

41st WEDC International Conference, Egerton University, Nakuru, Kenya, 2018

**TRANSFORMATION TOWARDS SUSTAINABLE
AND RESILIENT WASH SERVICES**

Implementing an engineering field testing platform for sustainable non-sewered sanitation prototypes

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PAPER 2916

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. The Engineering Field Testing platform is a collaboration between the Pollution Research Group at the University of KwaZulu-Natal, eThekweni Water and Sanitation and a private company, Khanyisa Projects, which provides a supportive space to test early engineering concepts in a real world environment, while still under the control of technology developers. Local teams of engineers, scientists and social scientists support technology developers through site selection, community engagement, ethical approval, site preparation, installation and commissioning, sampling, testing and feedback and decommissioning. This ensures that locally relevant risks can be identified and mitigated. The concentration of prototypes being tested in a single location allows support resources and expertise to be pooled and increases collaboration to overcome common challenges.

Background

Only 28 % of people in sub-Saharan Africa had access to basic or safely managed sanitation services in 2015 (WHO and UNICEF, 2017). In sub-Saharan Africa, 39 % of people are served by on-site sanitation compared to 7 % served by sewered sanitation systems (WHO and UNICEF, 2017). The cost of building sewerage systems and the chemical and maintenance costs associated with operating large wastewater treatment works make sewered sanitation a poor choice for under-developed countries (AMCOW, 2011). However, existing on-site alternatives are often unsafely managed, expensive or are unappealing to users (Cross and Buckley, 2016; Roma et al., 2013).

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). There is a need to provide a supportive space to test early engineering concepts for these systems in real world environments, whilst they are still 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), eThekweni 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.

Aim of the Engineering Field Testing platform

The EFT platform aims to provide technology developers with a supportive space for engineering testing of sanitation prototypes in a real world environment with many users. Developers can monitor and evaluate the performance of the prototype over an extended period of time (from a month to a year or longer) and through a number of adjustments. Community members using the systems can provide feedback as to its suitability, and provide information on the advantages and disadvantages of changes that are made. All of

this information, and the data generated, can be used to accelerate the development of socially acceptable on-site sanitation technologies that are safely managed and contribute to the growth of the circular economy.

The EFT platform works as a collaboration between a number of stakeholders, including those in Durban, South Africa, and internationally. As with all successful partnerships, all parties bring something to the collaboration and in turn benefit from it. The main contributions and benefits for each of the major stakeholders is summarised in Table 1.

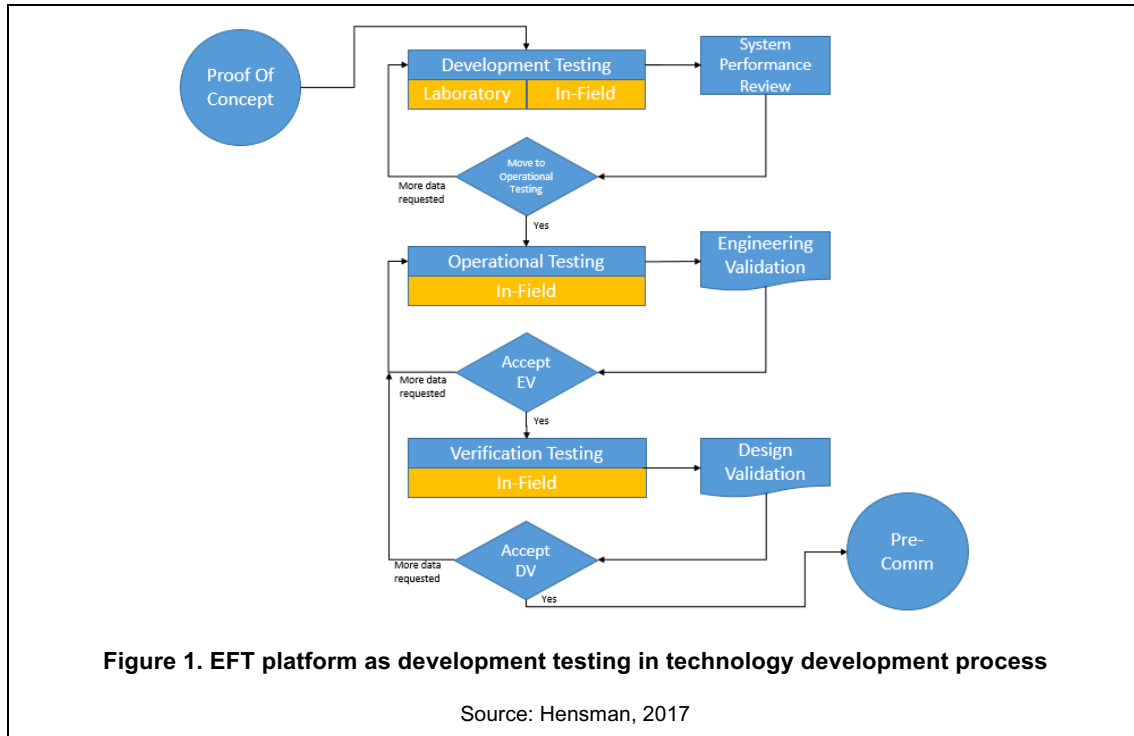
There are a number of advantages to basing the EFT platform in Durban. eThekweni Municipality supplies sanitation services to formal and informal housing in urban, peri-urban and rural settings. This allows for testing of sanitation prototypes designed for the individual household up to community scale. South Africa is a water-constrained country and Durban is located in a hilly area. As such, conventional flush toilets linked to sewers are an inappropriate solution for much of the municipality, and extensive experience of service provision in challenging environments is embedded within EWS. The existing relationships between EWS, the PRG and Khanyisa Projects have led to the implementation of innovative sanitation solutions that take into account the local context. These stakeholders have long-term and extensive experience of applied research in sanitation and of working with a range of communities and international organisations.

Stakeholders	Contribution [to platform]	Benefit [to stakeholder]
Technology developers	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
Municipality	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
University	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
Private engineering and project management company	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
Community	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
Funders	Funding, insight, long-term vision	Rapid development of sanitation technologies

The EFT platform forms part of early development testing, after initial proof of concept. With data gathered during field testing, a system performance review can determine whether the technology should move to operational testing. Operational testing takes place in a real-world environment and prototypes should operate without the regular intervention of the technology developer. The data from operational testing allows engineering validation of the system, which, if successful, can move to verification testing and design verification. Prototypes then move to pre-commercialisation as shown in Figure 1.

The EFT allows technology developers to reach market readiness more rapidly by demonstrating the real world capabilities of the prototype, which are viewed positively by investors and customers compared to laboratory trials where best-case conditions can be maintained. Additionally, the EFT platform has facilitated discussion with suitable local commercial partners, suppliers and investors, with the aim of

driving down manufacturing and maintenance costs. The municipality’s involvement in the EFT platform in an advance user capacity enables them to trial-run prototypes without any commitment to invest. This also benefits the technology developers as it opens up potential markets through networks with other municipalities.



Engineering Field Testing platform approach

The EFT platform follows through seven steps for each technology. The seven steps are:

Site selection

The PRG, EWS and Khanyisa Projects work with technology developers to understand the requirements of testing their system including number of users, access to energy, water or sewerage connections, footprint of the unit and requirements for installation e.g. crane access to site, and security requirements. The PRG and Khanyisa Projects liaise with EWS to identify potentially suitable community or household sites that need improved sanitation. EWS engages with ward councillors and community committees to ensure that the community understands the scope and nature of the testing platform and is willing to participate. The level of support from the councillors and community at this stage is a critical element in the choice of site.

Ethical approval

The PRG applies for ethical approval for the planned prototype testing through the ethics committee at UKZN. The level of ethical approval required depends on which sectors of the community are involved in the research and the level of their engagement.

Community engagement

Meetings are held with ward councillors (representing the wider geographical area that includes the specific community), local community committees and community members to ensure that they fully understand the study and the extent of their involvement should they choose to participate. Community liaison officers are appointed to provide the critical link between the EFT platform team and the community. Finally, the PRG, through collaboration with the UKZN School of Built Environment and Development Studies, conducts baseline surveys in the selected communities and households in order to obtain an indication of current sanitation practices and feelings towards making use of a different sanitation system.

Site preparation

Khanyisa Projects liaise with the technology developers to determine the detailed requirements for each testing site. Design basis documents, site preparation plans, engineering designs and tender documents where necessary are then developed. Thereafter contractors responsible for civil, electrical and mechanical installations at selected sites are appointed and any construction necessary for site preparation is supervised and coordinated. Wherever possible, local labour is used.

Installation and commissioning

Khanyisa Projects provide support for the import of equipment into the country and the logistics associated with transportation and storage. They also oversee the installation of the technology on-site with significant technical support from the technology developers. The PRG and Khanyisa Projects support the technology developers in commissioning the prototype and the technology developers are responsible for training the research and engineering teams at PRG and EWS respectively on the operation and maintenance of the prototype.

Sampling, testing and feedback

The technology developers are able to monitor and evaluate the performance of the prototype over an extended period, with significant support from the PRG including a dedicated prototype engineer. The PRG provides support on sampling, laboratory analysis of influents and effluents, collecting and analysing feedback from the community on their views of the sanitation prototype, and recommending system design changes based on testing.

Decommissioning

Once the testing period is complete, Khanyisa Projects support the technology developers with decommissioning of the prototype and restoration of the testing sites where applicable.

Impact

At the time of writing (April 2018) there are two technologies installed in Durban, either undergoing commissioning or with testing underway, and a further eight technologies expected to be installed in the next twelve months. The ten technologies are: (1) a flushable urine diversion pedestal which aims to improve stream separation; (2) a household pedestal with a dry flush linked to a processing unit which gasifies solids to generate energy and uses membranes to treat liquids for water reuse; (3) a household process which dries and burns waste to recover energy to reuse in the system; (4) a household system that stabilises and dries urine to produce a fertiliser; (5) a community handwashing unit that recycles water; (6) a community level process which uses fuel cells to break down urine and produce electricity; (7) a community level process which dries and burns solids to generate energy and treats liquids electrochemically for reuse; (8 & 9) two different community level processes which use anaerobic treatment and electrochemical treatment to recycle water; and (10) a process which integrates novel drying techniques to improve drying of faecal sludge. Even at this early stage, technology developers have expressed the benefits of testing as part of the EFT platform as compared to testing in other locations where there is minimal support. The infrastructure and support networks that are in place in Durban have allowed technology developers to focus on the technology, whilst the support team in Durban are able to deal with other issues such as: appointing and overseeing local contractors, providing laboratory facilities that can process faecal sludge samples, and working with communities to get permission for testing and to understand attitudes towards prototypes.

Challenges

The implementation of the EFT platform has highlighted a number of challenges around the testing of sanitation prototypes in a real world environment. Space for prototypes and the associated infrastructure in informal settlements is limited as space around existing communal toilets has multiple uses including hanging laundry, washing, fixing and parking cars, gardens and crèches. Combined with the poor quality of access roads and challenging topography in informal settlements and peri-urban areas, this can make site selection and installation of technologies challenging. In addition, there are numerous illegal service connections (i.e. water and electricity) present at the selected sites, which can delay and halt site preparation and installation. Obtaining legal service connections to the testing sites can be a several-month process if there are questions of land ownership. By the nature of the EFT platform, prototypes are installed in spaces

that are in continual use by the community, which means careful coordination of construction and installation activities to minimise impact on the community and a high level of attention to site safety.

Working in informal settlements comes with socio-political challenges as well. There are often political tensions between ward councillors and community councils who may be from different political parties, which can lengthen the timeline for decision-making. Appropriate communication with the community is vital to ensure that people understand the testing and their involvement in it, if they choose to participate. Identifying the right communication channels must take into account the availability of people for attending meetings (e.g. holding consultations at evenings and weekends), existing knowledge of the users and the potential for confusion due to language barriers. As the EFT programme can change rapidly for any given technology, it is important that expectations are managed, particularly around timelines. A major priority for many of the informal settlements is job creation and although the EFT platform does provide as many opportunities as possible for local employment (community liaison officers, caretakers, security and construction labour) there is obviously a limit to the number of jobs that can be created. This can lead to conflict within the community if external contractors are seen to be taking on work that the community perceives could have been awarded to local labourers.

Achieving a balance between encouraging community ownership to protect and look after systems with the use of security guards and other measures to prevent theft and vandalism is another challenge that needs to be addressed sensitively.

Lessons learnt

Although the EFT platform is in its early stages, a number of important lessons have been learned. It is of great value to involve the local EFT platform team as early as possible in the preparation of the prototypes for testing in Durban. This allows for the preparation of the testing sites to be specific to the needs of the technology developers, minimising installation issues during the periods where international teams are present on site. It also allows for the prototype design to be tailored to local conditions – for example by using locally-available or compatible parts for components that are likely to require replacement, or by the inclusion of security measures (e.g. window bars, appropriate alarms) in the initial design rather than retrofitting. The local EFT team can also advise on where flexibility is required in the design (for example, positioning of solar panels or pipe inlets) to enable installation at non-greenfield sites with constrained space and access. Some aspects of site preparation can have long lead times – for example obtaining utility connections or environmental approvals – and early planning and agreement on design and scope is needed to prevent delays.

It is important that local engineers are in a position to operate, maintain and trouble-shoot the prototypes with minimal support from technology developers so that sampling and testing is not reliant on the presence of international experts. This means both engagement between technology developers and operations and maintenance staff at the design stage (e.g. to agree on what level of remote monitoring will be provided) and well-planned and structured training during the installation and commissioning periods. Whilst this requires an investment of time on the part of the technology developers at the start of the project, it is worthwhile in the long-term. There is the added advantage that teams with knowledge and understanding of the local context are in position to identify risks and potential issues with operation in advance and come up with appropriate actions to mitigate the impact of these risks. For example, the theft of metal fittings from installations was highlighted as a concern by the local EFT team and security measures or replacement parts could be considered to deal with this risk in advance.

Scope creep has led to numerous project delays and setbacks to timelines. This has been accompanied by an increase in required budget and it is fortunate that the funders have been understanding and willing to support changes to the budget. Early engagement between all parties during the development of budgets is again helpful in coming to agreement on scope and responsibilities.

The quality of the community engagement process, the political dynamics in communities and the level of support received by ward and local level governance structures for the project have been key to the speed of progress and the level of success of the testing at different sites. It should be stressed that these factors usually have more of a bearing on the success of testing at a particular site than the physical characteristics of the location.

Careful management of communication and publicity is important. The purpose of the EFT platform is to provide a context to test technologies in the real world, during the phase of their development where design adjustments are still being made. It has therefore been important to avoid media coverage of specific testing locations, in order to keep the testing context as ‘normal’ as possible.

There is a distinct advantage to having a concentration of prototypes in a single location. This allows expertise and resources relating to many of the support functions (e.g. logistics, managing contractors, sampling and laboratory analysis) to be pooled. Technology developers are able to see other installations and work together to solve shared problems. This in turn leads to greater collaboration. In Durban, there is the added benefit that organisations that visit Durban (e.g. through the Municipal Institute of Learning (MILE)) to understand how the eThekweni municipality adopts an innovative approach to delivery of sanitation services are able to view a number of prototypes, which can act as publicity to open up new markets for successful prototypes.

Conclusion

The EFT platform offers technology developers a safe space to evaluate the performance and suitability of early sanitation prototypes. It is run as a collaboration between the PRG, EWS and Khanyisa Projects to deliver access to community sites and community engagement systems, a well-equipped faecal sludge laboratory and support on sampling, testing and logistics. This allows the rapid assessment of early engineering concepts to ensure that funding is directed towards the most promising technologies. The presence of a local team of engineers who are trained in the operation, maintenance and trouble-shooting of the prototypes has the advantage that they can identify locally relevant risks in advance and mitigate these risks. By having a number of technologies tested in one location, the expertise and resources of these support functions can be pooled and there is greater opportunity for collaboration between technology developers to solve common challenges.

Acknowledgements

The authors would like to extend thanks to the Bill & Melinda Gates Foundation for funding of the Engineering Field Testing platform and to the Water Research Commission of South Africa for support.

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