service delivery.

5.3 Recommendation: Develop inclusive fault reporting systems with residents

Municipalities have an opportunity to develop fault reporting systems specifically designed for informal settlement contexts—working collaboratively with residents to ensure systems meet their needs. Well-designed systems make it easier to address faults systematically and equitably, ultimately improving service delivery.

These systems should:

1. Use geographical location (GPS or description of the location of the fault), in addition to account numbers or formal addresses
2. Allow users to share photos of the problem directly
3. Offer specific fault categories to choose from (e.g., "door broken," "no water," "toilet blocked")
4. Be zero-rated or require minimal cellphone data
5. Provide reference numbers and status updates via SMS or WhatsApp
6. Be available in multiple languages
7. Have clear escalation procedures when faults aren't addressed within specified timeframes

6. Temporary sanitation requires clear transition plans to permanent solutions

In South Africa's informal settlements, "temporary" sanitation often remains in place for years, becoming permanent by default. This creates health risks, safety hazards, and environmental damage while locking municipalities into expensive, unsustainable service delivery models.

The scale of the problem is clear: 74% of Asivikelane respondents in March 2025 reported using temporary toilets—chemical toilets, VIPs, or communal flush facilities—for over three years. Yet only 6% were aware of any municipal plans to replace these facilities with full flush toilets.[19]

17 Community facilitators are residents of informal settlements trained by Asivikelane partner organisations to systematically monitor and document service delivery in their communities, as well as develop solutions and engage governments as part of the initiative. They collect evidence on water, sanitation, and refuse removal using standardised data collection tools.

18 https://asivikelane.org/wp-content/uploads/2024/12/2024-12-BCM-sanitation-summary.pdf

19 https://asivikelane.org/wp-content/uploads/2025/06/Learning-Paper-3-FINAL.pdf

6.1 Johannesburg: VIP toilets "temporary" for 20+ years

In 2024, Asivikelane community facilitators[20] from partner organisations Planact and 1to1 Agency of Engagement documented the age of VIP toilets in Johannesburg's informal settlements. The findings[21] revealed just how permanent "temporary" has become:

- More than half (52%) of mapped toilets were older than 15 years
- 32% were older than 20 years
- Only 28% were under 5 years old

VIP toilets have an estimated lifespan of 5-7 years. Yet Asivikelane's data shows they're routinely used for two or three times that long. The evidence reveals a gap: there is no plan for what happens when a toilet reaches the end of its functional life.

The evidence collected highlighted the following risks associated with the continued use of VIP toilets beyond their intended lifespan:

User safety: Broken doors, missing locks, and deteriorating structures compromise dignity and physical safety. As documented earlier, half of Johannesburg's mapped VIPs had doors that couldn't lock, and one-third were missing back covers.

- **Environmental damage:** Excreta seeps into the ground, potentially contaminating water sources. In areas with dolomitic soil—common around Johannesburg—this contributes to sinkhole risks.
- **Improper decommissioning:** When toilets are demolished, they're often not properly decommissioned. Pits remain in the ground, posing ongoing health and safety risks to communities.
- **Policy gap:** No clear policy exists for managing VIP toilets over their full lifecycle. This leaves residents and officials without clear guidance, make it difficult to ensure toilets remain safe or plan for replacement.

The same pattern exists with chemical toilets. Across the country, settlements have been using chemical toilets for years, despite these being marketed as short-term emergency solutions.

6.2 Draft norms and standards create an opportunity for change

The draft Norms and Standards for Water and Sanitation, which has not yet been gazetted in final form, indicates that temporary sanitation can only be used for a maximum of 12 months.[22] Once these norms and standards are approved and implemented, they will provide a clear framework for municipalities to transition from temporary sanitation within defined timeframes.

This creates an important opportunity for municipalities to start planning now for how they will transition from temporary to permanent sanitation. Early planning will enable municipalities to address backlogs strategically with adequate time for proper planning, budgeting, and community consultation.

6.3 Recommendation: Plan for transitioning to permanent solutions

Municipalities should plan and communicate the transition to permanent sanitation solutions from the very start of any temporary sanitation installation. Effective transition planning includes:

1. **Develop actionable, funded plans** for replacing temporary toilets with permanent infrastructure. Include specific timelines and budget allocations.
2. **Communicate clearly with residents** about how long temporary toilets will be in use and what the transition process looks like. Transparency builds trust and helps residents plan accordingly.
3. **Define roles and responsibilities** for residents in planning, service delivery, and maintenance during both temporary and permanent phases.
4. **Establish full lifecycle plans** for temporary infrastructure, including proper decommissioning procedures when facilities reach end-of-life.

The goal: ensure "temporary" truly means temporary—not decades-long makeshift solutions

20 https://asivikelane.org/wp-content/uploads/2024/12/2024-12-Joburg-summary-of-VIPs.pdf
21 https://asivikelane.org/wp-content/uploads/2024/12/2024-12-Joburg-summary-of-VIPs.pdf
22 Full submission available from: https://asivikelane.org/wp-content/uploads/2024/03/2024-02-compulsory-national-water-norms-submission.pdf

A worker desludging a pit through the manhole in the new backslab. Photo: Asivikelane.

7. Conclusion

Temporary sanitation plays a necessary role while municipalities address massive infrastructure backlogs. But as Asivikelane's evidence demonstrates, "temporary" too often becomes permanent—poorly planned, inadequately maintained, and excessively expensive.

The lessons from six years of monitoring are clear: Effective management of sanitation delivery requires municipalities to genuinely engage communities, provide comprehensive user education, understand true lifecycle costs, plan and fund adequate maintenance, establish accessible fault reporting systems, and—most importantly—plan the exit strategy from day one.

The current situation presents significant challenges. Johannesburg has 20-year-old "temporary" VIPs with no publicly communicated transition plan. Ekurhuleni has spent billions of rands on chemical toilets over the years—enough to have built permanent infrastructure for thousands of households. In Buffalo City, residents bypass official fault reporting because the systems don't accommodate their circumstances. As a result, many residents in informal settlements lack access to the safe, healthy, and dignified toilets they need.

However, the path forward is clear. Successful examples from Mangaung and Johannesburg demonstrate that when municipalities engage residents as partners, practical solutions emerge.

Improving sanitation delivery involves:

- Engaging informal settlement residents as key stakeholders from planning through implementation
- Allocating resources strategically to achieve long-term sustainability
- Shifting investment from ongoing temporary solutions to permanent infrastructure

Asivikelane's evidence-based recommendations provide municipalities with practical tools and insights for delivering safe, healthy, and dignified sanitation to all informal settlement residents.

One of the first backslabs cast under the pilot, featuring a small manhole for easy desludging.
Photo: Asivikelane.

Box 1: Tips for Officials to Consider When Planning Sanitation in Informal Settlements

These questions could guide municipal officials, planners, and community leaders when designing sanitation interventions. The most important principle: ***meaningful consultation with residents should happen at every stage****.*

1. **Starting point: Community Consultation**
   Ask residents what they need to feel safe, healthy, and dignified before making technical decisions.
   - What do residents need from their sanitation?
   - How do current arrangements fail them?
   - What are the gender-specific safety concerns?
2. **Technical Assessment**
   Assess infrastructure, soil conditions, and space to determine feasible sanitation types.
   - What infrastructure exists (water, sewer, electricity, roads)?
   - What are the soil conditions and flood risks?
   - Which sanitation types are technically feasible?
3. **Service Design**
   Design toilets that match resident preferences for safety, accessibility, and dignity.
   - Per household or communal? What do residents prefer?
   - If communal, how many households per toilet?
   - Where will toilets be placed for safe access?
   - What features are needed (locks, lighting, accessibility)?
4. **Maintenance & Operations**
   Plan and budget for maintenance with clear responsibilities and accessible fault reporting.
   - Who is responsible for maintenance tasks?
   - Is there a ring-fenced maintenance budget for informal settlement sanitation?
   - How will residents report faults without formal addresses?
5. **Budgeting & Costs**
   Calculate total lifecycle costs and compare to permanent solutions.
   - What is the total lifecycle cost?
   - How does this compare to permanent solutions?
   - Is the budget adequate to erase the full sanitation backlog?
   - How will it be funded and does the funding source restrict the choice of solution (e.g. infrastructure grant money can only be used for full flush toilets)?
6. **Transition to Permanent Solutions**
   Plan how long temporary toilets will be used and the pathway to permanent sanitation.
   - How long will temporary sanitation be in use (max 12 months)?
   - What is the transition plan and timeline?
   - Have residents been informed about timelines?
7. **User Education & Support**
   Provide clear, multilingual education on proper use through multiple channels.
   - What must users know about proper use? What responsibilities do they have?
   - How will education be delivered (meetings, posters, SMS)?
   - What are the most spoken languages in the area in which education should be provided?
   - Who can residents contact for support?
8. **Verification & Accountability**
   Verify that solutions align with resident needs and establish accountability mechanisms.
   - Do proposed solutions align with what residents need?
   - Have residents been consulted at each stage?
   - How will success be measured and monitored?

Remember: *These questions represent an ongoing conversation between municipalities and residents. Quality sanitation depends on engagement, transparency, and mutual accountability.*

Box 2: Case Study - Towards Safer Ventilated Improved Pit Toilets in Johannesburg

In 2025, the Asivikelane Initiative in Johannesburg reviewed the evidence gathered from years of working in the metro's informal settlements and **identified significant safety concerns** with the Ventilated Improved Pit (VIP) toilets provided by the city.

The toilets, intended as an improved level of service for informal settlements, **often face challenges:** many are dilapidated, broken, or old, **creating safety risks** for the communities using them and potential environmental concerns. Tragically, children have died falling into the back of pit toilets.

A key safety issue documented by Asivikelane hub partners over many years is that the backslabs (plates covering the pits of VIP toilets) are often broken, posing serious safety risks to residents. These backslabs break because contractors must move the heavy slabs to access the pit for desludging every month. The slabs are generally solid, heavy concrete that are difficult to move and often fragile as they are not sufficiently reinforced.

Whilst residents are expected to maintain the toilet structure, they lack the expertise to repair specialized components like backslabs. This has resulted in residents creating makeshift covers to ensure community safety and prevent refuse from blocking the pit.

Asivikelane partners 1to1 Agency of Engagement and Planact, after consulting with community members, identified the broken or missing backslabs as the priority safety issue to address.

Designing an improved backslab based on community observations

In response, Asivikelane's Bonginkosi Ndlovu redesigned the backslab, including a small manhole with a removable cover to ensure ease of access, safety, and longevity. The design also improves the desludging process for contractors, who now only need to remove the manhole cover instead of shifting the entire concrete slab. Commenting on his design, Ndlovu said when designing the slab, he considered that contractors must shift slabs "each and every month. We decided to put a manhole that they can just [remove] the lid and just drain. It will reduce the time [taken to desludge] and the breakage of the slab."

As part of the Asivikelane pilot project, the team has cast and installed three reinforced concrete backslabs for three separate households in Lawley Station in Region G, Johannesburg. In addition, a private company created a prototype using alternative materials based on the Asivikelane design, which has also been installed in Lawley Station. The initiative has already generated community momentum in the settlement. One household used the Asivikelane design to cast their own backslab, innovatively incorporating a bucket with a cover as the manhole to make the design even more cost-effective. Other households have contacted the Asivikelane team for assistance in casting their own slabs.

Community facilitators monitoring the slabs received positive feedback from contractors on the manhole design. Asivikelane also assisted ten community members and community facilitators in December 2025 to receive basic construction training, enabling them to build improved backslabs for their communities.

The solution is community-driven, and Asivikelane believes the redesigned backslab could be incorporated into tender specifications for future VIP toilets in Johannesburg, **making** toilets safer and easier to manage for all.

This project demonstrates a critical lesson: community experiences and observations are powerful tools when designing services. Municipalities can improve their services and keep residents safer and healthier by engaging communities, listening to them, and incorporating their ideas.

Bonginkosi Ndlovu, a community facilitator from the 1 to 1 Agency of Engagement and the Asivikelane Initiative living in Region G, designed the improved backslab. The design drew on community observations showing that backslabs frequently break when moved by contractors during desludging and replaced the traditional solid concrete cover with one featuring a small manhole for easier access. Photo: Asivikelane.

Bonginkosi Ndlovu, an Asivikelane community facilitator from Region G, measures a dilapidated backslab earmarked for replacement under the pilot. Photo: Asivikelane.

DEPARTMENT OF HUMAN SETTLEMENTS

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