Testing sustainable non-sewered sanitation prototypes in Durban, South Africa

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Introduction:

The Pollution Research Group at University of KwaZulu-Natal has long offered research support to eThekwini Municipality Water and Sanitation in its quest for water and nutrient recycling solutions that are appropriate to the numerous contexts present in the municipality. Population density and water usage play major roles in selecting appropriate technology for the containment and treatment of human waste, with centralised solutions seen as the go-to in high-density areas, whilst decentralised solutions are preferable in low-density areas. As a water-scarce and urbanising region, it is important for the municipality to look at how future sanitation can reduce water consumption whilst serving an increasing population.

eThekwini is not the only location facing these type of sanitation challenges and researchers globally are developing sanitation solutions that make faecal waste safe, are affordable, do not require external power, water or sewer connections and that recover and reuse water, energy and nutrients, in a move towards a circular economy (Toilet Board Coalition, 2016). However, to aid the development of systems that are functional in real world environments and that meet the needs of users and operators, there is a need to provide a supportive space to test early engineering concepts for these systems under the control of technology developers. The Engineering Field Testing (EFT) platform is a collaboration between the Pollution Research Group (PRG) at the University of KwaZulu-Natal (UKZN), eThekwini Water and Sanitation (EWS) and a local engineering and project management company, Khanyisa Projects, to provide the infrastructure required to allow this testing to take place in Durban, South Africa. Community engagement and user feedback is a key aspect of the EFT platform, and this is conducted through the EWS community liaison officer and researchers from the School of Built Environment and Development Studies at UKZN.

Project Description:

Project History:

The EFT platform is the real-world testing phase of the Bill & Melinda Gates Foundation's Reinvent The Toilet Challenge, which aimed to develop innovative sanitation technologies.

eThekwini Municipality was chosen as an appropriate location for testing these prototypes due to the strong research partnership between EWS and PRG, EWS's reputation for innovation and PRG's well-equipped laboratory for the analysis of faecal sludge.

Partners and resources:

The EFT platform is a collaboration between a number of stakeholders, including those in Durban, and internationally. The main contributions and benefits for each of the major stakeholders is summarised in Table 1.

Table 1. Contribution of and benefits to major stakeholders in the EFT platform

Stakeholders	Contribution [to platform]	Benefit [to stakeholder]
Technology developers (international universities, engineering companies, and designers)	Sanitation prototypes	Space to test engineering concepts in a real world environment, feedback on prototype design from users, designers, installers and operations and maintenance staff, local support for testing, generation of performance data
eThekwini Municipality Water and Sanitation	Access to community sites, existing community engagement systems, support with operations and maintenance	Early exposure to emerging technology, safely managed sanitation solutions suitable for unserved communities and acceptable to customers, exposure to new potential partnerships, supports ethos of innovation
Pollution Research Group and Development Studies, University of KwaZulu-Natal	Well-equipped faecal sludge laboratory, existing working relationship with municipality and private engineering company, technical and social research expertise, dedicated prototype engineer to operate, maintain and carry out sampling for each prototype	Research collaborations, research funding, post-graduate degrees, publications
Khanyisa Projects	Assistance in importing equipment, design and construction management experience, experience of sanitation installations in community settings, logistics and co-ordination of working with international partners	Income, increased knowledge and ability to extend the range of services offered
Communities	Local labour, feedback on prototypes, utilisation of communal spaces for prototype testing	Safely managed and socially acceptable sanitation, skills building, job opportunities, exposure to different organisations, contribution to the development of innovative systems
Funders	Funding, insight, long-term vision	Rapid development of sanitation technologies

Timelines:

The EFT platform was established in 2017 with four technology developers expected to test their systems on the platform, for between three months and a year each. The number of technologies undergoing testing on this platform has increased since then and as of May 2019, there are ten technology developers who are currently testing, or confirmed to test, 15 prototypes across 23 testing sites before the end of 2020.

The testing of each prototype follows seven steps:

- Step 1 - Site selection: The Durban research team work with technology developers to understand the requirements of the system including users, access to energy, water or sewerage connections, footprint and access requirements for installation. Suitable community or household sites are identified and EWS engages with ward councillors and community committees to ensure the community understands the scope and nature of the testing and is willing to participate.
- Step 2 - Ethical approval: Ethics approval for the testing of the prototypes and the user surveys is applied for through the ethics committees at UKZN.
- Step 3 - Community engagement: Meetings with ward councillors, local community committees and community members ensure that they fully understand the study and their involvement. Community liaison officers are selected from the area by the community committee members and are appointed as the link between the research team and the community. The UKZN School of Built Environment and Development Studies conduct baseline surveys to understand the current sanitation practices and views around the new system of the community or household where the test will be carried out.
- Step 4 - Site preparation: Khanyisa Projects carry out design work for each testing site based on the requirements of the technology developers and contractors are appointed to carry out civil, electrical and mechanical installations as required. Wherever possible, contractors use local labour.
- Step 5 - Installation and commissioning: Khanyisa Projects provide support to the technology developers for importing equipment and installing prototypes on site. The PRG and Khanyisa Projects support the technology developers during commissioning and PRG engineers are trained on the operation and maintenance of the prototypes.

- Step 6 - Sampling, testing and feedback: Each prototype has a dedicated prototype engineer from the PRG. They are able to monitor and evaluate the performance of the prototype, through regular sampling, analysis of influents and effluents in PRG's faecal sludge laboratory by a team of laboratory technicians, and documentation of operating and maintenance requirements, and recommend system design changes. On completion of the test period, the UKZN School of Built Environment and Development Studies collect feedback from users on their experience with the system.
- Step 7 - Decommissioning: At the end of the testing period, Khanyisa Projects support the technology developers with decommissioning of the prototype and restoration of the testing sites.

Testing timelines for a single prototype are affected by the type of site required (community or household) and the goal of the testing required by the technology developers. Experience to date shows that site preparation takes one to three months for a household site or two to five months for a community site, commissioning and testing can take between one month to one year and decommissioning takes one to two months.

Relevance and Impact to eThekwini Municipality:

Of the 15 prototypes being tested, six are designed for use in a household setting, seven are designed for use in a community setting and two can be scaled to be used at the household or community scale. This range of prototypes allows for the testing of systems that are relevant for application in both peri-urban households and linked to community ablution blocks in informal settlements as these represent underserved communities in eThekwini. The majority of the prototypes under test are treatment processes, which can either be connected to different user interfaces that are already used by the municipality (seven systems) or that have an integrated user interface component (five systems) allowing for on-site treatment. Given the high cost of sewerage networks in comparison to wastewater treatment costs and the high costs associated with emptying and removal of waste from pit latrines, this offers the opportunity for decentralised systems that may offer economically viable sanitation solutions to areas outside the water-borne edge.

Of the treatment systems, eight aim to recycle flush water, five aim to operate without an electrical connection, two aim to generate energy from the waste material collected and three aim to capture nutrients for reuse. This promotes the concept of the circular economy and the interconnectedness of food, water and energy in sanitation service provision.

These prototypes are a step towards a whole systems approach where decentralised treatment systems are based within a community and are able to treat urine, faeces and solid waste to recover valuable products, which can in turn be used within the same community.

Three of the prototypes under test are pedestals, which aim to use little to no flush water to separate waste from the user. Of these, a flushing urine-diversion pedestal has been identified as performing well. This pedestal operates on a low-volume dual flush of 1.6 and 3.4 L and separates on average 74 % of the urine, reducing the total volume that enters the treatment system and the nitrogen concentration in the wastewater. This would allow the wastewater from an upgraded informal settlement to be treated to sufficient quality using a DEWATS system that it can be discharged to environment, rather than increasing the load on existing wastewater treatment plants (that are often already over capacity).

During early field testing, the municipality has the opportunity to understand not only the performance of these prototypes but also the operation and maintenance requirements of the systems and how they integrate with existing municipal infrastructure and processes. The need for continuous community engagement throughout the testing period means that this early field testing also provides the opportunity for community feedback to be taken into account as changes are made to the system. This has been most notable with a dry pedestal, which was changed to increase the width and depth of the toilet bowl and to integrate a spray flush based on user feedback obtained during field testing in eThekwini. This helps to ensure that technology developers are producing systems that are relevant to the context of eThekwini and are acceptable to the users.

Conclusion:

The testing of next generation non-sewered sanitation prototypes in eThekwini Municipality allows the municipality to understand the performance of these technologies in the eThekwini context and to shape their development to better fit the municipality's needs. In addition, it cements eThekwini's reputation, nationally and internationally, as a leader in innovation in sanitation service provision.