Household Sanitation Technology Assessment and Evaluation

Report to the Water Research Commission

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EXECUTIVE SUMARY

INTRODUCTION

The household sanitation technology assessment protocol has been developed through an iterative process that commenced with the development of a draft protocol. This draft was presented to the technology suppliers, government departments and other key stakeholders during May and June 2015 to receive initial comment and feedback. An updated protocol was then used to conduct a preliminary evaluation of selected technologies through a desktop appraisal, field verification and laboratory analysis. The feedback from this evaluation process led to further development of the protocol as presented in the body of this report.

The development of the Household Sanitation Technology Assessment and Evaluation Protocol has been a valuable step towards improved regulation of the sanitation sector. The impact of urbanisation and increased water scarcity has resulted in the emergence of an innovative (but largely un-regulated) sanitation sector. If these technologies are to assist with clearing the backlog of household sanitation, they must be based on sound process design principles and must be proven to be robust and reliable through extended field trials within a particular context.

In addition to the Protocol itself, this process has informed the development of two key discussion documents, namely the **Sanitation Dossiers** and the **Policy Dialogue Report** included in the body of this report. The **Sanitation Dossiers** in **Annexure F** present an informative summary of the evaluation, including recommendations for the enhancement and proper application of the technology where relevant.

The Policy Dialogue Report, comprises the key recommendations that should be incorporated into Government policy and best practice in order to secure the implementation of robust and effective sanitation technologies which are appropriate for a specific context and which are well maintained to prevent disruption to the essential sanitation service.

The Protocol and associated Dossiers should be maintained as living documents that are refined and updated with consideration of the needs of the regulatory authority. The innovative nature of the sanitation sector means that new and existing technologies are constantly being developed. Extended field trials of emerging technologies will help to verify the performance of emerging technologies and ensure that future sanitation provision is effective and well suited to the needs of the user by providing the maximum health benefit.

OVERVIEW*

The Sanitation Technology Assessment and Evaluation Protocol is designed to enable the transparent assessment of different household sanitation technologies. This generally excludes septic tanks and stand-alone effluent treatment technologies that are not packaged with a toilet. These technologies should be evaluated in accordance with the Water Research Commission (WRC) guidelines for domestic wastewater package plants (Van Niekerk et al., 2009). The Protocol is designed to be used by sanitation experts. This protocol focusses specifically on the scientific functionality of the sanitation, to assess whether the technology is performing, or is able to perform the required collection, treatment and disposal functions in order to provide a reliable, hygienic sanitation facility.

The implementation of the Sanitation Technology Evaluation Protocol will produce a scientific assessment of household sanitation technologies to inform the appropriate selection and siting of on-site sanitation technologies and achieve the desired long-term benefits of effective sanitation systems. In order to aid standardisation of the sanitation evaluation process, a series of standard procedures have been developed which can be applied to the wide range of technologies on the market. The assessment process does however require a good understanding of sanitation technologies and the physical, chemical and biological treatment processes that are incorporated into the different technologies.

FUNCTIONALITY ASSESSMENT

The functionality of the sanitation technology considers the ability of the sanitation technology to perform the intended purpose. With reference to current Policy, functionality is regarded as a technology that is able to:

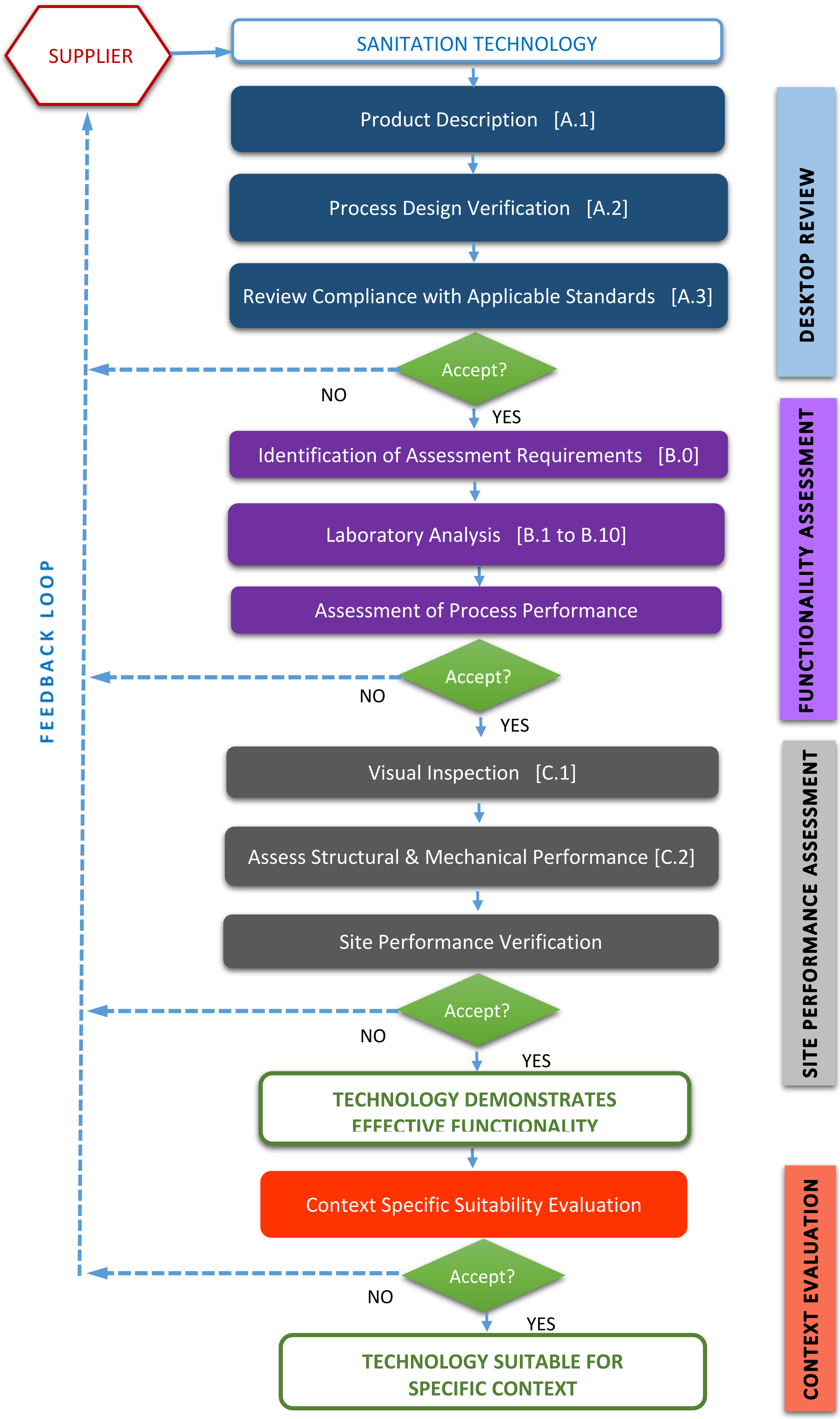
"provide a sanitation facility which is safe, reliable, private, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases. This technology must therefore facilitate the appropriate control of disease carrying flies and pests and enable safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner."

The assessment is sequential; after satisfactory performance for specific criteria, the assessment will proceed to the next stage. Unacceptable performance at any stage will be fed back to the supplier to inform modification of the sanitation technology for re-submission by the supplier. The assessment of the technology requires input from both the Supplier and the Assessor and will follow the Sanitation Technology Assessment and Evaluation Procedure.

The intention of the Sanitation Technology Evaluation Protocol is to highlight good performance and appropriate siting of the technology. The assessment process seeks to guide manufacturers towards improved product performance to improve the success of sanitation delivery.

Of the 30 technologies reviewed, a total of 10 technologies underwent scientific field trials. These field trials were primarily to verify the functionality assessment protocol, but they also enabled an initial assessment of individual sanitation technologies within a specific context. The findings of these assessments are presented in the Annexures and summarised in the Sanitation Dossiers. In general, the reviewed technologies did not achieve the minimum standard for effluent quality defined in the Protocol. In most cases, this could be directly attributed to the operation and maintenance procedure, highlighting the need for ongoing O&M for all sanitation technologies.

Sanitation Technology Assessment and Evaluation Procedure



REGULATION

There is a need for the Functionality Protocol to be framed within the context of the regulatory authority. Throughout the development of this protocol, the project team, the WRC and Department of Science and Technology (DST) has sought to establish a firm institutional home for the evaluation protocol. Initial discussions indicate that this Protocol should be located within the Department of Water and Sanitation (DWS), indeed Position 17 of the draft Sanitation Policy, 2016 states that “a formal process for certification and accreditation of appropriate sanitation technologies will be developed…” This Sanitation Protocol should feed directly into this process. It is recommended that a focussed workshop session be conducted between DWS, Agrément and the South African Bureau of Standards, to define the roles and responsibilities for this certification process. If the Protocol is to be adopted by these institutions, a specific training programme should be implemented to ensure that a consistent evaluation procedure is followed.

The initial results generated through this study should be repeated at multiple sites as part of an on-going monitoring programmes. In accordance with the General Authorisation process, ALL onsite treatment systems require basic monitoring, the detail of this depends on the size of the facility, but as a minimum should include *E. coli* and Chemical Oxygen Demand (COD) analysis. Where multiple systems are provided in a particular settlement, this analysis could be undertaken on a representative sample, but must be undertaken regularly. DWS is responsible for reviewing this data in order to maintain the approvals for a specific technology. The management of this data will however require the development of new systems to spatially map the data and alert to operational issues.

This research is an important move forwards towards improved sanitation provision. The Sanitation Dossiers provide initial guidance on the selection of suitable sanitation technologies, but this must be built upon through a sustained research effort and multi sector participation. The development of this Protocol has seen improved collaboration between technology suppliers, researchers and government departments. It is envisaged that this will continue to grow to see the establishment of a highly effective sanitation industry throughout South Africa and beyond its borders.

1 INTRODUCTION

The **Household Sanitation Technology Assessment** protocol has been developed through an iterative process that commenced with the development of a draft protocol that was workshopped with technology suppliers, government departments and other key stakeholders. Following some initial refinement, this draft protocol was used to evaluate selected technologies through a desktop appraisal, field verification and laboratory analysis. The feedback from this evaluation process led to further development (and simplification) of the protocol as presented in the body of this report.

In addition to the Protocol itself, this process has informed the development of two key deliverables, namely the **Sanitation Dossiers** and the **Policy Dialogue Report** included in the body of this report. The Sanitation Dossiers in **Annexure F** present an informative summary of the assessment, including recommendations for the enhancement and proper application of the technology where relevant.

The Policy Dialogue Report, comprises the key recommendations that should be incorporated into Government policy and best practice in order to secure the implementation of robust and effective sanitation technologies which are appropriate for a specific context and which are well maintained to prevent disruption to the essential sanitation service.

The protocol and associated dossiers should be maintained as living documents that are refined and updated with consideration of the needs of the regulatory authority. The innovative nature of the sanitation sector means that technologies are constantly being improved. Extended field trials of emerging technologies will help to verify the performance of emerging technologies and ensure that future sanitation provision is effective and well suited to the needs of the user by providing the maximum health benefit.

In the next chapter, the background to the South African Legislative and Policy Framework is presented.

2 SOUTH AFRICAN LEGISLATIVE AND POLICY FRAMEWORK

2.1 INTRODUCTION

This section provides a brief overview of South African policy and legislation related to the delivery of sanitation infrastructure. This is intended to provide a brief outline of the legal context in which the WRC sanitation technology assessment sits, and therefore the minimum standard that must be achieved by a particular technology as constituted by law. This section refers to current Policy Frameworks and legal cases related to sanitation provision; much of which is well summarised in the publication by the Socio-Economic Rights Institute of South Africa (SERI) in their publication *Basic Sanitation in South Africa: A guide to Legislation: Policy and Practice* (Tissington, 2011).

2.2 GOVERNMENT POLICY DOCUMENTS

2.2.1 Constitution (1996)

There are several clauses within the South African Constitution and the Bill of Rights that refers to the right to basic sanitation.

Section 9 of the Bill of Rights prohibits the state from unfairly discriminating against any sector of society, section 9(2) states “equality includes the full and equal enjoyment of all rights and freedoms”. Therefore, with consideration of the points below access to sanitation should be equitable.

Section 10 states that “everyone has inherent dignity and the **right to have their dignity protected**”. Section 14 states that “everyone has a right to **privacy**”. Dignity and privacy have clear linkages with effective sanitation provision.

Section 24(a) of the Bill of Rights states that “everyone has a right to an **environment that is not harmful to their health or well-being**”. Effective sanitation is required to achieve this.

Sections 26(1) of the Bill of Rights states that “everyone has the right to have access to adequate housing”. In the Grootboom case, the Constitutional Court interpreted this to include the provision of water and **removal of sewage**.

2.2.2 White Paper on Water Supply and Sanitation Policy (1994)

Promptly after its inception, the then Department of Water Affairs and Forestry (DWAF) [name changed to Department of Water Affairs (DWA) and now Department of Water and Sanitation (DWS)] published the White Paper on Water Supply and Sanitation Policy. Adequate Basic Sanitation is defined in this policy as follows:

"The immediate priority is to ***provide sanitation services to all which meet basic health and functional requirements including the protection of the quality of both surface and underground water****. Higher levels of service will only be achievable if incomes in poor communities rise substantially.* ***Conventional waterborne sanitation is in most cases not a realistic, viable and achievable minimum service standard in the short term due to its cost****. The Ventilated Improved Pit toilet (VIP),* ***if constructed to agreed standards*** *and maintained properly, provides an appropriate and adequate basic level of sanitation service. Adequate basic provision is therefore defined as one well-constructed VIP toilet (in various forms, to agreed standards) per household" (DWAF, 1994, emphasis added)*

2.2.3 National Sanitation Policy (1996)

DWAF published the National Sanitation Policy (DWAF, 1996) to clarify the White Paper (DWAF, 1994) and as a precursor to the development of the national sanitation strategy. This policy defines sanitation as *"the principles and practices relating to the collection, removal or disposal of human excreta, refuse and waste water, as they impact upon users, operators and the environment"*

The main sanitation technologies used in South Africa at the time of publication are listed in the National Sanitation Policy, as follows:

- *traditional unimproved pits;*
- *bucket toilets;*
- *portable chemical toilets;*
- *Ventilated Improved Pit toilets;*
- *low flow on-site sanitation (LOFLOS);*
- *septic tanks and soakaways;*
- *septic tank effluent drainage (solids-free sewerage) systems; and*
- *full water-borne sewerage*

The policy also states that unimproved pits and bucket toilets do not provide adequate sanitation and chemical toilets are not encouraged except in emergencies due to the high running costs.

2.2.4 Water Services Act (1997)

The Water Services Act 108 of 1997 is the main law relating to the access and provision of water services (DWA, 1997). Section 3 of the Act states that "everyone has a right of access to basic water supply and sanitation". Where basic sanitation is defined as:

"the prescribed minimum standard of services necessary for the safe, hygienic and adequate collection, removal, disposal or purification of human excreta, domestic waste water and sewage from households, including informal households."

In June 2001, the Compulsory National Standards (General Notice 22355) was published in terms of Section 9 of the Water Services Act (South African Government, 2001). Regulation 2 of the Compulsory National Standards states that:
the minimum standard for basic sanitation services is
(a) the provision of appropriate education; and
(b) a toilet which is safe, reliable, environmentally sound, easy to keep clean, provides privacy and protection against the weather, well ventilated, keeps smells to a minimum and prevents the entry and exit of flies and other disease-carrying pests.

2.2.5 Housing Act (1997)

The Housing Act identifies that all citizens and permanent residents of South Africa will, **on a progressive basis**, have access to potable water, **adequate sanitary facilities** and domestic energy supply (South African Government, 1997).

2.2.6 White Paper on Basic Household Sanitation (2001)

The White Paper provides a framework for the provision of sustainable sanitation, particularly to households that have not previously benefited from improved sanitation facilities (DWA. 2001). The paper provides the following definitions:

"Sanitation refers to the principles and practices relating to the ***collection, removal or disposal of human excreta****, household waste water and refuse as they impact upon people and the environment. Good sanitation includes appropriate health and hygiene awareness and behaviour, and acceptable, affordable and sustainable sanitation services.*

the ***minimum acceptable basic level of sanitation*** *is:*
(a) appropriate health and hygiene awareness and behaviour;
(b) ***a system for disposing of human excreta****, household waste water and refuse, which is acceptable and affordable to the users, safe, hygienic and easily accessible and which does not have an unacceptable impact on the environment; and*
(c) ***a toilet facility for each household****."*

The White Paper adopts 12 policy principles, the following are most pertinent the context of the sanitation technology assessment:

- *Community participation:* ***Communities must be fully involved*** *in projects related to their health, and in decisions relating to community facilities like schools and clinics.*
- *Integrated planning and development: The 2001 White Paper acknowledged that the "current lack of coherence in the sanitation sector is largely a result of uncoordinated planning." Therefore, the Integrated Development Plan (IDP), with the WSDP as a component, must prioritise and coordinate service delivery so as to address the sanitation backlog and* ***ensure that any new sanitation intervention will be sustainable in the long term****.*

- *Sanitation is about the environment and health:* ***Sanitation improvement is more than just the provision of toilets; it is a process of sustained environment and health improvement****.*
- *Basic sanitation is a human right: "****Government has an obligation to create an enabling environment through which all South Africans can gain access to basic sanitation services."***
- *Economic value of water:* ***The way in which sanitation services are provided must take into account the growing scarcity of good quality water*** *in South Africa.*
- *Sanitation services must be* ***financially sustainable****: Sanitation services must be sustainable both in terms of capital costs and recurrent costs.*
- *Environmental integrity:* ***The environment must be protected*** *from the potentially negative impacts of developing and operating sanitation systems.*

2.2.7 Strategic Framework for Water Services (2003)

The Strategic Framework for Water Services (DWA, 2003) defines sanitation as follows:

Basic sanitation facility:
The infrastructure necessary to provide a sanitation facility which is ***safe, reliable, private, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases*** *by facilitating the appropriate control of disease carrying flies and pests, and* ***enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner****.*

A basic sanitation service entails:
The provision of a sanitation facility (that is appropriate to the settlement conditions) which is ***easily accessible to a household****, the sustainable operation and maintenance of the facility, including the safe removal of human waste and waste water from the premises where this is appropriate and necessary, and the communication of good sanitation, hygiene and related practices (to users).*

This concept of the "sanitation ladder" is an important part of the Strategic Framework. The Strategic Framework refers to basic sanitation provision as the first step and describes how, as economic affordability increases and the backlog in the provision of basic services reduces, it will become possible for more households to be provided with higher levels of services (moving up the ladder).

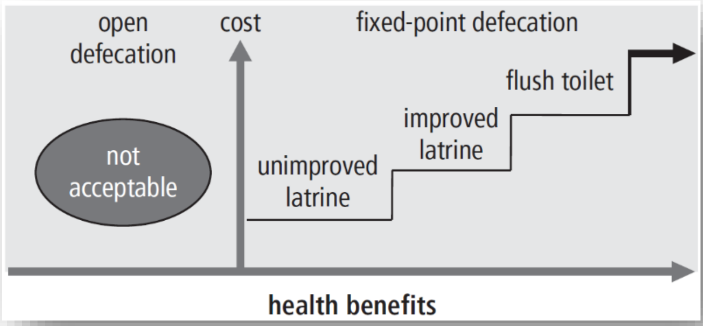


***Figure 2.1 The Sanitation Ladder** (Source: Morella et al., 2009)*

The Strategic Framework **does not define the technology option to be used** in its definition of basic sanitation service, and this choice is left up to the Water Service Authority. The Strategic Framework does however state that **waterborne sanitation is usually the most suitable technology option in urban areas with high densities** and should be regarded as the basic level of service for the purposes of the policy. **In rural areas, with low densities, on-site technology options are an appropriate level of service.** In intermediate areas, e.g. peri-urban areas or rural areas with high densities, the Strategic Framework states that the WSA must **decide on a sanitation technology option that is financially viable and sustainable**, and that in most instances, on-site sanitation systems are likely to be the most appropriate solution.

2.2.8 National Sanitation Strategy (2005)

The National Sanitation Strategy (2005) was compiled to provide a coherent approach to sanitation delivery in South Africa which aligns with the previous publications listed in 2.2.6 and 2.2.7 above. The strategy states that:

*"**informal settlements must not be treated as emergency situations** for the purpose of this strategy but **should be provided with viable and sustainable solutions**. Solutions such as **communal facilities and chemical toilets should not be used** where the system is expected to have a duration of more than one month."*

This is particularly relevant in light of the recent South African Human Rights Commission (SAHRC) ruling that chemical toilets are not to be provided as a long term solution (ref. Section 2.3)

2.2.9 Free Basic Sanitation Implementation Strategy (2009)

On 21 March 2009, the Minister of Water Affairs approved the Free Basic Sanitation Implementation Strategy, which was developed to guide WSAs in providing all citizens with free basic sanitation by 2014.

The Strategy acknowledges that there is a "**right of access to a basic level of sanitation service**" enshrined in the Constitution

While in some areas the basic service level could be a VIP, in other areas (usually urban and well-established), waterborne sanitation could be the basic service level to be provided free to the poor.

2.2.10 Status of sanitation services in South Africa (2012)

The Report on the Status of sanitation services in South Africa was published in March 2012 by the Department of Water Affairs in collaboration with the Department of Performance Monitoring and Evaluation in The Presidency (DPME), the Department of Human Settlements (DHS), the Department of Cooperative Governance (DCoG) and National Treasury to establish the quality of sanitation in South Africa. This publication affirms the definition for basic sanitation provided in the Strategic Framework for Water Services (2003), as summarised in Section 2.2.7 above.

The Report also refers to Regulation 2 of the Compulsory National Standards states that the minimum standard for basic sanitation services is: -

- the provision of **appropriate education**; and
- a toilet which is **safe, reliable, environmentally sound, easy to keep clean, provides privacy and protection against the weather, well ventilated, keeps smells to a minimum and prevents the entry and exit of flies and other disease carrying pests**.

Key to all these standards is the requirement for **privacy**, **safety**, **health** (barriers to disease transmission) and **structural soundness**. From a norms and standards point of view, South Africa therefore compares positively with international practice and underscores the point that the country views access to acceptable sanitation services as fundamentally a human rights issue.

The publication provides a summary of the sanitation service levels in South Africa and provides the following definition of a '***sanitation need':*** This acknowledges that a poorly maintained basic sanitation service may still be regarded as a backlog, therefore highlighting the importance of providing sanitation technologies which are easy to operate and maintain.

The report defined the sanitation need as follows:

- service delivery backlogs (people who have never been served);
- refurbishment backlogs (sanitation infrastructure that has deteriorated beyond regular maintenance requirements);
- extension backlogs (existing infrastructure that needs to be extended to provide the service to new households in the communities);
- upgrade needs (infrastructure that does not meet the minimum standards);
- O&M backlogs (infrastructure that has not been properly operated and maintained, but can be adequate if funds are allocated to ensure proper operation and maintenance); and
- water resource requirements to be able to effectively operate the sanitation system.

The publication discusses the South African Human Rights Commission investigations into the Makhaza and Moqhaka cases which found that:

- there is a lack of uniform norms regarding service delivery standards
- there is a lack of community participation in the provision of integrated services

Both this Status report and the SAHRC investigations confirm some of the challenges and issues negatively impacting on sustainability identified through the National Sanitation Audit of 2005, – these include:

Governance

- **The need for consolidated norms and standards.**
- **Need for sanitation strategies to give better guidance on implementation of higher levels of service.**

Institutional

- Inadequate technical capacity at municipal level.
- Inadequate O&M capacity at local level.
- Lack of M&E systems.
- **Lack of O&M guidelines for on-site sanitation.**

Community

- **Low community acceptance of toilet quality**.
- Inadequate involvement of communities in the planning and implementation.
- Low affordability of households to pay for maintenance.
- Inadequate health awareness and user education.

Health

- Health and hygiene education not provided in many cases.

Technical

- **Quality of facilities is not standardised.**
- **Quality of some facilities does not comply with the definition of an acceptable basic sanitation facility.**
- Inadequate and un-coordinated M&E and regulation functions with sector departments.
- Effective service level choice and affordability is lacking.

O&M

- Inadequate maintenance of infrastructure (need of proper O&M plan).
- Few municipalities have a maintenance programme for on-site dry sanitation systems.
- Small municipalities do not effectively operate and maintain their waterborne sanitation schemes.

2.3 SOUTH AFRICAN HUMAN RIGHTS COMMISSION

The SAHRC (2014) published the "Report on the Right to Access Sufficient Water and Decent Sanitation in South Africa: 2014". This report provides a summary of national and international policy, together with a summary of the SAHRC investigations into sanitation provision.

The table below is included in the SAHRC report and is derived from the 2011 census data. Contrary to the recent SAHRC ruling (see below) Chemical Toilets are listed as an acceptable form of sanitation.

Province	RDP-Acceptable			Not RDP-Acceptable		
	Flush Toilet	Chemical Toilet	Ventilated Pit Latrine	Unventilated Pit Latrine	Bucket Latrine	None
Eastern Cape	43.0%	3.0%	13.9%	20.2%	2.3%	12.7%
Free State	67.1%	0.6%	87.0%	13.5%	5.5%	3.1%
Gauteng	85.4%	1.1%	2.4%	7.4%	1.8%	1.1%
KwaZulu-Natal	45.0%	8.2%	14.4%	20.7%	1.7%	6.3%
Limpopo	21.9%	0.9%	15.1%	52.9%	0.6%	7.2%
Mpumalanga	43.8%	1.4%	12.1%	33.9%	0.9%	6.3%
North West	45.4%	0.8%	11.3%	34.2%	1.0%	5.8%
Northern Cape	66.0%	0.6%	9.1%	10.7%	4.0%	8.0%
Western Cape	89.6%	0.9%	0.6%	0.6%	3.7%	3.1%
South Africa	60.1%	2.5%	8.8%	19.3%	2.1%	5.2%

Complaints were received by the SAHRC in all provinces of a complete lack of access to water and sanitation. The lack of access can be attributed to one of the followings:

a) A lack of access to any infrastructure;
b) Access to infrastructure that has never been operational; and
c) Access to infrastructure that is no longer in working order.

The South African Human Rights Commission investigations into Makhaza and Moqhaka are discussed in Section 2.2.11 above. A further investigation by the SAHRC into a complaint by the Social Justice Coalition regarding the provision of chemical toilets by the City of Cape Town in four areas of Khayelitsha was completed in July 2014. The SAHRC ruled that
Sanitation provision within the City of Cape Town ruled as follows:

- The norms and standards should adhere to human rights principles and take into account the social context and lived reality of the persons who will be provided with services.
- That the norms and standards developed incorporate the context in which a sanitation facility is used into its determination of whether it meets all aspects of the applicable definitions of basic sanitation facility.
- Ensures that the service provided is available, accessible, and acceptable to users of appropriate quality.
- The provision of a particular technology in a particular area be informed by an analysis… of whether the technology employed complies with the norms and standards.
- The Department of Water and Sanitation provide training and/or materials designed to assist municipalities with devising norms and standards.
- The use of long-term contracts for the provision of Chemical toilets is a violation to the occupants of informal settlements.

The findings of this investigation, highlight the urgent need for improved guidance and assessment of sanitation technologies, and furthermore that chemical toilets should only be provided as an emergency measure.

In the next chapter, Sanitation Standards and Guidelines are presented.

3 SANITATION STANDARDS AND GUIDELINES

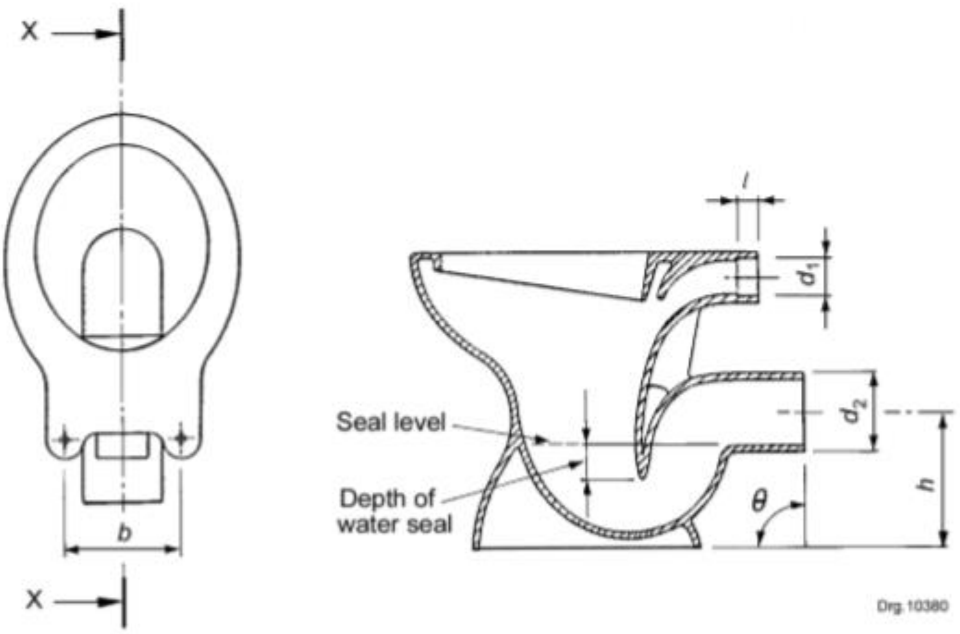
3.1 SOUTH AFRICAN NATIONAL STANDARDS (SANS)

3.1.1 Introduction

The South African National Standard sets out the prescribed standard for the manufacture, construction and testing of several different sanitation technologies, as detailed in the following standards.

3.1.2 SANS 497:2011 – Glazed Ceramic Sanitaryware

This document relates specifically to the design and testing of ceramic flush toilets and stipulates the required dimensions for the water seal, pedestal height and plumbing connection. And therefore, has limited relevance to the sanitation technology assessment.



Type A pan (with seat fixing holes) **Section X - X (pan with straight "P" trap)**

3.1.3 SANS 10400-Q:2011 – Non-Waterborne Means of Sanitary Disposal

Part Q of the National Building Regulations outlines the minimum standard for Chemical Toilets and Ventilated Improved Pit Toilets; no other technologies are identified.

This standard describes a chemical toilet as a "toilet with a fixed pan, the excreta from which pass into a tank where they are acted upon by chemicals which sterilise and break them down". The only other reference to the design of the chemical toilet states that *"A chemical toilet shall be provided with a seat and a receptacle of such height that a space of not more than 25 mm is left between the underside of such seat and the top of the receptacle. The aperture in such seat shall be at least 25 mm less in every diameter than the corresponding* *diameter of the top of such receptacle and such aperture shall be fitted with a self-closing, fly-proof lid"*.

The prescribed standard for the VIP Latrines is more comprehensive and provides standard details for single pit and double pit VIPs.

3.2 DEPARTMENT OF WATER AFFAIRS GUIDELINES

3.2.1 Sanitation Technology Options (2002)

The DWAF (2002) report on "Sanitation Technology Options" provides a useful reference for different technologies, and indicates that Bucket toilets, Unimproved Pits, Chemical and communal toilets are not recommended.

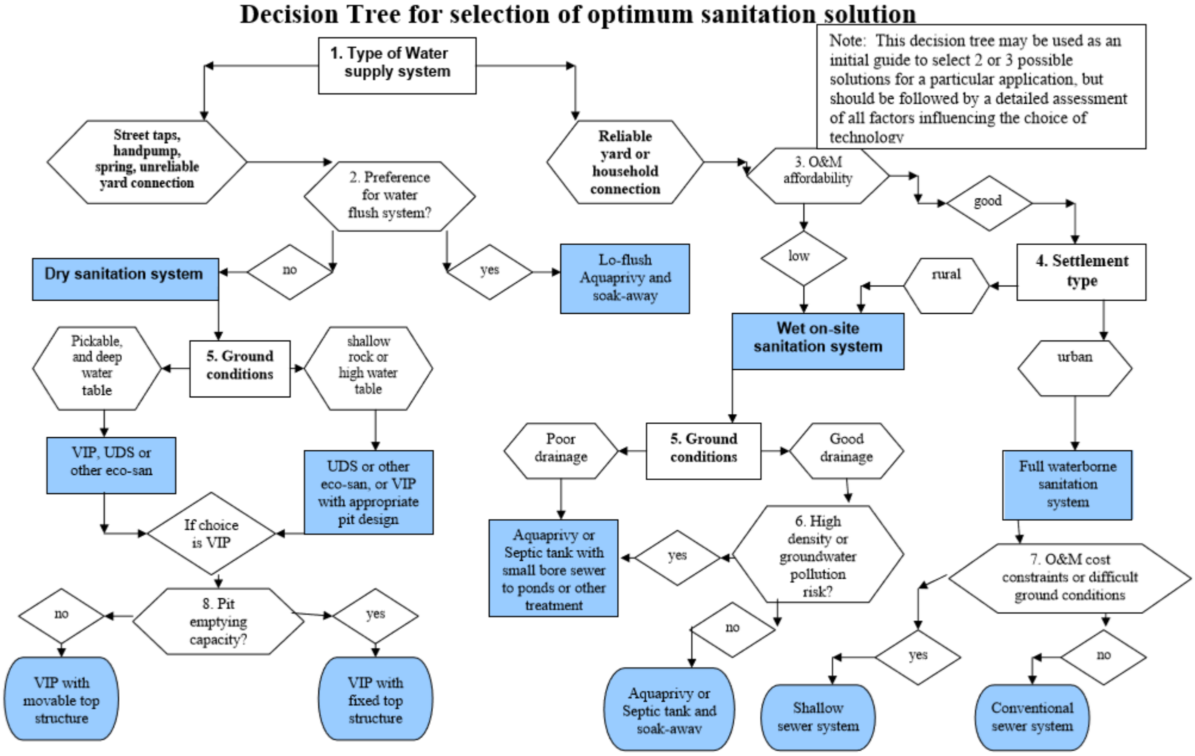
The guide provides a useful reference for the operation and maintenance requirements as indicated in the **Table 3.1** below.

Table 3.1: Sanitation Technological Options (from DWAF, 2002).

Sanitation scheme	O&M tasks	Skills level	Time requirements	Equipment and materials	Comments
All latrines	Maintaining structure & pedestal	Maintenance skills	± 1 day per year	Some cement, paint, wood	May be done by home owner or small contractor
VIP Latrines	Cleaning vent pipe	None	1/2 hour per month		Undertaken by home owner
	Emptying pit	Brief training	1 day in 5 to 10 years	Vacuum tanker or hand equipment + roughage for composting sludge + safety clothing	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
UDS latrines	Emptying pit	None	1/2 day each year	None	Most activities can be undertaken by home owner
Aquaprivy	Removing sludge from tank	Brief training	± 1/4 day every 3 months	Vacuum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
	Maintaining soak pit	Brief training	Monthly for grease trap	None	Soak pit may need to be unblocked or moved every 5 to 10 years in some soils
Flush toilet with septic tank and adsorption trench	Repairs to pipes	Pipe skills	± 1 day every 5 years	Pipes and joints	May be done by home owner or small contractor
	Removing sludge from septic tank	Brief training	± 1/4 day every 3 years	Vacuum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
	Maintaining soil adsorption trench	Brief training	Monthly for grease trap	None	Soak pit may need to be unblocked or moved every 5 to 10 years in some soils
Flush toilet with septic tank, solids free sewer and pond treatment	Repairs to pipes	Pipe skills	± 1 day every 6 years	Pipes and joints	May be done by home owner or small contractor
	Removing sludge from septic tanks	Brief training	± 1/4 day every 3 years per household	Vacuum tanker + roughage for composting sludge	Composting is not generally practiced, but holds potential for lowering costs and creating jobs
	Maintaining stabilization pond	Brief training	Daily	Minor tools	This can provide permanent job positions for 2 to 5 people.
Full waterborne sanitation	Repairs to pipes	Pipe skills	± 1 day every 6 months	Pipes and joints	May be done by home owner or small contractor (if on-site) or municipality (if off-site).
	Sewer blockages	Minor training	± 1 day per week	Rodding equipment + transport	May be done by municipality or small contractor
	Operating and maintaining wastewater treatment works	Full training to diploma level	Daily	Monitoring equipment + tools	Municipal responsibility providing permanent job positions for 4 to 10 people.
Sewage pump stations	Maintaining pumps, clearing screens and grit channels	Full training to certificate level	± 4 hours per week	Pump maintenance tools, safety clothing	Municipal responsibility but pump maintenance may be contracted in.

The Sanitation Technology Options (2002) guideline also presents the flow chart below for the selection of appropriate sanitation solutions based on user preference, water availability, ground conditions and settlement density.

Decision Tree for selection of optimum sanitation solution



3.2.2 Technical Guidelines (2004)

The *Technical Guidelines for The Development of Water and Sanitation Infrastructure* (DWAF, 2004) provides standard details for the design and construction of VIP latrines and describes basic sanitation as follows:

A basic sanitation facility is:
The infrastructure necessary to provide a sanitation facility which is safe, reliable, private, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases by facilitating the appropriate control of disease carrying flies and pests, and enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner.

A basic sanitation service is:
The provision of a basic sanitation facility which is easily accessible to a household, the sustainable operation of the facility, including the safe removal of human waste and wastewater from the premises where this is appropriate and necessary, and the communication of good sanitation, hygiene and related practices.

3.3 CURRENT AND PLANNED RESEARCH

3.3.1 Introduction

The following section provides a brief summary of the key documentation and research related to the evaluation of sanitation technology. The key evaluation criteria used in this research are outlined in the following section to inform the selection of an appropriate evaluation protocol for the sanitation technology study.

3.3.2 Integrated Urban Sanitation Decision Support Tool (2014)

Review of Support Resources in Sanitation by the Centre for Study of Science, Technology and Policy (C-STEP) (C-STEP, 2014). This document provides some of the following indicators that are used in various benchmarking tools for urban sanitation

- Coverage of toilets
- Coverage of connections to sewerage
- Collection efficiency of sewerage network
- Cost recovery (O&M) in wastewater management
- Quality of wastewater treatment
- Wastewater treatment adequacy
- Extent of reuse and recycling of wastewater
- Efficiency in collection of sewerage related charges
- Coverage of household connections to sewerage network in slums
- Efficiency in redressal of customer complaints
- Length of sewer system
- Blockages in sewer system
- Volume of wastewater collected and treated to primary level\secondary level

It also describes the different decision support tools that address all components of the sanitation chain, which are used by planners and decision makers including the following:

The Performance Improvement Planning (PIP) Model
An exhaustive tool to measure, monitor and improve delivery of water and sanitation

City Sanitation Planning (CSaP) Tool by Water and Sanitation Program (WSP)
User interactive tool used to aid in choosing options for citywide sanitation planning

The WhichSan Tool (Resources & Tools – Free Software)
Excel-based decision-support tool based on cost, and financial feasibility

The SANEX (Loetscher, 2000)
Takes into account the context (physical, demographic characteristics, etc.) and evaluates the impact of implementing a combination of technologies in specific contexts

The Sanitation Decision Support Tool (AKVO)
Helps the user select the chain of technologies for a sanitation chain

The Resource Recovery and Reuse Model
For developing business models for resource recovery and reuse.

3.3.3 Performance Assessment for Urban Water Supply and Sanitation (2014)

The Performance Assessment (PAS) was developed as a tool to measure, monitor and improve delivery of water and sanitation, with the target being urban India (Mehta et al., 2014). This list and definition of local action indicators was developed for the PAS tool. *The indicators are:*

- *Access and coverage*
- *Service levels and quality*
- *Financial sustainability*
- *Efficiency in service operations*
- *Equity*

3.3.4 Procedure for the Pre-Selection of Sanitation Systems (2011)

This tool developed by Eawag-Sandec/WSSCC/UN-HABITAT (2011) provides a Multi-Criteria Analysis (MCA) procedure. The following are the attributes used to evaluate the performance of a sanitation option:

- *Expected flow of nutrients and pathogens*
- *Expected exposure of user to pathogens*
- *Expected odour nuisance*
- *Cost per household*
- *Risk of failure*
- *Reusability of products*
- *Realisation time*
- *Maintenance frequency at household level*

3.3.5 Criteria for The Evaluation and Classification of Conventional and Innovative Low Cost Sanitation Technologies (2006)

By Network for the Development of Sustainable Approaches for Large Scale Implementation of Sanitation in Africa (NETSSAF, 2006):

Provides the criteria and the indicators for the assessment of technologies:

- *health issues (qualitative indicators)*
- *impact to the environment/nature (detailed quantitative indicators)*
- *technical characteristics of the sanitation system and its operation (qualitative indicators)*

- *economical and financial issues (quantitative indicators)*
- *social, cultural and gender aspects (qualitative indicators)*

Provides a 10-step methodology of applying the above criteria using a 'human-centred environmental sanitation approach'

3.3.6 Decentralised Wastewater Treatment Methods for Developing Countries (2001)

The advantages and disadvantages of different decentralised wastewater treatment systems are assessed against: environmental, socio-economic and financial benefits (GTZ, 2001).

3.3.7 SANDEC Training Tool – Sanitation Systems & Technologies (2008)

This tool developed by Sandec (Department of Water and Sanitation in Developing Countries) / Eawag Aquatic Research considers both technical and non-technical aspects of sanitation (SANDEC/EAWAG, 2008).

- *Technical: the type of technology and the physical/environmental requirements*
- *Non-technical: socio-cultural, political, institutional, financial and economic aspects.*

3.3.8 Evaluation of Sanitation and Wastewater Treatment Technologies (2013)

Through these Indian Case studies different technologies are assessed based on: failure/success of technology, hygiene, socio-economic aspects (Starkl, et al., 2013).

3.3.9 Maximum Performance Testing of Popular Toilet Models (MAP)

This Canadian-American Test Protocol developed in 2003 identifies a standard procedure for the testing of conventional flush toilets (see http://www.map-testing.com/performance-toilets-testing/background.html). The performance of the toilet is rated based on the total mass of flush media that the toilet is able to flush, with a minimum threshold of 250g required to pass the test.

3.3.10 Selection of Sustainable Sanitation Technologies for Urban Slums (2012)

The following criteria developed by Katukiza et al. (2012) are used to assess the appropriateness of the technology in Ugandan slums:

- *Socio-culture: acceptance, perception/complexity, operation and maintenance, use-ability Technical: local labour, Robustness, Materials, Fit existing system*
- *Health and environment: Environmental pollution, Exposure to pathogens*
- *Economics: capital cost, Land, Operation and maintenance, Resource recovery, Energy*

- *Institutional: adoptability*
- *Management*

3.3.11 Handbook on Service Level Benchmarking (2010)

This handbook by the Ministry of Urban Development (2010) in India c*ontains a description of standardised service level benchmarks for basic municipal services including sanitation. The benchmarks for sanitation are: coverage of toilets, coverage of sewage network services, collection efficiency of the sewage network, adequacy of sewage treatment capacity, quality of sewage treatment and its re-use, efficiency in redressing customer complaints and cost recovery. Each of these benchmarks has performance indicators.*

3.3.12 How to Select Appropriate Technical Solutions for Sanitation Water and Sanitation for All, Methodological Guide No. 4 (2010)

This 2010 guideline was developed by Concerted Municipal Strategies (CMS), a Program Coordinated by the Municipal Development Partnership (PDM) and Programme Solidarité Eau (pS-Eau) (Monvois et al., 2010). The guideline provides the selection criteria for an appropriate technological solution in three steps:

1. Characterizing the area in terms of physical, urban and socio-economic areas. Should answer questions about:

- *Physical – soil type, groundwater table, topography*
- *Urban – population density, available surface area, land status.*
- *Socio-economic – water consumption, local investment capacity, local technical skills, local financial management skills*

2. Determining a sanitation chain for the area identified: select a sanitation chain by eliminating chains that are inappropriate based on the data collected in step 1. Assess the pros and cons of the possible sanitation chains against the criteria from step 1.

3. Selecting appropriate technological solution. Determine the feasibility of a technology based on the following criteria: acceptance by households and by local sanitation professionals, lifespan of the infrastructure, efficiency of the service, investment and operating cost, design, construction and care and maintenance (C&M), accessibility, range, electrical energy, required surface area, water requirements.

The next chapter presents information of types of on-site sanitation technology.

4 ONSITE SANITATION TECHNOLOGIES

4.1 INTRODUCTION

This section provides a summary of the existing on-site sanitation technologies in use in South Africa and elsewhere.

4.2 COMPENDIUM OF SANITATION TECHNOLOGIES

The *Compendium of Sanitation Technologies* (Tilley, 2014) published by EAWAG is now in its second edition. The terminology contained within the compendium has become the accepted norm for describing sanitation technologies. The compendium provides a guide to generic sanitation options and their application and includes the following 'functional groups' and associated technologies that are relevant to the WRC Sanitation Technology Assessment:

User Interface

- Dry Toilet
- Urine Diverting Dry Toilet (UDDT)
- Pour Flush Toilet
- Cistern Flush Toilet
- Urine Diverting Flush Toilet (UDFT)

Collection and Storage / Treatment

- Single Ventilated Improved Pit (VIP)
- Double Ventilated Improved Pit (DVIP)
- Fossa Alterna
- Twin Pits for Pour Flush
- Dehydration Vaults
- Composting Chamber
- Septic Tank
- Anaerobic Baffled Reactor (ABR)
- Anaerobic Filter
- Biogas Reactor

The vast majority of commercial sanitation technologies can be categorised according to the above criteria, or a combination of the 'User Interface' technology and the 'collection and storage/treatment' technology. The second edition now includes a brief discussion of emerging technologies which includes the following applicable technologies:

- **Peepoo** – biodegradable bag used for excreta collection where no 'User Interface' is available.
- **Compost Filter** – various designs of filter exist based on the combine filtration and aerobic filtration of solids.

- **LaDePa Sludge Pelletiser** – is a dehydration and pasteurisation system designed to produce organic fertiliser from pit latrine sludge.

4.3 A COLLECTION OF CONTEMPORARY TOILET DESIGNS (2014)

4.3.1 Introduction

This collection is the result of the findings of EOOS research which was supported by Sandec, the Department of Water and Sanitation in Developing Countries at the Swiss Federal Institute of Aquatic Science and Technology (Eawag). It covers a wide range of contemporary designs along with a valuable list of website links where additional information about each design can be sought. This publication is a synthesis of the different technologies designed and produced by The Water Engineering and Development Centre (WEDC) at Loughborough University (Shaw, 2014).

The publication includes a number of different technologies, particularly derived from urine diversion and other dry sanitation systems, several of the featured technologies are very high tech such as the Blu Loo, water recycling toilet and the Cinderella combusting toilet. Other feature technologies are listed below. The collection does not provide any information related to the performance or suitability of the different technologies.

4.3.2 Urine Separation Systems

In addition to the common Urine Diversion systems where the urine is collected from a specific point on the pedestal, this collection includes some interesting alternatives, including the Otji toilet from Namibia, which uses the surface tension on the sides of the bowl to divert urine and the Aquatron vortex separator.

4.3.3 Portable Toilets

Several designs are catalogued that enable the easy collection and hygienic transport of the waste. In addition to the camping toilets, this includes an interesting rolling called the X-Runner toilet for good mobility in slums

4.3.4 Dehydration Conveyance Toilets

Mechanical components such as the helical screw of the Intestinal Toilet and the conveyor belt systems on the Eco Domeo and Drysan simultaneously transfer and dehydrate the waste on route to a convenient disposal point.

4.3.5 Packet Collection Systems

Three of the featured technologies seek to package waste after each use. The Peepoo bag includes urea to help digest the waste inside the sealed bag and the Loowatt seals faeces in a biodegradable film.

4.4 CSIR SANITATION TECHNOLOGY DEMONSTRATION CENTRE

4.4.1 Introduction

A Sanitation Technology Demonstration Centre has been established by the Council for Scientific and Industrial Research (CSIR). The centre, a first in South Africa, was conceptualised and jointly funded by the Water Research Commission (WRC) and the CSIR Built Environment unit. It is located on the CSIR Built Environment Innovation Site in Pretoria.

The purpose of the centre is to provide visitors with the opportunity to view full-scale examples of sanitation products and technologies and acquaint themselves with various sanitation systems available in South Africa. The displays, combined with information sheets and other supporting documentation, provide invaluable information that could assist with decisions regarding sanitation options.

The centre is aimed at a wide range of stakeholders and role players, including government officials and politicians at local, provincial and national levels, schools, universities, engineering consultants, developers, non-governmental organisations (NGOs), community organisations, as well as members of the public.

A comprehensive range of sanitation technologies and products are on display at this open-air facility, including systems that could be regarded as conventional, as well as some alternative approaches.

Amongst the exhibits, examples can be viewed of dry sanitation, urine diversion and/or separation technologies, water-borne systems and ecological sanitation. The centre includes examples provided by commercial suppliers, as well as exhibits constructed by the CSIR.

4.4.2 Technologies and products displayed

Sanitation includes the collection and removal, or disposal, of human excreta (faeces and urine) to promote healthy living conditions. The purpose of any sanitation system is to contain human excreta and prevent the spread of sanitation-related diseases.

A range of technologies can be utilised to achieve this, as demonstrated at the Sanitation Technology Demonstration Centre. The exhibits are grouped into five display areas as follows:

Exhibit area A
This area deals with sanitation technologies that dispose of human waste without the use of water as a carrier. The purpose of the exhibits in this area is to display some of the technology components that would normally be concealed/underground.

Exhibit area B
Included in this area are examples of various top structures ("huts") available for the technologies demonstrated in exhibit area A.

Exhibit area C
In this area, the focus is on sanitation technologies that dispose of human waste by diverting urine away from faeces and re-using the nutrients in the excreta as fertiliser.

The purpose of the exhibits in this area is to display some of the technology components that would normally be concealed / underground.

Exhibit area D

This area contains examples of various top structures ("huts") available for the technologies demonstrated in exhibit area C.

Exhibit area E

In this area, technologies that dispose of human waste by using water as a carrier are on display.

4.4.3 Relevance to Sanitation Technology Evaluation Study

The technologies on display include Ventilated Improved Pit (VIP) latrines, top structures and some emerging technologies that offer a complete sanitation solution. The technologies on display are not in use, but are on display to demonstrate the appearance and general functioning of the technologies. The commercial technologies on display were selected on the basis that they are currently supplying the sanitation industry and were willing to install their unit free of charge. The inclusion of a technology at the demonstration centre does not in any way merit its performance and the CSIR does not present any data to this effect.

The following is a list of the technologies / suppliers that are relevant to this study:

Waterless Systems

- VIP Toilet *(not the focus of this study)*
- Blair Toilet *(Variation on VIP)*
- Fossa Alterna
- Ecosan Toilet www.ecosan.co.za/
- Eco Mite www.calcamite.co.za/
- Enviro Loo www.enviro-loo.com/
- Waterless Sanitation https://sites.google.com/site/waterlessanitation/
- African Sanitation www.0860dryloo.co.za/

Waterborne Systems

- NWS Bacterial Toilet www.greensanitation.co.za/
- Biofil Digestor (digestor only) www.biofiltechnologies.com/
- Bio Mite Recycling System www.calcamite.co.za/
- Lowflush Toilet www.calcamite.co.za/

These technologies are discussed in more detail in the Sanitation Technology Dossiers.

4.4.4 CSIR Sanitation Capacity Building Study

Louiza Duncker from the CSIR Built Environment Unit is responsible for the demonstration site and is herself an expert in the sanitation field. The CSIR is currently busy with a Capacity Building Study which will investigate the effectiveness of sanitation selection tools, with a view to compiling a sanitation selection tool to assist stakeholders with the selection of sanitation technologies which are appropriate to their specific context. This study will not go into the detail of specific technology suppliers but will discuss the generic groups (i.e. dry sanitation, waterborne toilets, etc.).

The CSIR's capacity building study will complement the Sanitation Technology Evaluation Tool, and as such our research team has agreed to work closely to develop the respective decision making and evaluation tools.

4.5 EXISTING TECHNOLOGIES

4.5.1 Introduction

Several Existing Technologies have been identified as indicated in the section below. The technologies are discussed in further detail in the **Dossier Reports** provided in **Annexure F**.

4.5.2 Complete Systems

The following complete systems will be the main focus of the sanitation technology assessment since they seek to provide a complete solution to onsite sanitation (incorporating the components for user interface, collection and storage or treatment).

Waterless Toilets

VIP Latrines (included for context only)
ZerH_2O Waterless Toilet
Gran Taldoro de la tierra
Enviro Loo
Eco-Mite Toilet
Biofil Toilet
Solar San
Eco San Waterless Toilet
Afrisan Toilet
Various BMGF projects (included for discussion)

Waterborne Toilets
Low-flush – Calcamite
Low-flush – DSA
Smartsan – New World Sanitation
Bio-Mite Recycling System (BRS)
The Bubbler
HS toilet
DSA toilet

4.5.3 User Interface

The user interface will, in some form be incorporated in the complete system, with the exception of the Chemical Toilet and Porta Potty. A summary of these systems will be incorporated into the sanitation technology assessment for completeness.

Waterless Toilets
Dry Toilet
Urine Diverting Dry Toilet (UDDT)
Chemical Toilet
Porta Potty

Waterborne Toilets
Conventional Cistern Flush Toilet
Low Flush
Pour Flush
Eazi Flush – EnviroSan

4.5.4 Collection and Storage / Treatment

These systems are normally linked to a user interface to form a complete system. A summary of these systems will be incorporated into the sanitation technology assessment for completeness; however detailed assessment of the different treatment systems will not be undertaken since this is well documented elsewhere and the performance of these components will depend of the linkage with the user interface.

Waterless Toilets
Single Pit (included for discussion)
Double Alternating Pit (Included for discussion)
Fossa Alterna
Bio-fill Digestor
Peepoo
LaDePa
Black Soldier Fly Lavae (BSF)

Waterborne Toilets

Leach pits
Septic Tanks
Soakaways / French Drains
Advanced Baffled Reactors (ABR)
Anaerobic Filter
Biodigestors
Horizontal Constructed Wetlands
Vertical Constructed Wetlands
Facultative Lagoons & Maturation Ponds
Package Plants (Excluded from study but will be included for discussion)
Ecological Wastewater Treatment Systems

4.6 EMERGING TECHNOLOGIES

There are numerous emerging technologies that are being developed with funding from the Bill and Melinda Gates Foundation as part of the Reinvent the Toilet Challenge. Most of these technologies are in the prototype development stage and have limited field trials.

In the next chapter, a synthesis of the literature is provided.

5 SYNTHESIS OF LITERATURE REVIEW

5.1 INTRODUCTION

This chapter presents an overview of literature review.

5.2 LEGISLATION

The South African Legislation, provides a useful context against which the success of a sanitation technologies should be measured. This highlights that people have a right to access to sanitation, and describes the following requirements of sanitation:

- Collection, removal and disposal of human excreta
- Safe for the user and operator
- Reliable
- Affords privacy and protection from the weather
- Minimises odours
- Easy to keep clean
- Minimises the risk of sanitation related diseases
- Environmentally sound

5.3 SANITATION STANDARDS AND GUIDELINES

The existing guidelines focus primarily of the selection of suitable sanitation system for a particular site based on the physical conditions (such as settlement density, availability of existing infrastructure, ground conditions, climate, etc.), potential health benefits, risks, cost implications, operation, user acceptance, and environmental performance. These guidelines however do not provide a framework to evaluate the performance of an individual technology, instead they enable the selection of a generic sanitation system such as composting toilets verses waterborne sewage.

The Maximum Performance Test provides a useful protocol for testing the flush performance of waterborne toilets against a minimum required standard. However, the literature review did not identify anything similar for evaluating the performance of the composting systems or other technologies. Without such guidance, it is impossible to assess a technology and ascertain whether they achieve the required standard, the minimum standard has not been set.

5.4 ON-SITE SANITATION TECHNOLOGIES

The Compendium of Sanitation Technologies (2014) provides a useful standardisation of the language and categories of sanitation but does not go into the depth of the performance of individual technologies. Similarly, the CSIR Demonstration Centre and the Collection of Contemporary Toilet Designs provides a useful reference of different sanitation innovations but does not evaluate the performance of these technologies. These resources do however provide a useful guide to the vast range of technologies that exist and therefore the complexity associated with developing an evaluation protocol that can be applied equally to the different technologies.

5.5 CONCLUSIONS AND RECOMENDATIONS

With reference to the literature review it is recommended that the evaluation protocol be developed around the following criteria:

Criteria	**Description**
1) Safety	Prevention of physical harm
2) Heath	Prevention of excreta related disease
3) Acceptability	Acceptability to user and implementing agent
4) Environmental Performance	Ability to protect and enhance the environment
5) Reliability	Long term performance of technology
6) Cost	Economic considerations

There is a need for a sanitation technology evaluation protocol that enables a thorough and transparent assessment of different sanitation technologies. This protocol must clearly establish a minimum performance benchmark to guide the selection and future development of good technologies.

In the next chapter, the standardisation of the assessment protocol is presented against these minimum performance benchmarks

6 STANDARDISATION OF SANITATION PROTOCOL

6.1 SUMMARY

It is critical that the Household Sanitation Assessment and Evaluation Tool aligns with existing legislation and guidelines wherever practical. This chapter identifies these key standards to which the tool must align to.

6.2 EXPERTISE OF THE ASSESSOR AND EVALUATOR

To aid standardisation of the sanitation evaluation process, it is also important to define the expertise of the individual undertaking an assessment, or specific portions of the assessment.

The Sanitation Technology Assessment and Evaluation Protocol is considered in two parts each requiring a different expertise:

Part 1: Sanitation Functionality Assessment
This is a detailed assessment of the functionality of the technology and includes an assessment of the process design, material selection and quality of manufacture for a specific technology. This assessment will therefore be undertaken by persons with suitable expertise in wastewater treatment design. Other portions of this assessment may be undertaken by materials scientists and an appropriate laboratory or test facility.

This assessment will usually only be undertaken once for a specific technology.

Part 2: Sanitation Suitability Evaluation
This evaluation considers a range of criteria to evaluate the applicability of the sanitation technology in a specific context. This will consider the physical environment, the institutional structure and supporting infrastructure. This evaluation must be undertaken by an experienced sanitation practitioner who is suitably qualified to evaluate the specified criteria.

This evaluation may be undertaken for a specific technology to evaluate its suitability in a particular application.

6.3 ALIGNMENT WITH EXISTING STANDARDS

The sanitation technology assessment and evaluation protocol are intended to supplement existing guidelines by providing specific information related to on-site sanitation technologies.

Table 6.1 provides a list of applicable standards and guidelines against which the technology should be evaluated. This is not an exhaustive list, and additional standards may apply subject to the design of the sanitation technology. Specific reference must also be made to local by-laws that may apply to the sanitation technology, in particular where the use of soakaways or infiltration systems for the discharge of effluent may be prohibited.

Table 6.1: Relevant Standards and Guidelines

Reference	Date	Title	Publisher
Act 108	1997	The Water Services Act	DWS
Red Book	2000	Guidelines for Human Settlement Planning and Design	CSIR
Technical Guidelines	2004	Guidelines for the development of water and sanitation infrastructure	DWAF (now DWS)
SANS 121	2011	Hot Dip Galvanising	SABS
SANS 310	2011	PE Storage Tanks	SABS
SANS 497	2011	Glazed Ceramic Sanitaryware	SABS
SANS 966-1	2014	Components of Pressure Pipe Systems (PVC-U)	SABS
SANS 1186	2011	Symbolic Safety Signs	SABS
SANS 3001	2014	Soil Testing	SABS
SANS 5221	2011	Microbiological analysis of water – General test methods	SABS
SANS 5667-10	2007	Water quality – Sampling Part 10: Guidance on sampling of waste waters	SABS
SANS 5667-13	2007	Water quality – Sampling Part 13: Guidance on sampling of sludges from sewage and water treatment work	SABS
SANS 6048	2010	Water – Chemical oxygen demand	SABS
SANS 6049	2010	Water – Suspended solids content	SABS
SANS 10100-1	2000	The Structural Use of Concrete Part 1: Design	SABS
SANS 10100-2	2014	The Structural Use of Concrete Part 2: Materials and Execution of Work	SABS
SANS 10112	2011	The installation of PE and PVC pipes	SABS
SANS 10162-1	2011	The Structural Use of Steel	SABS
SANS 10252	2012	Water Supply Installations	SABS
SANS 10400-P	2010	The Application of the National Building Regulations – Part P: Drainage	SABS
SANS 10400-Q	2011	The Application of the National Building Regulations – Part Q: Non waterborne means of sanitary disposal	SABS
SANS 10142-1	2012	The Wiring of Premises Part 1: Low Voltage Installations	SABS
SANS 12944-4	1998	Paints and Varnishes	SABS
SANS 52566	2004	Small Wastewater Treatment Systems	SABS
SANS 53121	2009	GRP Storage Tanks	SABS
General Authorisation	2013	General Authorisations in Terms of the National Water Act, 1998 (Act No. 36 of 1998)	DEA
By-Laws		Applicable Local By-laws	

6.4 STANDARD DESIGN PARAMETERS

This protocol applies to **onsite, household sanitation.** This broadly defines the context of the technology. However, it is evident from the literature review that there is a need to standardise the influent loading rates, and minimum standards for effluent discharge.

Schools and clinics will have different loading rates due to the peak loading patterns and higher concentrations of urine to faeces and as such the influent loading rates included in **Table 6.2** will not be applicable to these institutions. Where a toilet is shared between multiple households, or the household has more the 6 people, these loading rates will underestimate the loadings that the technology will be subjected to and therefore the peak number of users per toilet must be qualified.

Table 6.3 presents the General Authorisation Limits for effluent discharge. In the event that the technology makes specific claims about the effluent quality, the treatment performance of the technology should be measured against this claim, and also compared to the General Authorisation Limits.

Table 6.2: Typical Daily Influent Loading Rates (based on 6 people per household)

				Waterborne				
Determinant	**Unit**	**UDDT**	**Dry San***	**1 ℓ Flush**	**2 ℓ Flush**	**Dual Flush**	**6 ℓ Flush**	**With. Sullage**
Liquid Volume	Litres/day	0	10	40	70	100	190	790
Wet Solids	Kg/day	1,2	1,2	-	-	-	-	-
COD	mg/ℓ	720 000	72 000	18 000	10 000	7 200	4 800	900
Suspended Solids	mg/ℓ	-	-	13 500	7 700	5 400	2 800	700
TKN	mg/ℓ	60 000	6 000	1 500	900	600	300	80
Total P	mg/ℓ	12 000	1 200	300	170	120	60	15
Soap, Oil & Grease	mg/ℓ	-	-	2 000	1 100	800	400	100
E. coli	No./100 mℓ	$1x10^{10}$	$1x10^{10}$	$3x10^{7}$	$2x10^{7}$	$1x10^{7}$	$5x10^{6}$	$1x10^{6}$

Table 6.3: Minimum Standards for Effluent Discharge

Determinant	**Unit**	**General Limit**	**Special Limit**
Faecal Coliforms	CFU/100 mℓ	1000	0
Chemical Oxygen Demand*	mg/ℓ	75	30
pH		5.5-9.5	5.5-7.5
Ammonia (as Nitrogen)	mg/ℓ	6	2
Nitrate/Nitrite as Nitrogen	mg/ℓ	15	1.5
Chlorine as Free Chlorine	mg/ℓ	0.25	0
Suspended Solids	mg/ℓ	25	10
Electrical Conductivity	mS/m	(70 mS/m above intake) max 150 mS/m	(50 mS/m above intake) max 100 mS/m
Ortho-Phosphate as phosphorous	mg/ℓ	10	1 (med.) 2.5 (max)
Soap, Oil & Grease	mg/ℓ	2.5	0

**after the removal of algae*

More recently, the American National Standards Institute (ANSI) and TUV-SUD Water Services, with support from the Bill & Melinda Gates Foundation, are in the process of developing an International Organization for Standardisation (ISO) International for non-sewered sanitation systems (**Table 6.4**). In the draft ISO for non-sewered sanitation systems, the liquid output performance is expected to have the following threshold:

Table 6.4: Effluent threshold for discharge from non-sewered sanitation systems

	Category A usage: Threshold for unrestricted urban uses	**Category B usage: Threshold for discharge into surface water or other restricted urban uses**
COD (mg/l)	≤50	≤150
TSS (mg/l)	≤10	≤30
Health thresholds		
E. coli (CFU/g)	100	
Ascaris suum (viable ova)	<1	
Crystospridium (oocysts)	<1	

7 STANDARD SYMBOLOGY & TERMINOLOGY

7.1 SUMMARY

To aid clear communication of the Assessment & Evaluation Protocol, a series of symbols have been developed to provide a quick visual reference to the different components of the sanitation technology, together with details related to the suitable siting and operation of the technology.

7.2 TECHNOLOGY FEATURE

The sanitation technology is categorised according to its components and functionality. The terminology used in the EAWAG *Compendium of Sanitation Technologies* has become the accepted language for describing sanitation technology. EAWAG's category names and colour schemes are therefore used in this protocol to assist with consistency across the different publications. A single sanitation technology may comprise just one or many of the features described below by the five square symbols.

7.2.1 User Interface

The part of the sanitation technology that the user interacts with as part of normal use. This includes the toilet pedestal and any flush mechanism or levers that need to be operated after use.

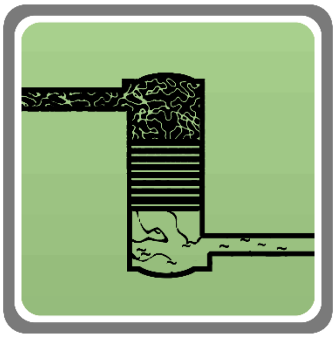
7.2.2 Collection and Storage / Treatment

This describes the method of collecting and storing the faecal waste and urine. Full or partial treatment may be integrated with this process.

7.2.3 Conveyance

The method by which the waste is transported from the point of use to subsequent treatment and /or disposal. This will typically be via a piped sewer system or carting the waste by hand or machine to a suitable treatment / disposal site.

7.2.4 Treatment



The process of treating the faecal waste for subsequent use or disposal. This will primarily involve the removal of faecal coliforms but may also include trash removal and dehydration processes.

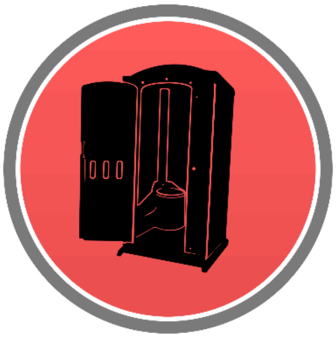
7.2.5 Use / Disposal

This category describes the use or disposal of the faecal waste that is removed from the sanitation technology

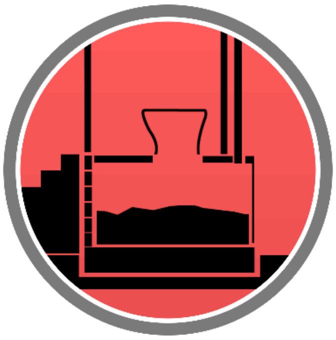
7.3 TECHNOLOGY DESIGN AND OPERATION

The category of the technology design is considered in addition to the other key parameters which provide quick reference to the suitability of the technology in different applications (i.e. shallow groundwater, or high-density settlements). The circular symbols are presented below under five colour coded categories.

7.3.1 Sanitation Category



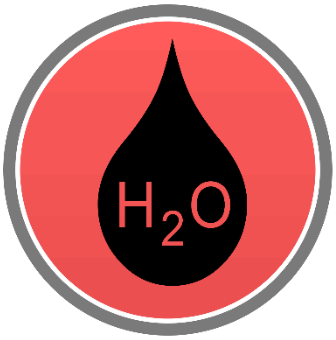
Chemical Toilet
Requires chemicals to be added to the toilet to control odours and to assist with the breakdown of faecal waste.



Dry Toilet
Toilet does not require water or chemicals to be added during normal operation. The faecal waste dries while it is being stored.

Urine Diversion Dry Toilet
Similar to the dry toilet, this chemicals to be added during separate from the faecal waste process and help to control urine may be harvested for

(UDDT)
does not require water or normal operation. Urine is to assist the drying odours. The collected fertiliser.



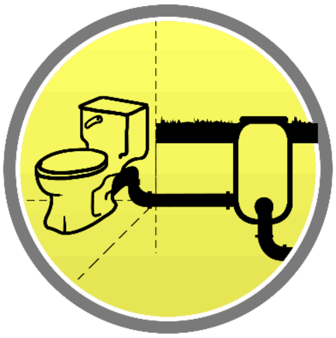
Waterborne Toilet
The toilet requires water for flushing and possibly conveyance of the faecal waste. The water is usually used to create a water seal to prevent odours inside the toilet cubicle.

7.3.2 *Standard Operation Details*

Emptying Frequency
Most systems require periodic emptying to remove faecal sludge from the storage facility. This may be as frequent as every 2 to 3 days or longer than a year depending on the design and loading rate of the toilet

Requires Consumables
Some sanitation technologies require the supply of consumable items for their day to day use, this may be lime or sawdust used to control odours, or bags/membranes used to collect and store the faecal waste.

7.3.3 Method of Emptying / Disposal



Requires a Sewer Connection
The faecal waste is discharge into a pipe that must be connected to a sewer for conveyance to a treatment facility, this may be a centralised municipal treatment works, or a treatment facility that is integrated with the technology.

Requires Mechanical or
The faecal waste must be mechanical means to toilet and transport it to a either on site or off site.

Manual Emptying
emptied by hand or by remove the waste from the treatment / disposal facility,

7.3.4 Location of Treatment

Treatment on site
Faecal sludge is treated on site as part of the sanitation technology

Treatment off site
Faecal sludge must be carted away from the site for treatment at a separate facility that is not part of the sanitation technology design.

7.3.5 Siting of the Technology

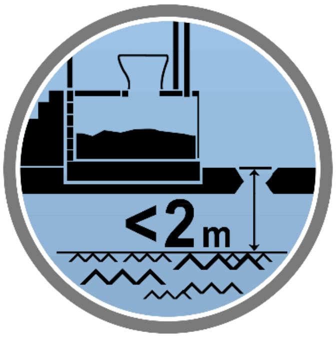
Can be installed inside the home
The technology is considered to be suitable for installation insider the home without problem odours. The technology is also sufficiently compact or can be configured so that the user interface can be installed inside the home.

Suitable for high density settlements
The technology is considered to be sufficiently robust and compact that it can be installed within high density urban settlements.

Suitable for shared use
The design of the technology and its operation is considered suitable for installation in shared or communal facilities.

Suitable for a single household
The design of the technology and its operation is considered suitable for installation in a single household.

Suitable for Shallow Groundwater Conditions



The technology is suitable for installation where there is shallow groundwater or shallow rock that would prohibit excavation of deep pits.

8 FUNCTIONALITY ASSESSMENT

8.1 INTRODUCTION

The functionality of the sanitation technology considers the ability of the sanitation technology to perform the intended purpose. With reference to the Standard Symbology and Terminology, **all household sanitation technologies applicable to this protocol must have a user interface (toilet pedestal) and means of collecting and storing the waste for convenient disposal or treatment**.

This assessment should be applied to all sanitation technologies not fully covered by the standard guidelines identified in **Table 3.1**. For this reason, Ventilated Improved Pit toilets and Septic Tanks do not need to be evaluated by this assessment protocol. Similarly, this assessment should not be applied to stand-alone effluent treatment technologies that are not packaged with a user interface. These technologies should be evaluated in accordance with the WRC guidelines for domestic wastewater package plants as presented WRC report numbers K5/1869, TT 620/14 and TT 621/14.

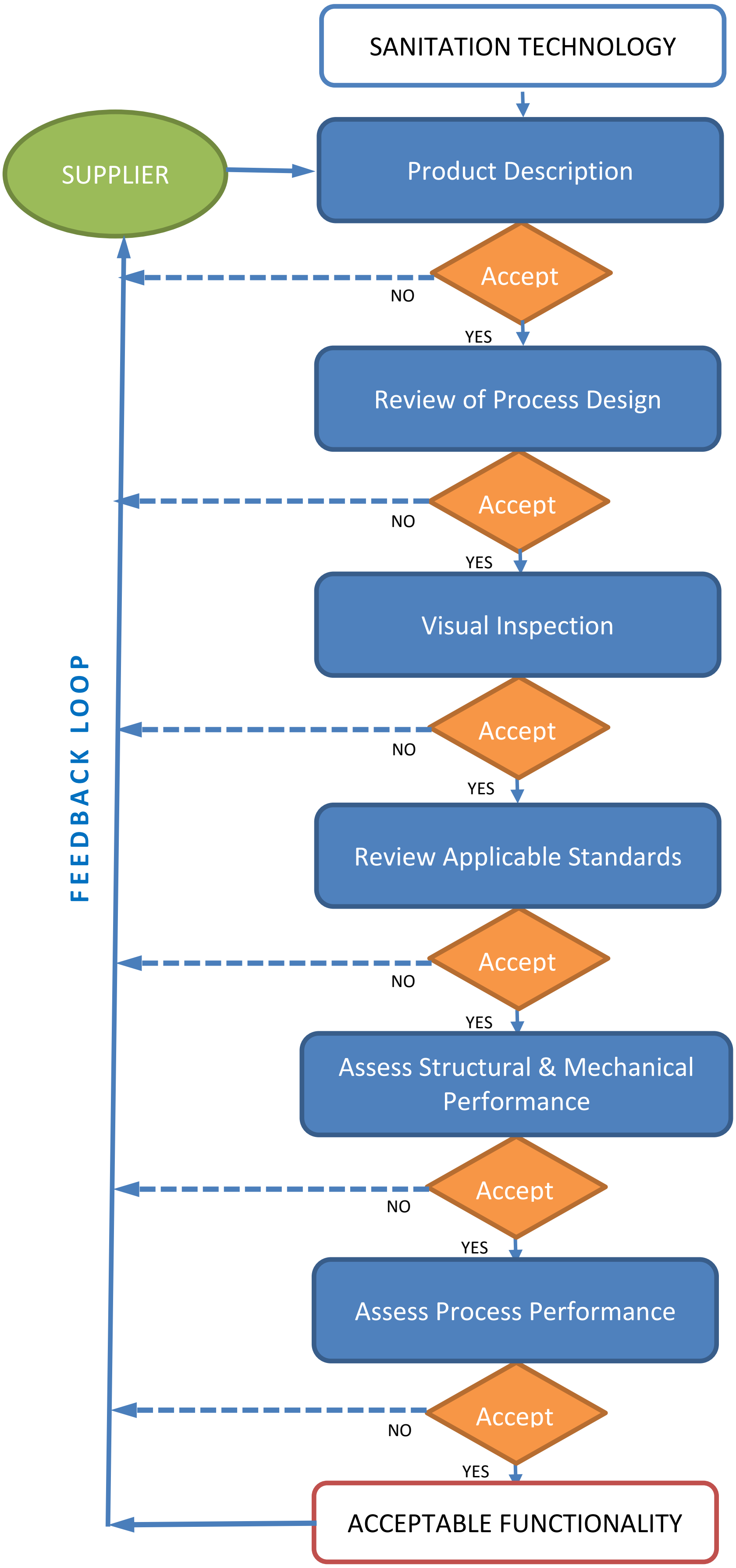
Most sanitation technologies applicable to this protocol will include a treatment process for the on-site disposal of treated effluent or to enable the recycling of liquid within the sanitation technology. The functionality assessment of these technologies will consider whether the technology is able to consistently treat the faecal waste to a sufficient quality for disposal or re-use. Where a sanitation technology contains the faecal waste for off-site disposal, the integrity of this container is considered together with an evaluation of filling rates and emptying cycles. The presence of the supporting infrastructure and the institutional structure required for the sustainable operation of the technology is considered under the suitability evaluation of this protocol.

8.2 ASSESSMENT PROCEDURE

The assessment of the technology requires input from both the supplier and the assessor. The flow chart presented in **Figure 8.1** presents a summary of the assessment procedure and feedback loops to the technology supplier. The assessment is sequential. After satisfactory performance for a specific criterion, the assessment will proceed to the next stage. Unacceptable performance at any stage will be fed back to the supplier to inform modification of the sanitation technology for re-submission by the supplier.

Where the overall functionality of the sanitation technology is considered to be acceptable, the technology will be recommended for household use within a defined context. The acceptance of the technology may also be accompanied by recommendations for the supplier to further improve the performance and robustness of the technology.

Figure 8.1: Functionality Assessment Procedure.



8.2.1 Product Description

The supplier must provide a full description of the product that will include the following information:

- A clear description, illustration and photographs of the technology and its components.
- A full description of the intended context of the sanitation technology, (number of users, ground conditions, supporting infrastructure, etc.)
- A full description of the process design, which will include the following information:
  - A scientific explanation of how the product works and details of limiting parameters (if any).
  - Mass balance and loading diagrams clearly indicating the function of each component and the complete system. This will include quantification of the following parameters which may enter and leave the system:
    - Water
    - Materials and Consumables
    - Chemical and Microbiological determinants.
- A full description of how the technology is operated, including details of all access points, maintenance intervals and any operational structures required for the effective performance of the technology.
- Full details of the hygiene benefits and impact on public health with specific reference to effective barriers against faecal related diseases, fly and vector infestations and odour control.
- The details of all applicable standards to which the technology complies, together with certification where available.
- Where scientific testing has been undertaken by a qualified independent third party, the supplier should provide full details of this evaluation, and any modifications to the design that have been undertaken since the evaluation was completed.

8.2.2 Desktop Review of Process Design

The process design of the sanitation technology will be reviewed with reference to the influent and effluent parameters identified in **Table 6.2** and **Table 6.3**. Any discrepancy between the suppliers' description and the reference parameters will be assessed together with the expected performance of the technology. The desktop review means the technologies can be evaluated during their conceptual and prototype stages. The purpose of this assessment is to identify fundamental flaws in the process design so that these can be identified before expensive laboratory and field assessments are undertaken. This theoretical assessment may also be used to identify why a given technology is not performing as expected in the field. This assessment must be undertaken by an experienced sanitation engineer and cannot easily be guided by empirical data due to the variety of technologies on the market.

8.2.3 Visual Inspection

The supplier must provide a sample of the sanitation technology for visual inspection by the assessor or must provide details of where this technology can be inspected. Full details of existing installations, the period of operation and any failures that have occurred should be provided as applicable. The assessor will conduct a visual inspection of the technology to appraise the quality of materials and fabrication.

8.2.4 Review of Applicable Standards

The assessor will consider which standards apply to the technology and the extent to which the technology complies with these standards. This will include, but not be limited to the standards summarised in **Table 6.1**.

8.2.5 Assessment of Structural and Mechanical Performance

In the absence of long term field trials, it may be necessary to conduct laboratory tests to assess the strength and robustness of materials used to fabricate the technology. Where the technology includes bespoke mechanical components that are not directly covered by an appropriate SANS document, it may be necessary to undertake cyclic testing to assess the performance of the technology against the intended design life.

8.2.6 Assessment of Process Performance

The overall performance of the technology to provide the required treatment function, will preferably be undertaken at an existing installation that has been subjected to extended and continual use. Where the technology is located in an area subjected to large climatic variations, it may be necessary to test the performance of the technology during both warm and cool conditions. If it is only possible to complete a single test, this should preferably be undertaken in the winter when ambient temperatures are cooler, as most treatment process perform better in warmer conditions.

Where the technology has not been subjected to extended field trials, it may be possible to establish a laboratory test facility for the technology, whereupon it will be fed with an appropriate influent as indicated in **Table 6.2**. This test must be conducted for a minimum of 12 months to allow the measurement of seasonal performance. However, the cost of establishing and running a 12-month laboratory test is likely to be prohibitive, and in any case the extended field trials will provide the only true measure of functionality in a real application.

This assessment will focus on the characteristics of the influent and the treated effluent to ensure that the technology is achieving the minimum performance requirements identified in **Table 6.3**. Where the supplier claims a higher level of performance, this will also be evaluated.

8.3 DETAILED ASSESSMENT OF PROCESS PERFORMANCE

Figure 8.2 provides a summary of the different sanitation processes and the typical tests required to assess the performance of a technology. The technologies are categorised according to their treatment process, namely Chemical, Physical, Biological and Mechanical. Examples of the different sanitation treatment technologies which use these processes are given together with the typical tests required to assess the performance of the different technologies. Full details of the test procedures are given in **Annexure B**.

Figure 8.2: Process Design Assessment Criteria.

	IDENTIFY TREATMENT PROCESS					
Process	**CHEMICAL**		**PHYSICAL**	**BIOLOGICAL**		**MECHANICAL**
Category	**CHEMICAL**	**DRY SANITATION**			**WATERBORNE**	
Example Technologies	Chemical Toilets Porta Potty	Pyrolysis Hydrothermal Carbonisation	Dehydration Desiccation Urine Diversion Bag Separation	**AEROBIC** Leach Pits Compost Toilets Activated Sludge Biofilm	**ANAEROBIC** Septic Tanks Biodigestor ABR Bio-Augmentation	Membrane Ultrafiltration
Process Tests	Loading Rates *(Form B.1)* & Sludge Accumulation Rates *(Form B.2)*					
	Water tightness *(B.3)*	Temperature *(Form B.5)*			Water tightness *(Form B.3)* Air tightness (Form B.4)	Water tightness *(B.3)* Filter Integrity *(B.6)*
Effluent Tests	Moisture content *(Form B.7)* Faecal Coliforms *(Form B.8)*				Determinant identified in Table 2.3 *(Form B.9)* (COD, TSS, *E. coli*, N, P, etc.)	
	Protozoa and Helminths (Where supplier claims waste is sanitised) (Form B.10)					

9 EVALUATION CRITERIA

9.1 INTRODUCTION

The sanitation technology evaluation criteria need to be applied to a range of different technologies with varying operation principles. For this reason, it is not possible to produce a SABS style document that prescribes specific design requirements for each component. The evaluation criteria must apply equally and fairly to all sanitation technologies.

Based on the findings of the literature review and an assessment of the performance requirements of a sanitation technology, six evaluation criteria have been identified. While a successful sanitation technology must perform well under all six criteria, they are also listed sequentially whereby the technology MUST perform satisfactorily in the initial criteria for their performance on the remaining criteria to be of any relevance. I.e. if a technology presents undue risk of physical injury due to unprotected excavations or unstable construction, it is irrelevant that the same technology may have excellent Environmental Performance and is very low cost.

A minimum standard is identified within the evaluation criteria. If the technology should fail on any one of these criteria it will be considered unacceptable and inappropriate for use. The technology will be evaluated according to the features that are included in its design.

9.2 SAFETY

The technology must not present undue risk to children or adults during the normal use of the facility.

It is fundamental that the sanitation technology does not cause physical harm to the user, in particular children and the elderly who are more vulnerable to injury. Key considerations will include whether the technology presents a risk of falling into deep excavations or water. For example, criteria would include whether the outlet of the pedestal is small enough to prevent small children from falling through, and whether covers to septic tanks are secure and robust. Other safety considerations will be associated with the strength of the pedestal to support the user and the mode of failure in the event that the pedestal or other component should break during use or maintenance.

9.3 HEALTH

The technology must effectively contribute to the prevention of excreta related disease for the user and neighbouring community.

Faecal sludge is unpleasant to deal with but is not necessarily in and of itself hazardous. A significant percentage of faecal sludge is comprised of harmless strains of *E. coli* and other bacteria which populate the human digestive tract and assist with the processing and absorption of food. Some of these bacteria assist with the further decomposition of the faecal material after it has been deposited in the pit. The fresh faeces of a healthy individual contains in the order of 100 000 000 faecal coliform bacteria per gram, none of which are harmful.

Sludge becomes dangerous when the people who use the toilets are carriers of infectious diseases. Unfortunately, there is typically a high incidence of infectious diseases amongst the very communities where the sanitation technologies are more commonly used. Some of the pathogens encountered are:

- Bacteria: Shigella (Bacillary dysentery / Shigellosis), certain strains of *E. coli* (Eschericha Coli), salmonella, typhoid and cholera.
- Viruses: Rotovirus, Hepatitis A & E.
- Protozoa (parasitic): Giardia, Amoeba (Entamoeba Histolytica).
- Helminths (intestinal parasitic worms): e.g. **Ascaris lumbricoides** (roundworm), *Trichuris trichiura* (whipworm), *Necator americanus*, Taenia (tapeworm) and *Ancylostoma duodenale* (hookworm).

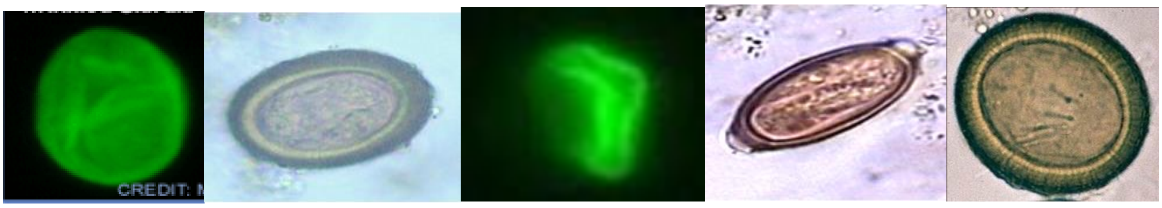


Figure 9.1: Helminths commonly occurring in faecal sludge, from left Giardia; Taenia sp.; Cryptosporidium; Trichuris trichiura; and Ascaris

In South Africa, Ascaris, Giardia, Trichuris, Cryptosporidium and Taenia are the most prevalent parasites infecting humans, with sludge samples extracted from latrines located in densely populated informal settlements often revealing massive parasite loads. An investigation into helminthic and protozoan parasites conducted by the University of Kwa-Zulu Natal (PRG, 2008) based on samples from VIP latrines used by 120 households indicated that:

- 10 % of samples had neither type of parasite
- 60% had Ascaris
- 55% had Giardia
- 50% had Trichuris
- 21% had Cryptosporidium
- 11% had Taenia; and
- 60% had either Cryptosporidium or Giardia

The primary reason for a sanitation facility is to provide a hygienic means for collecting and disposing human excreta and urine. Consequently, it is important that the technology minimises contact with faeces through good containment of faeces and effective vector control (to prevent flies from coming in contact with faeces and subsequently contaminating food). If the technology does not easily soil and is easy to clean, this also contributes to the provision of a hygienic toilet. If the location and operation of the toilet is convenient and simple, it is more likely to be used properly, therefore contributing to continued health benefits.

9.4 ACCEPTABILITY

The technology must (on reasonable justification) **be deemed acceptable by both the user and implementing agent who will be responsible for the supply and maintenance of the technology.**

The acceptability of a technology can often become politicised, and it is therefore important to establish the acceptability of the technology for both the user and the implementing agent. The provision of a private, convenient toilet that is of a high quality which is equitable to the standard of sanitation in neighbouring areas, and which is free from odours is likely to lead to user acceptance. The implementing agent is likely to weigh these considerations against the cost and practicality in terms of supporting infrastructure that is required to service the toilets and treat the faecal waste.

9.5 ENVIRONMENTAL PERFORMANCE

The technology must effectively protect and where possible enhance the environment.

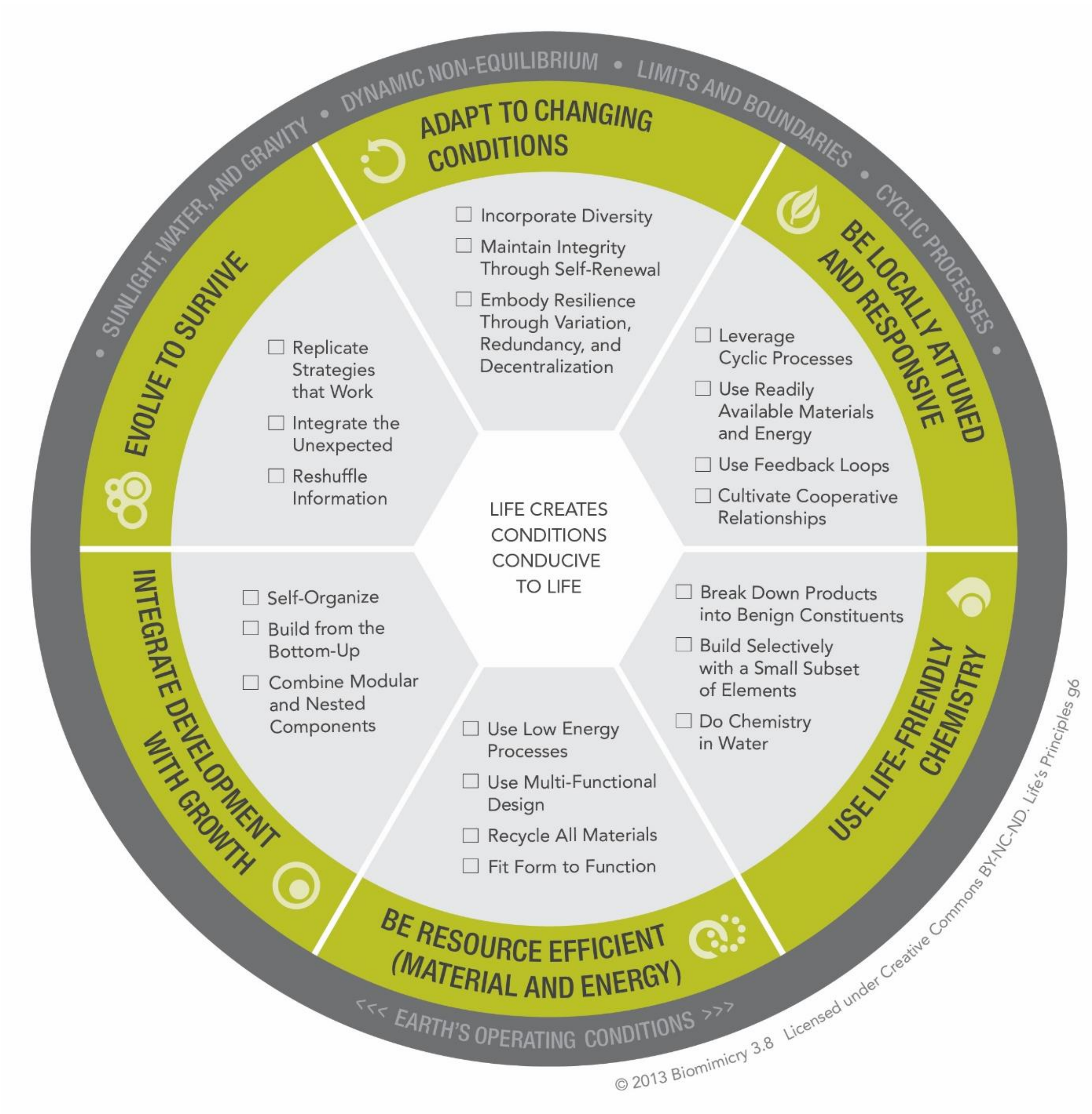
Sanitation technology must prevent leaching of faecal contaminants and chemicals into groundwater and rivers and must minimise the waste that is disposed to landfill during both operation and decommissioning of the facility. A good sanitation technology will apply all of 'life principles' as illustrated in **Figure 9.2**. The principles can be applied to all aspects of a good sanitation technology. Specific to the environmental performance, the technology must be 'resource efficient' and 'use life-friendly chemistry'. A good technology will therefore use minimum natural resources and will enable recovery of resources such as energy and nutrients. The technology should also use biodegradable or recyclable materials.

9.6 RELIABILITY

The technology must demonstrate, or have good potential for reliable, long term performance.

The success or failure of a technology may be attributed to a large number of factors, including the robustness of the technology itself, the correct application of the technology, effective training and proper operation by the user, operational support by the implementing agent, and availability of spares and maintenance support. Consequently, it is almost impossible to hypothesise about the reliability of a sanitation technology without actual field trials that demonstrate the technology is reliable. A minimum of two years' successful trial is required to prove that the technology is reliable; however shorter trials may highlight failures or weaknesses in the technology.

Figure 9.2 – Life's Principles, Biomimicry Design Lens.



9.7 COST

The technology must be available at a reasonable cost with consideration of the full life cycle (supply, operate and maintain)

There is a tendency for buyers to evaluate technologies on the upfront cost, or perhaps with consideration of a 12-month or 24-month maintenance agreement. The actual cost of the technology for the full life cycle is however a fundamental consideration that must be considered to ensure effective use of funds. The capital cost of buying the sanitation technology may be relatively small in comparison with the cost of operating and maintaining the technology over a 15 to 20-year period.

Key considerations in the cost calculation will be the cost of consumable items such as lime or collection bags, the cost of emptying and disposing the waste, and the cost of replacement parts. Frequent emptying cycles can result in very high operation costs.

9.8 SUMMARY

Table 9.1 – Summary of Evaluation Criteria.

Criteria	Description	Key Considerations	Evaluation Procedure
1) Safety 	Prevention of Physical harm	-Safe for Children -Proximity to home (crime risk) -Deep Excavation -Risk of Drowning	Risk Assessment *Likelihood and severity of a particular hazard*
2) Health 	Prevention of excreta related disease	-Easy to Clean -Hygienic -Convenient (more likely to be used) -Good Fly Control -Prevents / Minimises contact with undigested faecal matter during use and maintenance	Faecal Contact Assessment *-Frequency of contact,* *-Concentration of faecal sludge,* *Likelihood of ingestion (handling procedure)*
3) Acceptability 	Acceptability to user and implementing agent	-Privacy -Ease of use / comfort -Convenience -Versatility -Safety -Equity / Quality -Odour Control -Employment Creation -Supporting infrastructure requirements (i.e. WWTW?)	Scorecard / Questionnaires
4) Environmental Performance 	Protect and Enhance the Environment	-Freshwater Consumption -Resource Recovery Potential -Pollution Control -Hazardous Materials	Scorecard
5) Reliability 	Long term performance of technology	-Historic Performance -Number and age of working installations -Robustness -Resistance to Vandalism -Availability of spares & consumables -Material durability (UV stable, fire resistance, etc.) -Design Life	Scorecard
6) Cost 	Economic Considerations	-Capital Cost -Operational cost (consumables) -Maintenance costs (spares, emptying)	Life Cycle Cost

10 EVALUATION PROCEDURE

10.1 HAZARD RISK ASSESSMENT

A Risk Assessment is the process of analysing the level of risk associated with an activity, considering whether hazards are adequately controlled. The completion of risk assessments is common to the construction industry and as part of good Occupational Health and Safety practice.

With reference to the sanitation technology evaluation, the purpose of a risk assessment is to identify any unacceptable risks people may be exposed to during the normal operation and maintenance of the technology. The significant hazards are those which might pose serious risks to the user, the operators, or others who might be affected by the sanitation technology.

To calculate risk, consider the likelihood of an event happening and the severity of the event's consequences. This can be expressed in the formula: **Risk = Likelihood x Severity**.

Step 1

Consider who might be harmed and how. Identify groups at risk, e.g. the user maintenance personnel, the public, etc.

Step 2

Analyse and evaluate the risks and determine the effectiveness of control measures included in the design of the technology. Estimate the likelihood of events combined with the probable severity of the outcome of the risk and award a score based on the scales given in **Table 10.1**. Note that it cannot be assumed that simply because a control measure exists it is being effectively applied.

Table 10.1: Risk Assessment Scales.

Score	Likelihood	Severity
0	Impossible – cannot happen	no effect
1	Unlikely – has never happened	Slight – minor injury
2	Possible – has happened	Moderate – resulting in absence
3	Likely – happens regularly	Serious – urgent medical attention
4	Probable – happens regularly and frequently	Major – major injury, death or chronic medical condition
5	Imminent – will definitely happen soon	Catastrophic – large number of seriously injured and/or death

Step 3

Plot the risk assessment score for each activity on **Table 10.2** in order to determine whether a risk is **High**, **Medium** and **Low**.

Table 10.2: Risk Assessment Matrix.

			SEVERITY					
			No Effect	Slight	Moderate	Serious	Major	Catastrophic
	SCORE		0	1	2	3	4	5
LIKLIHOOD	Impossible	0	0	0	0	0	0	0
	Unlikely	1	0	1	2	3	4	5
	Possible	2	0	2	4	6	8	10
	Likely	3	0	3	6	9	12	15
	Probable	4	0	4	8	12	16	20
	Imminent	5	0	5	10	15	20	25

Risk Factor Rating:

Low	**1-4**
Medium	**5-12**
High	**15-25**

Step 4

Use the matrix given in **Table 10.3**: to provide the Evaluation Score.

Table 10.3: Risk Evaluation Matrix.

ASSESSMENT RESULT	SCORE
All Identified hazards considered impossible or have no effect	**100**
All Hazards considered **Low Risk**	**75**
A maximum of two Hazards considered to be **Medium Risk**, all other hazards low risk	**50**
Three or more hazards considered to be **Medium Risk**, all other hazards Low Risk	**25**
One or more hazards considered **High Risk**	**0**

10.2 FAECAL CONTACT ASSESSMENT

Following on from the information given in Section 6.4, faecal coliforms, and more specifically *Escherichia coli* can be used as an indicator of residual faecal pollution by warm-blooded animals (including human faeces). Consequently *E. coli* is commonly used to evaluate the quality of wastewater effluents and faecal sludge, and most water quality laboratories are able to provide analysis of the number of *E. coli* found in a faecal sludge sample.

The presence of faecal pollution may indicate the presence of pathogens, which if ingested in sufficient quantity are responsible for infectious diseases such as gastroenteritis, salmonellosis, dysentery, cholera and typhoid fever.

Low levels of *E. coli* in faecal waste may indicate effective treatment of the faecal bacteria, but this does not necessarily mean that protozoa and helminths have been effectively removed from the waste. Helminth eggs in particular are particularly resilient and survive in digested faecal waste for several years. However, with the exception of a handful of specialised laboratories, the sampling and detection of protozoa and helminths in faecal waste is not reliable, and for this reason the faecal contact assessment is based on the quantity of *E. coli* in the faecal waste correlated with the handling procedure and risk of ingestion of faecal waste.

Epidemiological studies by the United State Environmental Protection Agency (EPA) identified a rough correlation between the incidence of gastrointestinal illness amongst people who swam in rivers, according to the following formula:

Illness rate per 100 000 people = -150.5 + 423.5 x $\log_{10}$ (no. *E. coli* per 100 ml of water)

This means that where *E. coli* rates are 1 000 per 100 ml, approximately 1% of swimmers would suffer from gastrointestinal illness, increasing to 2.4% where *E. coli* counts reach 1 000 000 per 100 ml. As discussed in in Section 9.3, the quantity of harmful pathogens in an *E. coli* count is likely to be higher in the context of the sanitation technology study. It would be expected therefore that the above equation underestimates the illness rates in the South African context. However, the logarithmic correlation between *E. coli* and illness still applies. This forms the basis of the faecal contact assessment described in **Table 10.4**.

Table 10.4: Health Evaluation Factors.

***E. coli* Concentration**	
***E. coli* Count per 100 ml**	***Factor***
<1	**0**
10	**1**
100	**2**
1 000	**3**
10 000	**4**
100 000	**5**
1 000 000	**6**
10 000 000	**7**
100 000 000	**8**

X

Frequency of Contact	
Frequency of Contact	***Factor***
Longer than a year	**1**
Once a year	**2**
Every 6 months	**3**
Every 2 months	**4**
Every month	**5**
Every 2 weeks	**6**
Every week	**7**
Twice a week	**8**
Every Day	**9**

X

Likelihood of Ingestion	
Nature of Activity	***Factor***
Handling of sludge in sealed container	2
Mechanical handling of sludge	4
Manual handling dry sludge	6
Manual handling wet sludge	8
Appropriate PPE not worn	10

The likelihood score assumes that all people involved in the operation and maintenance of the technology will wear the appropriate Personal Protective Equipment (gloves, gum boots, face mask, etc.) and will observe good hygiene practice (washing hands and clothes). Failure to use appropriate PPE will automatically result in a factor of 10 to be applied regardless of the nature of the activity.

Where there are multiple activities associated with the operation of the sanitation technology, these shall be evaluated separately and added together to establish the final rating. For example, where the excavation and disposal activities are separate these shall be evaluated separately.

$$\textbf{Health Rating} = 100 \times \frac{300 - (\text{Score1} + \text{Score2} + \text{Score3} + \ldots)}{300}$$

Where the sum of the scores is greater than 300, the minimum health rating of ZERO shall be applied and the technology deemed to have unacceptable performance.

With reference to **Table 10.4**, a sanitation technology with faecal sludge that has an *E. coli* count of 1 000 000 per 100 ml, which needs to be emptied every month by manual handling of dry sludge would score 6 x 5 x 6 = 180.

$$100 \times \frac{(300-180)}{300} = 40 \text{ points}$$

10.3 ACCEPTABILITY SCORECARD

The Acceptability scorecard asks a series of questions that probe into the acceptability of a technology for a given application. The questions should be completed in consultation with the user and Water Services Authority, supported by the reviewer's observations as necessary.

A cumulative score is obtained based on the response to the different questions (**Table 10.5**). **IF the response to ANY of the questions is marked in red text with a ZERO point score, the overall Acceptability rating of the technology will be ZERO.**

Table 10.5: Acceptability Scorecard

Category	Description	Response	Points
User Interface			**30**
Operation	Is the technology easy and safe to use?	*By adults &. children* *By adults only* *Difficult to operate* ***Unsafe***	*10* *6* *2* ***0***
	Does the technology effectively control odours?	*No odours observed* *Slight odour* ***Significant odour***	*5* *2* ***0***
Quality	Is the technology of a comparable standard to other sanitation technologies supplied to neighbouring areas	*Higher Standard* *Similar Standard* *Lower Standard* ***Low Quality***	*5* *4* *2* ***0***
Siting	Can the technology be positioned close to people's homes?	*YES* *NO*	*5* *1*
	Is there sufficient space available for the technology to be installed?	*YES* ***NO***	*5* ***0***
Collection and Storage / Treatment			**20**
Versatility	Are the ground conditions suitable for the technology (i.e. can the technology be installed where there is shallow rock or groundwater?)	NO Excavation or infiltration req. Infiltration Required Excavation < 1 m Excavation > 1 m	10 6 4 2
Siting	Is there sufficient space available for the technology to be installed?	*YES* ***NO***	*10* ***0***

Table 10.5(cont): Acceptability Scorecard

Category	Description	Response	Points
Conveyance			**20**
Operation	What is the method of transporting the waste once the collection facility is full?	Sewer Integrated into design (helical screw / cart) Vacuum Truck By Hand	5 5 3 1
	How often does the collected waste need to be emptied?	Continuous (Sewer) > 1 year > 6 months > 1 month > 1 week < 1 week	5 5 4 3 2 1
	Does the Implementing Agent or appointed service provider have sufficient capacity to support the required operation and maintenance activities?	*YES* ***NO***	*10* ***0***
Treatment			**20**
Operation	Is the necessary Infrastructure in place to support the operation of the technology (i.e. Wastewater Treatment Works)	Included Full Infrastructure Req. Minor Upgrade Req. Major upgrade **No Infrastructure**	10 10 6 2 **0**
	Is the treatment facility easy and safe to operate?	*No on site treatment* *household operation* *local operation* *skilled operator req.* ***Unsafe***	*5* *5* *3* *1* ***0***
	Does the treatment effectively control odours?	*No odours observed* *Slight odour* ***Significant odour***	*5* *2* ***0***
Use / Disposal			**10**
Operation	Is there a demand for the use of the treated waste?	Active Market Local acceptance Limited acceptance Dispose to Landfill	5 4 2 1
	Is there a suitable place for the disposal of the treated waste	In the yard In the community Outside the community No local disposal	5 4 2 1

10.4 ENVIRONMENTAL PERFORMANCE SCORECARD

The Environmental Performance scorecard seeks to rank the technology according to the extent which it protects the environment from pollution and promotes effective use of natural resources (**Table 10.6**)

A cumulative score is obtained based on the response to the different questions. **IF the response to ANY of the questions is marked in red text with a ZERO-point score, the overall Environmental Performance rating of the technology is ZERO.**

Table 10.6: Environmental Performance Scorecard.

Category	Description	Response	Points
Water Consumption	How much water is required to operate the toilet?	*No Water (dry toilet)*	*25*
		Only Greywater or recycled water	*20*
		≤ 1 litre per flush	*15*
		> 1 and ≤ 2 litres per flush	*10*
		> 2 and ≤ 6 litres per flush	*5*
		≥ 6 litres per flush	***0***
Pollution Control	Does Effluent discharge or leachate meet the appropriate standards prescribed in the Department of Water Affairs general authorisation limits?	*No Effluent Discharge*	*25*
		Leachate/supernatant proven to meet required standard within 1 m of the base of the pit/soakaway	*20*
		Effluent Fully complies with General Authorisation limits	*20*
		Effluent Discharged to Municipal facility	*15*
		Effluent within 20% of General Authorisation limits	*10*
		Effluent more the 20% above the General Authorisation limits	***0***

Table 10.6 (cont.): Environmental Performance Scorecard.

Category	Description	Response	Points
Resource Recovery	Does the technology seek to recover resources (such as Energy in the form of biogas and Nutrients in the form of urine or compost fertiliser) as part of its design?	*Design demonstrates effective energy AND nutrient recovery*	*25*
		Design demonstrates effective energy OR nutrient recovery	*15*
		Design Incorporates energy or nutrient recovery measures with limited success	*10*
		Design does not include resource recovery measures	*5*
Materials	Does the technology use environmentally materials that are biodegradable, or can be effectively recycled?	*All materials are biodegradable or can be recycled*	*15*
		<20% of materials are not biodegradable or recyclable	*10*
		>50% of materials are not biodegradable or recyclable	*5*
Chemicals	Does the technology require the use of hazardous chemicals as part of its operation and maintenance?	*No hazardous chemicals used*	*10*
		Some hazardous chemicals are used that are well contained within the technology	*5*
		Hazardous chemicals are used that present a high risk of polluting the environment.	***0***

10.5 RELIABILITY SCORECARD

The Reliability scorecard concentrates on the long-term performance of the technology, where possible verified by historic performance data and field verification. Good scores will only be achieved where the technology can demonstrate successful historic performance for more than two years. Without the benefit of long term success, it is not possible to verify whether the technology is reliable. Emerging technologies which do not have a long-term performance record may still obtain an average score, while failed technologies or technologies with an inadequate support framework will achieve low scores.

A cumulative score is obtained based on the response to the different questions. **IF the response to ANY of the questions is marked in red text with a ZERO-point score, the overall Environmental Performance rating of the technology is ZERO.**

Table 10.7: Reliability Scorecard

Category	Description	Response	Points
Historic Performance	Total Number of functioning Installations (sample verified by references)	*>10 000* *>1 000* *>100* *>10* *Lab only*	*20* *15* *10* *5* *1*
	Duration of functional installations (excludes laboratory-based prototypes)	*>10 years* *> 5 years* *> 2 years* *≤ 2 years* *Lab only*	*20* *15* *10* *5* *1*
Robustness	Material durability (strength, UV Stable and fire resistance)	*Selected materials have proven durability* *Selected materials have theoretical durability* ***Selected materials not suitable***	*10* *5* ***0***
	Resistance to vandalism	*Proven resistance to vandalism.* *Theoretical resistance to vandalism* *Selected materials prone to vandalism*	*10* *5* *1*

Table 10.7(cont.): Reliability Scorecard

Category	Description	Response	Points
Maintenance	Technical Support	*Supplier demonstrates effective training and good long term support*	*20*
		Limited support available	*10*
		No technical support or training provided	***0***
	Availability of Spares and Consumables	*Readily available at local stores*	*10*
		Available from supplier on request	*5*
		Insufficient availability of spares and consumables	***0***
Design Life	Considered lifespan of technology before replacement of major components required.	*> 20 years* *> 15 years* *> 10 years* *> 5 Years* *< 5 Years*	*10* *15* *10* *5* *1*

10.6 LIFE CYCLE COST

The life cycle cost of a sanitation technology considers the following:

- capital cost of purchasing the technology
- annual cost of operation (including labour management and consumable items such as collection bags), plus
- Maintenance cost over the given period, repairs and disposal of faecal waste.

There is a need for sanitation technologies to provide a long-term solution to avoid the repeated provision of basic services, especially while there are still backlogs of service provision in South Africa. However, for the purpose of this protocol a design life of 10 years is used, i.e. at the end of 10 years this assumes that the capital cost needs to be paid again. Where the technology requires a large capital investment, a short design life is not acceptable, where lower cost technologies have a shorter design life that require more frequent replacement, the cost of replacement should be considered as part of the maintenance cost over the 10-year design life.

The conversion of this cost to a score out of 100 is not straight forward, as this will require comparison with the other technologies on the market. As one benchmark, The Bill and Melinda Gates Foundation *Reinvent the Toilet Challenge* has set a target of 5 US cents per person per day for the total lifecycle cost of the new sanitation technologies which it is striving to develop. This is calculated from the capital cost and the 10-year operation and maintenance cost.

The IRC has recently published an online tool at http://washcost.ircwash.org/en/calculators to calculate the life cycle cost of a sanitation technology. This tool provides a simple calculator to determine the life cycle cost without consideration of the Net Present Value.

For the purpose of the evaluation protocol, the life cycle cost shall be calculated as follows:
Emptying Cycle, E (days) = V / F x N

Where, **V** = Storage Capacity of sanitation Technology, litres
F = Design filing rate or sludge accumulation rate for specific technology (with consideration of dehydration). Litres/person/day (default = 0.15)
N = Number of people using the toilet (default = 5)

Life Cycle Cost, L = NPV(i; ((365/E) x 10 x C) + (O x 10)) + X

Where, **i** = annual interest rate
C = Cost per emptying
X = Capital Cost

Cost per person per day, D = L / (10*365*N)

Table 10.8: Life Cycle Cost Score.

Life Cycle Cost *(per person per day)*	**SCORE**
Less than R0,50	**100**
R1,00	**75**
R2,00	**50**
R3,00	**25**
Greater than R4,00	**0**

Using extrapolation, a more precise score may be assigned for life cycle costs which fall between the values shown in **Table 10.8**. For example, a Life Cycle cost of R2.20 per person per day would be given a score of 45.

10.7 SUMMARY

Table 10.9 – Summary of Evaluation Procedure.

Category	Evaluation Procedure	Methodology	Key Data Requirements
1) Safety 	Hazard Risk Assessment	*Likelihood and severity of a particular hazard*	-Identification of Hazards
2) Health 	Faecal Contact Assessment	*Quantify the following at sample sites:* *-Frequency of contact,* *-Concentration of faecal sludge,* *Likelihood of ingestion*	-Measured Filling Rates -Faecal Coliforms in handled sludge -Moisture Content -Handling Procedure
3) Acceptability 	Acceptability Scorecard/ Questionnaire	Survey of Users and Operators	-Privacy -Ease of use / comfort -Proximity to the home -Versatility – where can be installed -Safety -Equity / Quality -Odour -Employment Created -Supporting infrastructure
4) Environmental Performance 	Environmental Performance Scorecard	Measurement of Environmental Performance at sample sites	-Freshwater Consumption -Recovered Resources -Spillage and Leaching -Hazardous Materials
5) Reliability 	Reliability Scorecard	Measurement of performance at sample sites	-Historic Performance -Number and age of working installations -Incidents of Vandalism -Availability of spares and consumables -Material durability (UV stable, fire resistance, etc.)
6) Cost 	Life Cycle Cost	Calculation of actual Life Cycle Costs from field trials	-Capital Cost -Operational cost -Maintenance costs (spares, emptying)

11 SUITABILITY EVALUATION SCORING

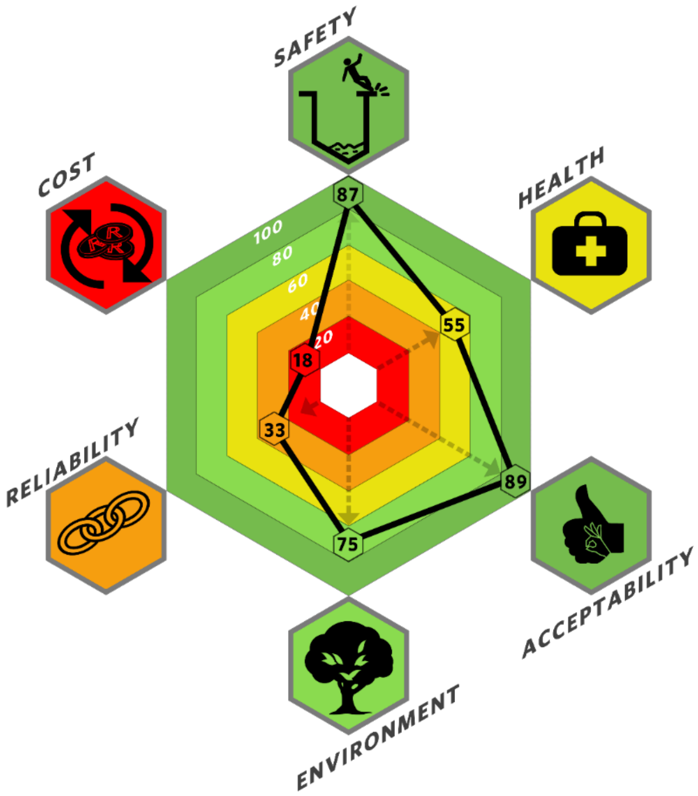
11.1 SUMMARY

A draft Suitability Evaluation procedure was developed as part of this study. This is a context specific evaluation for a particular technology. The technology is evaluated against six key criteria that are derived from the policy aims for a Basic Sanitation Facility. Full details of this suitability evaluation procedure are presented in Chapter 9. The evaluation for a given technology is presented on a hexagonal radar chart with colour coded bands to rate the performance under particular criteria as follows:

Table 11.1 – Evaluation Rating.

COLOUR	SCORE	EVALUATION
RED	0-20	Unacceptable Performance
ORANGE	20-40	Poor Performance
YELLOW	40-60	Average Performance
Light GREEN	60-80	Good performance
Dark GREEN	80-100	Excellent performance

Figure 11.1 – Sample Evaluation Rating.



11.2 MINIMUM STANDARDS

Minimum standards have been identified for the performance of the sanitation technology. Failure of the technology in any one of these areas will result in the technology being awarded an 'Unacceptable Performance' rating, whereby modifications are required before the technology can be used. The minimum standards are summarised below.

11.2.1 Safety

The technology must not present undue risk to children or adults during the normal use of the facility. No high-risk activities identified in the hazard risk assessment.

11.2.2 Health

The technology must effectively contribute to the prevention of excreta related disease for the user and neighbouring community and must therefore not result in undue risk of exposure to harmful faecal pathogens.

11.2.3 Acceptability

The technology must (on reasonable justification) be deemed acceptable by both the user and Water Services Authority who will be responsible for the supply and maintenance of the technology. This requires the technology to satisfy a number of considerations. Any of the following factors may result in the technology being deemed unacceptable:

- deemed unsafe
- causes significant odours
- low quality
- insufficient space to install the technology
- insufficient capacity of maintenance teams
- insufficient capacity of downstream treatment facility

11.2.4 Environmental Performance

The technology must effectively protect and where possible enhance the environment. Consequently, the technology must use less than 6 litres of clean water per flush. Effluent being discharged from the facility must be within the general authorisation guidelines and must not use hazardous chemicals that are at risk of spilling or leaching into the environment.

11.2.5 Reliability

The technology must demonstrate, or have good potential for reliable, long term performance, and as such must be manufactured from durable materials. The delivery of the sanitation technology must be accompanied by appropriate training, good maintenance support, and spares and consumable items must be readily available.

11.2.6 Cost

The technology must be available at a reasonable cost with consideration of the full life cycle (supply, operate and maintain)

12 FUNCTIONALITY ASSESSMENT AND EVALUATION PROTOCOL

12.1 SUMMARY

12.1.1 Overview

The Sanitation Technology Assessment and Evaluation Protocol is designed to enable the transparent assessment of different household sanitation technologies. This generally excludes septic tanks and stand-alone effluent treatment technologies that are not packaged with a toilet. These technologies should be evaluated in accordance with the WRC guidelines for domestic wastewater package plants. The Protocol is designed to be used by sanitation experts. This protocol focusses on the scientific functionality of the sanitation, to assess whether the technology is performing, or is able to perform the required collection, treatment and disposal functions in order to provide a reliable, hygienic sanitation facility.

The Protocol also included a Suitability Evaluation. This was developed to assist stakeholders to identify the appropriate siting of a specific technology within a specific context and included an assessment under six key categories, namely safety, health, acceptability, environment, reliability, and cost. The project reference group steered the development of the protocol towards a focus on functionality, such that the suitability analysis is not included in the Protocol. The findings and recommendations from the suitability analysis are however included in the Policy Dialogue report to assist the appropriate siting of technologies.

12.1.2 Aims of the Assessment Protocol

The implementation of the Sanitation Technology Evaluation Protocol will produce a scientific assessment of household sanitation technologies to inform the appropriate selection and siting of on-site sanitation technologies and achieve the desired long-term benefits of effective sanitation systems.

12.1.3 Standardisation of Sanitation Protocol

It is critical that the Protocol aligns with existing national legislation and guidelines wherever practical (as indicated on **Form A.3**). Specific reference must also be made to local by-laws that may apply to the sanitation technology, in particular where the use of soakaways or infiltration systems for the discharge of effluent may be prohibited.

In order to aid standardisation of the sanitation evaluation process, a series of standard procedures have been developed which can be applied to the wide range of technologies on the market. The assessment process does however require a good understanding of sanitation technologies and the physical, chemical and biological treatment processes that are incorporated into the different technologies.

To enable a consistent and objective evaluation process, the Protocol will be adopted by the Department of Water and Sanitation (DWS). DWS will therefore be the overall Regulator of sanitation technologies to ensure that results of the Protocol are accurate and well communicated to the relevant government departments and other interested parties. The South African Bureau of Standards (SABS) and Agrément may provide endorsement of specific components, but they do not adequately address the functionality of the sanitation technology or the suitability for a specific context. The wide variety and complexity of the sanitation technologies requires a regulation process that will ensure only effective technologies are deployed in an appropriate context, where they have the potential to provide a sustainable sanitation solution for long term health benefits of the user. The Department of Water and Sanitation (DWS) as Regulator of the Sanitation technologies can ensure that government funding is invested in suitable sanitation systems for a specific context that have the potential to provide a long-term benefit at an appropriate life-cycle cost.

In terms of standard design parameters, influent loading rates and effluent discharge requirements are standardised. Where toilets are shared between multiple households, or the household has a large number of users, influent loading rates should be adjusted based on liquid volume, solids, Chemical Oxygen Demand (COD), suspended solids, nitrogen, phosphorus, and *E. coli*. In the event that the technology makes specific claims about the effluent quality, the treatment performance of the technology should be measured against this claim, and also compared to the General Authorisation limits.

12.2 FUNCTIONALITY ASSESSMENT

The functionality of the sanitation technology considers the ability of the sanitation technology to perform the intended purpose. The assessment is sequential; after satisfactory performance for a specific criterion, the assessment will proceed to the next stage. Unacceptable performance at any stage will be fed back to the supplier to inform modification of the sanitation technology for re-submission by the supplier. The assessment of the technology requires input from both the Supplier and the Assessor and will follow the procedure illustrated in **Figure 12.1**.

Figure 12.2 provides a summary of the different sanitation processes and the typical tests required to assess the performance of a technology. Where the overall functionality of the sanitation technology is considered to be acceptable, the technology will be recommended for household use within a defined context. The acceptance of the technology may also be accompanied by recommendations for the supplier to further improve the performance and robustness of the technology.

The intention of the Sanitation Technology Evaluation and Assessment Tool is to highlight good performance and appropriate siting of the technology. The assessment process seeks to guide manufacturers towards improved product performance to improve the success of sanitation delivery.

Figure 12.1: Sanitation Technology Assessment and Evaluation Procedure

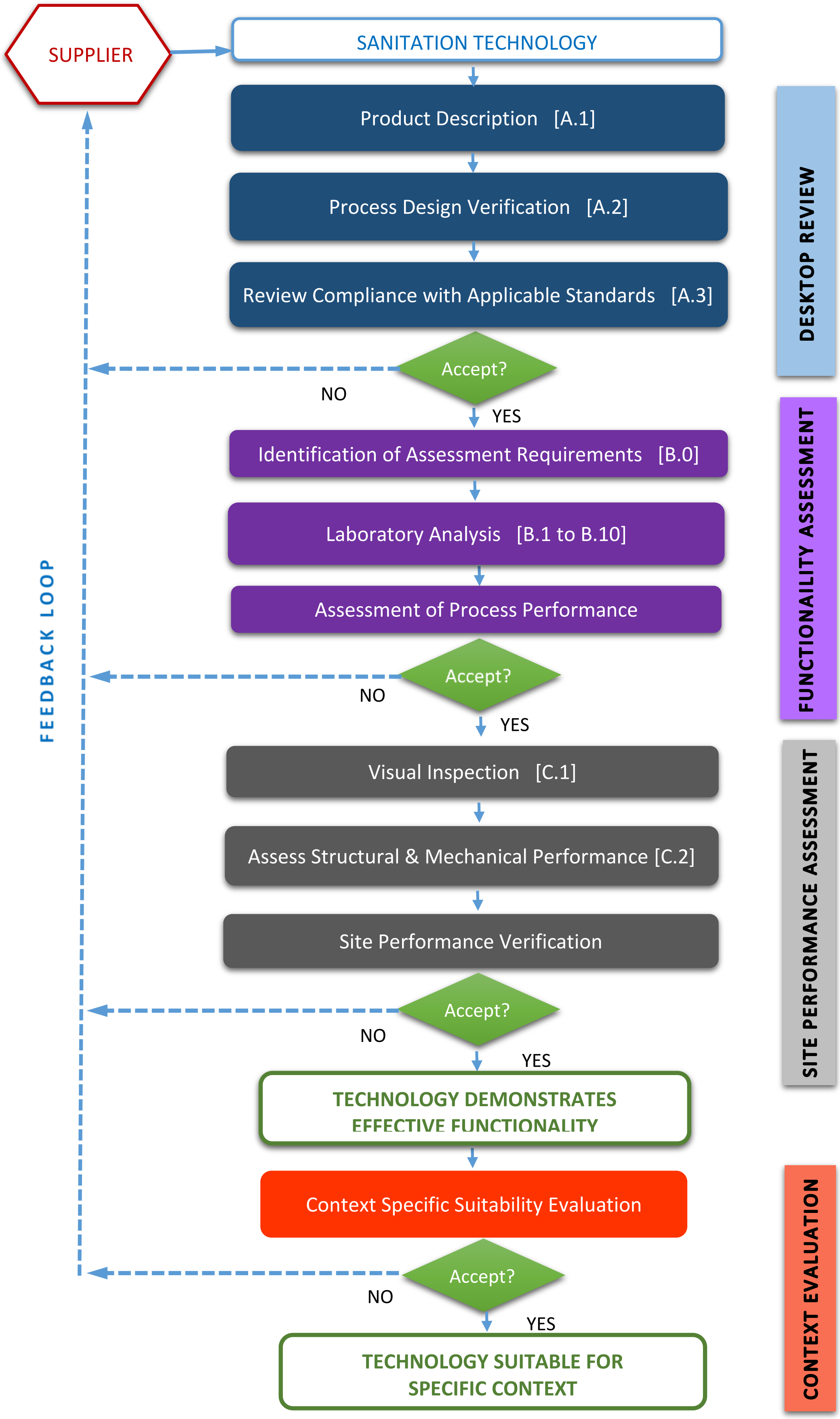


Figure 12.2: Functionality Assessment Requirements

	IDENTIFY TREATMENT PROCESS					
Process	**CHEMICAL**		**PHYSICAL**	**BIOLOGICAL**		**MECHANICAL**
Category	**CHEMICAL**	**DRY SANITATION**		**WATERBORNE**		
Example Technologies	Chemical Toilets Porta Potty	Pyrolysis Hydrothermal Carbonisation	Dehydration Desiccation Urine Diversion Bag Separation	**AEROBIC** Leach Pits Compost Toilets Activated Sludge Biofilm	**ANAEROBIC** Septic Tanks Biodigestor ABR Bio-Augmentation	Membrane Ultrafiltration
Process Tests	Loading Rates *(Form B.1)* & Sludge Accumulation Rates *(Form B.2)*					
	Water tightness *(B.3)*	Temperature *(Form B.5)*		Water tightness *(Form B.3)* Air tightness (Form B.4)		Water tightness *(B.3)* Filter Integrity *(B.6)*
Effluent Tests	Moisture content *(Form B.7)* Faecal Coliforms *(Form B.8)*			Determinant *(Form B.9)* (COD, TSS, *E.coli*, N, P etc.)		
	Helminths and Protozoa (Where supplier claims waste is sanitised) (Form B.10)					

13 FIELD VERIFICATION

13.1 BACKGROUND

This section documents the initial observations gathered during the site performance assessment for the Household Sanitation Technology Assessment and Evaluation Protocol. The Protocol is being developed to enable preliminary evaluation of different sanitation technologies. The protocol is designed to be used by sanitation practitioners with expertise in the field. The practitioners are to follow four core processes, two of which are the functionality assessment and suitability evaluation. Six evaluation criteria and minimum standards are then set out to be achieved by sanitation technologies. A total of twenty-nine (29) technologies participated in evaluation protocol (**Table 13.1**). Those which were selected for initial field verification are highlighted in the **Table 13.1**.

13.2 OBJECTIVE

The main objective of the site performance process is to assess the manner in which the technologies perform in the field. Following from the functionality assessment and the desktop review, the site performance assessment evaluates whether the performance of the technology is aligned with the process description and/or claims made.

Full details of existing installations, the period of operation and any failures that have occurred were provided. The assessor conducted a visual inspection of the technology to appraise the quality of materials and fabrication. The overall performance of the technology to provide the required treatment function, was preferably undertaken at an existing installation that has been subjected to extended and continual use. Where the technology has not been subjected to extended field trials, it was possible to establish a laboratory test facility for the technology, to date one technology underwent such laboratory installation.

Table 13.1: The list of all Sanitation technologies participating in the development of this protocol. Those which participated in the initial field verification are highlighted.

Product Name	Category	Organisation/Company
Andy Loo		
Afrisan toilet	Desiccation	African Sanitation
Blivet Package Plant	Package Plant	Bannow Africa
Composting Solar Powered Toilet	Desiccation	BathoPele Sanitation
Biofil Wastewater Treatment Technology	Compost	Biofil Technologies
Humanure	Compost	Bioresources Engineering UKZN
Bubbler Water Efficiency System	Membrane-Bio	Bubbler Pty Ltd
Ecomite, Low Flush, Wetloo, ST with Biomite	Various	Calcamite Water & Sanitation Solutions
Mtee Designs	Low Flush	DUT
EcoSan Waterless Toilet	Desiccation	ECOSAN
Vacuum toilet	Low Flush	Enactus UNISA
Auger toilet with liquid/solid separation	Desiccation	EnGenius Green Solutions
Enviro Loo	Desiccation	Enviro Options
EaziFlush	Low Flush	EnviroSan Sanitation Solutions
Flushing toilet with AnMBR	Membrane-Bio	ETE Solution
3in1eco	Biodigestor & Filter	Free Energy Living
Waterwise Toilet	Desiccation	Madibeng Water Services
Clarus Fusion	Package Plant	Maskam Water
SavvyLoo	Desiccation	Pennine Energy innovation
GUESS Green Universal Eco Sewerage System	Package Plant	Poly Phoenix Fibreglass Products cc
PQ Green Eco Porta Loo	Compost	PreQuip Green Pty Ltd
NIC and Repit	Chemical	Sanitech toilet hire
SmartSan Recycle Digester	Membrane-Bio	Smart San
My Fast ® 16.0	Package Plant	Tupelovox
Emergency Sanitation Operation System	Membrane-Bio	UNESCO
Vetiver grass Latrines	VIP variant	Wandima Environmental Services
Crappery Caterpillar & Portapoty	Various	WASTE
Nano Bio digestor system	Membrane-Bio	Waste Intrique Services[1]
ZerH$_2$O waterless toilet	Compost	ZerH$_2$O

13.3 FIELD VISITS

After the selection of technologies for the initial site verification process, suitable dates were organised with relevant suppliers (**Table 13.2**). A total of seven sanitation technologies (**Table 13.3**) were assessed between the 20th August 2015 and the 08th September 2015 at thirteen different sites. Full details of the field verification exercise are included in **Annexure C**.

[1] A site visit was requested by Waste Intrigue services, however the requested site visit could not be included in the initial field verification schedule due to time constraints.

Table 13.2: Site visit schedule.

Company/Organisation	Area (Site)	Time and Date of Site Visit
African Sanitation	Lethabong, Krugersdorp area, GP. (site 1a and site 1b)	8 September 2015 16H30 – 18H00
Bubbler Pty Ltd	Khayelitsha, Cape Town, WC. (site 1)	02 September 2015 09H00 – 11H30
Bubbler Pty Ltd	Durbanville, Cape Town, WC. (site 2a and site 2b)	02 September 2015 12H30 – 13H30
Calcamite	Factory, GP. (site 1a and site 1b)	8 September 2015 11H30 – 13H30
Calcamite	Diepsloot, GP. (site 2)	8 September 2015 15H00 – 17H00
Eco San	Teniqua tree tops, Sedgefield, Knysna area. (site 1a and 1b)	03 September 2015 12H45 – 14H00
Enviro Options Pty Ltd	Kogelberg-firelily. (site 1a, site 1b and site 1c)	02 September 2015 15H45 – 17H00
Enviro Options Pty Ltd	Factory, Chamdor Johannesburg. (site 2a, site 2b and site 2c)	09 September 2015 08H30 – 10H30
Enviro Options Pty Ltd	Bekkersdal, Westonaria, GP. (site 3)	09 September 2015 11H00 – 11H30
Enviro Options Pty Ltd	Boitumelo, Midvaal, GP. site (4a and site 4b)	09 September 2015 12H45 – 14H00
Smart San	Siyafunda school, Knysna. (site 1)	03 September 2015 09H00 – 11H00
Smart San	Oakhill school, Knysna. (site 2)	03 September 2015 11H15 – 11H00
ZerH$_2$O	Siyakhana, Johannesburg	20 August 2015

13.4 METHODOLOGY

At each site visit, an expert practitioner from the Pollution Research Group at UKZN was accompanied by one or more members of the project team to carry out measurements. As part of the verification tool, temperature readings were measured using a wireless temperature sensor. Identification of site visits was based upon the length of time that the installations had been functional. An increased number of field installations in differing environments was preferred, in order to gauge the robustness of the technology.

Samples were collected for laboratory analytical verification of selected properties of the influent/ fresh black water or faecal sludge material and the effluent after treatment (recycled flush water, dry sludge material or compost). The liquid samples were selected after a good mixing of the liquid effluent in the collecting treatment chambers and from the outlet pipe or the toilet cistern before flushing. The solid samples were collected from different sections and depth level of the faecal sludge within the treatment facilities/ chambers.

13.5 LABORATORY ANALYSIS

The samples taken during the field verification exercise were sent for laboratory analysis. This includes wet and dry samples that are being tested for, amongst other things, Chemical Oxygen

Demand (COD); Ammonia, Nitrates, Phosphorus (P), *E. coli* (CFU) and Ascaris. The laboratory results are presented in Chapter 14 of this report.

13.6 SUMMARY

The field verification exercise provided useful insight into the performance of the more established sanitation technologies. These field observations were combined with the laboratory analysis and desktop assessments to complete the technology evaluation process.

A common thread from the field verification process was the need for effective, ongoing maintenance of the technology. The consequence of inadequate maintenance will be different for each technology, and an important consideration that will be addressed in the final evaluation is the mode and consequence of failure, i.e. if the technology should fail, how will it fail and will this present a health or environmental hazard?

14 LABORATORY OF INVESTIGATION

14.1 SUMMARY

Nine sanitation technologies were sampled on-site during a field verification process with a tenth (Andy Loo) being assessed in the laboratory of the Pollution Research Group, UKZN. Health and safety standard operating protocols were following during sampling collection and transportation in order to avoid cross contamination and prevent health risk exposure. Appropriate personal protection equipment (PPE) was used at all times. The field verification tests served as the prelude for laboratory testing. Samples underwent laboratory testing at the University of KwaZulu-Natal – Pollution Research Group's laboratory. Standard operating protocols and procedures (Reddy, 2013) were applied during the laboratory analysis to ensure good quality assurance. Additional samples were tested at the Centre for Scientific and Industrial Research (CSIR) analytical laboratory and the Water Analytical Laboratory (Wal-Lab) in Stellenbosch.

The selected samples were indicative for initial verification of the influent and effluent materials on the day of collection for both liquid and solid samples. The results however cannot be used as a base for conclusion regarding the level of treatment efficiency of the investigated technologies and should this be required, further and more rigorous sampling and analytical work should be undertaken to statistically validate initial results presented here.

14.2 ON-SITE SAMPLING

Liquid and solid samples were collected onsite using 0.5 to 1 L plastic containers (**Figure 14.1**). Samples were labelled and sealed in airtight sterile containers during transportation. For dry samples, the container was lined with a plastic bag. Temperature was measured using a thermocouple. Temperature readings were taken, where possible, both for the inlet and outlet of all systems. The performance of the technology depends on the technology's treatment process, namely chemical, dry sanitation and waterborne (inclusive of physical, biological and mechanical).

14.2.1 Dry Sanitation

Dry sanitation systems often encompass both chemical and physical treatment processes. This is through hydrothermal carbonisation, dehydration, desiccation, urine diversion and solid-liquid separation.

14.2.2 Waterborne

Waterborne sanitation encompasses aerobic and anaerobic processes (biological), as well as membrane ultrafiltration (mechanical).

14.2.3 Chemical

These technologies are often in the form of porta potties, which were not analysed as part of this research project.

Figure 14.1: Sampling procedure during site verification, including taking temperature readings and sampling of solid faecal waste respectively.

Although previous deliverables have highlighted the different treatment processes listed above, the technologies tested for this report were generally waterborne and dry sanitation technologies. Therefore, the results of the tests carried out are divided into liquid (wet) and solid (dry) samples.

14.3 LABORATORY TESTING

The laboratory testing was completed[2] in accordance with the UKZN Standard Operating Procedures. The collected samples were tested for the following parameters:

- Chemical Oxygen Demand
- Electrical Conductivity
- pH
- Helminths
- *E. coli*
- Total Solids
- Suspended Solids
- Volatile Solids
- Nitrogen
- Ammonia
- TKN
- Moisture Content

For the solid samples the following parameters were measured: COD, Helminths, *E. coli*, Total solids, Volatile solids and moisture content. For the liquid samples, the measured parameters were: COD, Electrical conductivity, pH, Helminths*, E. coli*, Total solids, Suspended solids, Volatile solids, Nitrogen, Ammonia, TKN.

[2] The site visit for the Nano-biodigestor was requested at a later stage, thus the laboratory testing was carried out at a later stage as well. The results for this technology (Nano-biodigestor by Waste Intrigue Services), as well as the Andy Loo (a UDDT) are at times reported separately from other technologies, throughout this report.

Table 14.1: Area and time of sampling sanitation technologies.

Product Name	Company/Organisation	Type of sample	Description	Area (Site)	Time and Date of Site Visit
Andy Loo	Andy Loo	Solid faecal waste (dry)	Incineration UDDT with evaporation	UKZN laboratory	23 October 2015
Afrisan toilet	African Sanitation	Solid faecal waste (dry)	Solar-powered toilet that composts sludge	Lethabong, Krugersdorp area, GP. (site 1a and site 1b)	08 September 2015 (16H30 – 18H00)
Bubbler Water Efficiency System	Bubbler Pty Ltd	Membrane-Bio Liquid (wet)	Septic tank with some kind of filter	Khayelitsha, Cape Town, WC. (site 1)	02 September 2015 (09H00 – 11H30)
Bubbler Water Efficiency System	Bubbler Pty Ltd	Membrane-Bio Liquid (wet)	Septic tank with some kind of filter	Durbanville, Cape Town, WC. (site 2a and site 2b)	02 September 2015 (12H30 – 13H30)
Ecomite, Low Flush, Wetloo, ST with Biomat	Calcamite	Various Liquid (wet)	Various	Factory, GP. (site 1a and site 1b)	08 September 2015 (11H30 – 13H30)
Ecomite, Low Flush, Wetloo, ST with Biomat	Calcamite	Various Liquid (wet)	Various	Diepsloot, GP. (site 2)	08 September 2015 (15H00 – 17H00)
EcoSan Waterless Toilet	Eco San	Desiccation Solid faecal waste (dry)	EcoSan toilet, has helical screw conveyor	Teniqua tree tops, Sedgefield, Knysna area. (site 1a and 1b)	03 September 2015 (12H45 – 14H00)
Enviro Loo	Enviro Options Pty Ltd	Desiccation Solid faecal waste (dry)	Enviro Loo: Dry / Waterless-Dehydration-Evaporation Sanitation System	Kogelberg-firelily. (site 1a, site 1b and site 1c)	02 September 2015 (15H45 – 17H00)
Enviro Loo	Enviro Options Pty Ltd	Desiccation Solid faecal waste (dry)	Enviro Loo: Dry / Waterless-Dehydration-Evaporation Sanitation System	Factory, Chamdor Johannesburg. (site 2a, site 2b and site 2c)	09 September 2015 (08H30 – 10H30)

Product Name	Company/Organisation	Type of sample	Description	Area (Site)	Time and Date of Site Visit
Enviro Loo	Enviro Options Pty Ltd	Desiccation Solid faecal waste (dry)	Enviro Loo: Dry / Waterless-Dehydration-Evaporation Sanitation System	Bekkersdal, Westonaria, GP. (site 3)	09 September 2015 (11H00 – 11H30)
Enviro Loo	Enviro Options Pty Ltd	Desiccation Solid faecal waste (dry)	Enviro Loo: Dry / Waterless-Dehydration-Evaporation Sanitation System	Boitumelo, Midvaal, GP. site (4a and site 4b)	09 September 2015 (12H45 – 14H00)
Clarus Fusion	Maskam Water	Package Plant Waterborne	Compact activated sludge STP	Café Bon Bon, Franschhoek, Cape Town, WC	26 October 2015 (12H00 – 14H00)
SmartSan Recycle Digester	Smart San	Membrane-Bio Liquid (wet)	combination of anaerobic biological & Nano filtration process)	Siyafunda school, Knysna. (site 1)	03 September 2015 (09H00 – 11H00)
SmartSan Recycle Digester	Smart San	Membrane-Bio Liquid (wet)	combination of anaerobic biological & Nano filtration process)	Oakhill school, Knysna. (site 2)	03 September 2015 (11H15 – 11H00)
Nano Bio digestor system	Waste Intrigue Services	Membrane-Bio Liquid (wet)	ST with aeration	Gauteng	14 October 2015
ZerH$_2$O waterless toilet	ZerH$_2$O	Compost Solid faecal waste (dry)	Composting urine and toilet. Domestic Waterless, Dehydrating Toilet-needs no chemicals or other ‘additives’	Siyakhana, Johannesburg	20 August 2015

14.4 LABORATORY RESULTS AND ANALYSIS

The following are the results of the laboratory analysis carried out on the faecal samples, which were collected at different sanitation technologies[3].

14.4.1 Chemical Oxygen Demand

The Chemical Oxygen Demand (COD) is the number of oxygen equivalents taken up by organic compounds during oxidation (Yao, Wang & Zhou, 2014). COD is used to determine how many organic pollutants there are in a substance.

The COD values of the solid samples were expressed in g/g dry mass instead of mg/L to provide a base for comparison between the different samples that vary significantly in their moisture content and at the same time have a high solids content.

The COD values for the liquid samples were expressed in mg/L and compared to the minimum standards for effluent discharge.

Solid Faecal Samples

Of the solid samples, the highest COD values were measured for the samples containing fresh faeces as expected, mainly for the Enviro Loo's samples 7-2, 12-2 and 13-2, with COD values between 0.86 and 1.33 g/g dry solids (**Figure 14.2**). Fresh faeces usually have high COD values and the level of reduction with time indicates the efficiency of the sanitation technologies. For the samples collected from the Ecosan facility (samples 5 and 6), the COD values were still very high (0.89 and 1.08 g/g dry mass respectively). The reason for that could be the high moisture content of the samples and the lack of sunlight to ensure good drying process to take place as the sampled facilities were located under a shade. The high COD values of the compost from the Ecosan – sample 1 with 0.65 g COD/g dry sample also indicate that the treatment process may have not reduced significantly the COD values of the mixed sludge. The lowest COD values were measured from the Afrisan samples – from 14-2 to 16-2 (0.08 and 0.04 g/g dry sample respectively).

The COD is also an indication of how old and biodegradable the sludge is (UKZN &eThekwini Municipality, 2014), and the value seems to be highly variable with regards to age of sludge at different sites and depth of the pit. For VIPs, there was a reduction of the COD with the depth of the pit which is an indication of stabilisation of the sludge with age and depth respectively (Zuma et al., 2015). The COD for faecal sludge samples from a VIP latrine toilet have been recorded to mostly be between 0.3 and 4.4 g/g dry mass (Zuma et al., 2015). The COD values of the dry samples analysed in this study fit within this range. The highest values of COD are typically from fresh sludge or faeces and the treated product – aged sludge, compost, etc., have significantly reduced values compared to the fresh samples which could be attributed to the treatment process and the aging of the sludge over time. The COD values

[3] The averages recorded in this report are of the samples which have gone through their respective sanitation technology and undergone treatment in the system (from the outlets). For a full summary of all samples, consult Annexure D.

of the final products however should be compared to standards depending on their final use/application.

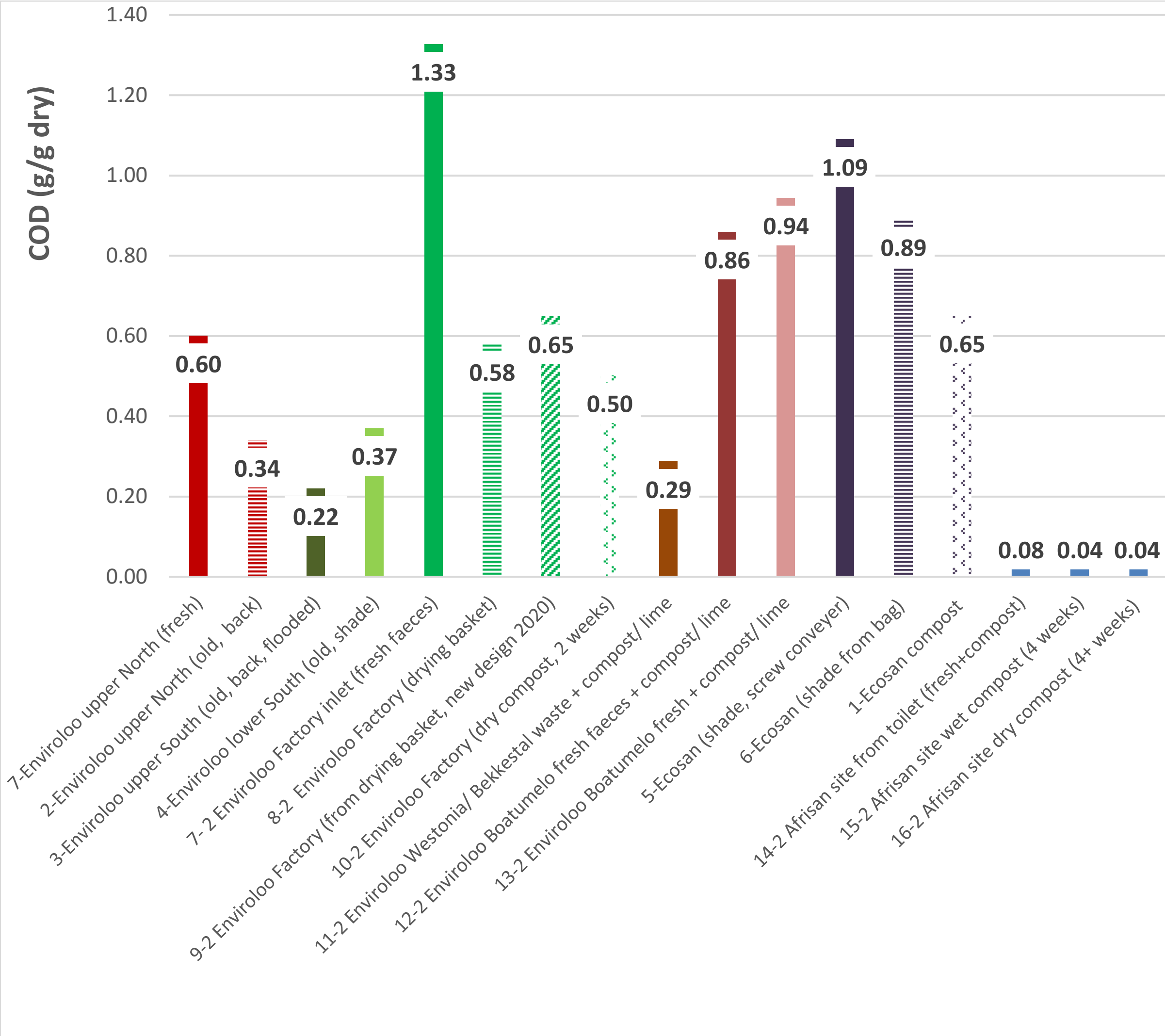


Figure 14.2: Chemical Oxygen Demand for solid samples.

Liquid samples

The highest value of COD was registered for the overflow liquid in one of the Enviro Loo dry systems (sample 12**, Figure 14.3**). The explanation for such a high value is that the sample was comprised mainly from urine contaminated with faeces. This was a dry, not a water-using system, as the other liquid samples and hence was more concentrated. The indication for such high values of COD suggests that overflows of these kind of systems should be limited to prevent from contamination to the environment.

The average COD for the rest of the liquid samples (**Figure 14.4**) was between 33.62 and 498.77 mg/L. As expected, for the inlet samples (untreated black water, just after the flush), the COD values were much higher – between 83.65 and 498.77 mg/L, than for the outlet samples that were in the range between 33.62 and 372.90 mg/L. The outlet (effluent values) were compared to the minimum standards for effluent discharge – 75 mg COD/L. **Figure 14.4** indicates that not all the effluents after passing the treatment technology might be compliant with the standard regulations, however as mentioned earlier, more detailed investigation and sampling would be required for each system in order to conclude on this.

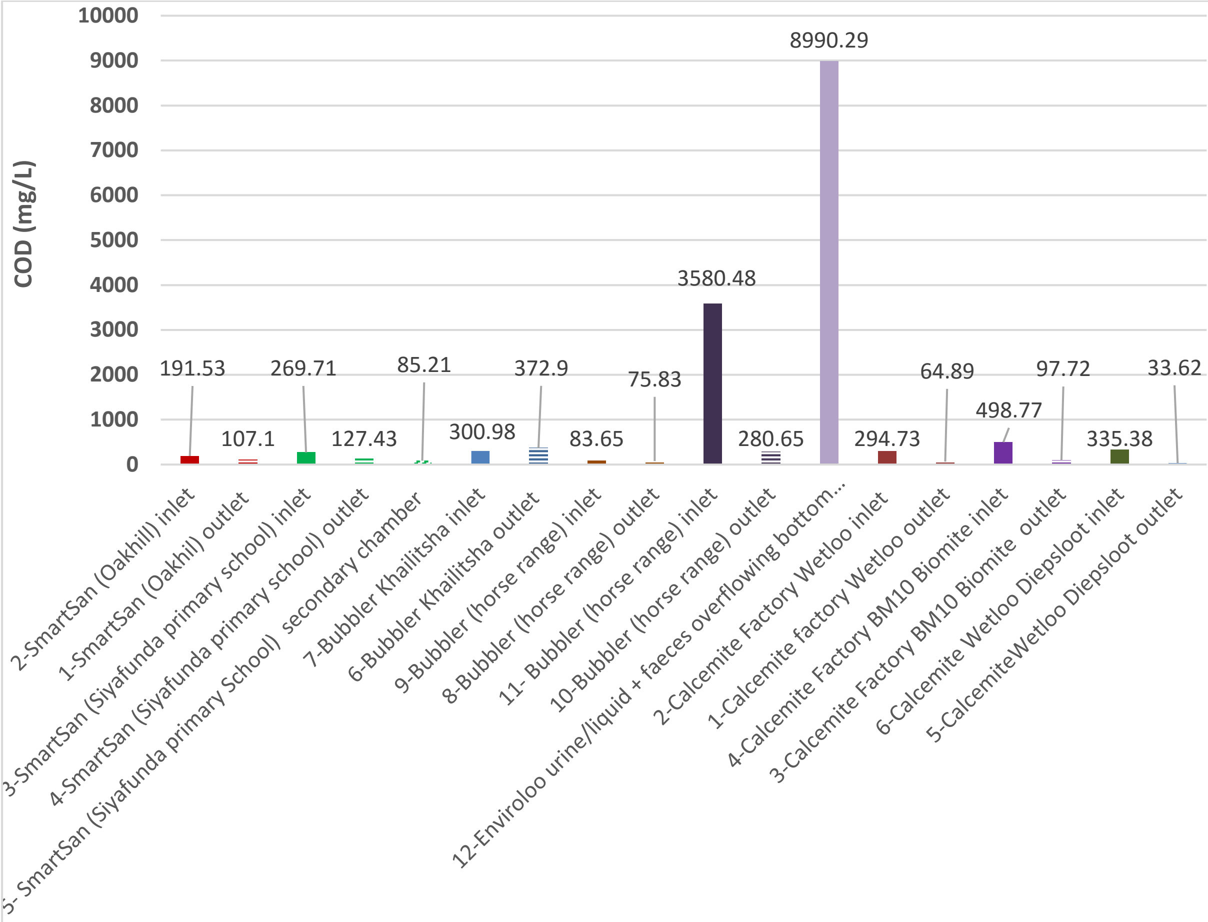


Figure 14.3: Chemical Oxygen Demand for collected liquid samples - 1.

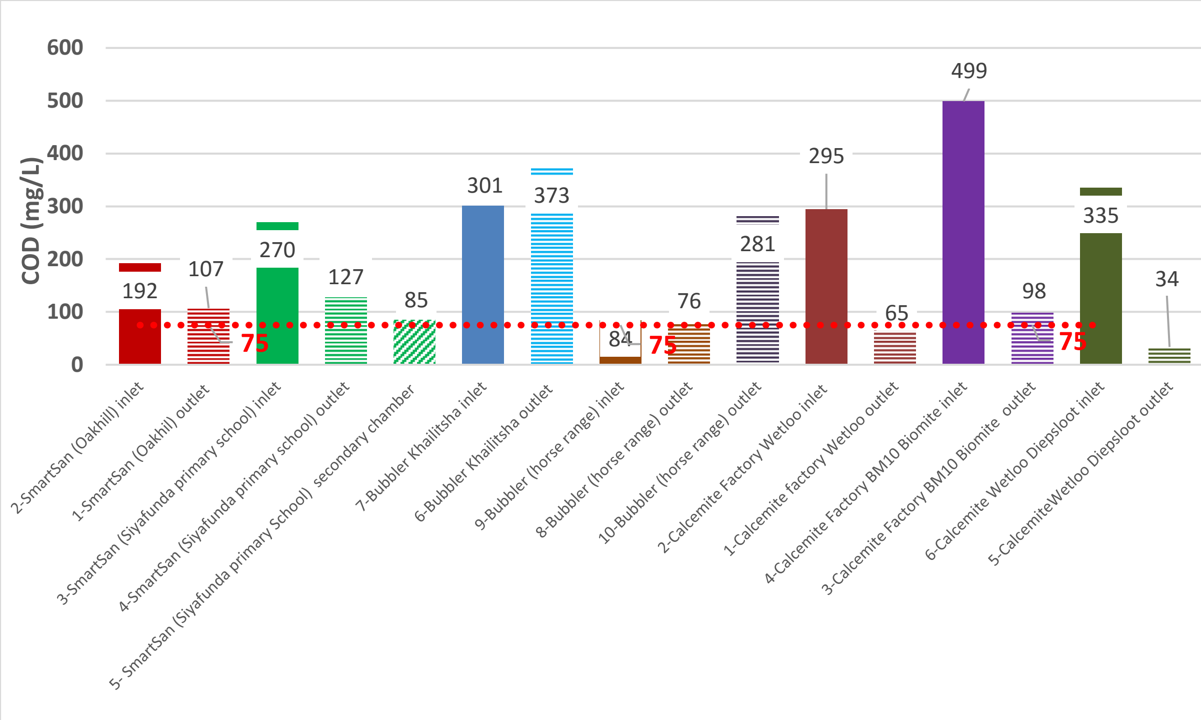


Figure 14.4: Chemical Oxygen Demand for collected liquid samples - 2

The Nano Recycling Bio Digester was also tested. The results from the grab sampling can be seen in **Table 14.2** and **Figure 14.5**.

Table 14.2: Reference of the samples during testing field for Nano Recycling Bio Digester System, 14/10/2015, Gauteng, South Africa.

Reference	Site	Sampling position	Observations
1M-1	Site 1 (individual WC)	Entrance of the sceptic tank (left side)	-
1M-2	Site 1 (individual WC)	Aerobic chamber (left side)	Problem with label – these samples could be switched
1M-3	Site 1 (individual WC)	WC tank from male restroom	
1W-1	Site 1 (individual WC)	Entrance of the sceptic tank (right side)	-
1W-2	Site 1 (individual WC)	WC tank from female restroom	-
2-1A	Site 2 (hospital wastewater)	Entrance of the sceptic tank (surface)	Problem with label – these samples could be switched
2-1B	Site 2 (hospital wastewater)	Entrance of the sceptic tank (middle)	
2-2	Site 2 (hospital wastewater)	Anaerobic chamber	-
2-3	Site 2 (hospital wastewater)	Aerobic chamber	-
2-3	Site 2 (hospital wastewater)	Outlet pipe	-

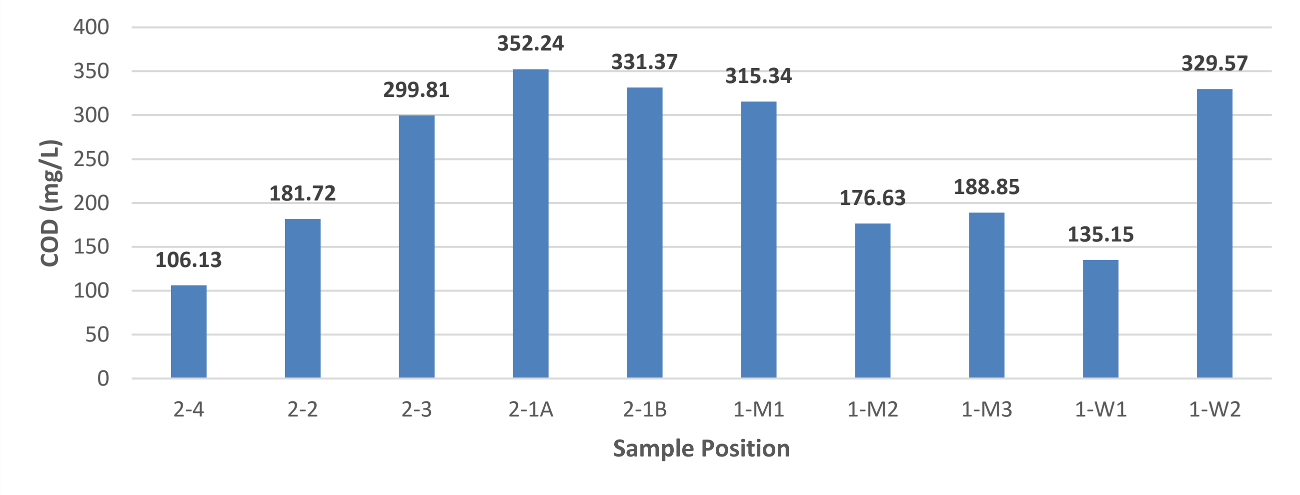


Figure 14.5: Summary Results of COD (Nano Biodigestor)

In order to calculate the average for the technologies, it would be necessary to have several readings. In the most cases the sample size was not of statistical significance for this report, however, the average for the technologies is recorded. The readings may be from different sites.

14.4.2 Electrical conductivity (EC)

The measurement of electrical conductivity of effluent is a measure of salinity (Pescod and Arar, 1988). In water quality, this means that there are more ions than can be physiologically tolerated by organisms. The EC readings for this study are summarised in **Table 14.4**.

The average EC readings for the solid samples are presented in **Figure 14.6**. The high EC values for some of the samples of up to 13 800 µs/cm (e.g. 1, 2, 3, 5, 7 and 7-2), compared to the rest of the solid samples, can be explained with the high presence of ions (probably due to mixing with urine) or with an error during the reading which is unlikely. For the rest the solid samples, the EC varied between 10 and 2000 µs/cm. Correlation of the EC reduction and the treatment processes was not observed.

For the liquid samples, there was a better correlation of the EC reduction after treatment although this was not clearly observed for all the samples. The EC of the effluent samples varied between 440 and 2565 µs/cm (**Figure 14.7**). The minimum standard for effluent discharge is 700 µs/cm. Sample 12 which was collected from the overflow of one of the Enviro Loo toilets showed a very high EC which should be due to the high concentration of urine, contaminated with faeces (**Figure 14.8**). This sample was collected from a dry sanitation technology and was not diluted with flush water.

The most of the results revealed high concentrations of ions.

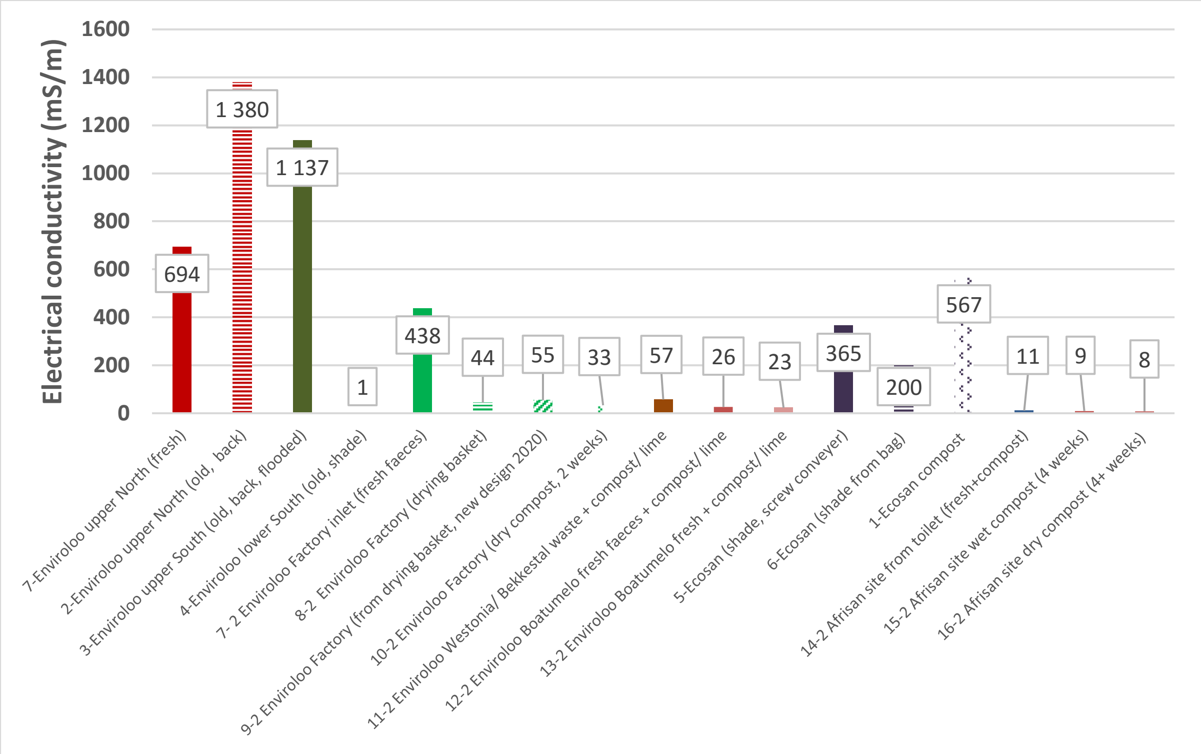


Figure 14.6: Average EC for solid samples.

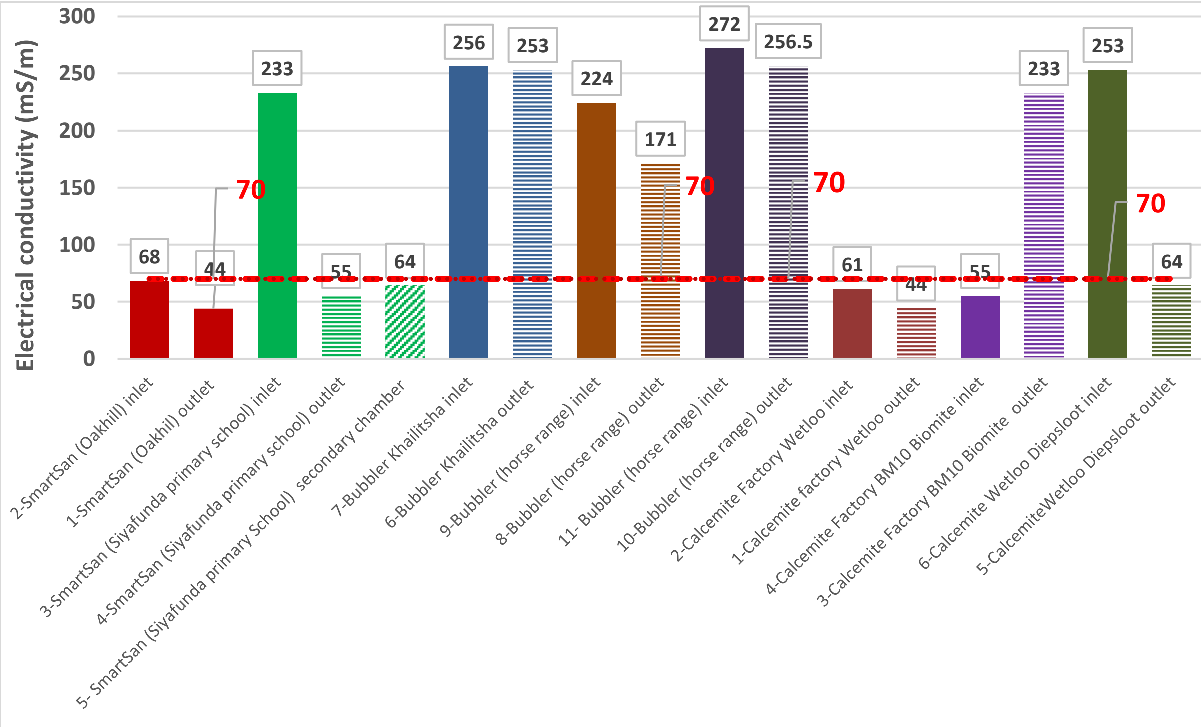


Figure 14.7: Average EC for liquid samples.

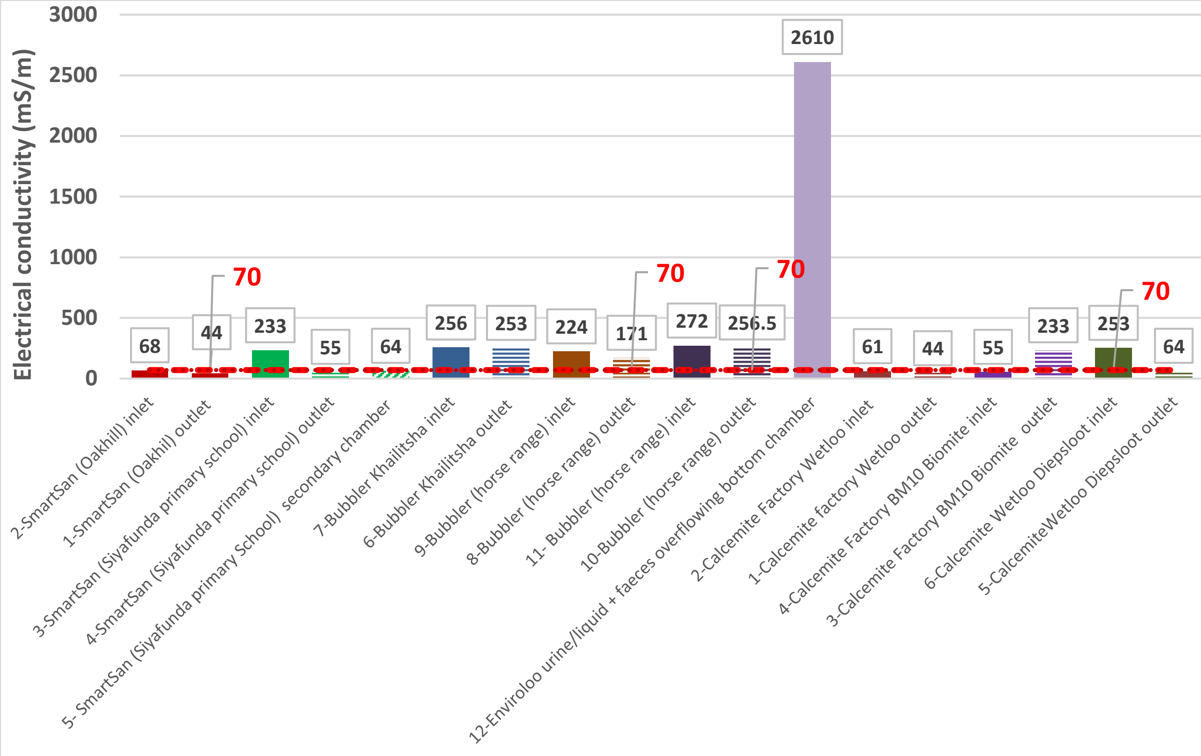


Figure 14.8: Average EC for liquid samples.

14.4.3 pH

The pH expresses how acidic or alkaline matter is on a logarithmic scale, at which neutral is at 7. The pH of faecal sludge is highly variable, often due to the aerobic or anaerobic processes which take place (Zuma et al., 2015) and the microorganisms which are usually sensitive changes in the pH, and other factors which may inhibit anaerobic digestion of sludge (UKZN & eThekwini Municipality, 2014; Bhagwan et al., 2008). Research shows that the optimal pH for biological activity in faecal sludge is between 6.5 and 8 (Zuma et al., 2015) and is neutral between 5.3 and 7.5 (Rose et al., 2015). Therefore, the pH impacts on the degradation of sludge.

The pH values of faecal sludge found in VIP latrines has been recorded to be between 4.7 and 8.6 (Zuma et al., 2015). For this study, the average readings were between 7.2 and 9.1 and some of these values were above the optimal range for biological activity, meaning that certain aerobic microorganisms might slow down their activity. The higher readings may also be due to high salinity or ions due to the presence of urine, as shown by the EC values (**Figure 14.6** to **Figure 14.8**) and the pH range of urine between 9.0 and 9.3 (Zuma et al., 2015; Jonsson and Vinneras, 2007). Some of the dry sanitation technologies such as African Sanitation, Enviro Options and ZerH$_2$O had more alkaline faecal wastes. This may be attributed to the addition of lime that is used to neutralise odours between each use.

For all the liquid samples, the pH was within the minimum standards for effluent discharge range (**Figure 14.10**). The recommended pH according to the minimum standards for effluent discharge is 5.5-9.5.

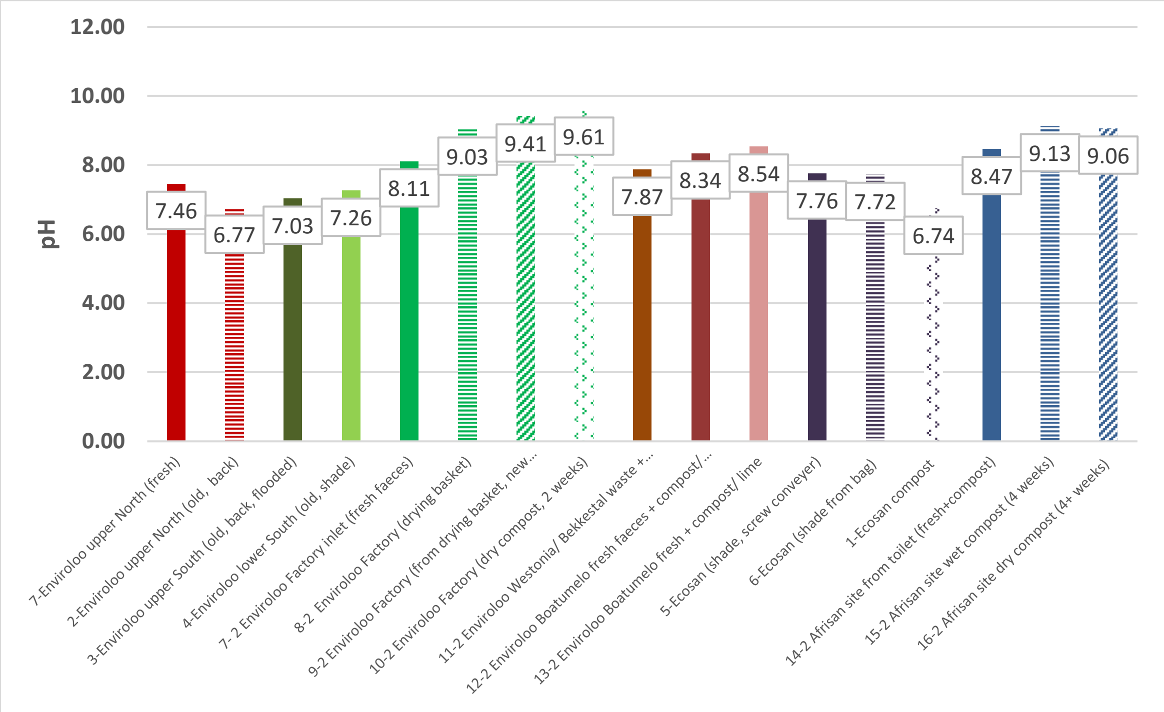


Figure 14.9: Average pH for solid samples.

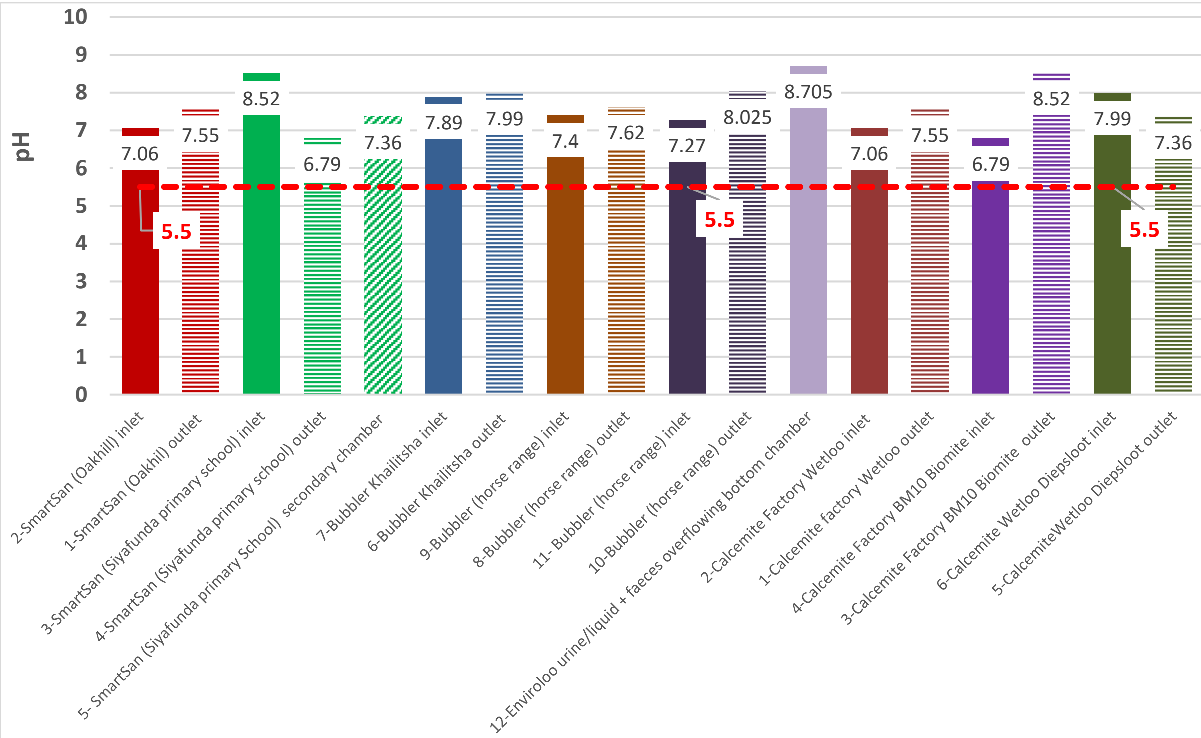


Figure 14.10: Average pH for liquid samples.

14.4.4 Helminths

Tests were carried out on solid waste to determine the presence of helminths (worms) which lay eggs (ova) which have the potential to be a health risk and for re-infection of humans. Helminths or nematodes which dwell in the intestine are parasitic infections such as *Ascaris lumbricoides* (roundworm) and *Trichuris trichiura* (wipworm) which spread easily in environments where sanitation is poor or insufficient (Koné et al., 2007).

Ascaris was found in the Bubbler, African Sanitation and Enviro Options' systems, however, most were either infertile, underdeveloped or dead. Ascaris necrotic larva were found in Afrisan and Enviro options at 0.2 eggs per gram (see **Table 14.6**). Only the informal settlement of Boitumelo, where Enviro Loo toilets were installed, had H. nana ova at 1.2 eggs per gram. As helminths are spread from person to person, the presence of *H. nana* ova may be a reflection of the contextual situation. The toilets serve approximately two households each but are installed externally on the side of the streets. Although these are maintained, there is no compost or ash used to cover the faeces after use, it was a very warm weather (27 degrees Celsius) at the time of sampling, and the faecal waste was due for collection (see site verification report). These and other factors may have attributed to the development of *H. nana* ova. Helminths have also been found to be able to survive in moisture content of about 80% (Koné et al., 2007). The fresh faeces at Boitumelo was between 73% and 77% moisture content, and the average moisture content for most of other systems were well above 90% (see section 14.10).

Table 14.3: Content of Ascaris found in Samples.

	Bubbler primary chamber (wet sample)		Afrisan compost (4 weeks old dry sample)		Enviro Loo informal settlement-Boitumelo	
Sample Vol. or Mass	277 ml		20 mg		10 mg	
Ascaris infertile	1	0.00098 eggs per litre	1	0.05 eggs per gram	63	6.3 eggs per gram
Ascaris Undeveloped	2	0.002 eggs per litre	0		0	
Ascaris dead	0		2600		3144	0.0032 eggs per gram
Ascaris Necrotic Larva	0		4	0.2 eggs per gram	7	0.7 eggs per gram
Taenia Dead	0		11	0.55 eggs per gram	0	
H. nana ova	0		0		12	1.2 eggs per gram

14.4.5 E. coli

The *E. coli* (*Escherichia coli*) is measured in colony forming units (CFUs), that is, the number of colonies that would emerge from the incubated bacteria. These were used to identify bacterial load in the water. The count of indicator organisms present in any given volume of water often indicates microbial water quality. Faecal coliform are a general indicator of the quality, in terms of presence of disease causing bacterial pathogens (Ashbolt et al., 2001).

The recommended *E. coli* count is <1000 CFU per 100 ml. The General Authorisation limit does permit higher CFU readings for small scale plants (such as a household system), however with reference to **Table 6.3**, this type of sanitation solutions consider this lower target to minimise the health risk associated with handling faces and to allow for the possible densification of a technology (i.e. the same technology applied to 500 neighbouring houses requires a more stringent control of effluent quality to mitigate the cumulative effect of these systems).

The *E. coli* content of the analysed samples is presented in **Figure 14.11** to **Figure 14.13**. As previously mentioned the results are based on a single sampling and more rigorous sampling and analytical investigation is required to be able to conclude about the efficiency of the investigated sanitation technology regarding faecal coliform reduction. Nevertheless, for the most of the analysed samples, the outlet/ treated sludge samples demonstrated reduction of the *E. coli* content compared to the inlet/ fresh sludge samples.

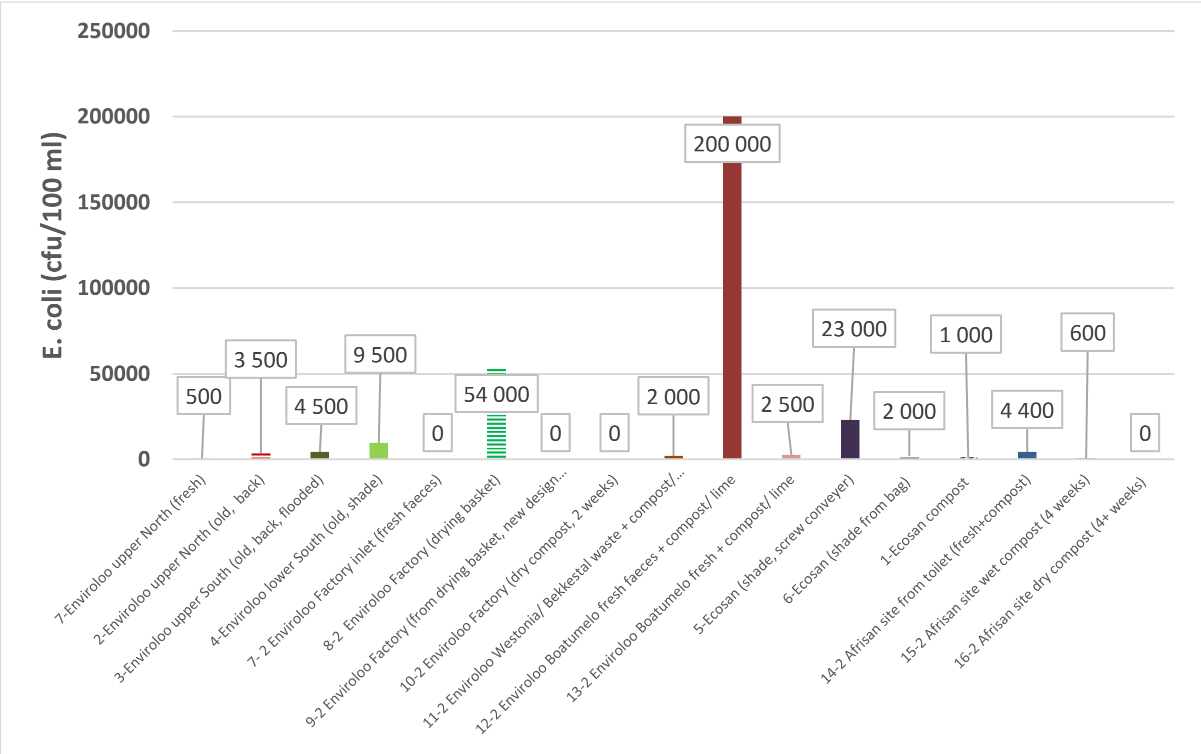


Figure 14.11: *E. coli* content for solid samples.

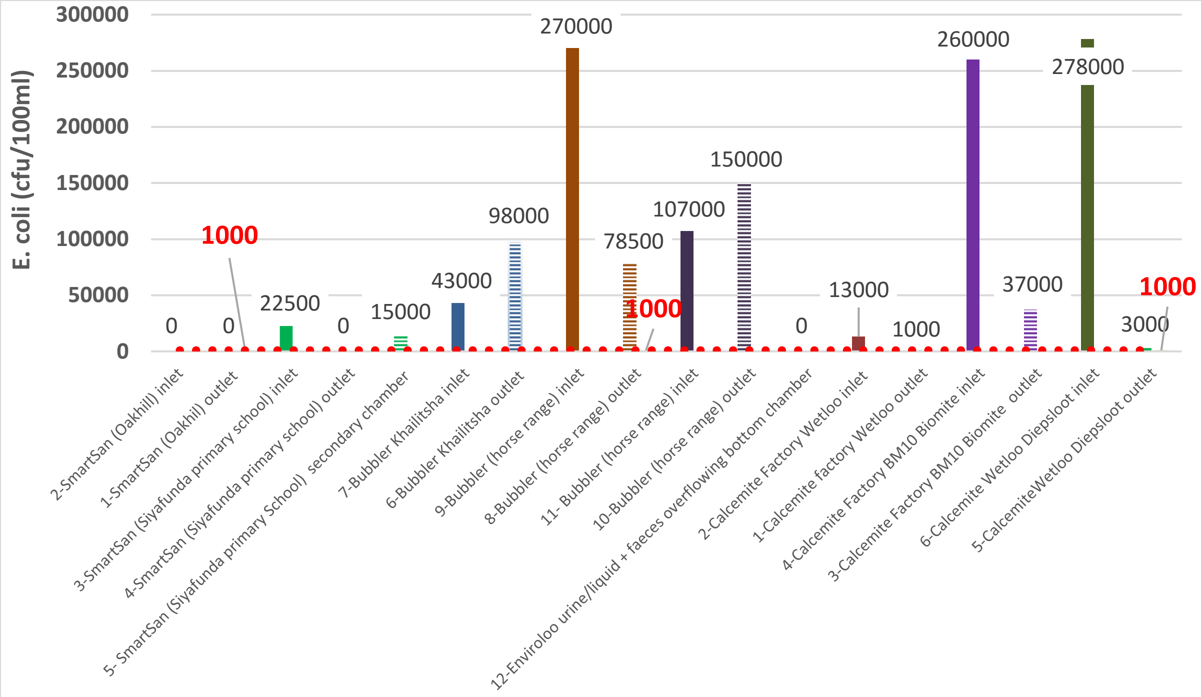


Figure 14.12: ***E. coli*** **content for liquid samples.**

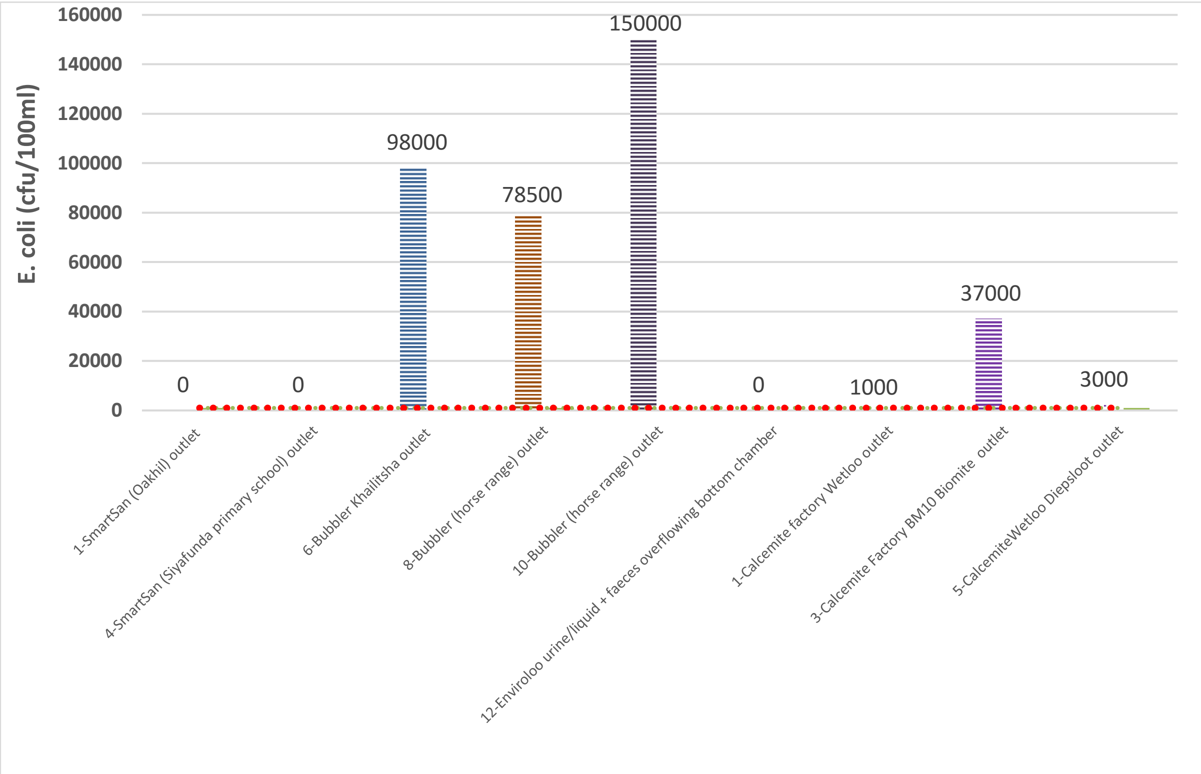


Figure 14.13: ***E. coli*** **content for liquid outlet samples.**

14.4.6 Total Solids

"Total solids (TS), volatile solids (VS), fixed solids (FS or ash) and suspended solids (SS) provide respectively, the total amount of solids and their distribution between organic, inorganic, suspended and dissolved fractions. The solids content helps to understand the degree of stabilisation in the pit and the mechanical behaviour of sludge in terms of mixing, drying, flowing, floating, settling, clogging and combusting" (UKZN & eThekwini Municipality, 2014).

As expected, the total solids content of the samples coming from the dry sanitation technologies was much higher than for the liquid samples. For the solid samples from dry sanitation technologies, the total solids content was between 17 and 97% depending on the state of biodegradation before, during or after the treatment process. The treated samples demonstrated higher total solids content than the fresh sludge samples (**Figure 14.14**).

The solids content for the liquid samples was insignificant but it is indicatively presented in **Figure 14.15**. The only sample that indicated a little higher total solids content (2.16%) than the rest of the liquid samples was sample 12 collected from the overflow of one of the Envirosan dry sanitation technologies. All the rest of the samples were collected from waterborne (flush) systems.

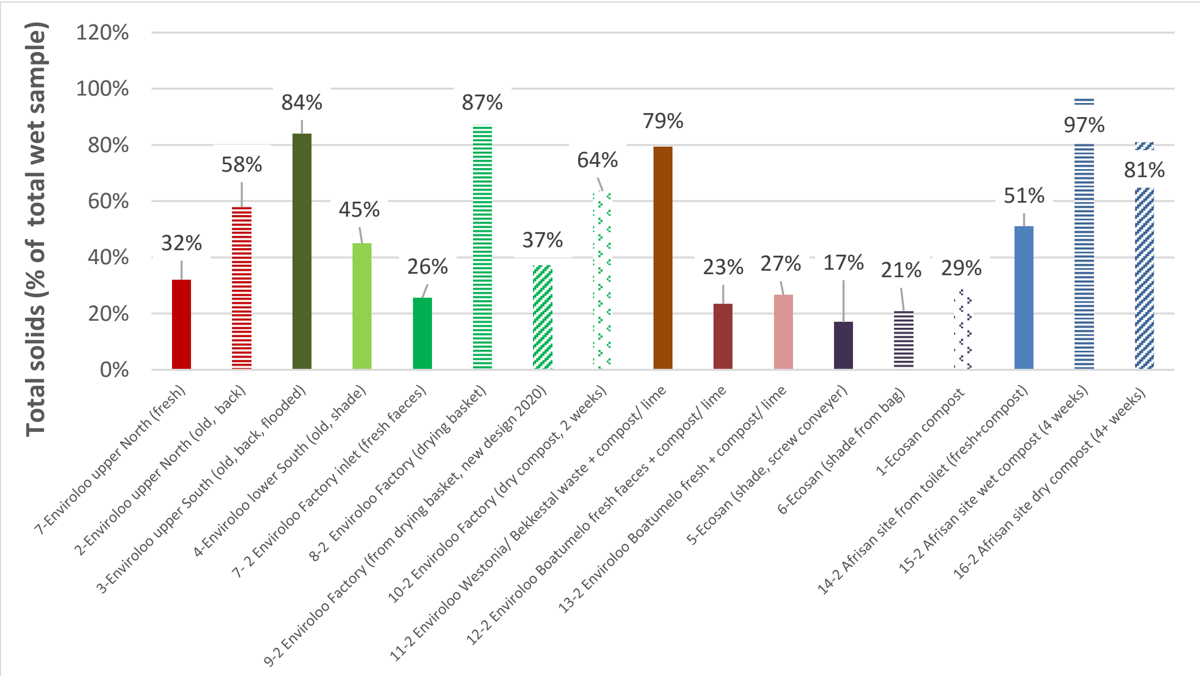


Figure 14.14: Total solids content of solid samples.

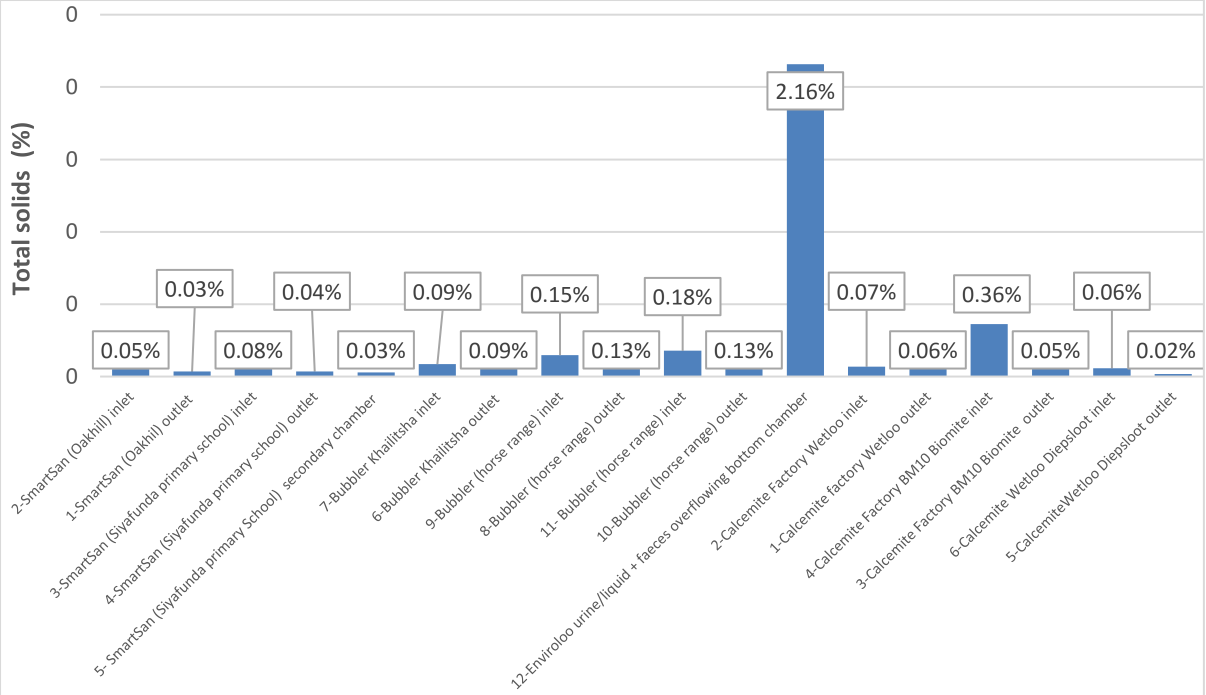


Figure 14.15: Total solids content of liquid samples.

14.4.7 Suspended Solids

Total suspended solids refer to the aggregate amount of organic and inorganic matter within a body of water, whether it be mass or concentration (Bilotta & Braizer, 2008). As suspended solids are an indicator of turbidity, the circulation of air in the systems for aerobic and anaerobic processes may contribute to lower water quality, with regards to suspended solids (Bilotta and Braizer, 2008). The suspended solids were measured only for the liquid samples and are presented in **Figure 14.16** and **Figure 14.17**. From the most of the analysed samples, a reduction of the suspended solids content was observed after passing through the treatment technologies. For most of the outlet technologies, the suspended solids content was under the minimum standard for effluent discharge (25 mg/L).

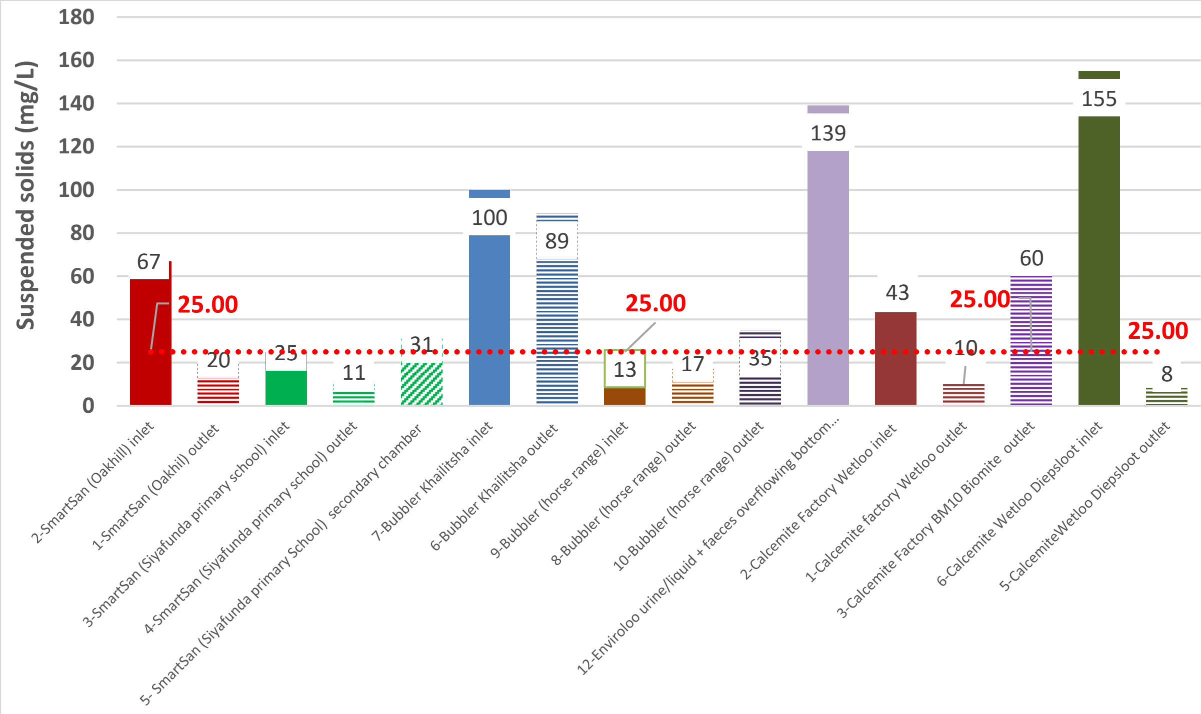


Figure 14.16: Suspended solids content of the analysed water-borne technologies.

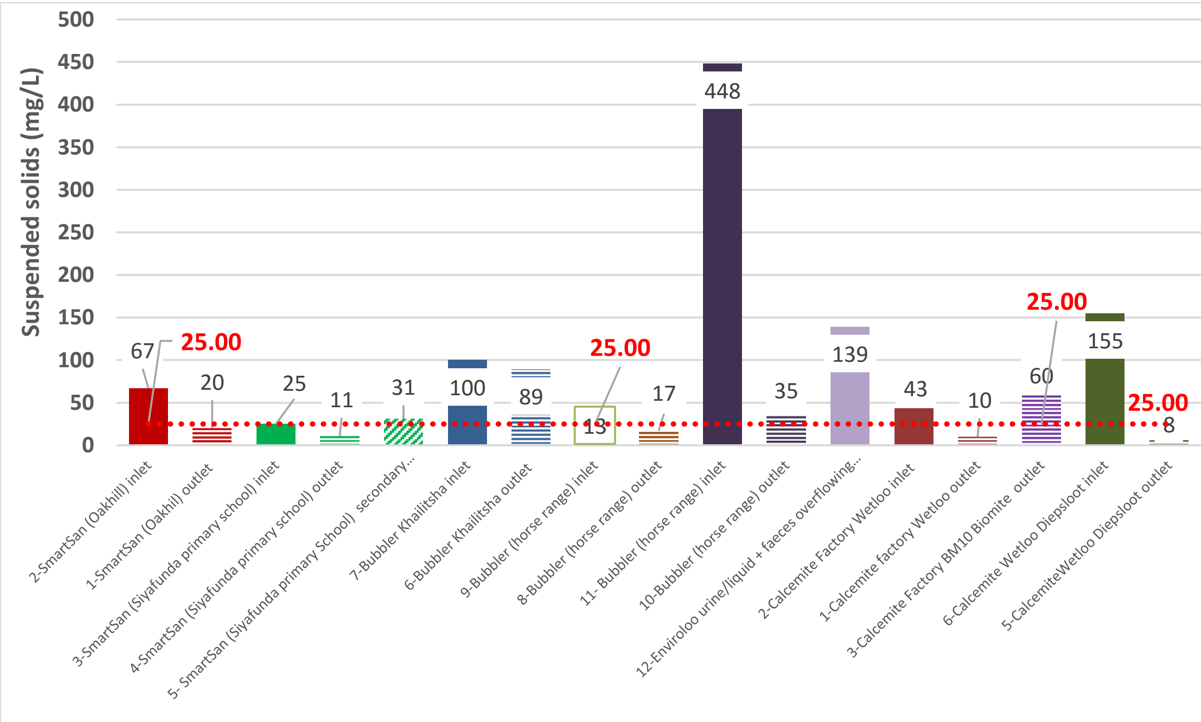


Figure 14.17: Suspended solids content of the analysed water-borne technologies – 2.

14.4.8 Volatile solids

The volatile solids represent an estimation of biodegradable organic components and for solid samples are expressed in g/g dry sample (**Figure 14.18**). The ash content is an indicator of the non-biodegradable, inert fraction of the total solids. For VIP latrines, volatile solids have been measured between 0.43 and 0.83 g/g dry mass, decreasing with depth of the sludge within a pit (Zuma et al., 2015). The content of biodegradable organics reduces with time and during the treatment processes; the ash content increase proportionally to the volatile solids reduction. For that reason, some of the analysed compost samples (e.g. Afrisan) demonstrated a very high ash content and very low volatile solids content respectively, indicating that the biodegradation processes have already been completed and stabilisation has been achieved. The EcoSan compost sample on the other hand showed high presence of volatile solids (0.66 g/g dry mass) which indicates that longer time for biodegradation stabilisation would be required. The fresh samples indicated as expected higher values for volatile solids as the presence of organics is the highest.

For the liquid samples, the volatile solids expressed as g/g dry solids were between 0.17 and 0.81 g/g dry mass. However, their content expressed per wet mass (the overall volume of the sample) was insignificant as the total solids content was very low (**Figure 14.19**).

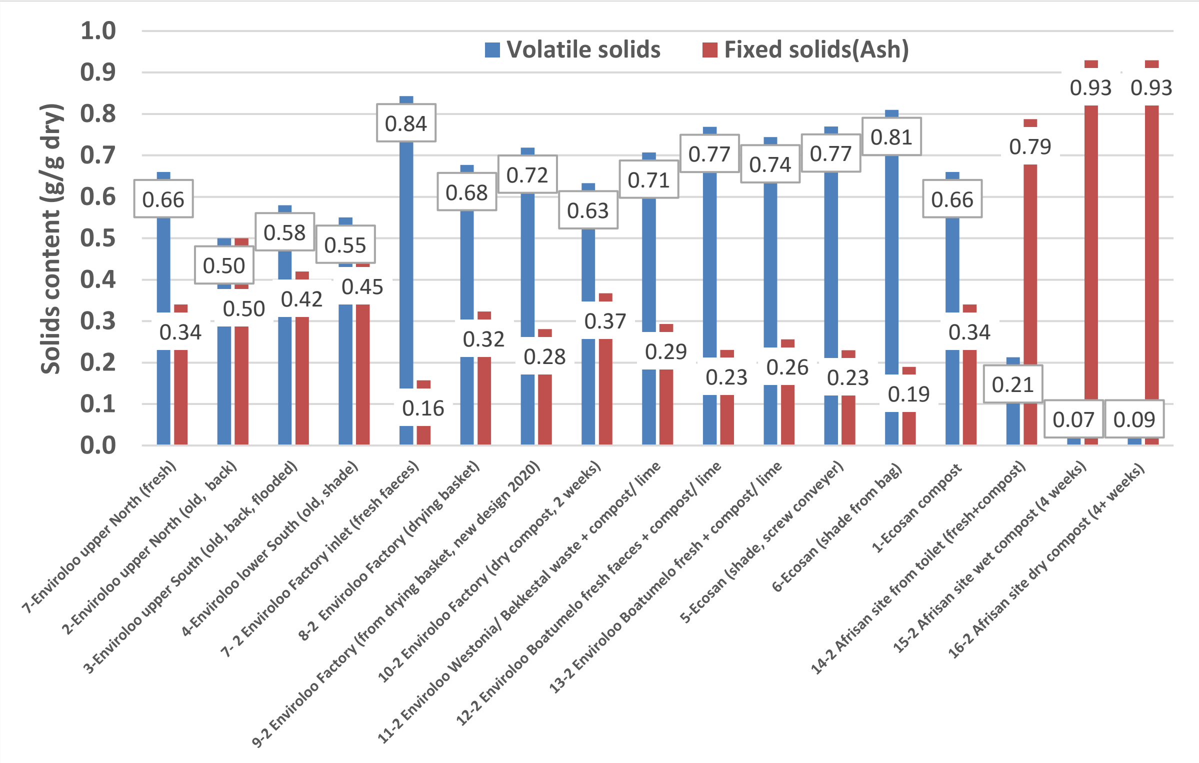


Figure 14.18: Summary of volatile solids and ash content of the analysed solid samples.

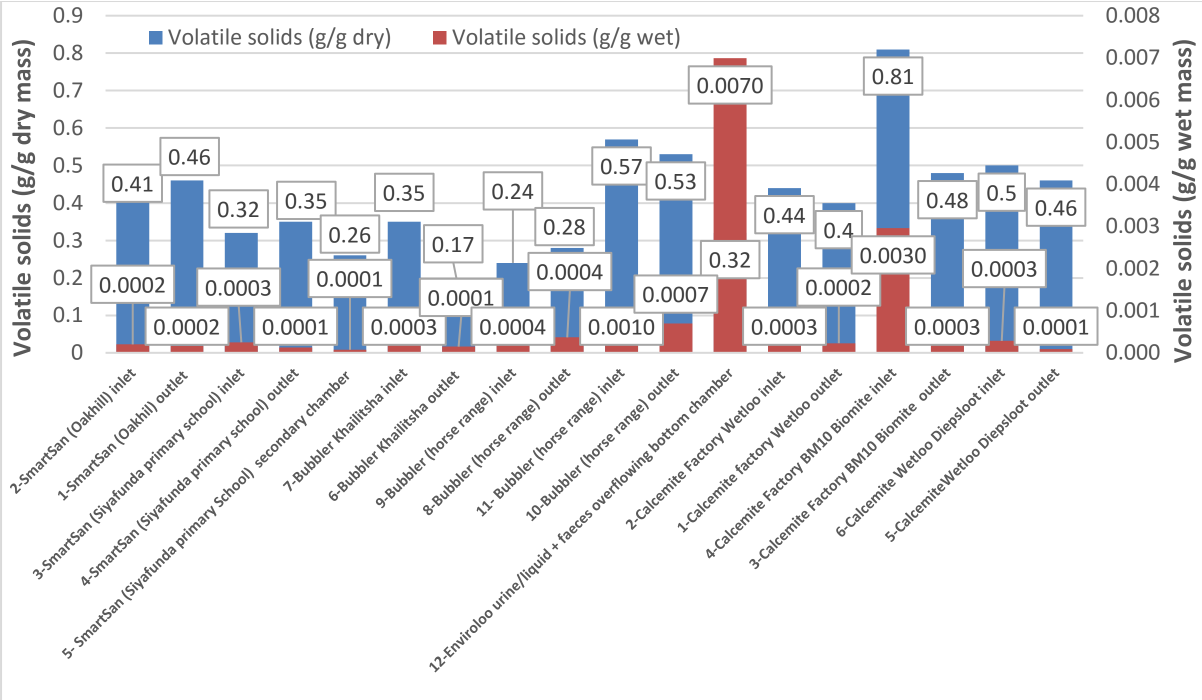


Figure 14.19: Summary of volatile solids and ash content of the analysed liquid samples

14.4.9 Total Nitrogen, Ammonia and TKN

The total nitrogen in faecal sludge is comprised of Total Kjeldahl Nitrogen (TKN), ammonia, nitrite, nitrate and ammonium. The TKN is a representation of the organic nitrogen in faecal sludge or black water. TKN and phosphates are indicative of the proteins and nutrients in the faecal sludge, and the feasibility for agricultural use (UKZN & eThekwini municipality, 2014).

The nitrogen content values of the liquid samples were expressed in mg/L. Most of the samples indicated a high nitrogen load by ammonia and TKN (**Figure 14.20**). The ammonia content of all samples was compared to the minimum standards for effluent discharge – 6 mg/L (**Figure 14.21**). Almost all the outlet samples showed ammonia values higher that this minimum standard.

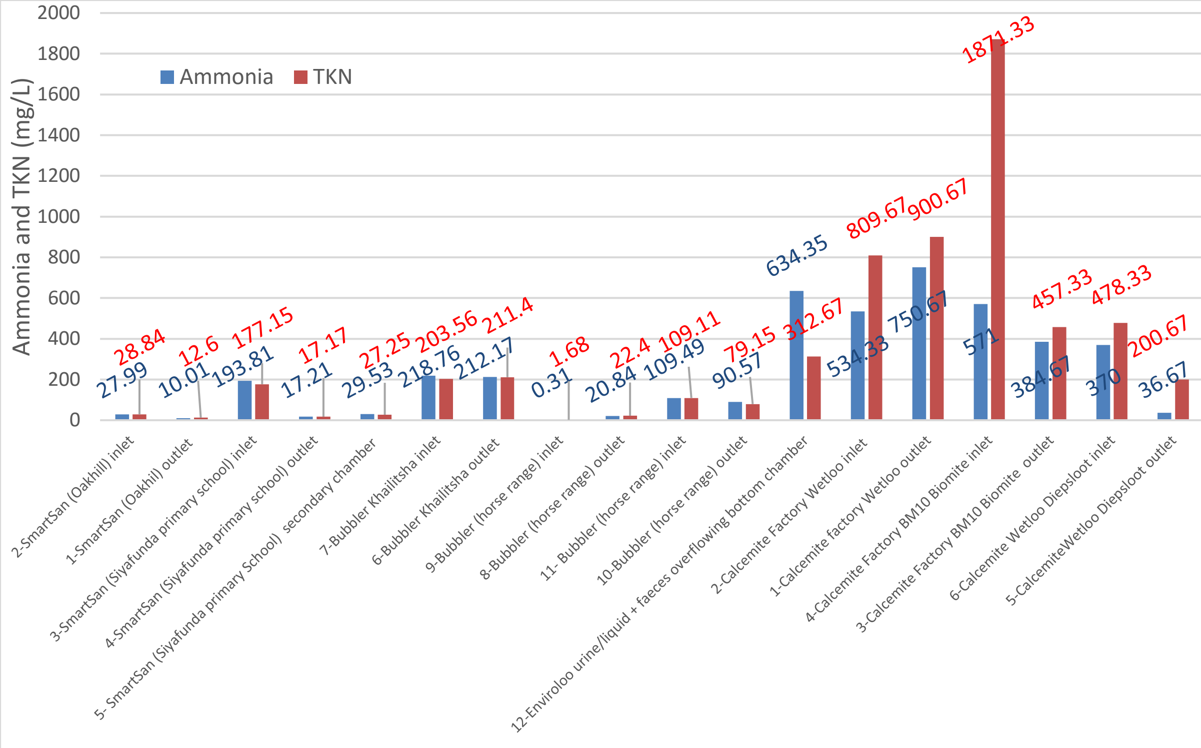


Figure 14.20: Summary of nitrogen content (ammonia and TKN) of the analysed liquid samples.

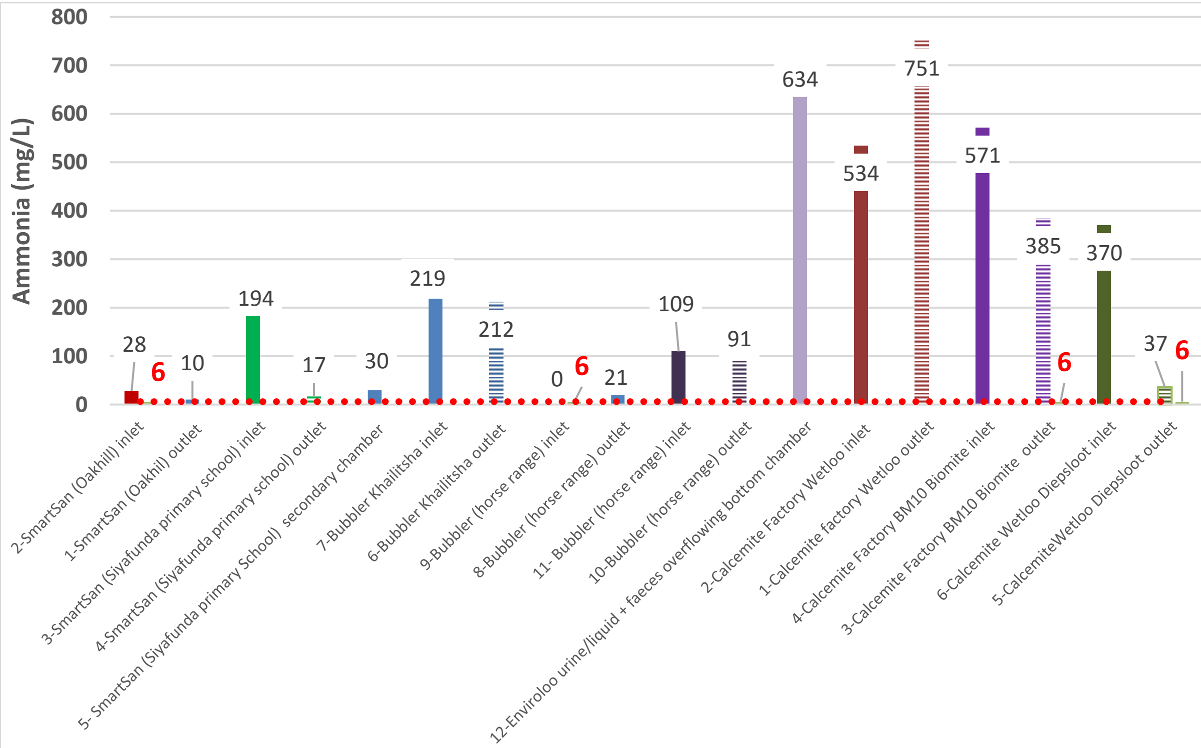


Figure 14.21: Summary of ammonia content of the analysed liquid samples.

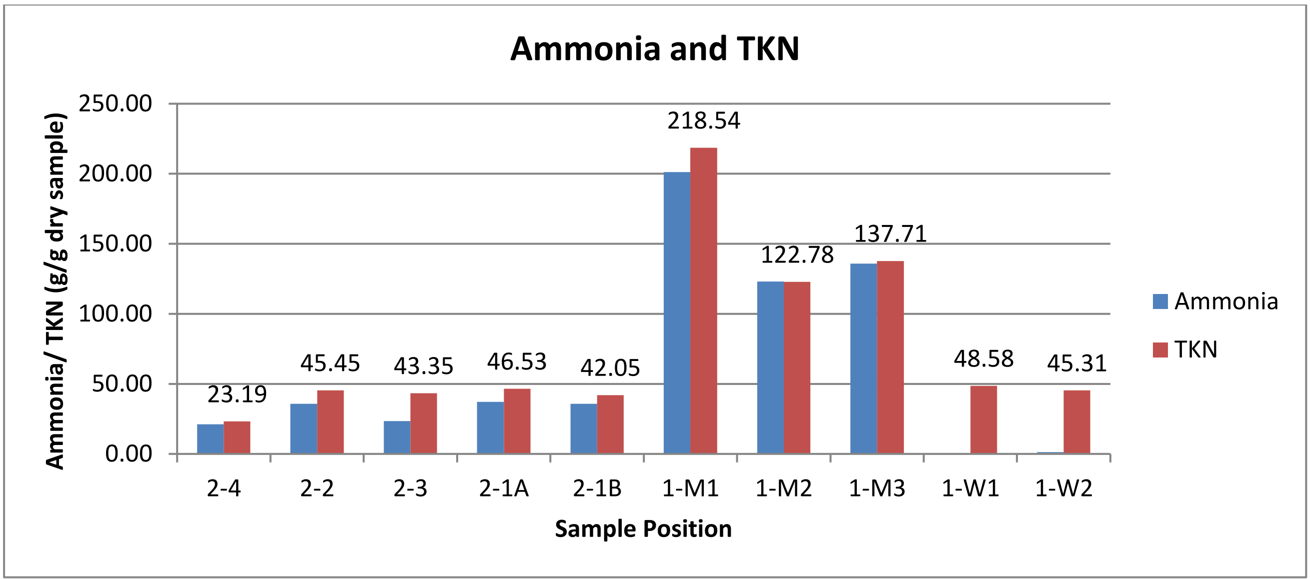


Figure 14.22: Summary Results of Ammonia and TKN (Nano Biodigestor).

Overview of results for Nano Biodigestor

This section provides an overview of the results obtained for the Nano Biodigestor.

1 – Samples 1-M1, 1-M2, 1-M3

- Decrease of COD, suspended solids, ammonia and TKN from the inlet to the outlet of the sceptic tank, may reflect thermal degradation of the organic and nitrogenous compounds, and settling of the solids, but may also be due to anomalies with sampling procedure from single data set.
- Increase of the nitrates may reflect nitrification.
- No variation of phosphates and Ortho-Phosphates.
- No specific trend was observed with the volatile and fixed solids.

2 – Samples 1-W1, 1-W2

- Unexpected results: higher COD and suspended solids at the outlet with respect to the inlet of the sceptic tank, as well as very low concentration of ammonia. These results may be explained by the fact that these toilets have not been regularly used; the increase of COD and suspended solids at the outlet (toilet tank) could come from the addition of WC disinfectant of blue colour.

3 – Samples 2-1A, 2-1B, 2-2, 2-3, 2-4

- Decrease of COD, suspended solids and volatile solids may reflect thermal degradation of the organic compounds and settling of the solids.
- No specific trend for the rest of the compounds, so nitrification cannot be identified in this biological reactor.

Comparisons between the three tested toilets:

- Lower volatile solids and higher fixed solids for samples "2-"
- Higher content of ammonia, TKN and total nitrogen for the samples "1-M", and very low content for the samples "1-W"
- Similar suspended solids, COD, phosphates and Ortho-Phosphates

- Lower nitrites and nitrates for the samples “2-”

14.4.10 Moisture Content

The moisture content for the solid sludge samples was found to be high, particularly for the fresh samples.

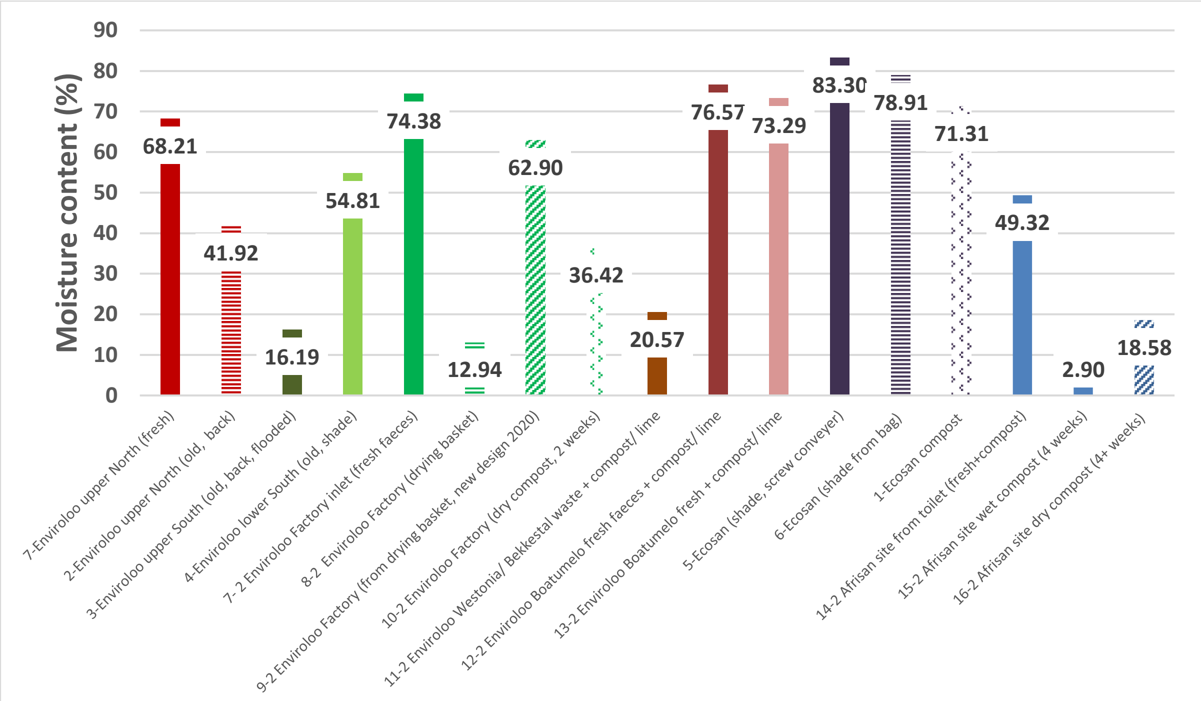


Table 14.23: Average for moisture content in solid samples.

14.5 TESTING OF ANDY LOO

The Andy Loo was a system which was directed for performance evaluation by the WRC (**Figure 14.14**).

Figure 14.14: Functionality testing of Andy Loo.

Overview of Performance Evaluation of Andy Loo

The initial concerns for the Andy Loo toilet was that there did not seem to be a specification for the air inlet system for combustion. Without adequate circulation of air in the system during the process, toxic carbon monoxide could be produced. Additional concerns included the possibility of poisonous combustion gas escaping into the room where the toilet is installed, if maintenance and clearing of clogged pipes is not ensured, nor is there a post-treatment gas to minimise atmospheric pollution.

<u>Actions:</u>

- Installation of the toilet in the laboratory
- Understanding of the different parts of the toilet and measuring of the dimensions
- Combustion test of the toilet without addition of faeces
- Combustion test of the toilet with the addition of faeces (4 stools)
- Measurement of urine evaporation chamber
- Test of flow ability of the toilets in the urine collection compartment
- Combustion test of the toilet without addition of faeces

<u>General observations:</u>

- Type of toilet: UDDT

- Unit relatively compact but heavy (2 persons needed to carry it)
- Materials:
    - Metal for the internal structure and the chimney
    - Wood for the external structure
- Waste disposal:
    - Mechanism to drop faeces in the combustion chamber simple and functional
    - Mechanism to recover urine functional for the first design (inclined wall), but not correctly designed in the new design (not inclined wall, so low flow ability leading o urine accumulations)
    - Material seems hydrophilic with respect to water (drops of water sticks to the wall)
    - Weak separation between urine and faeces collecting compartment
- Smell during operation:
    - combustion odourless
    - strong burning odour during faeces combustion
- Combustion gas during operation:
    - Colourless
    - Moist visible
    - Small quantity of gas going out from the system of faeces drop
- Temperature range during operation:
    - 60-100°C for the structure receiving the excreta and the chimney
    - ambient temperature for the external structure (wood)
    - ~ 270°C in the zone of faeces combustion
    - 50-60°C in the user interface (sit level)
    - ~ 100°C for the exhaust gas
- Briquette combustion:
    - Apparently good performance of combustion
    - Equal or less than 4 hours for a whole briquette
- Addition of faeces (+ toilet paper) during combustion
    - A small quantity of faeces remains on the surface of the rotating cylinder and gets dried, leading to the formation of a crust
    - Remaining solid of grey, brownish and black colour (look of a mixture of char and ash) after around half an hour
    - Remaining solid found on the pan, and at the ground level of the toilet
- Chimney:
    - Operational (gas exiting at velocity around 0.3 to 0.7 m/s)
    - Connection of the chimney too loose when cold, but tight when combustion in operation (surely due to thermal dilatation of the material after the increase of temperature)
    - After use, slight amounts of dust on the inner walls (could correspond to ash or black carbon)
- Normal appearance of pan after toilet operation.

14.6 CONCLUSION

The results presented here have shown that the values of the physico-chemical and biological properties of faecal sludge samples were fairly high. These readings are, however, not indicative of the overall situation as the results were obtained from one-time (grab) samples. This performance evaluation could therefore not be statistically validated. However, they do give a snapshot picture of the treatment ability of sanitation technology systems in South Africa. The readings were also dependent on the number of samples. Enviro-Options, for example, had a greater number of samples collected than other technologies. The results were often indicative of the different contexts and maintenance intervals. Further monitoring and laboratory analysis of all systems over a long period would be ideal.

15 SANITATION DOSSIERS

15.1 SUMMARY

The Sanitation Dossiers are included in **Annexure F** of this report. The purpose of the Dossiers is to clearly communicate the principles of the specific technology so that the information is widely accessible to the different sanitation stakeholders. The dossiers seek to present a realistic summary of the technology, highlighting the benefits, operation and maintenance requirements, and expected performance of the technology. Where laboratory analysis was undertaken, this was generally an isolated sample used to inform an understanding of the general performance of the technology. Continued monitoring in accordance with the evaluation protocol would be required at different sites to assess the long-term performance in a range of different contexts. The dossiers should be considered as a working document that should be updated and refined with statistical data as this becomes available, and as supplier modify their designs in response to the recommendations and their own operation experience.

15.2 SUPPORTING INFORMATION

The Dossiers have been developed on the back of the desktop evaluation, field verification and laboratory analysis. Where applicable, the dossiers incorporate feedback received from the suppliers in response to the assessment process. The full scientific analysis and desktop evaluation is discussed in previous deliverables and will be captured in the final report.

15.3 DOSSIER TEMPLATE

Figures 15.1 and **15.2** provide an illustration of the typical information provided in the Dossiers. The suitability symbology included in the top right of the dossier seeks to inform a more detailed suitability analysis that should be undertaken by the WSP. The details of this symbology is provided in Annexure E, and provides general information related to the context where the technology could be installed without compromising the minimum requirement for a basic sanitation technology. The assessment provides information related to the desk study and field verification (where relevant). The lab analysis is colour coded using the red, amber, green convention, whereby green means that the technology demonstrated adequate performance. The recommendations are intended to communicate key concerns to the supplier and potential purchaser of the technology. It is hoped that the supplier will utilise these recommendations to refine the design of the technology and that potential customers will take consideration of these points when selecting a suitable technology.

In the next chapter, the Policy Dialogue report is presented.

Figure 15.1 – Dossier Layout.

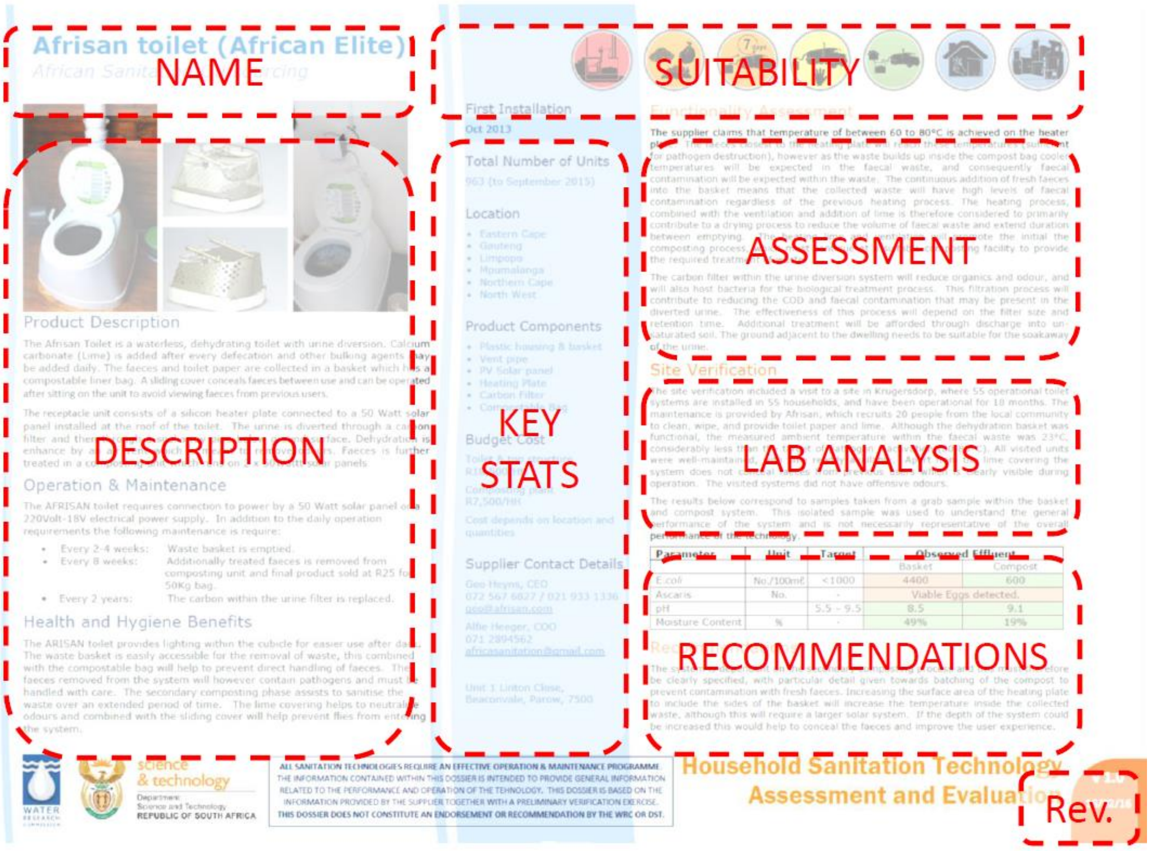


Figure 15.2 – Sample Dossier Report.

16 POLICY DIALOGUE REPORT

16.1 INTRODUCTION

This policy dialogue report is derived from the key findings if this project. The recommendations contained within this dialogue are considered to be essential for the future success of sanitation programmes in South Africa. These recommendations were presented at the reference group workshop for the national norms and standards for levels of sanitation service to communities on 27th November 2015 held at the CSIR in Pretoria. The content of this dialogue report incorporates feedback received from this session.

Current sanitation guidance focusses primarily on the sanitation planning with consideration of generic technology types. There is currently not specific standard for the evaluation of on-site sanitation technologies. The diverse range of technologies makes the development of such a standard problematic and could potentially restrict innovation within this sector. Consequently, SABS have not published a specific standard for sanitation, and Agrément is forced to measure evaluations against a set of standards that do not specifically address the functionality of the technology to perform the required treatment objective.

The limited guidance on evaluation and performance of different types of technology means that a technical protocol is required which enables the assessment of a particular technology to identify if it is fit for purpose. This assessment process must be transparent and repeatable for the range of sanitation technologies on the market.

16.2 SANITATION MINIMUM REQUIREMENTS

The Strategic Framework for Water Services (2003) defines sanitation as follows:

Basic sanitation facility:
The infrastructure necessary to provide a sanitation facility which is ***safe, reliable, private, protected from the weather and ventilated, keeps smells to the minimum, is easy to keep clean, minimises the risk of the spread of sanitation-related diseases*** *by facilitating the appropriate control of disease carrying flies and pests, and* ***enables safe and appropriate treatment and/or removal of human waste and wastewater in an environmentally sound manner****.*

A basic sanitation service entails:
The provision of a sanitation facility (that is appropriate to the settlement conditions) which is ***easily accessible to a household****, the sustainable operation and maintenance of the facility, including the* ***safe removal of human waste*** *and waste water from the premises where this is appropriate and necessary, and the communication of good sanitation, hygiene and related practices (to users).*

The functionality protocol must assess whether the sanitation technology is capable of performing the required performance of a basic sanitation facility, in particular minimising foul odour, prevention of excreta related diseases and environmental protection.

16.3 REGULATORY AUTHORITY

The Evaluation protocol must be framed with the context of the regulatory authority. Following preliminary discussions with the Water Research Commission, the Department of Water and Sanitation, and the Department of Science and Technology it is agreed in principle that the Sanitation Technology Assessment Protocol should be adopted and maintained by DWS as the government department responsible for the appropriate allocation of funds for the sanitation programme. This process would ensure that only reputable and effective technologies are provided by the Water Service Provider. It will however remain the responsibility of the WSP to ensure that the selected technologies are suitable for the specific context.

Certification should be explored in discussion with DWS and Agrément to ensure that the certification process aligns with the functionality criteria set out in the Protocol. DWS should co-ordinate the ongoing evaluation process, either in-house or through sub-contracting the assessment process to a suitable organisation (such as Agrément or an external certified laboratory). DWS would maintain a database of approved suppliers, together with the distribution a performance of these systems through a feedback reporting system with the Water Service Provider.

16.4 MINIMUM STANDARDS

To enable a comparative assessment of different technologies, they must be evaluated against a defined loading rate and an agreed effluent discharge quality. This process will inform the maximum number of users that can reasonably be serviced by a sanitation technology

Table 16.1 – Standard Loading Rates.

Determinant	Unit	Load per user
Liquid Volume	Litres / day	Dependent of Flush Volume
Urine	Litres / day	1.5
Wet Solids	g /day	200
COD	g /day	120
Suspended Solids	g /day	90
TKN	g /day	10
Total P	g /day	2
E. coli	No./day	$2x10^{10}$

Table 16.2 – Effluent Discharge Requirements.

Determinant	Unit	General Limit	Special Limit
Faecal Coliforms	No/100 mℓ	1000	0
Chemical Oxygen Demand*	mg/ℓ	75	30
pH		5.5-9.5	5.5-7.5
Ammonia (as Nitrogen)	mg/ℓ	6	2
Nitrate/Nitrite as Nitrogen	mg/ℓ	15	1.5
Chlorine as Free Chlorine	mg/ℓ	0.25	0
Suspended Solids	mg/ℓ	25	10
Electrical Conductivity	mS/m	(70 mS/m > intake) max 150 mS/m	(50 mS/m > intake) max 100 mS/m
Ortho-Phosphate as phosphorous	mg/ℓ	10	1 (med.) 2.5 (max)
Soap, oil or grease	mg/ℓ	2.5	0

The above effluent discharge requirements provide a reasonable quality target regardless of the nature of the discharge (recycling flush water, irrigation, etc.). Reasonable measures must however be taken to ensure that the effluent quality is suitable for the intended discharge / reuse.

16.5 SANITATION SUITABILITY

A sanitation technology which is considered acceptable in terms of its functionality performance, will only succeed if it is installed in the right context with proper effective operation and maintenance support. To ensure the selection of appropriate sanitation technologies for a specific context, the service provider should undertake a suitability assessment on a shortlist of preferred technologies. The six key suitability criteria in which an acceptable sanitation technology must perform satisfactorily for a given context are as follows, a technology which fails to satisfy these minimum requirements should not be selected for the assessed context.

16.5.1 Safety:

The technology must not present undue risk to children or adults during the normal use of the facility. Hazards must be clearly identified and mitigated.

16.5.2 Health:

The technology must effectively contribute to the prevention of excreta related disease for the user and neighbouring community. Health risks are assessed in terms of contact and concentration of faecal sludge. This considers ease of cleaning, hygiene, whether it is convenient (more likely to be used), good fly control, and whether it prevents/minimises contact with undigested faecal matter during use and maintenance. The assessment also includes measured filling rates, faecal coliforms in handled sludge, moisture content, and handling procedure.

16.5.3 Acceptability:

The technology must (on reasonable justification) **be deemed acceptable by both the user and implementing agent who will be responsible for the supply and maintenance of the technology.**

Scorecards or questionnaires are utilised to assess the privacy, ease of use/comfort, proximity to the home, versatility (where can be installed), safety, equity, quality, odour, employment creation, and supporting infrastructure requirements such as Waste Water Treatment Works.

16.5.4 Environmental performance:

The technology must effectively protect and where possible enhance the environment. A scorecard is used to assess the technology's freshwater consumption; resource recovery potential; pollution control; and hazardous materials.

16.5.5 Reliability:

The technology must demonstrate, or have good potential for reliable, long term performance. A scorecard is used to assess the historic performance, number and age of working installations, robustness, resistance to vandalism, availability of spares & consumables, material durability (UV stable, fire resistance, etc.), and design life**.**

16.5.6 Cost:

The technology must be available at a reasonable cost with consideration of the full life cycle (supply, operate and maintain). These include capital costs, operational costs, and maintenance costs.

16.6 KEY FINDINGS AND RECOMMENDATIONS

16.6.1 Feedback Loop

In the interest of supporting on-going innovation and best practice in the sanitation sector, an effective feedback and reporting process must be maintained to support further innovation in the sector and to deepen understanding of the long-term performance of sanitation technologies.

16.6.2 Regulation

In accordance with the National Environmental Management Act, many of the sanitation technologies may be regarded as treatment facilities that would require a general authorisation prior to installation. This may not be practical at a household scale, but where there is the widespread roll out of a technology, the appropriate Authorisation process must be followed. Compliance with the effluent discharge characteristics identified in **Table 16.2** would help ensure that the technology aligns with this authorisation process, provided other requirements are met.

16.6.3 Permissible Failure Modes

As with any treatment facility it is critical that the occasional failure or interruption in the operation of the facility due to mechanical or electrical failure does not present undue risk to the user. The supplier should provide a risk assessment that clearly indicates the possible modes of failure, and the consequence of such events. Wherever possible the system should not present a hygiene risk or an environmental hazard during a 24-hour interruption in service.

16.6.4 Operation and Maintenance

All sanitation technology installations must be accompanied by a clearly defined operation and maintenance strategy, whereby the required support is provided by the WSP, the supplier or an appointed sub-contractor. This ongoing O&M support service must be available to ensure that no sanitation facility is out of operation for more the 48 consecutive hours.

16.6.5 Monitoring

Regular monitoring must be undertaken by the WSP or an independent third party to ensure the ongoing performance of the technology is maintained. This monitoring programme will comprise visual inspections and laboratory analysis of a sample of each type of technology in use.

16.6.6 Summary

It is considered that the implementation of the above recommendations and standards will have a significant impact on the sustainable operation of on-site sanitation infrastructure. Where possible these guidelines should be incorporated into legislation and national standards to assist the implementation of effective and reliable sanitation technologies.

17 KNOWLEDGE DISSEMINATION WORKSHOP

Knowledge dissemination of this protocol has been central to the development of the evaluation protocol and has been completed through an iterative process with suppliers and government departments at three key events as indicated in the table below. These events facilitated stakeholder buy in to the evaluation process, and enabled interaction with the emerging sanitation policy.

Table 17.1 – Knowledge Dissemination Events.

Date	Event	Attendance
29 June 2015	Sanitation Technology Protocol – Initial Suppliers Workshop	45 Delegates
27 Nov 2015	Sanitation Policy – Norms and Standards Workshop	25 Delegates
16 Feb 2016	Sanitation Technology Protocol – Final Workshop	85 Delegate

In additional to the formal workshops, there have also been several other meetings with the Department of Water and Sanitation and the CSIR to explore the possible adoption of this Protocol and incorporation into Policy and the revision of the 'Guidelines for Human Settlement Planning and Design' (the RED Book). These conversations are ongoing and will seek to secure the long-term impact of this research.

The feedback received from the final workshop is included in **Annexure G**. In general, the responses were positive and in support of the process followed. Throughout the project engagement there has been overwhelming support from suppliers and government departments for the development of the Protocol. There was however a general request for the suitability assessment procedure to be developed more fully to assist the Water Service Authorities to select technologies that are applicable to a specific context.

18 CONCLUSIONS AND RECOMMENDATIONS

The development of the Household Sanitation Technology Assessment and Evaluation Protocol has been a valuable step towards improved regulation of the sanitation sector. The impact of urbanisation and increased water scarcity has resulted in the emergence of an innovative (but largely un-regulated) sanitation sector. If these technologies are to assist with clearing the backlog of household sanitation, they must be based on sound process design principles and must be proven to be robust and reliable through extended field trials within a particular context.

Of the 30 technologies reviewed, a total of 10 technologies underwent scientific field trials. These field trials were primarily to verify the functionality assessment protocol, but they also enabled an initial assessment of individual sanitation technologies within a specific context.

Throughout the development of this protocol, the project team, the WRC and DST has sought to establish a firm institutional home for the evaluation protocol. Initial discussions indicate that this Protocol should be located within the Department of Water and Sanitation, indeed Position 17 of the draft Sanitation Policy, 2016 states that "a formal process for certification and accreditation of appropriate sanitation technologies will be developed…" This Sanitation Protocol should feed directly into this process. It is recommended that a focussed workshop session be conducted between DWS, Agrément and the South African Bureau of Standards (SABS), to define the roles and responsibilities for this certification process. If the Protocol is to be adopted by these institutions, a specific training programme should be implemented to ensure that a consistent evaluation procedure is followed.

The initial results generated through this study should be repeated at multiple sites as part of on-going monitoring programmes. In accordance with the General Authorisation process, ALL onsite treatment systems require basic monitoring, the detail of this depends on the size of the facility, but as a minimum should include *E. coli* and COD analysis. Where multiple systems are provided in a particular settlement, this analysis could be undertaken on a representative sample, but must be undertaken regularly. DWS is responsible for reviewing this data in order to maintain the approvals for a specific technology. The management of this data will however require the development of new systems to spatially map the data and alert to operational issues.

The Functionality Protocol has been well developed through this research and should be kept under review as it is used to evaluate additional technologies. Through this research, a draft Suitability Assessment was developed to consider whether a technology is appropriate for a specific context. Following the establishment of a certification process (based on the Functionality Protocol), the next step is to ensure that a good technology is only applied to the right context (i.e. where there is sufficient water for flushing or where the climate suits the drying process). The Suitability Assessment tool has been requested by several levels of government through this research. While there are several technology selection tools available in the international arena, these tend to be for generic classes of technology (VIP latrine, flush toilets, etc.) and do not consider the details of a specific technology. With increased choice of emerging sanitation technologies, there is a greater need for such a tool that can assist the Water Service Authority to select a suitable technology that provides value for money in the long term and which is suitable for the community where it will be installed.

This research is an important move forwards towards improved sanitation provision. The Sanitation Dossiers provide initial guidance on the selection of suitable sanitation technologies, but this must be built upon through a sustained research effort and multi sector participation. The development of this Protocol has seen improved collaboration between technology suppliers, researchers and government departments. It is hoped that this will continue to grow to see the establishment of a highly effective sanitation industry throughout South Africa and beyond its borders.

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ANNEXURES

ANNEXURE A – INITIAL FUNCTIONALITY ASSESSMENT FORMS

PRODUCT DESCRIPTION *To be completed by the technology supplier*	Form A.1
Technology Name	**Supplier Name**
Supplier Contact Details	
Technology Description	
Provide a clear description of the technology. Attach illustrations & photos of the technology & components.	
Design Context for Sanitation Technology	
Maximum Number of Users per unit: **Type of User:** ***Household*** ☐ ***Shared*** ☐ ***Communal*** ☐ ***School*** ☐ ***Clinic*** ☐ **Ground Conditions:** ***Give details of ground conditions suitable for this technology, including reference to groundwater depth.*** **Supporting Infrastructure:** ***Give details of additional infrastructure required for the operation of this technology.***	
Process Design	
Description of Operation: ***Explain how the technology works and under what limiting conditions (i.e. temperature, maintenance, design number of users.*** **Mass Balance and Loading Diagrams:** ***Provide detailed mass balance diagram indicating the function of each component.*** ***Indicate and quantify all parameters which may enter and leave the system (Including: Water, materials and consumables, chemical and microbiological determinants)***	

PRODUCT DESCRIPTION (cont.) Form A.1

To be completed by the technology supplier

Operation Details

Operation Procedure:

Full description of how the technology is operated, access points, and operational structures.

Maintenance interval:

Details of maintenance interval for different components.

Consumables:

Provide details of all consumables required for the correct operation of the technology and the monthly cost per user.

Hygiene Benefits

List expected impact on health and hygiene with reference to barriers against faecal related disease, fly and vector infestations and odour control.

Design Standards

List all applicable design standards to which the technology complies. Attach any certification.

Scientific Testing

Provide details of scientific analysis of this technology (independent, Agrément South Africa, etc.). Attach all lab results and analysis reports as applicable.

PROCESS DESIGN VERIFICATION Form A.2

To be completed by the reviewer

Technology Name	Supplier Name

Primary Process

Provide summary of main treatment processes required for correct operation of the technology.

Influent Characteristics

Compare guideline characteristics from with the design characteristics, add comments related to the impact of any discrepancy, or omissions.

Design Influent Loadings

Number of Users **(n)**	*Users*
Flush Volume (Zero for Dry San) **(V)**	*Litres/user*
Additional greywater **(G)**	*Litres/user*

Determinant	**Unit**	**Load per User (L)**	**Assessment Loading (L x n)**	**Technology Design Loading**	**Notes**
Liquid Load	Flushes/day	5			
	Greywater *	(G)			
	Litres/day	(5xV)			
Urine	Litres/day	1.5			
Wet Solids	g/day	200			
COD	g/day	120			
Suspended Solids	g/day	90			
TKN	g/day	10			
Total P	g/day	2			
Soap, Oil & Grease	g/litre	(0.1xG)			
E Coli	No./day	$2x10^{10}$			

**** Note that the addition of greywater will impact on the chemical and organic loading and should be studied in detail.***

The total concentration of pollutants in the influent water can be calculated by dividing the Assessment Loading by the Liquid Volume.

PROCESS DESIGN VERIFICATION (cont.) Form A.2

To be completed by the reviewer

Effluent Targets

Identify the key determinants, and comment on any specific claims from the supplier.

Determinant	Unit	Guideline	Design	Comments
Faecal Coliforms	No./100 mℓ	1000		
Protozoa & Helminths	No./100 mℓ			
COD	mg/ℓ	75		
pH		5.5-9.5		
Ammonia	mg/ℓ	6		
Nitrogen	mg/ℓ	15		
Suspended Solids	mg/ℓ	25		
Electrical Conductivity	mS/m	max 150 mS/m		
Total P	mg/ℓ	10		
Soap, Oil & Grease	mg/ℓ	2.5		

Sludge Accumulation

Provide general comments on the expected sludge accumulation rates (including concentrate from filtration processes)

Theoretical Review of Process Design

Provide general comments on the suitability of the process design to achieve the required effluent targets.

Testing Requirements

Identify key areas of interest / concern for further laboratory and field tests. Where possible indicate how these tests should be undertaken for the given technology.

REVIEW OF APPLICABLE STANDARDS — Form A.3

To be completed by the technology suppliers

Technology Name	Supplier Name

Applicable Standards

Identify known standards and the requirements applicable to the sanitation technology under review. Indicate whether the technology complies with this standard or what action is required to validate compliance.

Reference	Date	Title	Publisher	Compliance
Act 108	1997	The Water Services Act	DWS	
Red Book	2000	Guidelines for Human Settlement Planning and Design	CSIR	
Technical Guidelines	2004	Guidelines for the development of water and sanitation infrastructure	DWAF (DWS)	
SANS 121	2011	Hot Dip Galvanising	SABS	
SANS 310	2011	PE Storage Tanks	SABS	
SANS 497	2011	Glazed Ceramic Sanitaryware	SABS	
SANS 966-1	2014	Components of Pressure Pipe Systems (PVC-U)	SABS	
SANS 1186	2011	Symbolic Safety Signs	SABS	
SANS 3001	2014	Soil Testing	SABS	
SANS 5221	2011	Microbiological analysis of water – General test methods	SABS	
SANS 5667-10	2007	Water quality – Sampling Part 10: Guidance on sampling of waste waters	SABS	
SANS 5667-13	2007	Water quality – Sampling Part 13: Guidance on sampling of sludges from sewage and water treatment work	SABS	
SANS 6048	2010	Water – Chemical oxygen demand	SABS	
SANS 6049	2010	Water – Suspended solids content	SABS	
SANS 10100-1	2000	The Structural Use of Concrete Part 1: Design	SABS	
SANS 10100-2	2014	The Structural Use of Concrete Part 2: Materials and Execution of Work	SABS	
SANS 10112	2011	The installation of PE and PVC pipes	SABS	
SANS 10162-1	2011	The Structural Use of Steel	SABS	
SANS 10252	2012	Water Supply Installations	SABS	
SANS 10400-P	2010	The Application of the National Building Regulations – Part P: Drainage	SABS	
SANS 10400-Q	2011	The Application of the National Building Regulations – Part Q: Non-waterborne means of sanitary disposal	SABS	
SANS 10142-1	2012	The Wiring of Premises Part 1: Low Voltage Installations	SABS	
SANS 12944-4	1998	Paints and Varnishes	SABS	
SANS 52566	2004	Small Wastewater Treatment Systems	SABS	
SANS 53121	2009	GRP Storage Tanks	SABS	
General Authorisation	2013	General Authorisations in Terms of the National Water Act, 1998 (Act No. 36 of 1998)	DEA	
By-Laws		Applicable Local By-laws		

RECORD OF INSTALLATIONS Form A.4

To be completed by the technology suppliers

Technology Name	Supplier Name

Technology Variations and Modifications

Please provide full details of any variations in the design of your technology that have been installed, or any previous versions of your technology that may have now been discontinued due to technological advancement. Include the current version(s) of your technology and the date that this was first used.

.

Variation Name	Description of Variation / Modification	Date First installed	Date Discontinued (or current)

Installations

Include full details of all installations to date, the Variation name should correspond with the above table. Where installations have been installed in other countries, please list these as total installations per country.

Variation Name	Type *(School, Clinic, public or private)*	Location *(Town, Municipality, Province)*	Date	Total No. of Installations

Add rows as necessary

RECORD OF INSTALLATIONS Form A.4 (Cont.)

To be completed by the technology suppliers

Installations *(Continued)*

Variation Name	**Type** *(School, Clinic, public or private)*	**Location** *(Town, Municipality, Province)*	**Date**	**Total No. of Installations**

Add additional pages as necessary

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ANNEXURE B – DETAILED FUNCTIONALITY ASSESSMENT FORMS

IDENTIFICATION OF ANALYSIS REQUIREMENTS Form B.0

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

Assessment Requirements Chart

	IDENTIFY TREATMENT PROCESS					
Process	CHEMICAL		PHYSICAL	BIOLOGICAL		MECHANICAL
Category	CHEMICAL	DRY SANITATION			WATERBORNE	
Example Technologies	Chemical Toilets Porta Potty	Pyrolysis Hydrothermal Carbonisation	Dehydration Desiccation Urine Diversion Bag Separation	**AEROBIC** Leach Pits Compost Toilets Activated Sludge Biofilm	**ANAEROBIC** Septic Tanks Biodigestor ABR Bio-Augmentation	Membrane Ultrafiltration
Process Tests	Loading Rates *(Form B.1)* & Sludge Accumulation Rates *(Form B.2)*					
	Water tightness *(B.3)*	Temperature *(Form B.5)*		Water tightness *(Form B.3)* Air tightness (Form B.4)		Water tightness *(B.3)* Filter Integrity *(B.6)*
Effluent Tests	Moisture content *(Form B.7)* Faecal Coliforms *(Form B.8)*			Determinant *(Form B.9)* (COD, TSS, *E.coli*, N, P etc.)		
	Helminths and Protozoa (Where supplier claims waste is sanitised) (Form B.10)					

IDENTIFICATION OF ANALYSIS REQUIREMENTS Form B.0 *(cont.)* ***To be completed by the technology reviewer***	
Technology Name	**Reviewer Name & Date of Assessment**

Primary Process

With reference to the Assessment Requirements Chart, identify the primary treatment process applicable to the technology.

CHEMICAL		**Required Test**
Chemical	☐	***Water tightness***
DRY SANITATION		
Chemical	☐	***Temperature***
Physical	☐	***Temperature***
Biological – Aerobic	☐	***Temperature***
WATERBORNE		
Biological – Aerobic	☐	***Water tightness***
Biological – Anaerobic	☐	***Water tightness, Air tightness***
Mechanical	☐	***Water tightness, Filter Integrity***

Process Tests

Indicate the relevant process tests to be undertaken for this technology

Loading Rates	☐	***See Form B.1***
Sludge Accumulation	☐	***See Form B.2***
Water tightness	☐	***See Form B.3***
Air tightness	☐	***See Form B.4***
Temperature	☐	***See Form B.5***
Filter Integrity	☐	***See Form B.6***
Other	☐	***(give details)* ……………………………………………………**

Effluent Tests

Indicate the relevant process tests to be undertaken for this technology

Moisture Content	☐	***See Form B.7***
Faecal Coliforms	☐	***See Form B.8***
Standard Determinants	☐	***See Form B.9***
Protozoa & Helminths	☐	***See Form B.10***
Other	☐	***(give details)* ……………………………………………………**

Specific test requirements

Add comments on the required test procedure for the specific technology

OBSERVED INFLUENT & LOADING RATES — Form B.1

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

Observed Loading Rates

Compare guideline characteristics from Form A2 with the actual characteristics of the influent characteristics of the laboratory analysis. Where possible take samples for chemical and microbiological analysis.

Actual number of users: …………… **Total number of uses per day: ……………**

Measured Flush Volume:…………...

Where applicable, measure volume of flush water per use, (include dual flush)

Determinant	Unit	Guideline*	Observed	Notes
Liquid Volume (incl. urine)	Litres/day			
Wet Solids	Kg/day			
COD	mg/ℓ			
Suspended Solids	mg/ℓ			
TKN	mg/ℓ			
Total P	mg/ℓ			
Soap, Oil & Grease	mg/ℓ			
E Coli	No./100 mℓ			

**** Adjust guideline values according to design number of users and technology type.***

Anal Cleansing

Provide details of the type of anal cleansing that the technology is able to handle

Toilet Paper ☐ **Newspaper** ☐ **Water** ☐ **Approx. volume …… *litres***

Other ☐ **……………………………………………………………………………………………..**

(Give Details)

Total Water per day: …………… litres **Total Solids per day: ……………….kg**

Additives

Provide details of all additive required as part of the routine operation of the toilet

Lime ☐ **Sawdust** ☐ **Ash** ☐ **Soil** ☐ **Other ………………..**

(Specify)

Approx. volume per use: …………… ml **Total Mass per day: ……………….kg**

Additional Loading

Provide details of other organic material routinely added to the toilet by the user. i.e. vegetable scraps

Total Mass per day: ……………….kg

SLUDGE ACCUMULATION RATES (Waterborne) Form B.2a

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

General Information

NOTE: Loading Rates to be calculated using Form B.1 and compared to sludge accumulation rates

Date of last sludge removal: ………….. Time since last emptying: ………. weeks

Method of sludge removal:
Vacuum Tanker ☐ Manual Emptying ☐ Auger ☐ Other ☐

Dimensions of Storage Container:

Length: ………. m Width: ………. m Height: ………. m Shape: …………………

Total storage capacity of container: ………. Litres

Test Methodology for Waterborne Systems

The methodology below enables the calculation of sludge accumulation rates in anaerobic treatment systems and other waterborne treatment systems.

Take sample of accumulated sludge at different positions, record the depth and sludge density of each sample: ***Obtain sample using 'sludge judge' or similar approved vertical sludge profiling tool. Sludge density to be determined by laboratory analysis or measurement on site.***

Sample Number	**Sludge Depth** (m)	**Sludge Density** (kg/m^3)	**Notes**
Sample 1			
Sample 2			
Sample 3			
Sample 4			
Sample 5			
Average			

Calculated Sludge Accumulation: ………… litres

Total Suspended Solids of effluent / concentrate: ………… mg/ℓ
Obtain representative sample and send for laboratory analysis or use calibrated probe

Measured thickness of sludge blanket / Scum: ………. mm
Measure thickness at accessible point, take average of several measurements where access permits.

Hydraulic retention time: ………. days

Calculated Accumulation Rates

Summarise the accumulation rates based on the observations from both wet and dry systems.

Total sludge accumulation per month: ………………. litres/month

Required sludge disposal frequency: ………………. months

SLUDGE ACCUMULATION RATES (Dry) — Form B.2b

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

General Information

NOTE: Loading Rates to be calculated using Form B.1 and compared to sludge accumulation rates

Date of last sludge removal: …………. **Time since last emptying: ………. weeks**

Method of sludge removal:
Vacuum Tanker ☐ Manual Emptying ☐ Auger ☐ Other ☐

Dimensions of Storage Container:

Length: ………. m Width: ………. m Height: ………. m Shape: ………………..

Total storage capacity of container: ………. litres

Test Methodology for Dry Sanitation Systems

The methodology below enables the calculation of sludge accumulation rates in dry sanitation systems where the liquid content is separated from the faecal sludge..

Measured Sludge Volume at time of assessment: ……….. litres

Normal interval of sludge removal: ………. days / weeks / months ***(delete as applicable)***

Normal Volume of sludge removed: ………. litres

Sludge Density: ………. kg/m^3
To be determined by laboratory analysis or measurement on site.

Sludge Moisture Content: ……… %
To be determined by laboratory analysis in accordance with Form B.7.

Other Observations:

Calculated Accumulation Rates

Summarise the accumulation rates based on the observations from both wet and dry systems.

Total sludge accumulation per month: ………………. litres/month

Required sludge disposal frequency: ………………. months

WATER TIGHTNESS TEST *To be completed by the technology reviewer*	**Form B.3**
Technology Name	**Reviewer Name & Date of Assessment**

User Observations

Provide details of observed water loss due to leakage, evaporation, wastage or scouring. Where possible quantify the volume of water loss according to the amount of water needed to 'top up' the system.
[NOTE: Not applicable to systems which discharge treated effluent.]

Test Details

Test to be undertaken in accordance with Section 5.3 a) of SANS 52566 Part 1 – Small Wastewater Treatment Systems.

Position and type of material being tested:

Ensure all valves are closed and fill container to maximum water level. Wait 15 minutes for water level to stabilise.

Water level at start of test: …….. m **Water level after 30 minutes: ……… m**

Volume of water to restore water level: ……. litres

Observed Leakage
(note position and extent of physical leakage or evidence of historic leakage)

Test Results

Attach full test results. Include recommendations to improve the water tightness of the technology.

Total measured Water loss ……. litres / m^2 of wet surface area

Other Comments:

AIR TIGHTNESS TEST *To be completed by the technology reviewer*	**Form B.4**
Technology Name	**Reviewer Name & Date of Assessment**

Test Details

The following test procedure will usually be applied to Biodigestors where an air tight seal is required for the effective harvesting of Biogas. An adapted methodology may be applied to pressure vessels where an airtight seal is required.

Position and type of material being tested:

Ensure all valves are closed and pressurise container to maximum operation pressure using air compressor or manual pump.

Pressure at start of test: …….. **Pressure after 30 minutes: ……**

Observed Pressure Drop: ………… ***(State Units)***

Volume of air to restore air pressure: ……. litres

Apply water to all exposed surfaces, joints and fittings. Look and listen for bubbles.
Note position of observed leaks

Test Results

Attach full test results. Include recommendations to improve the air tightness of the technology.

Total measured Air loss ……. litres / m^2 of surface area

Other Comments:

TEMPERATURE TESTS — Form B.5

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

General Observations

Provide general comments on the weather conditions at the time of the assessment, together with general observations of the installation of the sanitation technology relevant to any temperature dependent processes (orientation of heat absorbing surfaces, exposure to direct sunlight, etc.).

Orientation & Exposure to Sunlight:

Time of Test: ………..

Weather Conditions:

Sunny ☐ Partial Cloud ☐ Overcast ☐ Mist/ Fog ☐ Rain ☐

Ambient Air temperature at time of test: …….. °C

NOTE:
Where sludge disposal intervals are short (< 6 months) repeat assessment for different weather conditions

Test Procedure

Use a temperature probe to measure the in situ temperature at different sample positions

Sample Position	Near Inlet	Centre	Near Outlet *
Sludge Surface	°C	°C	°C
Centre of Sludge	°C	°C	°C
Base of Sludge	°C	°C	°C

***** ***Where there is no specific outlet position, this location represents the furthest position from the inlet.***

Comments

With Reference to the results and background information overleaf, provide comments on the expected treatment performance and sterilisation of the sanitation technology.

Where applicable refer also to the Moisture Content assessment (Form B.7)

TEMPERATURE TESTS (Cont.) Form B.5

To be completed by the technology reviewer

Background Information

Generally, soil is sterilised by heating between 82°C and 93°C, left for 30 minutes then allowed to cool down (GHG, 2014).

There are different types of aerobic bacteria which are decomposers, which thrive at different temperatures in compost. Psychrophilic **bacteria are most active at 13°C to 21°C and survive to 38°C and produce a small amount of heat.**

Between 38°C and 71°C, if the compost is not turned and fed new materials then Thermophilic bacteria raise temperatures and continue decomposition. Many decomposers become inactive at 60°C, and sterile above 71°C. **Other microorganisms such as Actinomycetes liberate nitrogen, carbon and ammonia.**

Fungi break down cellulose and lignin, after faster acting bacteria make inroads on them. They prefer cooler temperatures (21°C to 24°C) and easily digested food sources. (UIE, 2015)

THERMAL DEATH POINTS OF SOME COMMON PATHOGENS AND PARASITES

Adapted from Shuval *et al*., (1981)

Organism	Death Point
Salmonella typhosa	No growth beyond 46 °C; death within 30 minutes at 55°C to 60 °C
Salmonella spp	Death within one hour at 55 °C; death within 15 minutes to 20 minutes at 60 °C
Shigella spp	Death within one hour at 55 °C.
Escherichia coli	Most die within one hour at 55 °C, and within 15 to 20 minutes at 60 °C
Endamoeba histolytica cysts	Thermal death point is 68 °C
Taenia saganita	Death within five minutes at 71 °C
Trichinella spiralis larvae	Infectivity reduced after one hour exposure at 50 °C; thermal death point is 62-72 °C
Micrococcus pyogenes var. aureus	Death within 10 minutes at 50 °C
Streptococcus pyogenes	Death within 10 minutes at 54 °C
Mycobacterium tuberculosis var. hominis	Death within 15 to 20 minutes at 66 °C, or momentary heating at 67 °C
Corynebacterium diptheriae	Death within 45 minutes at 55 °C.

References:

(GHG) Green Home Gnome. 2014. The importance of greenhouse sanitation and sterilizing soil. [Online]. Available: http://www.greenhomegnome.com/greenhouse-sanitation-sterilizing-soil/. *[20/04/2015].*

Shuval, H., Gunnerson, C., Julius, D. 1981. Appropriate Technology for water supply and sanitation: nigh-soil composting. Volume 10. International Bank for Reconstruction and Development/World Bank. Available: http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2000/04/20/000178830_98101911035772/Rendered/PDF/multi_page.pdf. *[20/04/2015].*

(UIE) University of Illinois Extension. 2015. Composting for the homeowner. [Online]. Available: http://web.extension.illinois.edu/homecompost/science.cfm. ***[20/04/2015].***

FILTER INTEGRITY TEST Form B.6

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

Membrane Details

Type of Membrane / Filter to be Tested

Product Name & Supplier: ………………………………………………… **Pore Size: ………….µm**

Date Membrane was installed: ………………………… **Age of Membrane: ……………. months**

Sampling

Obtain sample of influent and filtrate in accordance with SANS 5667 Part 10 Guidance on sampling of waste waters. Complete site analysis and visual inspections before submitting the sample for detailed lab analysis. Where the site analysis and visual inspections confirm that the integrity of the filter is compromised, it is not necessary to proceed with laboratory analysis.

Sample Position	**Turbidity** (NTU)	**TSS** (mg/ℓ)	**Event Marker *** (present / absent)	**Notes**
Influent				
Filtrate				
Concentrate				

*** Complete analysis of event marker only after successful site analysis and visual inspection completed**

Visual Inspection

After taking samples, conduct a visual inspection of the membrane and associated fittings. Note any observations below related to the condition of the membrane.

Event Marker

Select a suitable event marker with reference to the membrane pore size and filtration spectrum. Where necessary this event marker should be dosed into the influent stream and the treatment system allowed to run a full cycle before the sample is taken.

Event Marker: **Name: ………………………………………………** **Particle Size: …….µm**

Summary of Findings:

FILTER INTEGRITY TEST (Cont.) Form B.6

To be completed by the technology reviewer

Background Information

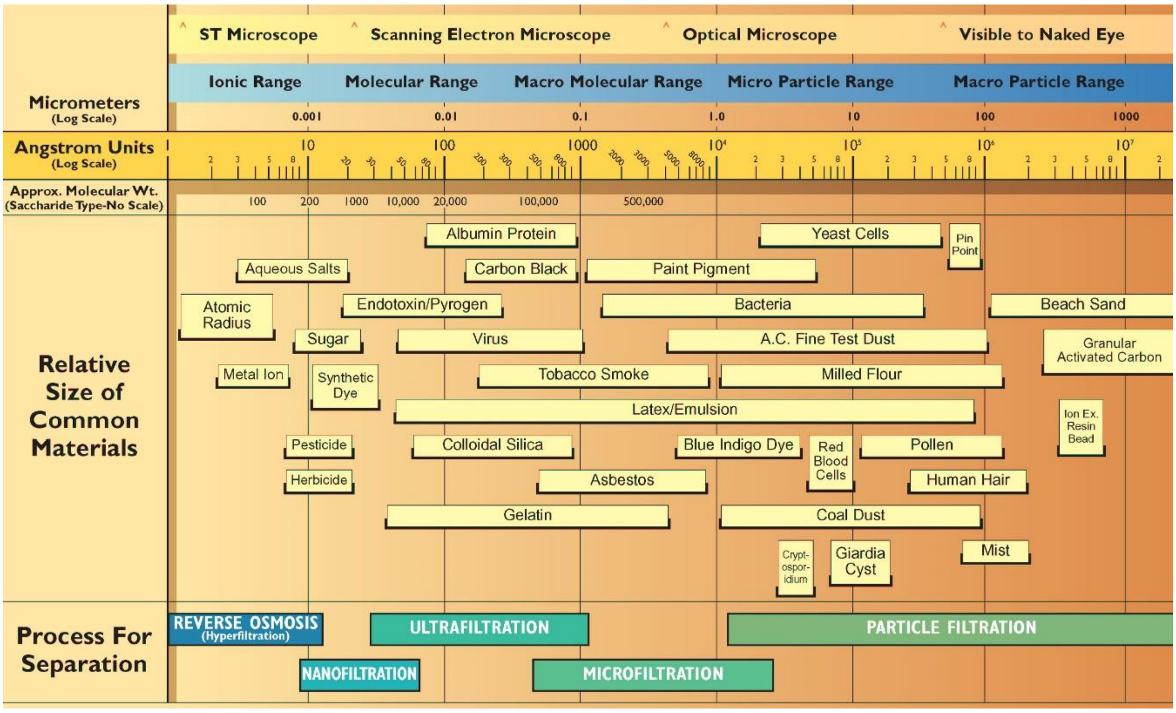
Event Testing

One of the most critical aspects of employing membrane technology is ensuring that the membranes are intact and continuing to provide a barrier between the feedwater and the permanent or product water. There are several different methods that can be employed to monitor membrane integrity, including turbidity monitoring, particle counting or monitoring, air pressure testing, bubble point testing, sonic wave sensing, and biological monitoring.

In order for a membrane process to be an effective barrier against pathogens and other particulate matter, the filtration system must be integral, or free of any integrity breaches.

Marker-based tests utilize either a spiked particulate or molecular marker to verify membrane integrity by directly assessing removal of the marker. The marker should have a particle size slightly larger than the pore size such that it should not pass through the membrane being tested unless the integrity has been compromised.

The Filtration Spectrum



Source: Osmonics (2015)

FILTER INTEGRITY TEST (Cont.) Form B.6

To be completed by the technology reviewer

Background Information

Membrane Category

Microfiltration (includes ceramic filters)

- A microfiltration filter has a pore size of approximately 0.1 micron (pore size ranges vary by filter from 0.05 micron to 5 micron);
- Microfiltration has a very high effectiveness in removing protozoa (e.g. Cryptosporidium, Giardia);
- Microfiltration has a moderate effectiveness in removing bacteria (e.g. Salmonella, *E. coli*);
- Microfiltration is not effective in removing viruses (e.g. Enteric, Hepatitis A, Norovirus, Rotavirus);
- Microfiltration is not effective in removing chemicals.

Ultrafiltration

- An ultrafiltration filter has a pore size of approximately 0.01 micron (pore size ranges vary by filter from 0.001 micron to 0.05 micron.
- Ultrafiltration filters remove particles based on size, weight, and charge;
- Ultrafiltration has a very high effectiveness in removing protozoa;
- Ultrafiltration has a very high effectiveness in removing bacteria;
- Ultrafiltration has a moderate effectiveness in removing viruses;
- Ultrafiltration has a low effectiveness in removing chemicals.

Nanofiltration

- A nanofiltration filter has a pore size of approximately 0.001 micron (pore size ranges vary by filter from 0.008 micron to 0.01 micron;
- Nanofiltration filters remove particles based on size, weight, and charge;
- Nanofiltration has a very high effectiveness in removing protozoa;
- Nanofiltration has a very high effectiveness in removing bacteria;
- Nanofiltration has a very high effectiveness in removing viruses;
- Nanofiltration has a moderate effectiveness in removing chemicals.

Reverse Osmosis Systems

- Reverse Osmosis Systems use a process that reverses the flow of water in a natural process of osmosis so that water passes from a more concentrated solution to a more dilute solution through a semi-permeable membrane. Pre- and post-filters are often incorporated along with the reverse osmosis membrane itself.
- A reverse osmosis filter has a pore size of approximately 0.0001 micron.
- Reverse Osmosis Systems have a very high effectiveness in removing protozoa;
- Reverse Osmosis Systems have a very high effectiveness in removing bacteria;
- Reverse Osmosis Systems have a very high effectiveness in removing viruses;
- Reverse Osmosis Systems will remove common chemical contaminants (metal ions, aqueous salts), including sodium, chloride, copper, chromium, and lead; may reduce arsenic, fluoride, radium, sulfate, calcium, magnesium, potassium, nitrate, and phosphorous.

References:

Osmonics, 2015. The filtration Spectrum [online]
http://www.gewater.com [15/04/2015]

CDC 2015. Household water treatment [online]
http://www.cdc.gov/healthywater/drinking/travel/household_water_treatment.html [15/04/2015]

MOISTURE CONTENT *To be completed by the technology reviewer*	**Form B.7**
Technology Name	**Reviewer Name & Date of Assessment**

Sampling Procedure

Grab Samples to be taken in accordance with SANS 5667 – Part 13: Guidance of sampling of sludges from sewage and water treatment works.

Samples to be taken at various positions within the treatment system as required to evaluate the treatment efficiency.

Samples to be tightly sealed in an air tight bag for delivery to a suitable SANAS accredited laboratory for analysis

Sample Log

Record details of samples on the table below.

Sample Number	**Date / Time**	**Notes / Location of Sample**	**Moisture Content** (%)

Observations / Analysis

Attach full laboratory analysis. Note observations from sampling and detailed analysis of results.

FAECAL COLIFORMS *To be completed by the technology reviewer*	**Form B.8**
Technology Name	**Reviewer Name & Date of Assessment**

Sampling Procedure

Grab Samples to be taken in accordance with SANS 5667, part 10 and Part 13 as applicable.

Samples to be taken at various positions within the treatment system as required to evaluate the treatment performance.

Samples to be tightly sealed in an air tight container for delivery to SANAS Accredited Testing Laboratory for Microbiological analysis. Analysis to be undertaken in accordance with SANS 5221: 2011 - Microbiological analysis of water – General test methods

Bacteriological samples must be ideally be stored at <5 °C in a dark container analysed within ± 6 hours

For solid samples, prepare the sample by weighing a suitable sample size and place that into a known volume of diluent. Determine moisture content of the sample in order to express the final results in the number of colony forming units per gram dry mass.

For liquid samples the results are expressed per 100 ml of sample.

Sample Log

Record details of samples on the table below.

Sample Number	**Date / Time**	**Notes / Location of Sample**	**Faecal Coliforms** CFU per 100 ml or gram

Observations / Analysis

Attach full laboratory analysis. Note observations from sampling and detailed analysis of results.

STANDARD DETERMINANTS Form B.9

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

Sampling Procedure

Grab Samples to be taken in accordance with SANS 5667, part 10 and Part 13 as applicable.

Samples to be taken at various positions within the treatment system as required to evaluate the treatment performance.

Samples to be tightly sealed in an air tight container for delivery to SANAS Accredited Testing Laboratory for the required Chemical analysis.

For solid samples, prepare the sample by weighing a suitable sample size and place that into a known volume of diluent. Determine moisture content of the sample in order to express the final results per gram dry mass.

For liquid samples the results are expressed per litre of sample as applicable.

Sample Log

Record details of samples on the table below.

Date and Time of Samples: ……………………………….....

			Sample Number / Location		
Determinant	**Unit**	**General Limit**			
Faecal Coliforms	No./100 mℓ	1000			
COD*	mg/ℓ	75			
pH		5.5-9.5			
Ammonia (as Nitrogen)	mg/ℓ	6			
Nitrogen	mg/ℓ	15			
Chlorine as Free Chlorine	mg/ℓ	0.25			
Suspended Solids	mg/ℓ	25			
Electrical Conductivity	mS/m	< 150 mS/m			
Phosphorous	mg/ℓ	10			
Soap, Oil & Grease	mg/ℓ	2.5			

***after the removal of algae**

Observations / Analysis

Attach full laboratory analysis. Note observations from sampling and detailed analysis of results.

HELMINTHS & PROTOZOA *To be completed by the technology reviewer*	**Form B.10**
Technology Name	**Reviewer Name & Date of Assessment**

Sampling Procedure

Analysis usually only applicable where supplier claims effluent is 'sanitised'

Grab Samples to be taken in accordance with SANS 5667, part 10 and Part 13 as applicable.

Samples to be taken at various positions within the treatment system as required to evaluate the treatment performance.

Samples to be tightly sealed in an air tight container for delivery to suitable Laboratory for analysis.

Samples must be ideally be stored at <5 °C in a dark container analysed within ± 48 hours

For solid samples, prepare the sample by weighing a suitable sample size and place that into a known volume of diluent. Determine moisture content of the sample in order to express the final results as the number of per gram dry mass.

For liquid samples the results are expressed per 100 ml of sample.

Sample Log

Record details of samples on the table below.

Sample Number	**Date / Time**	**Notes / Location of Sample**	**Helminth & Protozoa** Indicate presence

Observations / Analysis

Attach full laboratory analysis. Note observations from sampling and detailed analysis of results.

VISUAL INSPECTION OF TECHNOLOGY Form C.1

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

Type of Inspection

Where more than one type of inspection was undertaken complete multiple sheets.

Non – Operational Demonstration ☐
Technology off the shelf, not in use

Operational Demonstration Model ☐
Fully plumbed and operational for demonstration purposes only

Fully Operational Model ☐ **Number of months in use: …………**
Technology in continuous use

Conditions during Inspection

Provide general comments on the conditions of the inspected technology
(Incl. location, orientation, exposure to adverse weather, etc.).

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	Brief Description	Observations
User Interface		
Collection & Storage		
Conveyance *Pipework & Pumps*		
Treatment		
Effluent Disposal		
Access points		
Superstructure / Enclosure		
Other		

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

STRUCTURAL & MECHANICAL PERFORMANCE Form C.2

To be completed by the technology reviewer

Technology Name	Reviewer Name & Date of Assessment

Key Structural Components

Where structural components are not in accordance with an accepted Standard (SANS / ISO, etc.), and where the reviewer has concerns about the robustness of these components, structural and impact tests may be necessary.

Structural Component	Normal Loading Condition	Test Requirement

Key Mechanical Components

Where mechanical components are not in accordance with an accepted Standard (SANS / ISO, etc.), and where the reviewer has concerns about the reliability of these components, cyclic mechanical tests may be necessary.

Structural Component	Design Life	Test Requirement

Test Results & Recommendations

Attach full results of structural and mechanical tests. Identify any sub-standard results together with recommendations for how the performance of this component may be improved.

ANNEXURE C – Field Verification Reports

TECHNOLOGY DESCRIPTION AND INITIAL RESULTS

Afrisan

Brief Technology Description

The Afrisan is a waterless dehydration toilet which is solar powered. The technology works by a dehydration and aerobic process, followed by composting of waste. There are air vents to facilitate drying. The electricity from the solar is connected to a charger within a toilet cubicle, as well as for lighting. Lime or bulking agent is added into the toilet. Removal is through a basket.

Special Claims

- Odourless.
- Composting processing cycle of 4 weeks.

Field results

VISUAL INSPECTION OF TECHNOLOGY ***To be completed by the technology reviewer***	**Form C.1**
Technology Name	**Reviewer Name & Date of Assessment**
Afrisan	Karabo and Tina 08 September, 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets.	
Non – Operational Demonstration ☐ ***Technology off the shelf, not in use***	
Operational Demonstration Model ☐ ***Fully plumbed and operational for demonstration purposes only***	
Fully Operational Model ☑ **Technology in continuous use**	**In use for about 18 months.**

Assessment location	**Number of users**
Lethabong, Krugersdorp, GP	55 households, 4-6 users per unit per day per unit (frequent users)
Conditions during Inspection	
Provide general comments on the conditions of the inspected technology (Incl. location, orientation, exposure to adverse weather, etc.). On the day of the visit, it was warm, windy and sunny (the outside temperature at 16:00h was 18-20^{o}C). The Afrisan toilet is specialised, waterless self-contained dehydration, solar or electric powered urine diversion toilet. It can be retrofitted within an existing bathroom or toilet. In Krugersdorp, these toilet systems are installed in 55 households, based on 4-6 regular users per unite per day and have been operational for about 18 months so far. The maintenance is provided by Afrisan – 20 people form the local community are recruited for the maintenance of the toilets (“maintenance team”). They come to work every day to clean, wipe, and provide toilet paper and lime. The basket with faeces is usually emptied every month but if there is a higher load, they empty it every 2 weeks. Data base is kept on record for the maintenance – require the scanning of a bar code and record of the activity, together with relevant information such as date, weight of the sample emptied, report any faults of the system. Before building the toilets, Afrisan use the CENSUS and community participation to obtain all the information required to adjust the design specifications if necessary. After that they start the building process. There is a composting facility on the site that composts the faeces emptied from the toilets. The compost is used then in communal gardens and household gardens to grow vegetables and flowers. From the observation of all toilets, it appeared that they have been used and maintained regularly. The measured ambient temperature of the solids inside the dehydration basket was 22˚C and the temperature in the toilet cubicle was 23˚C. The outside temperature was 18-20˚C. The measurements were taken at 16:00h. The temperatures measured inside the faecal material was lower than the predicted temperature for processing of the solid waste which raises questions regarding the forced decomposition pathogen inactivation and the safety of handling this waste (60-80^{o}C). Adding calcitic lime powder might contribute to faster decomposition and pathogen inactivation. This needs to be validated through the laboratory tests of selected samples.	

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	Brief Description	Observations
User Interface	White plastic pedestals with white seats installed above ground. The solids and the liquids are diverted. A hand operated lever is provided to open and close the areas between the dehydration basket and he urine bowl. The toilet is used for urine purposes when the lever is in closed position to ensure that urine is collected in the urinal bowl at all times.	During the site visit it appeared that the toilets were properly used as indicated by the supplier – an instruction of how to use it was attached to the toilet lid. The pedestals were clean and well maintained.
Collection & Storage	The toilet diverts urine into a carbon urine filter with gravity flow which bypasses the dehydration basket of the toilet. This ensures maximum dehydration of the collected faecal matter. The urine filter is installed below ground surface, outside the installed structure at 500 mm below surface. The carbon within the urine filter can be replaced every 2 years. The faeces together with the toilet paper are collected in a dehydration basket connected to a heat technology that increases the ambient temperature to enhance the dehydration of the collected faecal matter. The heat is provided by a 50-Watt solar panel installed at the roof of the toilet, aiming to generate required surface heat temperature of 60-80^{o}C. This is enhanced by a wind driven air vent that continuously aerates the interior surface of the toilet.	The toiled seemed that has been serviced properly. There was some solid waste and toilet paper, covered by lime, available in the dehydrating baskets. It appeared that there was a regular collection of the solid waste (every 2-4 weeks). The measured ambient temperature within the faecal matter was too low (17^{o}C) which suggests that there was no active decomposition process and no high enough temperatures to ensure pathogen inactivation. However, as a part of the operation and maintenance process every three months, lime, enzymes and compost are added to the system which may contribute to pathogen

	A small amount of calcitic lime powder is added to the dehydration basket after every faecal use to ease further the decomposition process. The waste forms the basket is emptied every 2 to 4 weeks, depending on the use load.	inactivation and faster decomposition.
Conveyance *Pipework & Pumps*	All the pipes and mechanical units were intact and fully operational.	
Treatment	The toilet diverts urine into a carbon urine filter with gravity flow which bypasses the dehydration basket of the toilet. This ensures maximum dehydration of the collected faecal matter. The urine filter is installed below ground surface, outside the installed structure at 500 mm below surface. The carbon within the urine filter can be replaced every 2 years. The faeces together with the toilet paper are collected in a dehydration basket (lined with a 100% compostable bag) connected to a heat technology that increases the ambient temperature to enhance the dehydration of the collected faecal matter. The heat is provided by a 50-Watt solar panel installed at the roof of the toilet, aiming to generate required surface heat temperature of 60-80°C. This is enhanced by a wind driven air vent that continuously aerates the interior surface of the toilet. A small amount of calcific lime powder is added to the dehydration basket after every faecal use to ease further the decomposition process.	The measured ambient temperature of the solids inside the dehydration basket was 22°C and the temperature in the toilet cubicle was 23°C. The outside temperature was 18-20 °C. The measurements were taken at 16:00h. The temperatures measured inside the faecal material was lower than the predicted temperature for processing of the solid waste which raises questions regarding the forced decomposition pathogen inactivation and the safety of handling this waste (60-80°C). Adding calcitic lime powder might contribute to faster decomposition and pathogen inactivation. This needs to be validated through the laboratory tests of selected samples. Samples were collected from the dehydrating baskets of two toilet facilities.

Effluent Disposal	After collection from the dehydrating baskets, the faeces are treated further in a composting unit or a larger composting plant. The composting unit runs by solar energy (2 solar panels are installed on the roof of the compost unit storage – a shipping container). The waste resides for about 4 weeks in the composter – 2 weeks in the first chamber, 2 weeks in the second one. The value of the final product is R25 per 50 kg bag of compost. There is a soakaway pipe behind the toilet unit which drains the filtered urine into the ground.	The temperature inside the composting chambers was also measured – in the first one it was 28.5^{o}C. The first chamber is fed on a daily basis. In the second chamber the temperature was about 42^{o}C and the waste inside was about 3 weeks old. The measured temperatures in both chambers were lower than the suggested operational temperatures of the composting facility (70-80^{o}C). Strong smell of ammonia could be felt from both composting chambers. Samples were collected for analysis from both chambers. There are communal gardens or household gardens where the compost is used for growing of vegetables, flowers, etc. There is a business model where the local households are encouraged to sell the produced compost to local farmers. This is still in a project phase. Currently there is no urine collection for nutrient recovery. They intend, however, to check the possibilities for installation of a struvite reactor.
Access points	The main access point for the extraction of dried faeces is from the back side of the toilet. There is a lid at the top part of the	The access to the dried solid waste seemed to be easy to reach. The process of emptying also appeared

	container and the waste emptied by lifting of the dehydrating basket or just the compostable bag where the faeces are collected.	to be simple, with no mechanical or electronic components involved.
Superstructure / Enclosure	The superstructure was built of concrete walls, roof and walls with a metal door.	
Other: Vent Pipe	The vent pipe is installed adjacent to the waste collection container. It extends approximately 1 meter above the roofing and has a rain cover installed. It is wind driven and not connected to electricity supply. There is a 50-Watt solar panel installed on the roof of the toilet. It provides heat required for heating of the dehydrating basket and power for charging of mobile phones.	The ventilation is weather/ wind dependant. The power generated by the solar panel for phone charging in the toilets appeared to be very well accepted within the community.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Dry Sanitation

	Toilet 1	Compost sample 1	Compost sample 2
Temperature outside unit	23°C	17°C	17°C
Temperature inside faeces in container	23°C	28.5 °C	42 °C
Description of end product	Fresh and dry, mixed with lime and toilet paper	Dry, mixed with toilet paper	Dry, compost/ soil-like material
Initial sample collected (Y/N)?	Y		
Treated sample collected (Y/N)?	Y		

Description of solid samples (appearance, age):

1. **A few weeks old. Well mixed with lime and toilet paper.**
2. **Dry, well mixed with toilet paper**
3. **Dry, compost-like material**

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Further regular temperature tests to check what temperatures are reached in the faeces during treatment.**
- **Investigation of the final product to establish whether pathogen inactivation has been achieved**

User experiences

Users were very satisfied with the technology. Respondents cited that they like the toilet because toilet paper and cleaning is provided every day. This is part of African's three-year maintenance plan, of which they are contracted by the Department of Rural Development and Land Reform. Users said that during December holidays or vacation times, they could leave their waste bag as a designated place and it would still be collected in a regular and reliable manner.

Photos


Location of toilets in Lethabong Community gardening using compost

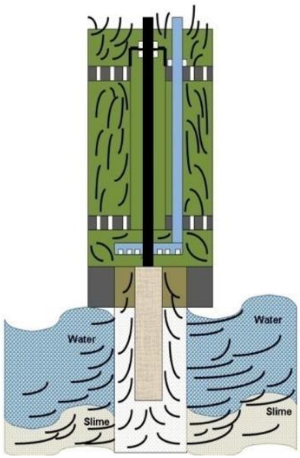

Enviro Options tank to dry urine Composter User interface and plug point


Dehydration basket with heating plate. Vegetable garden.

Bubbler

Brief Technology Description

The Bubbler Water Efficiency System modifies the way in which traditional septic tanks work. The technology uses and airlift pump with a sludge and potable water strainer to allow for filtration. The contents are circulated 20 to 30 times to convert anaerobic to aerobic metabolism for the biofilms forming on medium. The water is then recycled for flushing.



Airflow in the multiple bacteria airlift (MBA).

Special Claims

- No odours
- No suspended solids or slime

Field Results

VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	**Form C.1**
Technology Name	**Reviewer Name & Date of Assessment**
(Bubbler) Water Efficiency System	Jonny, Karabo, Tina
Assessment Location	**Number of Users**
Khayelitsha, Cape Town. Site 1	11
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use*** **Operational Demonstration Model** ☐ ***Fully plumbed and operational for demonstration purposes only*** **Fully Operational Model** ☒ **Technology in continuous use**	 **Number of months in use: 26 months**

Conditions during Inspection

Provide general comments on the conditions of the inspected technology (Incl. location, orientation, exposure to adverse weather, etc.).

The inspection occurred in the morning on a sunny but moderately windy day. The technology is installed in an informal settlement. The Water Efficiency system is located underneath a sandy area frequently walked on. The toilet which is attached to the septic system is indoors and the top of the septic system is exposed to sunlight throughout the day. The temperature indoor was cooler than outside.

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	Brief Description	Observations
User Interface	A white plastic pedestal with white seats were used. Grey water is poured into cistern and a flush mechanism used to send water to WET system.	The toilet was in doors and water used in the toilet was a brown colour. A plastic container holding greywater was placed close to the toilet for flushing. The motor to provide the airlift was also located close to the toilet. The power is delivered through a prepaid electricity meter and the bubbler runs all day. The flushing water had a faint odour.
Collection & Storage	The primary chamber is a 3600 L storage which uses bubbles. The second tank or chamber is a 2400 L.	Waste is flushed down the toilet and travels underground into the WET system. If there is a build-up of sludge, it usually floats and maintenance is provided. The supplier indicated that the municipality is contracted to maintain the toilets.
Conveyance *Pipework & Pumps*	Water, if the pump is full, in the primary chamber, water is conveyed into the secondary chamber.	
Treatment		The secondary chamber houses the bottom filter. One chlorine tablet is used every three months.
Effluent Disposal	The water soaks into a zone called the water efficiency draining field.	

Access points	The access point is via the opening of the primary chamber which is closed with a round black plastic lid and reinforced with a lockable metal mechanism.	Sand had to be removed and swept off the lids of the three chambers. The metal lock was only accessible with the supplier's key.
Superstructure / Enclosure	The superstructure comprises of three tanks in series, stored below ground.	The super structure is not visible, however the access points are.
Other		

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

	Khayelitsha	Durbanville site 1a	Durbanville site 1b
Temperature outside unit	19°C	21	22
Inlet	16°C	15.5	15.5
Outlet	16°C	16	16.5
Description of end product	Wastewater sample	Wastewater sample with sludge	Wastewater sample with sludge
Initial sample collected (Y/N)?	Y	Y	Y
Treated sample collected (Y/N)?	Y	Y	Y

Description of waste water samples (appearance, age):
The flushing water in Khayelitsha was clean and the samples collected at the site in Khayelitsha

Further Investigations Required
Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11. - **Further temperature tests to check what temperatures are reached in the faeces during treatment.** - **Investigation of the final product to establish whether pathogen inactivation has been achieved** - **Investigation into the mechanisms contributing to high liquid accumulation and suggest solutions to overcome this** - **Investigate the possibility of urine diversion, including separation of urine from faeces at the source, collection and utilisation of urine in order to prevent from accumulation of excess liquid at the bottom and use of valuable nutrients**

Photos

Fig: 1 Location of the Bubbler system in Kayelitsaha street   Top lid-structure of the Bubbler WET system

Primary chamber of the WET system   Top lid of the secondary chamber leading to discharge field.

Recycled water is used to flush the toilet.   Motor used for 'airlift' pump, utilises prepaid electricity.

User experiences

Two respondents from two of the three households both mentioned that they preferred the Bubbler toilet to the 'Mshengu' chemical toilets as no infections were experienced, the toilet was safer for children and compared to the chemical toilets, grey water from household use could be utilised to flush the toilet. Contradictory to claims, users said the toilet connected to the system sometimes smells. Users utilised only toilet paper and newspaper. Respondents reported that electrical use of the as much electricity for the pumps as she does for other household electrical appliances. There was a wash station located near above the water efficiency system. The station is used by approximately thirteen households every day, where grey water is disposed of on ground directly above the WET system.

Bubbler site 2


Primary chamber at the site 2 Secondary chamber at site 2


User interface at Mystic horse ranch in Durbanville


Location of Female toilets within the Horse Ranch

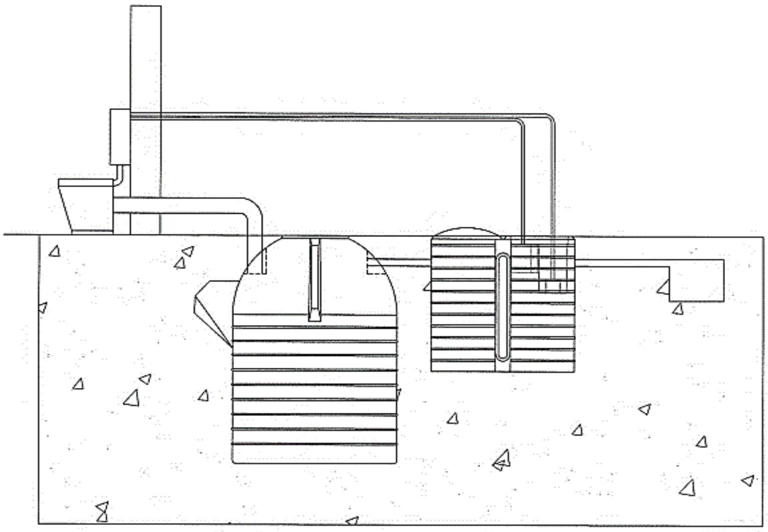
Calcamite

Brief Technology Description

The Wetloo (BRS) is a flushing toilet which recycles water through a septic tank. The septic tank comprises of a clarifying tank, treatment filter, and a 12V solar-driven pump. The waste and water flows into an accumulation chamber where there is aerobic and anaerobic digestion. The clarified effluent is the outflow which goes back to the cistern for flushing.

Special claims

- 90% reduction in BOD.



Calcamite - BRS -

VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	Form C.1
Technology Name	**Reviewer Name & Date of Assessment**
Wetloo (BRS) **Calcamite Sanitary Services (PTY)**	Karabo and Tina 08 September, 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use*** **Operational Demonstration Model** ☐ ***Fully plumbed and operational for demonstration purposes only*** **Fully Operational Model** ☑ **Technology in continuous use**	

Assessment location	**Number of users**
Calcamite factory, Rosslyn, Pretoria	50

Conditions during Inspection

Provide general comments on the conditions of the inspected technology (Incl. location, orientation, exposure to adverse weather, etc.).

On the day of the visit, it was warm and cloudy sunny – the outside temperature was 24.5ºC. At the end of the first site visit in the morning, it rained (quick light shower).

The Calcimite Wetloo is a recycling toilet that works on the principle of anaerobic degradation. It was developed to fill the need for a flushing toilet where a septic tank and soak away was not feasible due to ground conditions or lack of sewer systems.
The system requires a top structure or can be retrofitted. It consists of SABS tank, clarifier tank, aerobic treatment filter, 12V solar driven plant, 12V solar panel and power pack.
The system was fully operational on the day of the visit. The capacity of the system is about 5000 L/day and services approximately 50 users.

The measured flush volume is about 6 L.

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	**Brief Description**	**Observations**
User Interface	Common white ceramic flush pedestals with white seats installed above ground. Unconventional flush cistern (6 L capacity) with continuous flow design.	During the site visits it appeared that the cistern and the pedestal were working properly. The toilet seat and the cistern were not clean most probably because the flush water had a light brown colour. A sample was collected from the cistern in the male toilet to investigate its quality.
Collection & Storage	The user flushes the cistern to clean the toilet bowl and in this way the waste is transported into a septic tank. The same volume of water that enters the tank is transferred by hydraulic displacement into the clarifier tank and from there into the cistern via a lift pump. Once the cistern is full, excess water overflows via aerobic treatment	It requires a large initial amount of water. After that, however, it saves the use of fresh water.

	filter back to the clarifier tank. This process is continuous and automatically run.	
Conveyance *Pipework & Pumps*	12V solar driven pump	All the pipes and pumps looked intact and operational although it was difficult to check the operation of the entire system.
Treatment	Toilet waste is flushed into a septic tank where the gross solids settle at the bottom and the fats and grease float to the top. This allows for a relatively clear supernatant liquid to overflow into the second stage of the treatment – meander tank with pumping chamber to lift the effluent back to the cistern. The cistern has a continuous flow design – the overflow water passes through an anaerobic filter before re-entering the second stage tank that uses the solar pump to lift the water back to the cistern. The continuous aerobic/ anoxic process purifies the water. The system is reported to clean 50-100 L water/day for re-flushing (5000 L/24h).	The system implies a large reduction of the BOD and COD which is going to be checked through the laboratory analyses. Samples were collected from the effluent (from the cistern) and the influent (from the first chamber just after flushing). The brown colour of the effluent suggests the high content of suspended solids and possibly a biomass. A concern regarding this treatment will be the pathogen inactivation for the effluent water that is being re-flushed. This will be validated during the laboratory analysis. The aerobic filter was a plastic biofilm media as shown on the pictures.
Effluent Disposal	The purified water is pumped back to the cistern for re-flushing. Sludge is removed via vacuum tanker and disposed to a WWTW every 2-3 years.	The sludge accumulated at the bottom was not too thick and was not possible to collect a sample of it. It needs

Access points	The extraction points to the chambers were through plastic lids at the top of each chamber.	The access to the chambers was not difficult, however, they were deep and in case of failure of the system, it might be challenging to get inside the chamber. For the same reason, the sampling process was not too easy – the water level was too low and a sampling tool was required.
Superstructure / Enclosure	The toilets were installed in the office buildings.	Requires open surface area for installation. After installation, the system does not take too much of space.
Other: Solar pump, solar panel	Rated at 40 000 hours (5 years).	The solar pump requires replacement every 5 years. The solar battery requires replacement every 4 years. The security of the solar panel might be an issue. The presence of a solar panel makes the system independent of the grid.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Dry Sanitation

	1st chamber – inlet	Cistern – outlet
Temperature outside unit	19°C	19°C
Temperature inside faeces in container	24.5°C	24.5 °C
Description of end product	Liquid with dark brown colour	Liquid with light to clear brown colour
Initial sample collected (Y/N)?	Y	Y
Treated sample collected (Y/N)?	Y	Y

Description of solid samples (appearance, age):

4.

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Investigation of the effluent to establish whether pathogen inactivation has been achieved**

Photos

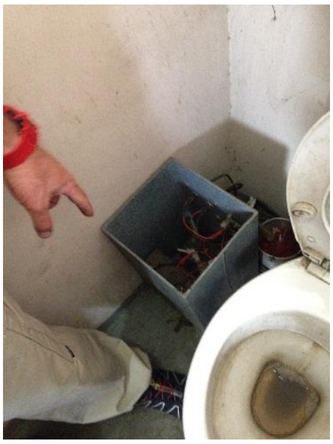

Recycling flush water system with solar panel


Overflow treatment tank


Biofilm media


Toilet with cistern

Cistern with solar pump on the left



Cistern with solar pump on the left

Inlet into a first chamber

Treatment into a second chamber

Biofilm media

Sampling

Collected samples

Collected samples

VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	**Form C.1**
Technology Name	**Reviewer Name & Date of Assessment**
Wetloo (BRS) **Calcamite Sanitary Services (PTY)**	Karabo and Tina 08 September, 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use*** **Operational Demonstration Model** ☐ ***Fully plumbed and operational for demonstration purposes only*** **Fully Operational Model** ☑ **Technology in continuous use**	
Assessment location	**Number of users**
Diepsloot community	500
Conditions during Inspection	
Provide general comments on the conditions of the inspected technology (Incl. location, orientation, exposure to adverse weather, etc.). On the day of the visit, it was warm and cloudy sunny – the outside temperature was 22^{o}C. The Calcimite Wetloo is a recycling toilet that works on the principle of anaerobic degradation. It was developed to fill the need for a flushing toilet where a septic tank and soak away was not feasible due to ground conditions or lack of sewer systems. The system requires a top structure or can be retrofitted. It consists of SABS tank, clarifier tank, aerobic treatment filter, 12V solar driven plant, 12V solar panel and power pack. The system was situated in Diepsloot community where it serviced 350 households (approximately 500 users). The volume capacity of the plant is 50 000 L (25 000 for male and 25 000 for female toilets). The systems accommodate for both black and grey water. The cistern flush volume is about 6 L. Two local ladies work full time to maintain the facility.	

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	**Brief Description**	**Observations**
User Interface	Plastic grey toilet bowls with white plastic seats were installed. Unconventional flush cistern (6 L capacity) with continuous flow design. The flush water is pumped into the cistern via solar pump on the left side of the pedestal. Plastic grey urinals were also installed.	During the site visits it appeared that the cisterns and the pedestal were working properly. The toilet seats and the urinals were well maintained and clean. The flush water had a light brown colour. A sample was collected from the cistern in the male toilet to investigate its quality.
Collection & Storage	The user flushes the cistern to clean the toilet bowl and in this way the waste is transported into a septic tank. The same volume of water that enters the tank is transferred by hydraulic displacement into the clarifier tank and from there into the cistern via a lift pump. Once the cistern is full, excess water overflows via aerobic treatment filter back to the clarifier tank. This process is continuous and automatically run.	It requires a large initial amount of water. After that, however, it saves the use of fresh water and cervices large amount of the community. This solution seems appropriate on a community level.
Conveyance *Pipework & Pumps*	12V solar driven pump	All the pipes and pumps looked intact and operational although it was difficult to check the operation of the entire system.
Treatment	Toilet waste is flushed into a septic tank where the gross solids settle at the bottom and the fats and grease float to the top. This allows for a relatively clear supernatant liquid to overflow into the second stage of the treatment – meander tank with	The system implies a large reduction of the BOD and COD which is going to be checked through the laboratory analyses. Samples were collected from the effluent (from the cistern) and the influent

	pumping chamber to lift the effluent back to the cistern. The cistern has a continuous flow design – the overflow water passes through an anaerobic filter before re-entering the second stage tank that uses the solar pump to lift the water back to the cistern. The continuous aerobic/ anoxic process purifies the water. The system is reported to clean 50-100 L water/day for re-flushing (3000 L/24h).	(from the first chamber just after flushing). The brown colour of the effluent suggests the high content of suspended solids and possibly a biomass. A concern regarding this treatment will be the pathogen inactivation for the effluent water that is being re-flushed. This will be validated during the laboratory analysis. The aerobic filter was a plastic floating biofilm as shown on the pictures.
Effluent Disposal	The purified water is pumped back to the cistern for re-flushing. Sludge accumulation per year – about 250 L. It is removed via vacuum tanker and disposed to a WWTW.	The sludge accumulated at the bottom was not too thick and was not possible to collect a sample of it.
Access points	The extraction points to the chambers were through plastic lids at the top of each chamber.	The access to the chambers was not difficult, however, they were deep and in case of failure of the system, it might be challenging to get inside the chamber. For the same reason, the sampling process was not too easy – the water level was too low and a sampling tool was required.
Superstructure / Enclosure	The toilets were installed in a metal shipping container. The treatment system was installed outside.	Requires open surface area for installation of the treatment system. After installation, the system does not take too much of space.

Other: Solar pump, solar panel	Each battery lasts for about 40 000 hours (5 years).	The solar pump requires replacement every 5 years. The solar battery requires replacement every 4 years. The security of the solar panel is already an issue. There is already a reported incident of theft. Additional security measurements were installed in place. The presence of a solar panel makes the system independent of electricity grid.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Dry Sanitation

	1st chamber – inlet	Cistern – outlet
Temperature outside unit	22°C	22°C
Temperature inside faeces in container	17°C	°C
Description of end product	Liquid with dark brown colour	Liquid with light to clear brown colour
Initial sample collected (Y/N)?	Y	Y
Treated sample collected (Y/N)?	Y	Y

Description of solid samples (appearance, age):

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Investigation of the effluent to establish whether pathogen inactivation has been achieved**

Photos

Community toilet

Solar panels installed on the roof

Wetloo treatment system

Toilet with solar run battery on the left

Urinals


Inlet chamber

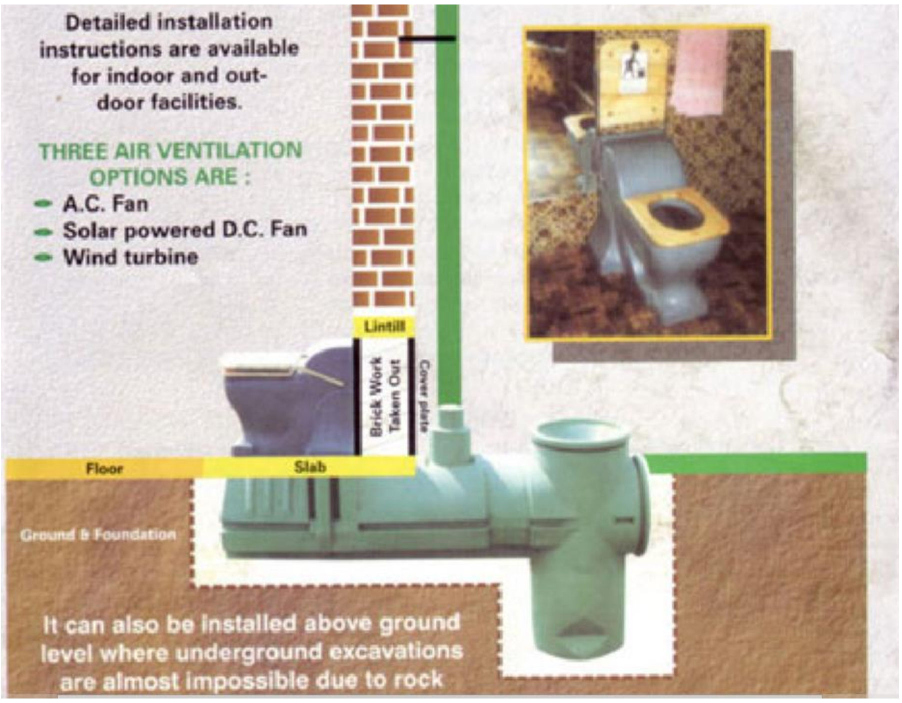
User experiences

The daily caretakers at Diepsloot community expressed that it was hard to keep a record of how many users there were as the communal toilets were open from 6am to 8pm and could be used by anyone. There had been experience of vandalism and theft of solar panels, however after the toilets were secured, vandalism ceased. There was a community garden approximately 500 m away on which, if necessary any, emergency soak away could occur.

Ecosan

Brief Technology Description

The Ecosan is a dry sanitation toilet with UD.



Special claims

- It takes six to nine months for the bag to fill with waste.

VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	**Form C.1**
Technology Name	**Reviewer Name & Date of Assessment**
Ecosan waterless toilet	Jonny, Karabo and Tina 03 September, 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use*** **Operational Demonstration Model** ☐ ***Fully plumbed and operational for demonstration purposes only*** **Fully Operational Model** ☑ **Technology in continuous use**	
Assessment location	**Number of users**
Sedgefield, Knysna area	Designed for 10 persons per day
Conditions during Inspection	
Provide general comments on the conditions of the inspected technology	

(Incl. location, orientation, exposure to adverse weather, etc.).

On the day of the visit, it was warm and sunny day with no wind. The outside temperature was above 20°C, but lower where the installation was assessed as it was under a forest canopy.

The Ecosan waterless toilet is a dry sanitation toilet. The solid waste and excess urine travels down a helical screw conveyer into a mesh bag with a bucket underneath. A steel mechanism rotates the conveyor each time the toilet lid is lifted (up and down once). Air flows down the toilet bowl and evaporates the moisture. The system is installed in a guesthouse where each unit houses between two and four (2-4) guests at a time. The toilet is designed to be cost efficient in rural areas where there is no water system. The system is also designed to be easily disassembled for easy implementation where necessary.

Caretakers clean the toilet every day with a brush. Instructions are displayed to not clean the toilet as guests often pour water down the inlet, which slows down the drying process.

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	Brief Description	Observations
User Interface	Green plastic toilet structure with white plastic seats and wooden conveyor mechanism. The mechanism is moved down to the pedestal level and back up again to move waste. Bucket containing leaves as additive and a scoop on the left side of the toilet.	The conveyor mechanism was easy to pull up and down. The toilet bowl is wide with a long narrow inlet. Toilet paper is provided, as well as user instructions on the bucket.
Collection & Storage	Waste drops into the superstructure which is black. The structure in this case was above ground. The waste goes through a drying process as it is conveyed	The waste seems to have enough time in the conveyor to break down some foreign materials and materials, however not enough time to completely dry the faeces as there was some urine visible under the waste bag.
Conveyance *Pipework & Pumps*	A black plastic helical conveyor moves in circular rotations to moves waste towards the disposal bag. The conveyor mechanism is lifted and dropped four times after use.	The helical conveyor is made of above twenty small grooves which act as pockets for waste. The conveyor required 9-10 lifts to complete a full cycle. Upon completion of one

		rotation, there is a strong odour.
Treatment	Waste is dried by air and heat within the conveyor.	No toilet paper was observed. The leaves which are poured down the inlet seem enhance the breaking down of solids. Waste is used for composting, where the owner layers of grass, wood and waste within a drying wooden box. At times, ash is added to adjust the PH of the compost.
Effluent Disposal	The conveyor drops faeces into a waste bag which is collected emptied every 2 to 3 months depending on usage.	Waste that is collected if used for composting which is dried on another part of the property.
Access points	The access point is at the end of the structure and it is covered by a plastic lidless than 1 meter above ground	There are handles to lift the waste bag. However, if there is excess urine, the waste bag must be removes and the bucket below it pulled up in order to dispose of.
Superstructure / Enclosure	The toilets are installed inside a wooden house and the conveyor is outside below the house.	Enough room was available to house the bucket next to the toilet and allow for room to pull the conveyor mechanism lever up and down. The toilet is above the black conveyor structure.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

	Dry Sanitation		
	Conveyor – inlet	Inside collection bag – outlet	Separate Compost
Temperature outside unit	18.5°C	18.5°C	23.5°C
Temperature inside faeces in container	13°C	12.5°C	17°C
Description of end product	Brown waste with liquid	A brown soft mass of leaves and waste, with worms.	Brown soil-like material
Initial sample collected (Y/N)?	Y	Y	N
Treated sample collected (Y/N)?	Y	Y	Y

Description of solid samples (appearance, age):
Brown soft and moist waste with organic material.

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Investigation of the effluent to establish whether pathogen inactivation has been achieved**

Photos


Helical waste conveyer


User interface


Position of the superstructure outside bungalow.


Plastic bucket into which leaves are placed for users.


Composting


Toilet with bucket, leaves and scoop.

Temperature reading in partly shady area.

Toilet inlet

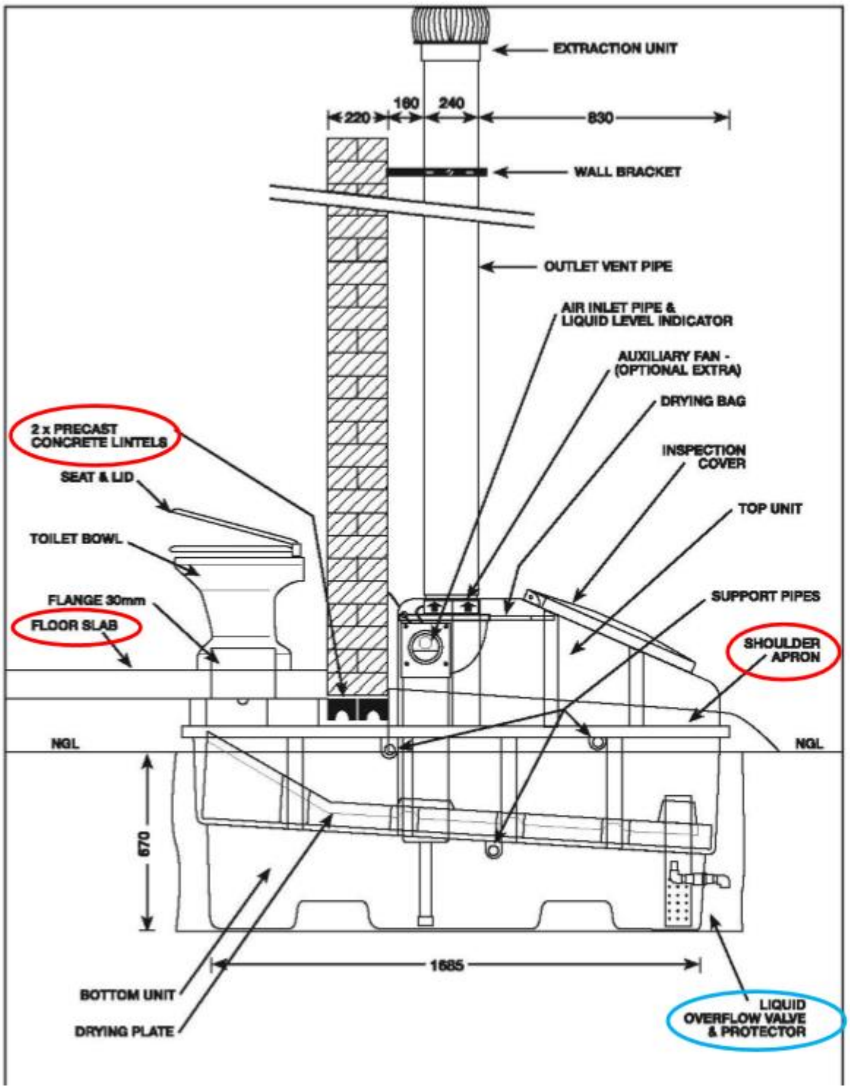
User experiences

The owner of the guest house has modified many of the operational features. The original wooden seat has been replaced with a white plastic seat, which the owner found to be more acceptable to guests. Leaves are added down the toilet to improve composting process and to enhance user acceptability.

Enviro Loo

Brief Technology Description

The Enviro Loo is a dry sanitation system which uses heat and airflow via wind vents to dry waste. The waste is moved down the drying plate during which evaporation and drying occur. The system is designed for both urban and rural contexts.



VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	**Form C.1**
Technology Name	**Reviewer Name & Date of Assessment**
Enviro Loo	Jonny, Karabo and Tina 02 September, 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use***	

<table>
<tr><td colspan="2">Operational Demonstration Model ☐
Fully plumbed and operational for demonstration purposes only

Fully Operational Model ☑ In use since 2011.
Technology in continuous use</td></tr>
<tr><th>Assessment location</th><th>Number of users</th></tr>
<tr><td>Kogelberg Nature Reserve in Greater Hermanus area</td><td>12 units in a recreational eco-tourism site (capacity of 10-20 users per day; they have less users per unit for this site)</td></tr>
<tr><th colspan="2">Conditions during Inspection</th></tr>
<tr><td colspan="2">Provide general comments on the conditions of the inspected technology
(Incl. location, orientation, exposure to adverse weather, etc.).
On the day of the visit, it was windy, warm and sunny (the outside temperature was 20 to 22^{o}C). The toilets were situated at the back end of the buildings (bungalows). Each building accommodates between 4 and 6 users. The different toilet units were facing north or south depending on the design of each building.

No smell was observed from the toilet pedestals inside the buildings which could be attributed to the extractors provided as parts of the toilet systems (run by ….. kW power). There was also a small container with compost provided for scooping and spreading this material over after use. Four units were inspected in total.

From the inspection of the back side of the toilets (where the human waste is usually stored and collected from), it appeared that the toilets have been used on a regular basis. There was a large amount of faeces in a mix of toilet paper and compost material. A build-up of liquid (urine and/or other) was observed at the bottom of the container which suggested that the liquid does not evaporate at a fast-enough rate or that larger amounts of liquids have been disposed into the toilets. The exposure/ lack of sunlight (primarily south or north) did not seem to have a significant effect on the drying of solids and/or the liquid evaporation.

From the observation of all toilets, it appeared that they have been maintained regularly and the human waste has been moving to the drying basked as suggested by the suppliers.
However, at the temperature check via temperature probe it appeared that the ambient temperature of the solids inside the containers (16^{o}C) was lower than the measured air temperature (22^{o}C). The measurements were taken at 14:00-14:30h.
The lower temperatures measured inside the faecal material questions the pathogen inactivation and the safety of handling this waste.</td></tr>
<tr><th colspan="2">Quality of Fabrication</th></tr>
</table>

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	Brief Description	Observations
User Interface	White ceramic, pedestals with a white seat were used. The solids and the liquids were not separated. No flush or a mechanical device for advancing of the faeces was present.	The faeces seemed to be properly advanced by gravitation. After use the faeces were covered with a compost material provided in a small container next to the toilet. At the time of the visit no faeces or liquids were visualised from the top part of the pedestal. It appeared that the toilet was properly used as indicated by the supplier.
Collection & Storage	The waste enters a plastic container via a ceramic pedestal. The solid waste remains onto a drying plate while the liquid drains to the bottom of the container. The waste is continuously exposed to a flow of air provided by inlet toilet pipes and the toilet bowl. The air is then extracted through an extraction unit at the top of the structure. The air flow is supposed to dehydrate the solid wastes and results in evaporation of the liquid at the bottom. The sunlight is supposed to increase the ambient temperature within the container and contribute to its decomposition. The liquid at the bottom is expected to evaporate and its mechanical emptying is not included in the system operation. The faeces rest between 12 and 18 months and are occasionally pushed from underneath the drop hole to the back side of the container to ensure better drying	There were two main concerns. First, the measured ambient temperature within the faecal matter was too low (less than 20ºC) which suggests that there was no active decomposition process and no high enough temperatures to ensure pathogen inactivation. Second, a liquid accumulation was observed at the bottom of the container which suggested that there was no enough evaporation or the amount of the liquids disposed into the system was higher than the design restrictions. An excessive build-up of liquid was observed in some of the inspected toilet units. The supplier and the maintenance person could not explain the reason for that. One of the possibilities was that

	and prevent their build up underneath the toilet pedestal. Every 6 weeks the driest faeces (at the back end of the pedestal) are moved into a mesh basket, provided by the supplier, to ensure better drying after which the material is emptied from the basket and buried or disposed.	additional liquid (non-urine) may have been disposed in the toilets. The excessive liquid accumulation could be prevented by urine collection into a separate container that could be emptied on a regular basis. Currently, the urine/liquid is cross-contaminated with faecal matter and even if emptied manually, this will pose a health hazard. The system hence could be optimised by urine diversion into a separate container which will prevent from cross-contamination with faeces, build-up of excess liquid and utilisation of valuable nutrients.
Conveyance *Pipework & Pumps*	All the pipes and extraction units were intact and fully operational. The baskets for extraction of faeces were in place.	
Treatment	The solid waste dehydrates as a result of the air flow moving through the system, as it moves down a sloped drying plate. At the same time, the sunlight increases the ambient temperature within the container. The waste dehydrates and decomposes as a result of the intense heat, prolonged retention periods and oxygen rich air. The final product is inoffensive dry stabilised product reduced to 5% of its original volume. The liquid at the bottom of the container evaporates as a result of the aeration and intensive heating of the system.	Based on the visual inspection during the visit, the most of the faeces looked fry at the back of the container. Some of them however, were wet at the lower level due to the very high levels of the liquid accumulated at the bottom. It did not seem that the ambient temperatures inside the container were very high which may result in slower drying and decomposing, and inefficient pathogen inactivation. This is currently being checked

	While on the turn-table, the unit receives sunlight, which heats the unit. There is also a ventilation pipe installed adjacent to the access point. Over the course of 2-3 weeks, the water evaporates, rendering the faeces much drier and simpler to remove and transport.	through the laboratory analyses.
Effluent Disposal	When faeces are removed, the basket is lifted out of the sump by a handle at the top. By raising the basket, the faeces can be transported to a compost pile for further composting or other treatment for reuse. At this site in particular, dried faeces had been moved to a compost pile (in a bathtub), in a mix with other organic material, such as leaves and wood chips. At this site, vermicomposting was applied, with a large number of earth worms present in the compost pile. Water was added to ensure optimum moisture for the vermicomposting process.	The basket was simple to remove, although on the visit day, it was only approximately 1-2% full of dried faeces. The basket is typically removed when it is 50% full, in which case it would be heavier to remove. In addition, there were steps up to the access point, because this installation was above ground. In the men's toilet, the rubber wall on the turn-table had been dislocated, such that it blocked removal of the basket. The inspectors had to move the rubber wall in order to remove the basket, which made it slightly non-ideal to remove. However, the overall removal process appeared to be very simple and easy. In addition, the compost pile on the site appeared to be very active with worms, further breaking down the faecal matter. The community garden at this site may have many opportunities in the future with the use of composted faeces.

Access points	The main access point for the extraction of dried faeces is from the back side of the toilet. There is a lid at the top part of the container and the waste can be shovelled out.	The access to the dried solid waste seemed to be easy and straightforward. The process of emptying also appeared to be simple, with no mechanical or electronic components involved.
Superstructure / Enclosure	The superstructure was attached to the back side of the building with a separate access to the waste container from the outside. The toilet pedestal was installed inside the building.	
Other: Vent Pipe	The vent pipe is installed adjacent to the waste collection container. It extends approximately 1 meter above the roofing and has a rain cover installed. It requires electricity supply connected to the building.	The vent pipe operation is dependent on electricity which is going to be affected during power outages.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Dry Sanitation			
	Fire Lily (south facing)	Erica (north facing)	Everlasting (lower south facing)
Temperature outside unit	17°C	21°C	20°C
Temperature inside faeces in container	19°C	17.5°C	16°C
Description of end product	Dry, mixed with compost and toilet paper	Dry, mixed with compost and toilet paper	Dry, mixed with compost and toilet paper
Initial sample collected (Y/N)?	Y	Y	Y
Treated sample collected (Y/N)?	Y	Y	Y

Description of solid samples (appearance, age):

5. **18 months old – dry and hard.**

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Further temperature tests to check what temperatures are reached in the faeces during treatment.**
- **Investigation of the final product to establish whether pathogen inactivation has been achieved**
- **Investigation into the mechanisms contributing to high liquid accumulation and suggest solutions to overcome this**
- **Investigate the possibility of urine diversion, including separation of urine from faeces at the source, collection and utilisation of urine in order to prevent from accumulation of excess liquid at the bottom and use of valuable nutrients**

Photos

The white ceramic user interface.

Signage and instructions for users

Dry faeces at the back pf the superstructure.


Air vents Location of superstructure in Kogelberg Nature Reserve

VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	Form C.1
Technology Name	**Reviewer Name & Date of Assessment**
Enviro Loo	Karabo and Tina 09 September, 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use*** **Operational Demonstration Model** ☐ ***Fully plumbed and operational for demonstration purposes only*** **Fully Operational Model** ☑ **In use since 2013.** **Technology in continuous use**	
Assessment location	**Number of users**
Chamdor, Krugersdorp (Enviro Loo Factory)	100 employees, 10-20 users per unit per day
Conditions during Inspection	
Provide general comments on the conditions of the inspected technology (Incl. location, orientation, exposure to adverse weather, etc.). On the day of the visit, it was windy and sunny (the outside temperature was 23^{o}C). The toilets were situated at the back end of the factory building. The back-side toilet units were facing an easterly direction. The level of smell inside the toilets was low which could be attributed to the extractors provided as parts of the toilet systems. No container with compost was provided inside the toilets to cover the faecal material over after use. Two units were inspected in total. The Enviro Loo toilet units were connected to the male toilet facilities only. The female toilet facilities were flush toilets connected to septic tanks for waterborne systems. The inspected facilities were model C2020 with some improvements in the design – the angle of the slab was changed from 25 to 15 degrees to increase the sun radiation and better sealing was provided.	

From the inspection of the back side of the toilets (where the human waste is usually stored and collected from), it appeared that the toilets have been used on a regular basis. The inspected units have been overused in some cases – the number of users per day was higher than the designed number.

There was a small amount of liquid present (urine and/or other) at the bottom of the container but the amount did not exceed the maximum capacity (320 L) as observed at the Kogelberg Nature Reserve. This can be attributed to the presence of an Evaporative urinal unit which services 40 users per day (800 litre liquid waste capacity). There was a formation of "crystals" (sludge) in the urine tank – it was last emptied in June 2015.
In the conventional Enviro Loo toilet facilities, there was a large amount of faeces in a mix of toilet paper and compost material. The last date when the faeces were moved onto the basket was 19 August 2015.

The toilets are usually serviced by the owner every 3 months by the user when they add enzyme, lime and compost to the faeces in order to overcome bad smells. The O&M per unit per year costs R500.

From the observation appeared that the toilets were maintained regularly and the human waste has been moved to the drying basked as suggested by the suppliers.

However, at the temperature check via temperature probe it appeared that the ambient temperature of the solids inside the containers (17^{o}C) was lower than the measured air temperature (23^{o}C). The measurements were taken at 09:00-09:30h.

The lower temperatures measured inside the faecal material questions the pathogen inactivation and the safety of handling this waste, although adding lime and enzymes may contribute to faster decomposition and pathogen inactivation. This needs to be validated through the laboratory tests of selected samples.

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	**Brief Description**	**Observations**
User Interface	White ceramic, pedestals with a white seat were used. The solids and the liquids were not separated. No flush or a mechanical device for advancing of the faeces was present.	The faeces seemed to be advanced by gravitation, however at the time of the visit, a small amount of faeces, in a mix with toilet paper, could be visualised from the top part of the pedestal. This indicated a large amount of waste accumulated in the container below which prevented the waste from advancing further. It appeared, however, that the toilet was properly used as indicated by the supplier – an instruction of how to use it was attached on the toiled lid.
Collection & Storage	The waste enters a plastic container via a drop hole through the pedestal. The solid waste remains onto a drying plate while the liquid drains to the bottom of the container. The waste is continuously exposed to a flow of air provided by inlet toilet pipes and the toilet bowl. The air is then extracted through an extraction unit at the top of the structure. The air flow is supposed to dehydrate the solid wastes and results in evaporation of the liquid at the bottom. The sunlight is supposed to increase the ambient temperature within the container and contribute to its decomposition. The liquid at the bottom is expected to evaporate and its mechanical emptying is not included in the system operation.	The toiled seemed that has been serviced properly and the dried waste was moved regularly to the basket. It also appeared that the toilet systems were over used by the large amounts of faeces and toilet paper collected in the container. However, no system fails were observed as a result of the overuse. All elements seemed intact and operating normally at this stage. There was no an excess accumulation of urine. Only a small amount was observed at the bottom probably because there were separate urine chambers for collection of urine from urinals.

	The faeces rest between 12 and 18 months and are occasionally pushed from underneath the drop hole to the back side of the container to ensure better drying and prevent their build up underneath the toilet pedestal. Every 6 weeks the driest faeces (at the back end of the pedestal) are moved into a mesh basket, provided by the supplier, to ensure better drying after which the material is emptied from the basket and buried or disposed.	The measured ambient temperature within the faecal matter was too low (less than 20ºC) which suggests that there was no active decomposition process and no high enough temperatures to ensure pathogen inactivation. However, as a part of the operation and maintenance process every three months, lime, enzymes and compost are added to the system which may contribute to pathogen inactivation and faster decomposition.
Conveyance *Pipework & Pumps*	All the pipes and extraction units were intact and fully operational. The baskets for extraction of faeces were in place.	
Treatment	The solid waste dehydrates as a result of the air flow moving through the system, as it moves down a sloped drying plate. At the same time, the sunlight increases the ambient temperature within the container. The waste dehydrates and decomposes as a result of the intense heat, prolonged retention periods and oxygen rich air. The final product is inoffensive dry stabilised product reduced to 5% of its original volume. The liquid at the bottom of the container evaporates as a result of the aeration and intensive heating of the system.	Based on the visual inspection during the visit, the most of the faeces looked dry at the back of the container. Some of them however, were still fresh even at the back side of the container possibly because of the intensive use. It did not seem that the ambient temperatures inside the container were very high which may result in slower drying and decomposing, and inefficient pathogen inactivation. This is currently being checked through the laboratory analyses.
Effluent Disposal	Faeces from the back side of the container are moved to a basket	The process of moving of dried faeces from the back

	and left for 2 to 3 weeks to ensure additional drying. The basket is then emptied and the dried matter is further composted in a composting facility or disposed. In this particular case, the dried faeces were further composted in a small facility on the site for further 2 to 4 weeks. The compost in then used for communal gardens but this is still in a very initial stage.	of the container to the drying basket and from the drying basket to the composting facility looked simple and easy. The composting process is expected to reach a temperature of 70-80ºC but at the temperature control during the site visit, the temperature of the waste inside the composting facility was 20ºC. This once again raises the question of pathogen inactivation during the composting process which is currently being checked from the selected samples. If the pathogen inactivation is successful, the application of compost in communal gardens on the site will have a beneficial effect.
Access points	The main access point for the extraction of dried faeces is from the back side of the toilet. There is a lid at the top part of the container and the waste can be shovelled out.	The access to the dried solid waste seemed to be easy and straightforward. The process of emptying also appeared to be simple, with no mechanical or electronic components involved.
Superstructure / Enclosure	The superstructure was attached to the back side of the building with a separate access to the waste container from the outside. The toilet pedestal was installed inside the building.	
Other: Vent Pipe	The vent pipe is installed adjacent to the waste collection container. It extends approximately 1 meter above the roofing and has a rain cover installed. It requires	The vent pipe operation is dependent on electricity which is going to be affected during power outages.

	electricity supply connected to the building.	

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Dry Sanitation	Toilet system 1	Toilet system 2	Compost from facility onsite
Temperature outside unit	22.5°C	23°C	23°C
Temperature inside faeces in container	17°C	20.5°C	20°C
Description of end product	Dry, mixed with compost and toilet paper	Dry, mixed with compost and toilet paper	Very dry, compost-like material mixed with some toilet paper
Initial sample collected (Y/N)?	Y	Y	Y (2 weeks old)
Treated sample collected (Y/N)?	Y	Y	Y (4 weeks old)

Description of solid samples (appearance, age):

6. **A few weeks old. At the surface – very dry and hard, mixed with compost, toilet paper and lime. Deeper in the pile, the some of the faeces were still fresh.**
7. **Compost – very dry, soil-like material**

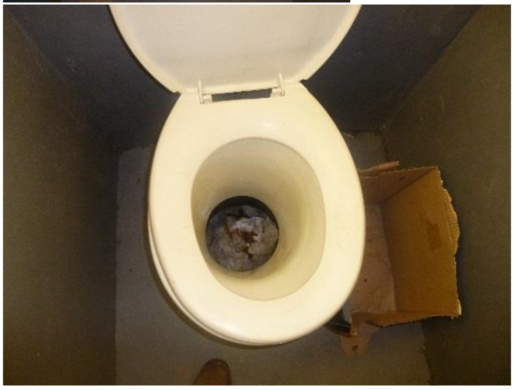
Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Further regular temperature tests to check what temperatures are reached in the faeces during treatment.**
- **Investigation of the final product to establish whether pathogen inactivation has been achieved**

Photos


ATTENTION
THIS IS A WATERLESS TOILET
PLEASE FOLLOW THESE INSTRUCTIONS
DO NOT
DO NOT
DO NOT
DO NOT
TO CLEAN THE TOILET
THEN
THE ENVIRO LOO




Drying of urine


Dry urine crystals


Testing site at factory


Composter


Swiss-made composter






Enviro Loo site 3

VISUAL INSPECTION OF TECHNOLOGY — Form C.1

To be completed by the technology reviewer

Technology Name	**Reviewer Name & Date of Assessment**
Enviro Loo	Karabo and Tina 09 September, 2015

Type of Inspection

Where more than one type of inspection was undertaken complete multiple sheets.

Non – Operational Demonstration ☐
Technology off the shelf, not in use

Operational Demonstration Model ☐
Fully plumbed and operational for demonstration purposes only

Fully Operational Model ☑ **In use since March 2015.**
Technology in continuous use

Assessment location	**Number of users**
Bekkersdal **Westonaria Local Municipality, Gauteng**	25 units, one unit per household

Conditions during Inspection

Provide general comments on the conditions of the inspected technology
(Incl. location, orientation, exposure to adverse weather, etc.).

On the day of the visit, it was windy and sunny (the outside temperature was 25^{o}C). The toilets systems service one household each and are installed externally to the household, i.e. as separate superstructures. The inspected facilities were model C2020, servicing 10-20 users per day.

Three units were inspected in total – one of the units was empty (only one person lives in the household), the second one was in use (5 people living in the household) and the third one contained a very small amount of faeces (with 4 people living in the household). The low use of the toilets was attributed also to the presence of VIP toilets in the same households. The Enviro Loo toilets were built as an initiative of the municipality to assess

the social acceptance of these toilets compared to VIPs. It seemed that the VIP toilets were also in use. Samples we collected only from the second Enviro Loo unit – a sample of fresher faeces (initial sample) and a sample of dried, old faeces (treated sample). It appeared that the toilets have been serviced very recently which was confirmed by the supplier – a week or two before the visit and the faeces were mixed with a lot of compost and possibly lime. The maintenance is provided by the Enviro Loo Services. The level of smell inside the toilets was low to moderate but not strong which could be attributed to the extractors provided as parts of the toilet systems (these extractors were not run by electricity, only by wind power). No container with compost was provided inside the toilets to cover the faecal material over after use. The toilet pedestals were not in a clean condition as the previous visited sites. From the inspection of the back side of the toilets (where the human waste is usually stored and collected from), it appeared that the toilets have not been used regularly basis. There was a small amount or no liquid present (urine and/or other) at the bottom of the container. From the observation of all toilets, it appeared that they have been maintained regularly but there was no enough waste accumulated in the container and a lot of trash was disposed in the toilet. The temperature check via temperature probe showed that the ambient temperature of the solids inside the containers (20-26.5^{o}C or an average of 22^{o}C) was lower than the measured air temperature (25^{o}C). The measurements were taken at 14:00-14:30h. The lower temperatures measured inside the faecal material questions the pathogen inactivation and the safety of handling this waste, although adding lime and enzymes may contribute to faster decomposition and pathogen inactivation. This needs to be validated through the laboratory tests of selected samples.
Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	**Brief Description**	**Observations**
User Interface	White plastic pedestals with white seats were used. The solids and the liquids were not diverted. No flush or a mechanical device for advancing of the faeces was present.	The faeces seemed to be advanced by gravitation. At the time of the visit no faeces or liquids were visualised from the top part of the pedestal. It appeared that the toilet was properly used as indicated by the supplier – an instruction of how to use it was attached on the inside of the toilet door. The pedestal was very dirty which suggested that there was no regular maintenance of the toilet bowl.
Collection & Storage	The waste enters a plastic container via a drop hole through the pedestal. The solid waste remains onto a drying plate while the liquid drains to the bottom of the container. The waste is continuously exposed to a flow of air provided by inlet toilet pipes and the toilet bowl. The air is then extracted through an extraction unit at the top of the structure. The air flow is supposed to dehydrate the solid wastes and results in evaporation of the liquid at the bottom. The sunlight is supposed to increase the ambient temperature within the container and contribute to its decomposition. The liquid at the bottom is expected to evaporate and its mechanical emptying is not included in the system operation.	It seemed as though the toilet had been serviced properly. There was not much solid waste or liquid in some of the inspected units; trash was also disposed into the toilets. The measured ambient temperature within the faecal matter was too low (lowest point measured being 21^{o}C) which suggests that there was no active decomposition process and no high enough temperatures to ensure pathogen inactivation. However, as a part of the operation and maintenance process every three months, lime, enzymes and compost are added to the system which may contribute to pathogen

	The faeces rest between 6 and 18 months and are occasionally pushed from underneath the drop hole to the back side of the container to ensure better drying and prevent their build up underneath the toilet pedestal. Every 6 weeks the driest faeces (at the back end of the pedestal) are moved into a mesh basket, provided by the supplier, to ensure better drying after which the material is emptied from the basket and buried or disposed.	inactivation and faster decomposition.
Conveyance *Pipework & Pumps*	All the pipes and extraction units were intact and fully operational. The baskets for extraction of faeces were in place.	
Treatment	The solid waste dehydrates as a result of the air flow moving through the system, as it moves down a sloped drying plate. At the same time, the sunlight increases the ambient temperature within the container. The waste dehydrates and decomposes as a result of the intense heat, prolonged retention periods and oxygen rich air. The final product is inoffensive dry stabilised product reduced to 5% of its original volume. The liquid at the bottom of the container evaporates as a result of the aeration and intensive heating of the system.	Based on the visual inspection during the visit, the most of the faeces looked dry and mixed with a large amount of compost and lime. It did not seem that the ambient temperatures inside the container were very high which may result in slower drying and decomposing, and inefficient pathogen inactivation. This is currently being checked through the laboratory analyses.
Effluent Disposal	Faeces from the back side of the container are moved to a basket and left for 2 to 3 weeks to ensure additional drying. The basket is then emptied and the dried matter is further	These facilities have been installed recently (March 2015) and it did not appear that the solid waste has been emptied yet as there was no high accumulation.

	composted in a composting facility or disposed. In this particular case, the dried faeces were further composted in a small facility on the site for further 2 to 4 weeks. The compost in then used for communal gardens but this is still in a very initial stage.	
Access points	The main access point for the extraction of dried faeces is from the back side of the toilet. There is a lid at the top part of the container and the waste can be shovelled out.	The access to the dried solid waste seemed to be easy and straightforward. The process of emptying also appeared to be simple, with no mechanical or electronic components involved.
Superstructure / Enclosure	The superstructure was built of concrete walls, roof and walls with a metal door.	
Other: Vent Pipe	The vent pipe is installed adjacent to the waste collection container. It extends approximately 1 meter above the roofing and has a rain cover installed. It is not connected to electricity supply and runs with wind power.	The ventilation is weather/ wind dependant.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Dry Sanitation

	Toilet system 1
Temperature outside unit	25°C
Temperature inside faeces in container	22°C
Description of end product	Dry, mixed with compost, toilet paper and trash materials
Initial sample collected (Y/N)?	N
Treated sample collected (Y/N)?	Y

Description of solid samples (appearance, age):

8. **Four weeks old. Well mixed with compost and lime.**

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Further regular temperature tests to check what temperatures are reached in the faeces during treatment.**
- **Investigation of the final product to establish whether pathogen inactivation has been achieved**
- **Establish if the toilets have been regularly used.**

Photos

Waste and other materials

Collection of waste sample

User Experiences

Toilets were provided after service delivery protests and so users expressed that they preferred the Enviro Loo to the pit latrines because there was no smell and clime is added by maintenance. They said the toilets were ideal because water in the area was extremely erratic. One female respondent emphasised that she preferred the Enviro Loo because it was the similar to conventional toilets which are installed indoors, and she prefers that her young children use it to the it toilet.

Enviro Loo site 4

VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	**Form C.1**
Technology Name	**Reviewer Name & Date of Assessment**
Enviro Loo	Karabo and Tina 09 September, 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use*** **Operational Demonstration Model** ☐ ***Fully plumbed and operational for demonstration purposes only*** **Fully Operational Model** ☑ **In use since June 2014.** **Technology in continuous use**	
Assessment location	**Number of users**
Boitumelo Informal Settlement **Midvaal Local Municipality, Gauteng**	68 units, 10 users per unit per day per unit
Conditions during Inspection	
Provide general comments on the conditions of the inspected technology *(Incl. location, orientation, exposure to adverse weather, etc.).* On the day of the visit, it was windy and sunny (the outside temperature was 27^{o}C). The toilets systems were communal and each of them services two households. They are installed on the street, externally but nearby the households they service. The inspected facilities were model C2010, servicing 10 users per day. Three to four units were inspected in total and all of them looked operational. The containers for the faeces were nearly full. They have been installed last year but have not been emptied yet, although they have been serviced regularly by Enviro Loo (every 3-6 months). The cost of a complete unit with superstructure and maintenance for two years' costs R13 000. Samples we collected from two of the toilet units (toilets 28 and 36). The solids in toilet 28 looked drier and mixed with more compost. Toilet 36 was fuller with fresher faeces. The doors of the toilets were locked and the keys are stored with the households. The level of smell inside the toilets was low to moderate but not strong which could be attributed to the extractors provided as parts of the toilet systems (these extractors were not run by electricity, only by wind power). No container with compost was provided inside the toilets to cover the faecal material over after use.	

The toilet pedestals were in clean condition demonstrating good care of the owners. Before the installation of these toilets, there were no other toilet facilities in the informal settlement. The households were using mainly "flying toilets" (plastic bags).

There is an intention of installing a small composting facility nearby to provide the household with opportunity for development of small scale local business using human manure (the area around the informal settlement is primarily rural). If this is not successful, the intention is to bring the material emptied form the toilets to a bigger composting facility, WWTW or a landfill site in the area.

From the inspection of the back side of the toilets (where the human waste is usually stored and collected from), it appeared that the toilets have been used regularly. There was a small amount or no liquid present (urine and/or other) at the bottom of the container.

From the observation of all toilets, it appeared that they have been maintained regularly but there was no enough waste accumulated in the container and a lot of trash was disposed in the toilet.

The temperature check via temperature probe showed that the ambient temperature of the solids inside the containers (22^{o}C) was lower than the measured air temperature (27^{o}C). The measurements were taken at 14:00-14:30h.

The lower temperatures measured inside the faecal material questions the pathogen inactivation and the safety of handling this waste, although adding lime and enzymes may contribute to faster decomposition and pathogen inactivation. This needs to be validated through the laboratory tests of selected samples.

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	**Brief Description**	**Observations**
User Interface	White ceramic pedestals with white seats. The solids and the liquids were not diverted. No flush or a mechanical device for advancing of the faeces was present.	The faeces seemed to be advanced by gravitation. At the time of the visit no faeces or liquids were visualised from the top part of the pedestal. It appeared that the toilet was properly used as indicated by the supplier – an instruction of how to use it was attached on the inside of the toilet door. The pedestal was clean and well maintained.
Collection & Storage	The waste enters a plastic container via a drop hole through the pedestal. The solid waste remains onto a drying plate while the liquid drains to the bottom of the container. The waste is continuously exposed to a flow of air provided by inlet toilet pipes and the toilet bowl. The air is then extracted through an extraction unit at the top of the structure. The air flow is supposed to dehydrate the solid wastes and results in evaporation of the liquid at the bottom. The sunlight is supposed to increase the ambient temperature within the container and contribute to its decomposition. The liquid at the bottom is expected to evaporate and its mechanical emptying is not included in the system operation. The faeces rest between 9 and 12 months and are occasionally pushed from underneath the drop hole to the back side of the	The toiled seemed that has been serviced properly. There was not much of solid waste or liquid in some of the inspected units; trash was also disposed into the toilets. The measured ambient temperature within the faecal matter was too low (less than 19°C) which suggests that there was no active decomposition process and no high enough temperatures to ensure pathogen inactivation. However, as a part of the operation and maintenance process every three months, lime, enzymes and compost are added to the system which may contribute to pathogen inactivation and faster decomposition.

	container to ensure better drying and prevent their build up underneath the toilet pedestal. Every 6 weeks the driest faeces (at the back end of the pedestal) are moved into a mesh basket, provided by the supplier, to ensure better drying after which the material is emptied from the basket and buried or disposed.	The units have been installed in June 2014 but they have not been emptied as yet.
Conveyance *Pipework & Pumps*	All the pipes and extraction units were intact and fully operational. The baskets for extraction of faeces were in place.	
Treatment	The solid waste dehydrates as a result of the air flow moving through the system, as it moves down a sloped drying plate. At the same time, the sunlight increases the ambient temperature within the container. The waste dehydrates and decomposes as a result of the intense heat, prolonged retention periods and oxygen rich air. The final product is inoffensive dry stabilised product reduced to 5% of its original volume. The liquid at the bottom of the container evaporates as a result of the aeration and intensive heating of the system.	Based on the visual inspection during the visit, the some of the faeces looked dry and mixed with a large amount of compost and lime. Other faeces looked fresh and moist. It did not seem that the ambient temperatures inside the container were very high which may result in slower drying and decomposing, and inefficient pathogen inactivation. This is currently being checked through the laboratory analyses.
Effluent Disposal	Faeces from the back side of the container are moved to a basket and left for 2 to 3 weeks to ensure additional drying. The basket is then emptied and the dried matter is further composted in a composting facility or disposed. In this particular case, the dried faeces were further composted in a small facility on the site for further 2 to 4 weeks. The compost in then used for	These facilities have been installed recently (June 2014) and have not been emptied yet.

	communal gardens but this is still in a very initial stage.	
Access points	The main access point for the extraction of dried faeces is from the back side of the toilet. There is a lid at the top part of the container and the waste can be shovelled out.	The access to the dried solid waste seemed to be easy and straightforward. The process of emptying also appeared to be simple, with no mechanical or electronic components involved.
Superstructure / Enclosure	The superstructure was built of concrete walls, roof and walls with a metal door.	
Other: Vent Pipe	The vent pipe is installed adjacent to the waste collection container. It extends approximately 1 meter above the roofing and has a rain cover installed. It is not connected to electricity supply and runs with wind power.	The ventilation is weather/ wind dependant.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

	Toilet 28	Toilet 36
Temperature outside unit	29°C	27°C
Temperature inside faeces in container	19°C	22°C
Description of end product	Dry, mixed with compost, toilet paper and trash materials	Fresher, mixed with compost
Initial sample collected (Y/N)?	N	N
Treated sample collected (Y/N)?	Y	Y

Description of solid samples (appearance, age):

9. **Fourteen months old. Well mixed with compost and lime.**

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Further regular temperature tests to check what temperatures are reached in the faeces during treatment.**
- **Investigation of the final product to establish whether pathogen inactivation has been achieved**

Photos


36


28

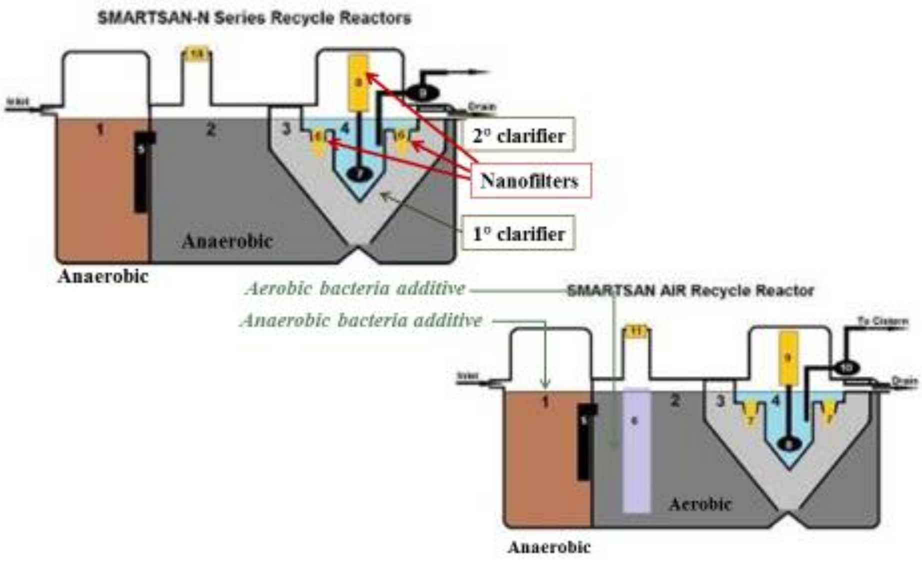
User Experiences

According to one of the household heads, her family was satisfied with the Enviro Loo except at the end of the day, especially after a hot day then there is a strong odour.

Smartsan

Brief Technology Description

The smart san is an anaerobic and aerobic reactor which treats sewerage. It allows for both reuse of flush water, as well as disposal of effluent. It utilises bacteria to reduce the BOD load.



Special Claims

- Removal of all dissolved compounds via nanofiltration
- Safe discharging of effluent into the environment

Field Results

VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	Form C.1
Technology Name	**Reviewer Name & Date of Assessment**
Smartsan	Jonny, Karabo and Tina 03 September, 2015

Type of Inspection

Where more than one type of inspection was undertaken complete multiple sheets.

Non – Operational Demonstration ☐
Technology off the shelf, not in use

Operational Demonstration Model ☐
Fully plumbed and operational for demonstration purposes only

Fully Operational Model ☑ **Operational since: 2008**
Technology in continuous use

Assessment location	Number of users
Siyafunda primary school, White Location, Knysna area.	87

Conditions during Inspection

Provide general comments on the conditions of the inspected technology (Incl. location, orientation, exposure to adverse weather, etc.).

On the day of the visit, it was a cool sunny day and the air temperature was 18°C

The Smartsan aerobic and anaerobic reactors treat water through three chambers. The waste water moves from the first chamber, through a filter, into a second chamber. Water then flows through another filter which is located in a header tank. From the second filter, the water is gravity fed to the third filter and into the toilet cistern. The Anaerobic reactor which is 1600 L is designed to serve a 1-6 people and the 2500 L 1-12 people. The 1600 L Aerobic reactor is designed to serve 1-12 people, and the 2500 L Aerobic reactor is for 1-24 people. The filters are recycled once a year and bacteria is added every 6 months.

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	Brief Description	Observations
User Interface	The toilet is a white plastic pedestal and seat with flush mechanism located on the left of the cistern. The toilet sits on a metal step	The cistern in the first toilet that was installed at the school was much smaller. The toilet was clean and seemed to be used often. A bucket and container for water were place next to

		the toilet, as well as a cleaning brush.
Collection & Storage	The user flushes the cistern to clean the toilet bowl and in this way the waste is transported into a septic tank. The same volume of water that enters the tank is transferred by hydraulic displacement into the clarifier tank and from there into the cistern via a lift pump. Once the cistern is full, excess water overflows via aerobic treatment filter back to the clarifier tank. This process is continuous and automatically run.	It requires a large initial amount of water. After that, however, it saves the use of fresh water. Water was refilled a few days earlier.
Conveyance *Pipework & Pumps*	12V solar driven pump. The pressure pumps have now been changed to submersible pumps.	The pump Is fully functional.
Treatment	The filter is made up of three rock layers which, called Nano filter. The Bothe at the top and bottom of the filter, the first layer is made of 10-20 mm particles. The second layer is made of 6-10 mm rocks. The middle layer houses the 2 mm activated carbon for treatment.	
Effluent Disposal	20 L of sludge are removed on a yearly (dry) basis.	The sludge accumulated at the bottom was not too thick and was not possible to collect a sample of it. It needs
Access points	The extraction points to the chambers were through plastic lids at the top of each chamber.	The access points to each chamber were easily accessible, which may pose a safety hazard for children because it is in a school.
Superstructure / Enclosure	The toilets were installed in blue and purple plastic, stand-alone outdoor cubicles.	The plastic cubicle is safe and private. Children were assisted in and out of the structure.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

	Dry Sanitation		
	1st chamber – inlet	2nd Chamber – filter	3rd Chamber – outlet
Temperature outside unit	18°C	18°C	18°C
Temperature inside faeces in container	15.5°C	15.5 °C	15.5 °C
Description of end product	Liquid with light brown colour	Translucent liquid	Translucent liquid
Initial sample collected (Y/N)?	Y	Y	Y
Treated sample collected (Y/N)?	Y	Y	Y

Description of solid samples (appearance, age):

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Investigation of the effluent to establish whether pathogen inactivation has been achieved**

Photos

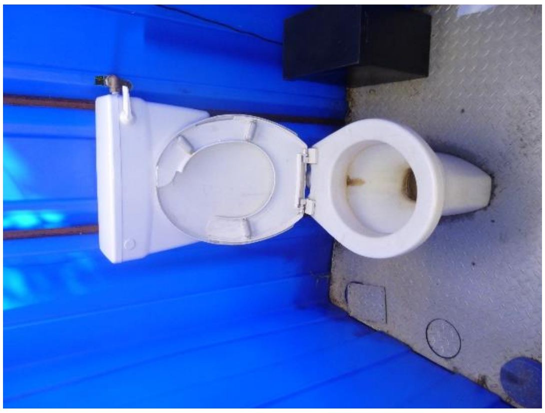
Header tank and pipe

Toilet with cistern

Location of the reactors at Siyafunda School.

Leaners at Siyafunda.

Inlet into a first chamber




Filter


Collected samples

User Experiences

Toilet had been working regularly since 2008. If maintenance is required, the company is contacted.

Smartsan site 2

VISUAL INSPECTION OF TECHNOLOGY *To be completed by the technology reviewer*	**Form C.1**
Technology Name	**Reviewer Name & Date of Assessment**
Smartsan	Jonny, Karabo and Tina 03 September, 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use*** **Operational Demonstration Model** ☐ ***Fully plumbed and operational for demonstration purposes only*** **Fully Operational Model** ☑ **Operational since: 2013** **Technology in continuous use**	
Assessment location	**Number of users**
Oakhill school sports campus, Knysna area	Average of 300 school children per day
Conditions during Inspection	
Provide general comments on the conditions of the inspected technology (Incl. location, orientation, exposure to adverse weather, etc.). On the day of the visit, it was a warm sunny day with a temperature of 20.5 °C. The technology which was assessed was package plant with a series of four chambers with filters. The technology services 300 users who use ablution block and toilets every day. The system comprises of 16KL capacity in total.	
Quality of Fabrication	

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	**Brief Description**	**Observations**
User Interface		
Collection & Storage	Waste water is transported into a septic tank and treated through an aerobic and anaerobic system.	The site was isolated and in the open. The water colour from inlet to outlet, as well as the temperature between the two were very similar. The main concern would be whether the system can adequately handle the daily treatment demand.
Conveyance *Pipework & Pumps*	12V electromagnetic solar pump ensures water flows through the series of chambers and is released with minimum impact.	The pump runs most of the day.
Treatment	Chlorine tablets are placed in the final tank once per month. A bubbling aeration system allows bacteria to grow and treat the water	The brown film on the individual filter holes may indicate that bacteria is growing well and water treatment occurs through a taking up of any access or toxic nutrients.
Effluent Disposal	The water is disposed of into a lagoon, through a soak away (French drain).	The waste water has a faint brown colour; however, it does not visibly indicate any sludge is in the water.
Access points	The extraction points to the chambers were through plastic lids.	The chambers were easily accessible. There are several access points which may require a person with experience to open and maintain. The pump was working well.

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Dry Sanitation

	1st chamber – inlet	Cistern – outlet
Temperature outside unit	20.5°C	20.5°C
Temperature inside faeces in container	16°C	15.5 °C
Description of end product	Liquid with dark brown colour	Liquid with light to clear brown colour
Initial sample collected (Y/N)?	Y	Y
Treated sample collected (Y/N)?	Y	Y

Description of solid samples (appearance, age):

Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Investigation of the effluent to establish whether pathogen inactivation has been achieved**

Photos

Inlet into first chamber with 12V pump

Solar panel

Filters

Filter

Sampling

Discharging of effluent

ZerH$_2$O

Brief Technology Description

ZerH$_2$O is a dry sanitation system with Urine diversion. The faeces is contained on a rotating disk in a sealed unit, dried and diverted to a sump basket. The dry faeces is removed every 2-3 weeks and placed in a composite pit. The urine is sent to a soak away pit.

Special Claims

- Fully dehydrated after 2 weeks.

Field Results

VISUAL INSPECTION OF TECHNOLOGY ***To be completed by the technology reviewer***	**Form C.1**
Technology Name	**Reviewer Name & Date of Assessment**
ZerH$_2$O	Jeanette and Tina, 20 Aug 2015
Type of Inspection	
Where more than one type of inspection was undertaken complete multiple sheets. **Non – Operational Demonstration** ☐ ***Technology off the shelf, not in use*** **Operational Demonstration Model** ☐ ***Fully plumbed and operational for demonstration purposes only*** **Fully Operational Model** ☑ **Number of months in use: Since 2011.** **Technology in continuous use**	
Assessment location	**Number of users**
Siyakhana Gardens, Johannesburg	1 women's and 1 men's (each w/ 7-8 users)
Conditions during Inspection	
Provide general comments on the conditions of the inspected technology (Incl. location, orientation, exposure to adverse weather, etc.). On the day of the visit, it was windy and warm (between 20 and 23˚C), and it was mostly sunny. The toilets are situated near the front entrance to the gardens, with the discs facing north. When we entered the women's toilet, there was no smell but a couple of flies (because the seat was not closed). It also did not seem that this toilet was much in use, because the basket and the turn-table were almost empty. There was also a small amount of faeces on the urine section of the pedestal, which demonstrates the potential for misuse of the UD toilet.	

The smell of the men's toilet was much stronger at entry. Looking down the pedestal, faeces were visible on the turntable below. A number of users had not properly advanced their faeces after use, which caused the smell inside the superstructure. The supplier then advanced the faeces a number of times, which allowed them to drop into the basket.

Quality of Fabrication

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Component	Brief Description	Observations
User Interface	There is a black plastic, urine-diversion pedestal with a white seat. On the floor, on the right side of the seat is the handle for advancing the faeces.	In the women's toilet, there was a small amount of faeces on the UD portion of the pedestal. In the men's toilet, single stools were visible on the turntable below, because they had not been properly advanced.
Collection & Storage	The faeces drop down onto a turn table, which is advanced with the handle near the user interface. The faeces are advanced to the sun-lit area of the turntable, and eventually dropped into a basket. At the end of the rotation, there is a thick rubber wall, which directs the faeces into the slatted basket. The slatted basket sits in a sealed container. The faeces are removed after 2-3 weeks in collection and storage. Urine is directed through a pipe to a soak-away pit behind the toilet.	When asked about liquid build-up in the sealed container, the supplier said that holes could be drilled at the bottom of the container to allow for drainage. This will work so long as there is not a high-water table, in which case proper usage is very important (though the liquids could also simply be siphoned out with a hose pipe if liquid does build up). The advance mechanism was simple to operate, although if the handle is to break, it would cause problems for the operation of this technology.
Conveyance *Pipework & Pumps*	The pipe for urine diversion was in-tact, directing the urine underground to be released into the soak pit.	
Treatment	While on the turn-table, the unit receives sunlight, which heats the unit. There is also a ventilation pipe installed adjacent to the	Based on the faeces in the basket during the visit, treatment appears effective. The faeces were

	access point. Over the course of 2-3 weeks, the water evaporates, rendering the faeces much drier and simpler to remove and transport.	very dry and hard in texture. There were also bits of toilet paper present in the faecal matter.
Effluent Disposal	When faeces are removed, the basket is lifted out of the sump by a handle at the top. By raising the basket, the faeces can be transported to a compost pile for further composting or other treatment for reuse. At this site in particular, dried faeces had been moved to a compost pile (in a bathtub), in a mix with other organic material, such as leaves and wood chips. At this site, vermicomposting was applied, with a large number of earth worms present in the compost pile. Water was added to ensure optimum moisture for the vermicomposting process.	The basket was simple to remove, although on the visit day, it was only approximately 1-2% full of dried faeces. The basket is typically removed when it is 50% full, in which case it would be heavier to remove. In addition, there were steps up to the access point, because this installation was above ground. In the men's toilet, the rubber wall on the turn-table had been dislocated, such that it blocked removal of the basket. The inspectors had to move the rubber wall in order to remove the basket, which made it slightly non-ideal to remove. However, the overall removal process appeared to be very simple and easy. In addition, the compost pile on the site appeared to be very active with worms, further breaking down the faecal matter. The community garden at this site may have many opportunities in the future with the use of composted faeces.
Access points	The main access point of the faeces is via the lid of the sump basket in the centre of the unit. Through this point, users can access the basket and turntable.	In the men's toilet, the rubber wall on the turn-table had been dislocated, such that it blocked removal of the basket. The inspectors had to move the

		rubber wall in order to remove the basket, which made it slightly non-ideal to remove
Superstructure / Enclosure	The superstructure was built with timber and fibre green walls. There were stairs leading up to the toilets and also a shower included in the superstructure. The doors were wooden, with rope locks, which did not function perfectly.	
Other: Vent Pipe	The vent pipe is installed adjacent to the lid of the sump basket. It extends approximately 1 meter above the roofing and has a rain cover installed.	

On-site Measurements

List observations, including material thickness, colour, etc. Where a component is not included as part of the technology mark as 'N/A'. Attach photographs of complete system and different components.

Dry Sanitation		
	Men's toilet	Women's toilet
Temperature outside unit	23.5°C	23.5°C
Temperature inside sump basket	24.5°C	25.5°C
Temperature on disc, close to inlet	27°C	26°C
Temperature on disc, close to exit to sump basket	27.5°C	31°C
Description of end product	Very dry and hard	
Initial sample collected (Y/N)?	N	
Treated sample collected (Y/N)?	Y	

Description of solid samples (appearance, age):

10. **2 weeks old – very dry and hard**

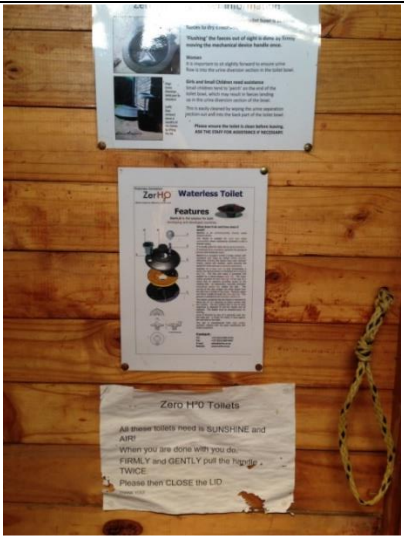
Further Investigations Required

Provide a summary of specific components requiring further testing to confirm their durability. This should also be addressed as part of the Structural and Mechanical Assessment covered on Form B.11.

- **Robustness testing of the advance mechanism would be useful, although the supplier expressed that they do not think it would aid their product, because the construction and design of it ensures it will not break.**
- **Further temperature tests with toilets regularly in use would be useful, to check what temperatures are reached on the turn table and in the faeces themselves during treatment.**

Photos

Location of Zerho toilets near the entrance to the Siyakhana Garden



Instructional messaging inside the door of the toilet stall

User interface in the women's toilet

Pedestal and seat with the advance mechanism handle – a video of advancing is also available

Urinal in the men's toilet

Image of the sump basket with some dried faecal matter

Image of the turntable and sump basket, with the directional wall for directing faeces into the basket

Sump basket removed from the unit

Sealed container for sump basket

Piping for diverted urine, leading to soak-away pit behind toilet

Superstructure and doors to toilet stalls

Back of toilet superstructure and collection, storage, and treatment unit

Vent pipe with rain cover

Sump basket removed for sampling purposes

Sampling of dry faecal material

Sample for analysis

Disposal of dry faeces in a compost bin (bathtub)

Dry faeces mixed with other organics and undergoing vermicomposting

Measuring temperature inside the unit

Taking temperature measurements with thermocouple and datalogger

RESULTS

Table 3: The list of sanitation technologies and the measured temperature results.

Company	Area (Site)	Installation/Use	Technology	Outside Average Temperature	Inside Faeces Average Temperature	Inlet (Faeces or wastewater) Average Temperature	Outlet (Faeces or wastewater) Average Temperature
African Sanitation	Lethabong, Krugersdorp area, GP. (site 1a)	Informal settlement	Dry sanitation	23	17		
African Sanitation	Lethabong, Krugersdorp area, GP. (site 1b)	Informal settlement	Composter	17		28.5	42.5
Bubbler Pty Ltd	Khayelitsha, Cape Town, WC. (site 1)	Informal Settlement, 3 houses.	Water Efficiency System (septic tank)	19		17	19
Bubbler Pty Ltd	Durbanville, Cape Town, WC. (site 2a)	Horse-ranch. For guests and workers	Water Efficiency System (septic tank)	21		15.5	15.5
Bubbler PTY Ltd	Durbanville, Cape Town, WC. (site 2b)	Horse-ranch. For gests and workers	Water Efficiency System (septic tank)	22		16.5	16
Calcamite	Factory, GP. (site 1a)		Biomite BM10	24.5		19	19
Calcamite	Factory, GP. (site 1b)		Wetloo	24.5		20	22
Calcamite	Diepsloot, GP. (site 2)	Informal settlement	Wetloo (BRS)	22	17		

Ecosan	Teniqua tree tops, Knysna. (site 1a)	Guest house	Dry sanitation with UD	18.5		12.5	13
Ecosan	Teniqua tree tops, Knysna. (site 1b)	Guest house	Compost	23.5	15.5	17	18
Enviro Options	Kogelberg-firelily. (site 1a)	2 guests at a time		22	16		
Enviro Options	Kogelberg-Erica. (site 1a)	2 guests at a time		21	17.5		
Enviro Options	Kogelberg-Everlasting. (site 1c)	6 guests at a time		16	16		
Enviro Options	Factory, Chamdor Johannesburg. (site 2a)	Services 100 employees	Composter	23	20		
Enviro Options	Factory, Chamdor Johannesburg. (site 2b)	Services 100 employees	Dry sanitation with evaporation (container-outlet)	22.5		16.75	23.25
Enviro Options	Factory, Chamdor Johannesburg. (site 2c)	Services 100 employees	Dry sanitation with evaporation (Bag-outlet)	23		20.5	16.8
Enviro Options	Bekkersdal, Westonaria, GP. (site 3)	Informal Settlement	Dry Sanitation	25	22.3		
Enviro Options	Boitumelo, Midvaal, GP. (site 4a)	Informal Settlement	Dry Sanitation	27	22		
Enviro Options	Boitumelo, Midvaal, GP. (site 4b)	Informal Settlement	Dry Sanitation	29	19		
Smart San	Siyafunda school, Knysna. (site 1)	Primary school	Package plant	18		15	15.5
Smart San	Oakhill school, Knysna. (site 2)	School sportsground	Package Plant	20.5		16	15.5
ZerH$_2$O	Siyakhana, Johannesburg	School	Dry sanitation	23.5			

ANNEXURE D – Laboratory Analysis

WO20150901 SanTechAssessmentsSolidSamples											
Sample Name	*Total solids*	*Moisture Content*	*Volatile solids*	*Volatile solids*	*Fixed solids(Ash)*	*Fixed solids(Ash)*	*COD*	*COD*	*pH*	*EC*	*E. coli count*
	(g/ g sample)	*(%)*	*(g/g wet sample)*	*g/g dry sample*	*(g/g wet sample)*	*(g/g dry sample)*	*(mg/L)*	*(g/g dry sample)*		(mS/m)	*(CFU/ 100 ml)*
ZerH$_2$O – A	0,80	20,41	0,67	0,84	0,13	0,16	0,35	0,44	8,38	56,00	965
ZerH$_2$O – B	0,76	24,04	0,61	0,80	0,15	0,20	0,32	0,43	8,11	56,85	4,600
ZerH$_2$O – C	0,81	19,45	0,65	0,81	0,16	0,19	0,35	0,44	8,21	41,65	3,300

LiquidSamples SanTechAssessments, [-]3/9/2015, [=]2/9/2015, [*]8/9/2015															
Sample Name	*Total solids*	*Moisture Content*	*Volatile solids*	*Volatile solids*	*COD*	Ammonia	TKN	TN	*Nitrates*	*Nitrites*	*Total Phosphates*	*Orthophosphates*	*pH*	*EC*	*E. coli count*
	(g/g sample)	*(%)*	*(g/g wet sample)*	*(g/g dry sample)*	*(mg/L)*	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mS/m)	*(CFU/ 100 ml)*
[-]1-Oakhill smartsan outlet	0,00	99,97	0,00	0,46	107,10	10,01	12,60	3,80	< 1.00	< 0.002	2.42	2.09	7,55	44	0
[-]2-Oakhill smartsan inlet (Sport facility)	0,00	99,95	0,00	0,41	191,53	27,99	28,84	8,50	< 1.00	0.03	4.42	3.54	7,06	68	TNTC
[-]3-Smartsan Siyafunda School (Primary Chamber)	0,00	99,92	0,00	0,32	269,71	193,81	177,15	14,60	< 1.00	< 0.002	20.20	4.82	8,52	233	22,500
[-]4-Smartsan (from toilet)	0,00	99,96	0,00	0,35	127,43	17,21	17,17	3,30	< 1.00	< 0.002	4.06	3.23	6,79	55	0

LiquidSamples SanTechAssessments, -3/9/2015, =2/9/2015, *8/9/2015															
Sample Name	*Total solids*	*Moisture Content*	*Volatile solids*	*Volatile solids*	*COD*	Ammonia	TKN	TN	*Nitrates*	*Nitrites*	*Total Phosphates*	*Orthophosphates*	*pH*	*EC*	*E. coli count*
	(g/ g sample)	*(%)*	*(g/g wet sample)*	*(g/g dry sample)*	*(mg/L)*	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mS/m)	*(CFU/ 100 ml)*
-5-Smartsan Secondary chamber	0,00	99,97	0,00	0,26	85,21	29,53	27,25	4,00	< 1.00	0.77	4.27	4.08	7,36	64	15,000
=6-Bubbler Khayelitsha (from toilet)	0,00	99,91	0,00	0,17	372,90	212,17	211,40	13,20	< 1.00	0.08	33.20	96.20	7,99	253	98,000
=7-Bubbler (Primary Chamber)	0,00	99,91	0,00	0,35	300,98	218,76	203,56	6,70	< 1.00	0.06	31.50	66.20	7,89	256	43,000
=8-Second visit (Toilet at the back, not in use)	0,00	99,87	0,00	0,28	75,83	20,84	22,40	4,50	6.2	1.02	4.99	4.50	7,62	171	78,500
=9-First chamber	0,00	99,85	0,00	0,24	83,65	0,31	1,68	2,20	7.8	0.92	4.11	46	7,40	224	270,000
=10-Toilet at the front, not working	0,00	99,87	0,00	0,53	280,65	90,57	79,15	11,60	< 1.00	< 0.002	20.8	4.53	8,02	256,5	150,000
=11- 1st chamber	0,00	99,82	0,00	0,57	3580,48	109,49	109,11	4,20	< 1.00	0.3	40.8	43.60	7,27	272	107,000
12	0,02	97,84	0,01	0,32	8990,29	634,35	312,67	6,20	0.8	0.60	75	69	8,70	2610	0
*1-Calcamite factory Wetloo Toilet outlet	0,00	99,94	0,00	0,40	64,89	750,67	900,67	12.60	No kits	1.07	102.50	465.00	7,55	44	1,000
*2-Calcamite Factory Wetloo inlet	0,00	99,93	0,00	0,44	294,73	534,33	809,67	5.40	Not kits	2.02	105.00	515.00	7,06	61	13,000

LiquidSamples SanTechAssessments, -3/9/2015, =2/9/2015, *8/9/2015														
Sample Name	*Total solids*	*Moisture Content*	*Volatile solids*	*Volatile solids*	*COD*	*Ammonia*	*TKN*	*TN*	*Nitrates*	*Nitrites*	*Total Phosphates*	*Orthophosphates*	*pH*	*EC*	*E. coli count*
	(g/ g sample)	*(%)*	*(g/g wet sample)*	*(g/g dry sample)*	*(mg/L)*	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mS/m)	*(CFU/ 100 ml)*
*3-Calcamite Factory BM10 Biomite after processing	0,00	99,95	0,00	0,48	97,72	384,67	457,33	6.53	Not kits	2.00	54.17	486.67	8,52	233	37,000
*4-Calcamite Factory BM10 Biomite outlet	0,00	99,64	0,00	0,81	498,77	571,00	1871,33	1.70	Not kits	0.30	335.00	295.00	6,79	55	260,000
*5-CalcamiteWetloo Diepsloot toilet outlet	0,00	99,98	0,00	0,46	33,62	36,67	200,67	0,63	Not kits	3.03	25.00	305.00	7,36	64	3,000
*6-Calcamite Wetloo Diepsloot inlet (first tank)	0,00	99,94	0,00	0,50	335,38	370,00	478,33	7.50	Not kits	0.20	92.50	375.00	7,99	253	278,000

Solid samples Enviro Loo SanTechAssessment, +9/9/2015, =2/9/2015											
Sample Name	*Total solids*	*Moisture Content*	*Volatile solids*	*Volatile solids*	*Fixed solids(Ash)*	*Fixed solids(Ash)*	*COD*	*COD*	*pH*	*EC*	*E. coli count*
	(g/ g sample)	*(%)*	*(g/g wet sample)*	*(g/g dry sample)*	*(g/g wet sample)*	*(g/g dry sample)*	*(mg/L))*	*(g/g dry sample)*		(mS/m)	*(cfu/ 100 ml)*
+7- Enviro Loo Factory 9/9/2015 inlet (fresh faeces)	0,256	74,377	0,216	0,843	0,040	0,157	0,340	1,327	8,11	437,50	TNTC
+8- Enviro Loo Factory f 9/9/2015 from drying bag	0,871	12,939	0,589	0,677	0,281	0,323	0,504	0,579	9,03	43,75	54,000
+9- Enviro Loo Factory 9/9/2015 from drying basket (new design 2020)	0,371	32,658	0,267	0,719	0,104	0,281	0,241	0,648	9,41	54,50	0
+10- Enviro Loo Factory 9/9/2015 from compost machine (2 weeks old)	0,636	36,417	0,402	0,633	0,233	0,367	0,319	0,501	9,61	54,50	0
+11- Enviro Loo Westonaria/ Bekkersdal 9/9/15 waste/month compost	0,794	20,569	0,561	0,707	0,233	0,293	0,228	0,287	7,87	33,45	2,000
+12- Enviro Loo Boitumelo 9/9/2015 fresh faeces + compost cover, unit 3	0,234	76,573	0,180	0,769	0,054	0,231	0,201	0,859	8,34	57,15	200,000
+13- Enviro Loo Boitumelo 9/9/2015 fresh faeces + compost cover unit 28	0,267	73,292	0,199	0,744	0,068	0,256	0,252	0,944	8,54	26,40	2,500
=2-Enviro Loo upper North Erica	0,58	41,92	0,29	0,50	0,29	0,50	0,20	0,34	6,77	1380	3,500
=3-Enviro Loo upper South	0,84	16,19	0,48	0,58	0,36	0,42	0,19	0,22	7,03	1137	4,500
=7-Enviro Loo upper	0,32	68,21	0,21	0,66	0,11	0,34	0,19	0,60	7,46	694	500
4-Enviro Loo lower South facing shade	0,45	54,81	0,25	0,55	0,20	0,45	0,17	0,37	7,26	1	9,500

Solid samples EchoAndAfriSanTechAssessment, *8/9/2015, -3/9/2015											
Sample Name	*Total solids*	*Moisture Content*	*Volatile solids*	*Volatile solids*	*Fixed solids(Ash)*	*Fixed solids(Ash)*	*COD*	*COD*	*pH*	*EC*	*E. coli count*
	(g/ g sample)	*(%)*	*(g/g wet sample)*	*(g/g dry sample)*	*(g/g wet sample)*	*(g/g dry sample)*	*(mg/L)*	*(g/g dry sample)*		(mS/m)	*(cfu/ 100 ml)*
*14- Afrisan site 8/9/2015 from toilet (fresh)	1,907	49.32	0,207	0,108	1,700	0,892	1,907	0.09	8,47	10,70	4,400
*15- Afrisan site 8/9/2015 wet compost (4 weeks old)	0,507	2.89	0,108	0,213	0,399	0,787	0,507	0.04	9,13	9,26	600
*16- Afrisan site 8/9/2015 dry compost (4 weeks old)	0,971	18.58	0,068	0,070	0,903	0,930	0,971	0.04	9,06	8,01	0
-1-Ecosan compost	0,29	71,31	0,19	0,66	0,10	0,34	0,19	0,65	6,74	567,00	1,000
-5-Ecosan The eyrie shade screw conveyer	0,17	83,30	0,13	0,77	0,04	0,23	0,18	1,09	7,76	365,00	23,000
-6-Ecosan the eyrie shade from the bag	0,21	78,91	0,17	0,81	0,04	0,19	0,19	0,89	7,72	200,00	2,000

Note: Markings refer to sampling date not date of sample analysis.

WO201501020_last batch															
Sample Name	Total solids	Moisture Content	Volatile solids	Volatile solids	COD	Ammonia	TKN	TN	Nitrates	Nitrites	T-Phosphates	O-phosphates	pH	EC	*E. coli* count
	(g/ g sample)	(%)	(g/g wet sample)	(g/g dry sample)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mS/m)	(cfu/ml)
2-1	0,00	99,93	0,00	0,22	106,13	21,25	23,19	500	1,13	2,83	41,33	9,90	8,06	1299,50	-
2-2	0,00	99,92	0,00	0,85	181,72	35,69	45,45	900	1,47	3,33	75,33	19,47	7,51	1516,5	-
2-3	0,00	99,92	0,00	0,24	299,81	23,35	43,35	530	2,53	1,50	32,67	9,90	7,86	1273,50	-
2-1A	0,00	99,87	0,00	0,33	352,24	37,13	46,53	650	1,50	1,83	63,67	12,57	7,64	1529,00	-
2-1B	0,00	99,89	0,00	0,33	331,37	35,68	42,05	790	2,43	5,17	43,00	8,23	7,50	1532.00	-
1-M1	0,00	99,85	0,00	0,47	315,34	201,15	218,54	4400	7,33	11, 00	58,00	26,57	8,35	2,60*	-
1-M2	0,00	99,84	0,00	0,54	176,63	123,05	122,78	4000	35,33	15, 67	55,00	26,37	7,96	2,37*	-
1-M3	0,00	99,83	0,00	0,54	188,85	135,86	137,71	4000	41,33	10,33	55,00	25,83	8,08	2,36*	-
1-W1	0,00	99,85	0,00	0,65	135,15	0,62	48,58	590	19,83	2, 67	43,67	14,93	5,98	1103,50	-
1-W2	0,00	99,87	0,00	0,50	329,53	1,33	45,31	720	12,80	11,00	71,33	46,53	6,54	1218	-

	Sample Name	*Total solids*	*Moisture Content*	*Suspended solids*	*Volatile solids*	*Volatile solids*	*COD*	*COD*	Ammonia		TKN		Nitrates	Nitrites	TN	Total Phosphates	Ortho Phosphates	*pH*	*EC*	*EC*	*EC*	*E.coli count*	*E.coli count*
		g/g dry sample	*%*	*mg/L*	*g/g wet sample*	*g/g dry sample*	*g/g wet sample*	*g/g dry sample*	NH3 (g/g wet sample)	NH3 (mg/L)	TKN (g/g wet sample)	TKN (mg/L)	(mg/l)	(mg/l)	(mg/L)	(mg/l)	(mg/l)		*ms/cm*	*uS/cm*	*mS/m*	*cfu/ml*	*cfu/100ml*
2-**SmartSan** (Oakhill) **inlet**	2-**SmartSan** (Oakhill sport facility) **inlet**	0.05%	99.95	67.00	0.0002	0.41	191.53	191.53	27.99	27.99	28.84	28.84	0.000	0.03	8.5	4.42	3.54	7.06	0.68	680	68	TNTC	TNTC
1-**SmartSan** (Oakhil) **outlet**	1-**SmartSan** (Oakhill sport facility) **outlet**	0.03%	99.97	20.00	0.0002	0.46	107.1	107.1	10.01	10.01	12.6	12.6	0.000	<0,002	3.8	2.42	2.09	7.55	0.44	440	44	0	0
3-**SmartSan** (Siyafunda primary school) **inlet**	3-**SmartSan** (Siyafunda primary school) **inlet** (primary chamber)	0.08%	99.92	25.00	0.0003	0.32	269.71	269.71	193.81	193.81	177.15	177.15	0.000	<0,002	14.6	20.2	4.82	8.52	2.33	2330	233	225	22500
4-**SmartSan** (Siyafunda primary school) **outlet**	4-**SmartSan** (Siyafunda primary school **outlet** (from toilet cistern)	0.04%	99.96	11.00	0.0001	0.35	127.43	127.43	17.21	17.21	17.17	17.17	0.000	<0,002	3.3	4.06	3.23	6.79	0.55	550	55	0	0
5- **SmartSan** (Siyafunda primary School) **secondary chamber**	5- **SmartSan** (Siyafunda primary School) **secondary chamber**	0.03%	99.97	31.00	0.0001	0.26	85.21	85.21	29.53	29.53	27.25	27.25	0.000	0.77	4	4.27	4.08	7.36	0.64	640	64	150	15000
7-**Bubbler** Khailitsha **inlet**	7-**Bubbler** Khailitsha **inlet** (Primary chamber)	0.09%	99.91	100.00	0.0003	0.35	300.98	300.98	218.76	218.76	203.56	203.56	0.000	0.06	6.7	31.5	66.27	7.89	2.56	2560	256	430	43000
6-**Bubbler** Khailitsha **outlet**	6-**Bubbler** Khailitsha **outlet** (from toilet cistern)	0.09%	99.91	89.00	0.0001	0.17	372.9	372.9	212.17	212.17	211.4	211.4	0.000	0.08	13.2	33.2	96.8	7.99	2.53	2530	253	980	98000
9-**Bubbler** (horse range) **inlet**	9-**Bubbler** (horse range) **inlet** - first chamber (toilet at the back, not used daily)	0.15%	99.85	13.00	0.0004	0.24	83.65	83.65	0.31	0.31	1.68	1.68	2.200	0.91	2.2	4.11	45.33	7.4	2.24	2240	224	2700	270000
8-**Bubbler** (horse range) **outlet**	8-**Bubbler** (horse range) **outlet** -cicstern (toilet at the back, not used daily)	0.13%	99.87	17.00	0.0004	0.28	75.83	75.83	20.84	20.84	22.4	22.4	4.500	1.02	4.5	4.96	4.5	7.62	1.71	1710	171	785	78500
11- **Bubbler** (horse range) **inlet**	11- **Bubbler** (horse range) **inlet** - first chamber (toilet at the front, currently out of order)	0.18%	99.82	448.00	0.0010	0.57	3580.48	3580.48	109.49	109.49	109.11	109.11	0.030		4.2	40.8	43.6	7.27	2.72	2720	272	1070	107000
10-**Bubbler** (horse range) **outlet**	10-**Bubbler** (horse range) **outlet** -cicstern (toilet at the front, currently out of order)	0.13%	99.87	35.00	0.0007	0.53	280.65	280.65	90.57	90.57	79.15	79.15	<0,002		11.6	20.8	4.53	8.025	2.57	2565	256.5	1500	150000
12-**Enviroloo** urine/liquid + faeces overflowing bottom chamber	12-**Enviroloo** upper, urine/liquid overflowing from the bottom chamber (contaminated with faecal material)	2.16%	97.84	139.00	0.0070	0.32	8990.29	8990.29	634.35	634.35	312.67	312.67	0.600		6.2	75	69	8.705	26.1	26100	2610	0	0
2-Calcemite Factory Wetloo inlet	**2-Calcemite Factory Wetloo inlet** (flush water)	0.07%	99.93	43.33	0.0003	0.44	294.73	294.73	534.33	534.33	809.67	809.67		2.016667	0.08	105	515	7.06	0.61	610	61	130	13000
1-Calcemite factory Wetloo outlet	**1-Calcemite factory Wetloo outlet** (from cistern)	0.06%	99.94	10.00	0.0002	0.4	64.89	64.89	750.67	750.67	900.67	900.67		1.066667	0.04	102.5	465	7.55	0.44	440	44	10	1000
4-Calcemite Factory BM10 Biomite inlet	**4-Calcemite Factory BM10 Biomite inlet**	0.36%	99.64	2868.33	0.0030	0.81	498.77	498.77	571	571	1871.33	1871.33		0.3		335	295	6.79	0.55	550	55	2600	260000
3-Calcemite Factory BM10 Biomite outlet	**3-Calcemite Factory BM10 Biomite – outlet after processing**	0.05%	99.95	60.00	0.0003	0.48	97.72	97.72	384.67	384.67	457.33	457.33		2	0.08	54.17	486.67	8.52	2.33	2330	233	370	37000
6-Calcemite Wetloo Diepsloot inlet	**6-Calcemite Wetloo Diepsloot inlet** (first tank)	0.06%	99.94	155.00	0.0003	0.5	335.38	335.38	370	370	478.33	478.33		0.2	0.01	92.5	375	7.99	2.53	2530	253	2780	278000
5-CalcemiteWetloo Diepsloot outlet	**5-CalcemiteWetloo Diepsloot – outlet** (from toilet cistern)	0.02%	99.98	8.33	0.0001	0.46	33.62	33.62	36.67	36.67	200.67	200.67		3.033333	0.12	25	305	7.36	0.64	640	64	30	3000

	Sample Name	Total solids g/ g sample	Moisture Content %	Volatile solids g/g wet sample	Volatile solids g/g dry sample	Fixed solids(Ash) g/g wet sample	Fixed solids(Ash) g/g dry sample	COD g/g wet sample	COD g/g dry sample	pH	EC mS/cm	EC uS/cm	EC mS/m	E.coli count cfu/ml	E.coli count cfu/100ml
	WO20150907_2a SanTechAssessmentsSolidSamples														
7-**Enviroloo upper North (fresh)**	7-**Enviroloo upper North** (Erica) - **fresh**	32%	68.21	0.21	0.66	0.11	0.34	0.19	0.60	7.46	6.94	6940.00	694.00	5	500
2-**Enviroloo upper North** (old, back)	2-**Enviroloo upper North** - Erica – old from the back	58%	41.92	0.29	0.50	0.29	0.50	0.20	0.34	6.77	13.80	13800.00	1380.00	35	3500
3-**Enviroloo upper South** (old, back, flooded)	3-**Enviroloo upper South** – Firelilly – old from the back (flooded)	84%	16.19	0.48	0.58	0.36	0.42	0.19	0.22	7.03	11.37	11370.00	1137.00	45	4500
4-**Enviroloo lower South (old, shade)**	4-**Enviroloo lower South (shade)** - Everlasting	45%	54.81	0.25	0.55	0.20	0.45	0.17	0.37	7.26	0.01	10.00	1.00	95	9500
7- 2 **Enviroloo Factory inlet** (fresh faeces)	7- 2 **Enviroloo Factory inlet** (fresh faeces)	26%	74.38	0.22	0.84	0.04	0.16	0.34	1.33	8.11	4.38	4375.00	437.50	TNTC	TNTC
8-2 **Enviroloo Factory (drying basket)**	8-2 **Enviroloo Factory from drying basket**	87%	12.94	0.59	0.68	0.28	0.32	0.50	0.58	9.03	0.44	437.50	43.75	540	54000
9-2 **Enviroloo Factory (from drying basket,** new design 2020)	9-2 **Enviroloo Factory from drying basket** (new design 2020)	37%	62.90	0.27	0.72	0.10	0.28	0.24	0.65	9.41	0.55	545.00	54.50	0	0
10-2 **Enviroloo Factory (dry compost,** 2 weeks)	10-2 **Enviroloo Factory dry from compost machine** (been there for 2 weeks)	64%	36.42	0.40	0.63	0.23	0.37	0.32	0.50	9.61	0.33	334.50	33.45	0	0
11-2 **Enviroloo Westonia/ Bekkestal waste + compost/ lime**	11-2 **Enviroloo Westonia/ Bekkestal waste** (1 month old) **+ compost and lime cover**	79%	20.57	0.56	0.71	0.23	0.29	0.23	0.29	7.87	0.57	571.50	57.15	20	2000
12-2 **Enviroloo Boatumelo fresh faeces + compost/ lime**	12-2 **Enviroloo Boatumelo fresh faeces + compost and lime cover**, unit 3	23%	76.57	0.18	0.77	0.05	0.23	0.20	0.86	8.34	0.26	264.00	26.40	2000	200000
13-2 **Enviroloo Boatumelo fresh + compost/ lime**	13-2 **Enviroloo Boatumelo fresh faeces + compost and lime cover** unit 28	27%	73.29	0.20	0.74	0.07	0.26	0.25	0.94	8.54	0.23	231.50	23.15	25	2500
5-**Ecosan (shade, screw conveyer)**	5-**Ecosan (shade)** from **screw conveyer** (the Eyrie)	17%	83.30	0.13	0.77	0.04	0.23	0.18	1.09	7.76	3.65	3650.00	365.00	230	23000
6-**Ecosan (shade from bag)**	6-**Ecosan shade from the bag** (the Eyrie)	21%	78.91	0.17	0.81	0.04	0.19	0.19	0.89	7.72	2.00	2000.00	200.00	20	2000
1-**Ecosan compost**	1-**Ecosan compost**	29%	71.31	0.19	0.66	0.10	0.34	0.19	0.65	6.74	5.67	5670.00	567.00	10	1000
14-2 **Afrisan site from toilet (fresh+compost)**	14-2 **Afrisan site from toilet (fresh+compost)**	51%	49.32	0.11	0.21	0.40	0.79	0.04	0.08	8.47	0.11	106.95	10.70	44	4400
15-2 **Afrisan site wet compost** (4 weeks)	15-2 **Afrisan site wet compost** (4 weeks old)	97%	2.90	0.07	0.07	0.90	0.93	0.04	0.04	9.13	0.09	92.60	9.26	6	600
16-2 **Afrisan site dry compost** (4+ weeks)	16-2 **Afrisan site dry compost** (4+ weeks old)	81%	18.58	0.07	0.09	0.74	0.93	0.03	0.04	9.06	0.08	80.10	8.01	0	0

ANNEXURE E – Dossier Symbology Legend

User Interface		The part of the sanitation technology that the user interacts with as part of normal use. This includes the toilet pedestal and any flush mechanism or levers that need to be operated after use.
Chemical Toilet		Requires chemicals to be added to the toilet to control odours and to assist with the breakdown of faecal waste.
Dry Toilet		Toilet does not require water or chemicals to be added during normal operation. The faecal waste dries while it is being stored.
Urine Diversion Dry Toilet (UDDT)		Similar to the dry toilet, this does not require water or chemicals to be added during normal operation. Urine is separate from the faecal waste to assist the drying process and help to control odours. The collected urine may be harvested for fertilizer.
Waterborne Toilet		The toilet requires water for flushing and possibly conveyance of the faecal waste. The water is usually used to create a water seal to prevent odours inside the toilet cubicle.

Collection and Storage / Treatment		This describes the method of collecting and storing the faecal waste and urine. Full or partial treatment may be integrated with this process.
Emptying / Maintenance Frequency	   	Most systems require periodic emptying to remove faecal sludge from the storage facility. This may be as frequent as every 2 to 3 days or longer than a year depending on the design and loading rate of the toilet 3
Requires Consumables		Some sanitation technologies require the supply of consumable items for their day to day use, this may be lime or sawdust used to control odours, or bags/membranes used to collect and store the faecal waste.

Conveyance		The method by which the waste is transported from the point of use to subsequent treatment and /or disposal. This will typically be via a piped sewer system or carting the waste by hand or machine to a suitable treatment / disposal site.
Requires a Sewer Connection		The faecal waste is discharge into a pipe that must be connected to a sewer for conveyance to a treatment facility, this may be a centralised municipal treatment works, or a treatment facility that is integrated with the technology.
Requires Mechanical or Manual Emptying		The faecal waste must be emptied by hand or by mechanical means to remove the waste from the toilet and transport it to a treatment / disposal facility, either on site or off site.

Treatment		The process of treating the faecal waste for subsequent use or disposal. This will primarily involve the removal of faecal coliforms but may also include trash removal and dehydration processes.
Treatment on site		Faecal sludge is treated on site as part of the sanitation technology
Treatment off site		Faecal sludge must be carted away from the site for treatment at a separate facility that is not part of the sanitation technology design.

Use / Disposal		This category describes the use or disposal of the faecal waste that is removed from the sanitation technology
Siting of the Technology		
Can be installed inside the home		The technology is considered to be suitable for installation insider the home without problem odours. The technology is also sufficiently compact or can be configured so that the user interface can be installed inside the home.
Suitable for high density settlements		The technology is considered to be sufficiently robust and compact that it can be installed within high density urban settlements.
Suitable for shared use		The design of the technology and its operation is considered suitable for installation in shared or communal facilities.
Suitable for a single household		The design of the technology and its operation is considered suitable for installation in a single household.
Suitable for Shallow Groundwater Conditions		The technology is suitable for installation where there is shallow groundwater or shallow rock that would prohibit excavation of deep pits.

ANNEXURE F – Sanitation Dossier Reports

This section presents the Sanitation Dossiers that were developed during this project. The Dossiers are to be considered “living documents” that are continually updated as soon as verified information is collected.

Afrisan toilet (African Elite)

African Sanitation Outsourcing

Product Description

The Afrisan Toilet is a waterless, dehydrating toilet with urine diversion. Calcium carbonate (Lime) is added after every defecation and other bulking agents may be added daily. The faeces and toilet paper are collected in a basket which has a compostable liner bag. A sliding cover conceals faeces between use and can be operated after sitting on the unit to avoid viewing faeces from previous users.

The receptacle unit consists of a silicon heater plate connected to a 50 Watt solar panel installed at the roof of the toilet. The urine is diverted through a carbon filter and then through a soakaway pipe below ground surface. Dehydration is enhance by an air vent which is meant to remove odours. Faeces is further treated in a composting unit which runs on 2 x 50Wattt solar panels

Operation & Maintenance

The AFRISAN toilet requires connection to power by a 50 Watt solar panel or a 220Volt-18V electrical power supply. In addition to the daily operation requirements the following maintenance is require:

- Every 2-4 weeks: Waste basket is emptied.
- Every 8 weeks: Additionally treated faeces is removed from composting unit and final product sold at R25 for 50Kg bag.
- Every 2 years: The carbon within the urine filter is replaced.

Health and Hygiene Benefits

The ARISAN toilet provides lighting within the cubicle for easier use after dark. The waste basket is easily accessible for the removal of waste, this combined with the compostable bag will help to prevent direct handling of faeces. The faeces removed from the system will however contain pathogens and must be handled with care. The secondary composting phase assists to sanitise the waste over an extended period of time. The lime covering helps to neutralise odours and combined with the sliding cover will help prevent flies from entering the system.

First Installation

Oct 2013

Total Number of Units

963 (to September 2015)

Location

- Eastern Cape
- Gauteng
- Limpopo
- Mpumalanga
- Northern Cape
- North West

Product Components

- Plastic housing & basket
- Vent pipe
- PV Solar panel
- Heating Plate
- Carbon Filter
- Compostable Bag

Budget Cost

Toilet & top structure
R18,500/HH

Composting plant
R7,500/HH

Cost depends on location and quantities

Supplier Contact Details

Geo Heyns, CEO
072 567 6827 / 021 933 1336
geo@afrisan.com

Alfie Heeger, COO
071 2894562
africasanitation@gmail.com

Unit 1 Linton Close,
Beaconvale, Parow, 7500

Functionality Assessment

The supplier claims that temperature of between 60 to 80°C is achieved on the heater plate. The faeces closest to the heating plate will reach these temperatures (sufficient for pathogen destruction), however as the waste builds up inside the compost bag cooler temperatures will be expected in the faecal waste, and consequently faecal contamination will be expected within the waste. The continuous addition of fresh faeces into the basket means that the collected waste will have high levels of faecal contamination regardless of the previous heating process. The heating process, combined with the ventilation and addition of lime is therefore considered to primarily contribute to a drying process to reduce the volume of faecal waste and extend duration between emptying. The heating lime and ventilation will promote the initial the composting process, which must continue at a suitable composting facility to provide the required treatment of waste.

The carbon filter within the urine diversion system will reduce organics and odour, and will also host bacteria for the biological treatment process. This filtration process will contribute to reducing the COD and faecal contamination that may be present in the diverted urine. The effectiveness of this process will depend on the filter size and retention time. Additional treatment will be afforded through discharge into un-saturated soil. The ground adjacent to the dwelling needs to be suitable for the soakaway of the urine.

Site Verification

The site verification included a visit to a site in Krugersdorp, where 55 operational toilet systems are installed in 55 households, and have been operational for 18 months. The maintenance is provided by Afrisan, which recruits 20 people from the local community to clean, wipe, and provide toilet paper and lime. Although the dehydration basket was functional, the measured ambient temperature within the faecal waste was 23°C, considerably less than the target of pathogen inactivation (60-80°C). All visited units were well-maintained, with lime readily available. Apart from the lime covering the system does not conceal faeces from previous users which is clearly visible during operation. The visited systems did not have offensive odours.

The results below correspond to samples taken from a grab sample within the basket and compost system. This isolated sample was used to understand the general performance of the system and is not necessarily representative of the overall performance of the technology.

Parameter	Unit	Target	Observed Effluent	
			Basket	Compost
E.coli	No./100mℓ	<1000	4400	600
Ascaris	No.	-	Viable Eggs detected.	
pH		5.5 – 9.5	8.5	9.1
Moisture Content	%	-	49%	19%

Recommendations

The system is dependent on the secondary composting process and this must therefore be clearly specified, with particular detail given towards batching of the compost to prevent contamination with fresh faeces. Increasing the surface area of the heating plate to include the sides of the basket will increase the temperature inside the collected waste, although this will require a larger solar system. If the depth of the system could be increased this would help to conceal the faeces and improve the user experience.

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Andy Loo Toilet System

Hygiene Complete Solutions

Product Description

The Andy Loo is a dry toilet that incinerates waste and evaporates urine. Lifting and lowering the toilet seat rotates a cylindrical drum by 180 degrees to move faeces from the toilet bowl to the incinerator. Urine is diverted into the burner housing where it is evaporated. The burner is fuelled by briquettes which are lit in the morning and then burn slowly through the course of the day.

The supplier claims that the unit can handle eight users per hour and that the faeces incinerates to an ash within 15 mins. The flume provides ventilation for the incinerator and removes odours away from the unit. The supplier offers the briquette manufacture as a micro enterprise for participating households.

Operation & Maintenance

The burner houses 3 briquettes that must be lit before the first use of the day, and will then burn for 6 to 8 hours, if extended burning is required, additional briquettes may be added. The sterile ash can be removed daily after incineration is complete. Occasional wiping of the bowl with a wet cloth or damp paper may be required to remove smears. Brickets are supplied to the household monthly at which time the system undergoes a routine check.

Health and Hygiene Benefits

The Andy Loo incinerates the faeces at high temperatures, destroying pathogens so that the remaining ash is fully sanitised. The user may encounter faecal contact during the cleaning of the bowl, although the risk of this is not different from usual anal cleansing practices.

First Installation

July 2015

Total Number of Units

3

Location

Mpumalanga

(business based in East London)

Product Materials

Galvanised Steel

Wood

Budget Cost

Installation to be confirmed

Briquettes = R215 / month

Supplier Contact Details

Ben Mfazwe

043 735 4718

079 734 3800

benmfazwe@hyperlink.co.za

7 Roslin Road
Stirling
East London

Functionality Assessment

The principle of faecal incineration is a novel approach to sanitation but is founded on sound practice. The location of the burner underneath the faeces receptor provide direct heat to incinerate the faeces. The urine is diverted from the pan into the outer casing of the incinerator where the high temperatures evaporate the urine. Important factors that required detailed investigation were as follows:

- The burning duration of the briquettes
- The time to incinerate the faeces
- The temperature of the bowl and whether this presents a hazard to the user
- The urine capacity and time to evaporate urine
- The presence of odours
- The impact of wet faeces / flooding of the burner.

Lab Verification

To fully understand this technology, the system was investigated at the Pollution Research Laboratory at UKZN where it underwent a series of tests over a two day period. These tests were designed to simulate normal use and monitor the performance of the system. Tests were conducted with 200g samples of moist faecal sludge (in 50g specimens).

Parameter	Unit	Target	Observed Effluent
E.coli	No./100mℓ	<1000	pending
Protozoa & Helminths	No./100mℓ	ZERO	pending
Faecal Waste Temp.	°C	>40	270 to 500°C
Temp. of external pan			60 to 100°C
Urine Capacity	mℓ		1600 mℓ
Faeces incineration time	mins	15	60 mins
Urine Evaporation Rate	mℓ/hour		400 mℓ/hour

Low to moderate odour was experienced during burning, smearing and caking of faeces on the pan was encountered. The unit demonstrated effective incineration of faeces including very wet samples.

Recommendations

The unit demonstrated promising performance but should incorporate the following modifications before undergoing further field tests:

- Insulation / thermal isolation of expose pan area to reduce hazard associated with hot surfaces, this should include consideration of alternative materials.
- Evaporation of urine unlikely to be sufficient under normal use, increase evaporation performance or consider urine diversion away from the unit, this will also alleviate some of the odour. Design of urine diverter also requires modification to reduce risk of faecal contamination.
- Investigate options for extending the burning duration to extend to a full days use and prevent risk of handling hot briquettes.
- The flume ventilation system could be modified to promote extraction of air (and odours) from the user interface.

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Waterless Toilet (WISE™)

BathoPele Sanitation

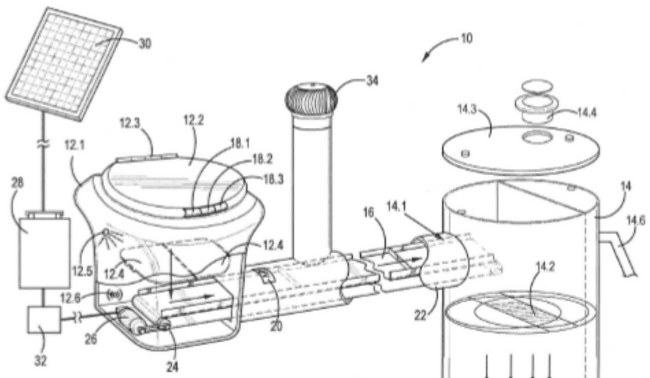

Fig 1

Product Description

the WATERLESS IMPROVED SANITARY ECOLOO™ (WISE) comprises a complex combination of mechanical and electrical components that together provide a dehydrating urine diversion composting toilet. Automatic flaps conceal waste between use and which open when the user sits down. Waste is moved by a Photo voltaic powered conveyor system which transports the waste to a treatment tank outside. A wind turbine vents this container to assist with drying. The toilet is to be fitted with an Alarm and SMS notification (telemetry system) – signaling malfunction or any foreign objects thrown into the toilet. Also providing security alert on tempering of solar panels, etc.

The WATERLESS Solar powered toilet unit would be manufactured using High-gloss polypropylene and recyclable plastic material (plastic injection moulding). These plastic materials are generally manufactured locally then positioned and post-tensioned together to form a solid and an integrated toilet unit. Once the toilet unit is assembled then mechanical components such as shaft, bearings, motor, control and solar panels are installed.

Operation & Maintenance

The dried faecal waste needs to be collected from the rear container every three months.

Health and Hygiene Benefits

The toilet minimises handling of fresh faeces while the ventilation system prevents odours building up inside the cubicle.

First Installation

Prototype Development

Total Number of Units

0

Location

N/A

Product Components

PV Cell
Toilet bowl
Conveyor system
Assisted ventilation
Storage container

Budget Cost

To be confirmed

Supplier Contact Details

Leepo Tiadi

076 053 6252

Functionality Assessment

The proper functioning of this toilet is wholly dependent on a secure electrical supply (solar) and the proper functioning of the mechanical components.

The faces is dried as it passes along the conveyor assisted by ventilation and solar heating. Additional drying occurs in the final container.

It is not clear how the system will manage excess liquids and urine.

Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

The unit needs to be effectively demonstrated in the field for at least a year (ideally 2 years) of operation.

The effluent faecal matter should be tested for pathogens and moisture content to demonstrate effectiveness of the treatment process. Careful monitoring of the excess liquids is also required to verify the need for additional liquid handling. The long term performance of the mechanical components must be monitored to ensure performance is sustained, in particular the conveyor system. The selected materials must be suited to the harsh environment of the saniation system.

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Biofil Wastewater Treatment

Biofil Technologies (PTY) Ltd.

Product Description

The Biofil wastewater treatment comprises of the biofilm digester and the Biofilm micro flush toilet system. The Biofil digester is an on-site wastewater treatment system which, through living organisms, aerobically degrades solids in its upper-most layers. Macro-invertebrates (red worms) inoculation provides stabilisation, volume reduction and aeration of solids. The Biofil digester can be installed above or below ground at a maximum depth of 0.6m. Excess liquids in the digester filter to lower layers and the waste water is discharged into a drain field, under 150mm of top soil or into a soak-away. The Biofil micro flush is a non-flush toilet system designed for rural and non-urban contexts. The toilet contains a movable flap underneath the seat, which provides a water seal. The seat is connected to a fresh-water hand-washing sink. When a lever is pulled the flap releases faecal matter into the digester. The flap then automatically closes and water in the in the toilet bowl is refilled from the hand-wash sink.

Operation & Maintenance

- Every month: Inspection of composting chamber.
- Every year: Inspection of composting material and removal of compost End product if necessary. General maintenance.

Health and Hygiene Benefits

The water seal in the toilet bowl prevents odours and infectious organisms coming into the toilet from the digester, including no human contact with excreta.

First Installation

n/a

Total Number of Units

n/a

Location

n/a

Product Components

Concrete toilet seat

Automatic flap

Precast concrete chamber

Filter material

Budget Cost

To be confirmed

Supplier Contact Details

Evelyn Gyampo

011 275 0449

1050 Printech Avenue,
Honeydew, 2040
Johannesburg

egyampo@biofiltechnologies.com

Functionality Assessment

The toilet design does not include a water seal and may therefore enable odours to enter the cubicle. Solids and liquids are separated through a filter medium made of bulking material, mesh lining and a filter membrane. Excreta is stabilized using living organisms through aerobic process, ending in the bio-filtration of effluent through a coarse sand filtering medium. Although the digester is installed in a way that is not susceptible to flooding, there's a possibility of ground water contamination with sub-surface installation. The aerobic digestion process should be effective at composting waste, however the coarse sand filtration of the liquid effluent may not be sufficient to treat the excess liquids.

Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

A field verification of a pilot installation is required to better understand the technology performance. A low flush toilet with a water seal could possibly be connected to this system to assist with odour control inside the unit, however this will probably lead to an increased liquid load.

The excess liquids being produced by the system may require additional treatment before being discharged from the unit. An alternating chamber design could be considered to prevent contact with fresh faeces when the unit requires emptying.

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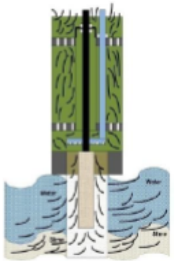
16/02/16

Water Efficiency System

Bubbler (Pty) Ltd



Product Description

The Bubbler Water Efficiency System consists of aerobic treatment and filtration, with the addition of patented specific bacteria mixture. Wastewater is sent to the Septic Boss, where a fine bubble diffuser provides oxygen for bacteria respiration and surface area is provided using foamed ceramic media and/or bio balls for attached growth. The Septic Boss is also called the "Multiple Bacterial Airlift" (MBA), due to the bacteria additives of bacillus genus and the addition of air, which moves the water through the system. Water is circulated 20 to 30 times per day, providing time for the breakdown of organic material and nitrification of ammonia in the tank. From the Septic Boss, water moves to the filter, which is meant to remove pathogenic bacteria and dissolved solids and chemical compounds. The membrane filter also includes a chlorine dose, which should disinfect the water. Water is then discharged to a field, as with typical septic systems.

Operation & Maintenance

The Bubbler Water Efficiency System requires a secure electrical supply to operate the recirculation pump and air compressor:

- Every month: General Inspection and clean filter; Replace Chlorine tablet remove floating debris. Replace Bacteria bag
- Every 12 months: Remove and high pressure clean Septic Boss; Re-connect Septic Boss

Health and Hygiene Benefits

The Bubbler Water Efficiency System enables the convenient use of a conventional flush toilet generally free from odour. The O&M requires minimal handling of faecal sludge, which is well contained between emptying cycles. The disinfection of recycled flush water will minimise risk of contact with faecal coliforms for the user.

First Installation

Jan 2014

Total Number of Units

58 (to July 2015)

Location

Western Cape

Northern Cape

Product Materials

PVC Tank

uPVC pipe and fittings

Filter Media

Recirculation Pump

Air Compressor

Budget Cost

Depends on system and number of households connected

Supplier Contact Details

021 905 6130

22 Electron Road, Blackheath

Western Cape. 7580

info@nwws.co.za

Functionality Assessment

The process design should reduce COD to a low level as well as pathogenic bacteria. In addition, the recirculation of water and provision of bacterial additives will encourage nitrification (and possible denitrification) of the ammonia. Another interesting benefit of forced aeration and addition of aerobic bacteria to the system is the control of anaerobic biomats, a common problem in septic system leach fields. Further denitrification can possibly occur on its own in the soil (regardless of the presence of the added bacteria). Flush water is provided via the recirculation pump, this means that the system cannot be operated when there is a loss of power (from mains electricity of theft of solar system). While this helps to prevent discharge of polluted effluent, it will inconvenience the user. The membrane filter consists of a non-woven fabric and has a small surface area. This filter will require regular maintenance to prevent clogging. The pore size of this filter may also be inadequate to achieve the filtration indicated in the supplied information.

Site Verification

The Site verification included a visit to two sites in the Western Cape. One at an informal settlement where the unit was connected to 3 houses and the drain of a tapstand, water was recycled for flushing. The second site was a large scale private development where three separate units were used as a conventional package plants and effluent was re-used for irrigation. Both schemes were operational at the time of the visit and were installed to a high standard. The household system had apparently not been maintained for some time (3 months); the membrane filter was damaged and the chlorine tablet had been used up. The water entering the toilet cistern was free from odour, but had a brown discolouration. The private installation was subjected to periodic peaks during weekend events. Some chlorine tablet remained in this system. The laboratory results indicated that the Nitrification process was not effective giving rise to high Ammonia readings. The *E.coli* was above the target limit although the values indicate that the biological and disinfection processes were not fully effective at this isolated sample. The high COD at the household site may be attributed to the additional greywater disposal.

Parameter	Unit	Target	Observed Effluent
E.coli	No./100mℓ	<1000	78,500 to 150,000
COD	mg/ℓ	<75	75 to 373
pH		5.5 – 9.5	7.6 to 8.0
Ammonia	mg/ℓ	<6	21 to 212
TKN	mg/ℓ	<15	22 to 211
Suspended Solids	mg/ℓ	<25	17 to 89
Electrical Conductivity	mS/m	<150	55 to 250

Recommendations

Monthly maintenance is required by trained personnel to ensure the effective operation of this system. Continual monitoring of the system is required to ensure that the Faecal Coliforms, COD, N and P are achieving the required limits. The drainage field is an integral component of the system and a monitoring point in the soil substrate is required to enable monitoring of the effluent discharged from this location. Elevated COD levels in the effluent being discharged to the drainage field could lead to clogging of the perforated pipework and surrounding soil and an alternative infiltration design should be considered to reduce this risk.

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Household Sanitation Technology Assessment and Evaluation

v 1.3
09/05/16

Wetloo (BRS)

Calcamite Sanitary Services (PTY) Ltd.

Product Description

The Calcamite Wetloo is a recycling toilet which works on the principle of anaerobic degradation. The development of the Wetloo was derived from the need for flush toilets in conditions where there is a lack of septic systems or where soakaways and septic tanks are not feasible for local ground conditions or lack of sewer systems. The system requires a top structure or can be retrofitted. After flushing, water from the toilet is transported into a two chamber septic tank where solids settle and fat and grease float. The rest of the liquid is transported, via hydraulic lift, into a clarifier tank. From the clarifier tank, a lift pump replaces water in the cistern until it is full. Once installed, the toilet does not need water to be replaced as excess water from the cistern will overflow via aerobic treatment filter and back to the clarifier tank

Operation & Maintenance

The system requires a secure electrical supply to operate the pump, this can be provided by a solar panel The following maintenance activities are required in addition to routine preventative maintenance:

- Every 3 years: Tank is desludged.
- Every 4 years: 12V battery replaced.
- Every 5 years: Solar pump is replaced (or every 40 000 hours).

Health and Hygiene Benefits

The Calcamite system has a water seal in the pan to prevent disease carrying insects and odours entering the toilet cubicle. The toilet can be installed inside the home for increased convenience and hygiene benefit

First Installation

2013

Total Number of Units

10 (to September 2015)

Location

Gauteng Province
Limpopo Province
North West Province

Product Materials

Primary tank
clarifier tank
aerobic treatment filter
12V solar driven plant
12V solar panel and power pack

Budget Cost

Contact the Supplier

Supplier Contact Details

012 742 0900
admin@calcamitetanks.co.za

Plot 2, 15 Sapphire street,
Klerksoord, Pretoria
0200

Functionality Assessment

The two stage treatment process incorporates anaerobic and aerobic stages to provide settlement and initial digestion of waste before the aerobic filtration step. The continuous recirculation step maintains the water level in the cisterns and should help to prevent stagnation of the cistern water. This recirculation process should also assist the nitrification and de-nitrification processes to reduce ammonia and nitrate levels in the treated effluent. The addition of urine will help to balance the evaporative losses in the system, however, the closed loop treatment system may however lead to increased concentrations of nutrients and salts arising from the urine load. The organic load of the system should stabilise as indicated by the supplier, however the misuse of the system and addition of inorganic materials will lead to a more frequent emptying requirement.

Site Verification

The site verification included two visits. The first visit (Site 1) was to an installation at the Calcamite factory in Pretoria which serviced 50 users at 5000L capacity per day. The toilet and cistern were not clean indicating turbidity in the recirculated water. The second visit (Site 2) was to a community installation in Gauteng which services 350 household (approximately 500 users). The 50 000L capacity plant was operational and well maintained, with all pumps and additional structures intact. The colour of the effluent was slightly brown. Although the site of access was easily accessible, sampling in both chambers was a challenge which may be of concern for future maintenance or servicing of the system. The maintenance included caretakers who monitored and kept the toilets clean from 6am to 8pm. This may prove costly. Other challenges included theft of solar panels, however security fencing was installed. Although the system promises minimal ground pollution, the presence of an emergency soak away increases the chance of environmental pollution.

Parameter	Unit	Target	Observed Effluent	
			Site 1	Site 2
E.*coli*	No./100mℓ	<1000	1,000	3,000
COD	mg/ℓ	<75	64.9	33.6
pH		5.5 – 9.5	7.55	7.36
Ammonia	mg/ℓ	<6	751	37
TKN	mg/ℓ	<15	901	201
Electrical Conductivity	mS/m	<150	440	640

Recommendations

The high ammonia high EC from the lab analysis are indicative of increasing concentrations of urine in the closed loop system. The relatively low COD indicates that there is insufficient carbon to drive the biological treatment process to reduce the ammonia and nitrates. Since this system does not discharge directly to the environment elevated nutrient level may be acceptable however, high concentrations of ammonia will result in an unpleasant odour. The E.*coli* levels are reasonable for the recirculating toilet, provided the flush does not result in excessive splashing which would increase the risk of human contact. The supplier should consider the incorporation of a urine diversion system which would

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Household Sanitation Technology Assessment and Evaluation

v 1.0
16/02/16

Eaziflush Sanitation System

Envirosan Sanitation Solutions

Product Description

The Eaziflush system can be used in all areas, ranging from rural to peri-urban to urban areas, in areas with water supply as well as areas with limited or restricted water supply. The Eaziflush system has revolutionized the way we use toilets; as the Eaziflush requires only 2 litres of water per flush. The unit can either be used as a pour-flush application or as a conventional cistern flush unit. The Eaziflush unit has been developed over 3 years of research, prototyping, testing and numerous pilot phases across South Africa.

Operation & Maintenance

The toilet is operated in the same way as a conventional flush toilet

Health and Hygiene Benefits

The toilet can be installed inside the house due to the incorporation of a P-Trap which prevents odours from escaping into the toilet cubicle. This increased convenience and the effective conveyance of waste away from the toilet provides a significant health benefit associated with improved sanitation services.

First Installation

2014

Total Number of Units

5000

Location

KZN

Eastern Cape

Western Cape

Product Components

Injection moulded plastic pedestal and removable P-Trap

Plastic Toilet Cistern and mechanism

Budget Cost

Please contact Supplier

Supplier Contact Details

Jacques Rust

+27 31 700 1866
+27 82 787 2112

info@envirosan.co.za

Functionality Assessment

Functionality Assessment to be undertaken in conjunction with selected downstream treatment facility

Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

A site verification of this technology should be undertaken after a minimum of one years continuous use.

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Household Sanitation Technology Assessment and Evaluation

v 1.0
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Eaziflush Sanitation System

Envirosan Sanitation Solutions

Product Description

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Product Components

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Budget Cost

Please contact Supplier

Supplier Contact Details

Jacques Rust

+27 31 700 1866
+27 82 787 2112

info@envirosan.co.za

Functionality Assessment

Functionality Assessment to be undertaken in conjunction with selected downstream treatment facility

Site Verification

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Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
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pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

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Household Sanitation Technology Assessment and Evaluation

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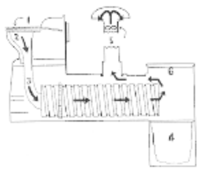
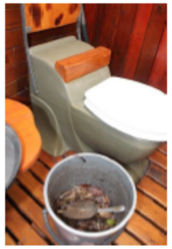
Ecosan waterless toilet system

G-Trade International c.c.





Product Description

Ecosan is a waterless toilet is a dry sanitation toilet composed of a sealed casing, wooden seat and a bowl. Faeces falls down a vertical chute into a helical, screw-shaped conveyor which moves waste forward each time the toilet is used. Over the course of 3 weeks, the waste dries by heat and via a ventilation pipe in the conveyor. At the end of the helical conveyor is a reusable mesh bag for the faeces with a bucket underneath to collect excess urine. The dry waste can be used to make compost or as a source of fuel. The household system is designed for 6 to 8 users daily, and for schools 20 to 25 users per day. The tank can be stored below ground and later removed then reinstalled elsewhere if necessary.

Operation & Maintenance

For each use, the Ecosan toilet seat is lifted and lowered once to operate the toilet mechanism and move the waste in the helical conveyor. The travel time of waste is approximately 3 weeks to a month. The dry waste is accessed by opening the cover at the end of the conveyor and lifted by two handles. Access urine Is removed, if present, in the bucket below the bag.

- Every 3 to 4 months: General maintenance (based on 6 users per day).
- Every 3 to 6 months: The waste in the bag at the end of the conveyor is Disposed of and replaced if necessary.

Health and Hygiene Benefits

Waste travels down a vertical chute away from the user interface and is not clearly visible. The addition of compost / leaf litter helps to manage odours. The design can be installed inside the home (against an external wall), this improved convenience has an added health benefit.

First Installation

To Be Confirmed

Total Number of Units

To Be Confirmed

Location

Western Cape

Product Components

- Casing and helical drum (Polyethylene)
- Wooden seat and bowl
- Vent Pipe
- Turning mechanism

Budget Cost

Contact Supplier

Supplier Contact Details

012 807 5002

gtrade@telkomsa.com

Functionality Assessment

Raising and lowering the toilet seat rotates a helical drum at the back of the unit. The system does not include urine diversion and therefore relies on the sun and ventilation to assist with drying. The rotating drum will natural turn the faecal waste which would assist effective composting. The capacity of the system will depend on the drying time and will therefore be subject to seasonal changes if the container only has a short retention time. The addition of compost / sawdust will assist with the drying and composting process although the turning process will continuously uncover faeces and may result in foul odours inside the toilet if there is not effective ventilation.

Site Verification

The site verification of the system occurred at a guesthouse in the Western Cape where the system was installed to service 2 to 4 users per day. The conveyor mechanism was easily operational. The conveyor, made of twenty groves, required 9 to 10 lifts of the mechanism to complete one full rotation cycle. A strong odour was observed upon completion of a full rotation cycle. Waste was collected and successfully used for composting. There was excess urine in the bucket below the waste bag which suggests that waste is not effectively dried within the conveyor.

The caretaking and maintenance of the system had been modified by the user. The lever is lifted and pushed down more than once. A bucket of leaves from the forest floor are provided with a scoop for the user to throw down the inlet as an additive. Instruction are also provided not to pour water down the inlet. Caretakers clean the bowl every day with a brush and try to avoid the addition of additional water, although. The visited units were in dense forest and would not receive much direct sunlight onto the plastic container. No flies were observed during the site visit, indicating effective vector control.

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	2000 to 23 000
pH		5.5 – 9.5	7.64 to 7.76
Moisture Content	%		79%
Volatile Solids	g/g (dry)		
Fixed Solids (Ash)	g/g (dry)		

Recommendations

The units should always be installed in area of direct sunlight to assist with the drying process. Additional ventilation could also assist with the drying process. Improved liquid separation (or urine diversion) could be incorporated to enable a dryer waste for more effective composting. The size of the casing and helical drum could be increased to prolong the retention time and reduce the impact of seasonal weather variations.

A secondary composting stage is an essential part of the treatment process. The handling process from emptying the drum to the subsequent composting stage requires careful consideration to prevent contact with contaminated faecal waste.

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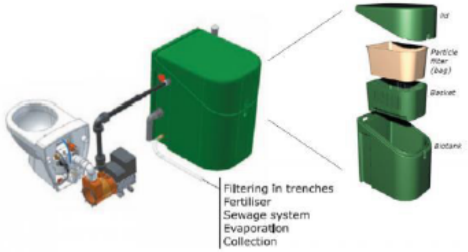
Vacuum Toilet System

Enactus Unisa



Product Description

The Vacuum water system is a closed system which uses 0.5 litres of water, this is less than conventional flushing toilet systems. The toilet creates a strong vacuum which sucks waste from the toilet, through a small diameter pipe and into a waste handling facility. The constant vacuum system (CVS) or the vacuum on demand system (VOD) is installed depending on the context. The CVS system can service a large number of toilets and requires a lot of energy. The VOD system required low amounts of energy and can therefore make use of solar pump..

Operation & Maintenance

The user pushes a button which opens a valve, creates a vacuum of air and transports waste, while simultaneously opening a water valve which cleans and sprays the toilet bowl, retaining a small amount of clean water in the bowl. The VOD system creates a vacuum only when the toilet needs to be used, and evacuates air from the drain pipes to create an air pressure difference. Less energy is required in this system because the pressure difference causes sewage to be flushed. The flushed effluent goes through a particle filter and into a composting 'bio-tank'. Liquid collected at the bottom of this tank will require further treatment before discharge or reused.

The toilet requires minimal maintenance. The composting tank is emptied and cleaned periodically. If there are technical or operational challenges, the manufacturer can be contacted.

Health and Hygiene Benefits

The proper operation of the user interface and containment of faeces in the bio-tank will minimise contact with human faeces. Subsequent handling of this waste is improved by containment in a collection bag.

First Installation
Prototype Development

Total Number of Units
n/a

Location
n/a

Product Components
Toilet valve

Vacuumarator*

Biotank with particle filter bag and basket.

Budget Cost
To be provided by supplier

Supplier Contact Details
012 429 2480/8519

P.O BOX 392, Muckleneuk, 0003

manyediwanema@gmail.com

Functionality Assessment

The technology provides an alternative method for conveyance of faecal waste that requires less water (0.5 litres per flush), and is not constrained by topography as the vacuum is able to convey waste at flat or inclining gradients. The system is wholly dependent on a secure electrical supply and proper operation and of the mechanical components, and must therefore be accompanied by an effective maintenance programme. The system will produce excess liquid from urine and flush water that will be contaminated with faeces and will require secondary treatment.

Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

The performance of this system requires effective maintenance of mechanical components. Consideration should be given to a liquid containment system or secondary treatment of liquid effluent. This effluent will not be suitable for infiltration due to the faecal contamination and potentially high COD and suspended solids.

Further development of the treatment component is required before piloting of the technology.

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Household Sanitation Technology Assessment and Evaluation

v 1.0
16/02/16

Enviro Loo

Enviro Options (Pty) Ltd

Product Description

The Enviro Loo is a dry toilet system that uses heat and ventilation to dry out faeces and urine. Urine and faeces both pass through the toilet bowl to the perforated drying plate. Urine trickles past the plate to the bottom section of the sealed container, where it is evaporated from the unit. Faeces are left to dry on the plate, which is slanted so older material falls towards the access door.

Periodically, faeces are moved from the drying plate to the drying bag, to further the drying process and prevent cross-contamination with new, untreated faeces. Heat is supplied naturally, by the sun, and is enhanced by the black material used in Enviro Loo construction. Ventilation is provided by inlet pipes on the sides of the unit and a large ventilator pipe, equipped with a Whirly Bird, to suction the air out of the unit. An additional ventilation is provided via the cubicle and toilet bowl. An electrical extractor fan is included to improve the ventilation and drying processes.

Operation & Maintenance

Compost is added after defecation as a part of regular operation. Enzymes are also added, which are meant to encourage the growth of aerobic bacteria that carry out the composting process. Dried faeces is periodically raked towards the access hatch, and then into the drying bag for further composting. This bag must then be emptied to a suitable composting or disposal facility.

Health and Hygiene Benefits

The ventilation system prevents odours building up inside the cubicle. The toilet opens directly onto the collected faeces although the dark container and this from being observed. The potential hygiene benefits afforded by access to this sanitation system are good. The operator responsible for raking and removal of waste may come into contact with contaminated faeces and should exercise usual precautions during this operation. The dry waste being removed from the system may contain E.*coli* and should not be considered as sterile during handling.

First Installation

1993

Total Number of Units

> 75,000 units in South Africa

+ 10,000 units worldwide

Location

Throughout South Africa

51 Countries Worldwide

Product Materials

Roto-moulded Polyethylene tank

Ceramic Pedestal

Budget Cost

Depends on Model & Service Plan

Supplier Contact Details

Lance Joel

011 244 5563

082 908 3335

lance.joel@enviro-loo.com

Functionality Assessment

Faeces accumulate on the drying plate but are dried over time, which leads to volume reduction. The supplier provides that the unit has 0.8m^3 capacity for solid waste. Fresh faeces has a moisture content of approximately 75%. If the moisture content is reduced to 20%, the total solids accumulation will be 33 litres per person per year plus the volume of ash or compost added as part of normal operation. Assuming 100ml of dry solids, it would take more than a year for 10 users to fill the unit, this is well within the 6 months operational guideline. The warm temperatures achieved inside the drying unit will enable sterilisation of the waste assuming that these temperatures can be achieved for sustained periods to ensure that the required temperature is achieved throughout the mass of faecal waste. The liquid overflow valve in the bottom chamber (where fitted) ensures that excessive amounts of urine do not build up in the unit. However, build-up of liquid at the bottom is very possible and could present non-ideal odour issues. Increased salinity of liquid will be expected over time which will reduce the evaporation performance of the system, solids may also form at the bottom of the unit. The supplier addresses these concerns through a regular maintenance programme.

Site Verification

The site verification included a visit to one site in the Western Cape, two sites in Gauteng and the factory. Despite maintenance not being in accordance with the manufacturers guidelines, the units were performing reasonably well, with the exception of a couple of units in the Western Cape that were flooded with highly turbid liquid. The quality of construction was good, although the disposal bags were missing from several installations leading to an increased risk of contamination with fresh faeces. The volatile solids were observed to reduce through the treatment system indicating the biological composting was occurring, although was not complete in the dry faeces. There was no evidence of flies within the units during the site verification. The observed faecal waste temperature (during winter) was not sufficient to sterilise the waste, although this may have been provided at other times during the day. The laboratory analysis of this waste however indicated good treatment of the waste, one site having zero E.*coli*.

Parameter	Unit	Target	Observed Effluent
E.*coli*	No./100mℓ	<1000	500 to 9,500
Protozoa & Helminths	No./100mℓ	ZERO	No viable parasites
Faecal Waste Temp.	°C	>40	16.0 to 20.5
Moisture Content of Solids	%		13 to 54 (Av. 32)
Suspended Solids (Liquid)	mg/ℓ	<25*	139

**Liquid Effluent usually contained within system.*

Recommendations

Continual monitoring and regular maintenance is required by trained personnel. Disposal must first be into the drying baskets as per the operational guidelines to minimise risk of faecal contamination. Any waste removed from the system must not be regarded as sterile, appropriate precautions should be exercised during the handling of waste. Urine diversion could be considered as an option to reduce risk of flooding inside the unit. The forced ventilation will reduce the temperature inside the may prevent the temperature required for effective sterilisation of the waste. The rapid drying may also halt aerobic digestion as the moisture content drops below optimum levels. Slower ventilation should be considered to prolong aerobic digestion and increase the temperatures inside the units

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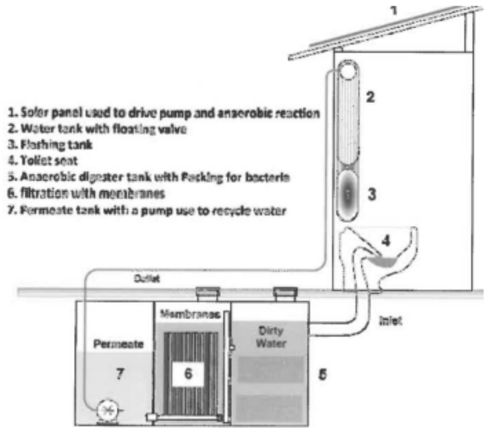
Household Sanitation Technology Assessment and Evaluation

v 1.1
04/03/16

Reusable water flushing toilet

ETE SOLUTION



Product Description

The reusable water flushing toilet is a recycling toilet. The toilet reuses used water by a process of bio-treatment, filtration, anaerobic reaction, recycling and reusing of the water. Dirty water is filtered through a membrane technology and bioreactors purify water. The water then moved into a permeate tank where a solar pump provides air and energy for water to be pumped to the toilet storage tank. This 300L toilet can be used by a family of 5 people.

Operation & Maintenance

The toilet is operated like a standard toilet system which is flushed. The flush water from the toilet goes through a bioreactor process, cleaned by the membrane and pumped back by a solar pump.

- Every year: Effluent disposal.
- Every 5 to 10 years: Replace membrane if necessary.

Health and Hygiene Benefits

The toilet uses a water seal to prevent odours from entering the toilet cubicle.

First Installation

2011

(Operational demo model).

Total Number of Units

30 Testing units

Location

Eastern Cape

Limpopo

Product Components

Solar panel

Pump

Membrane

Polymer tanks

Biological reactor tank

Toilet structure

Budget Cost

To be confirmed by supplier

Supplier Contact Details

Blessing Thokozani Mncube

011 5596438

1 maple road, Trefnent road,
Ormande ex22,
Johannesburg, 2091

Blessing@live.co.za

Functionality Assessment

Although the membrane has been tested and removes bacteria, the bioreactor is only active when soap and hydro oils are not added to the system. The membrane may leak due to age or poor installation, thus testing prior to installation is essential and can prevent membrane poisoning. A cause for concern is that water may be pumped back to the toilet contaminated if the membrane is not checked more regularly, especially in a context where users are prone to add soapy water.

The proper functioning of the unit is dependent on a secure power supply and the effective maintenance of mechanical components

Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

A field verification of the test units should be undertaken to establish performance. Regular maintenance (monthly) is required by trained personnel.

The clarity of water being recycled into the cistern should be observed to indicate performance of membrane. Regular monitoring of EC and nutrients should be undertaken to identify whether these determinants are becoming elevated over time. Urine diversion could be considered to help prevent elevated EC and nutrients should this be identified to be a problem.

A disinfection step may be required to prevent high levels of faecal coliforms in the flush water, this will depend on the integrity and performance of the membrane

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Household Sanitation Technology Assessment and Evaluation

v 1.0
16/02/16

LUSEC Waterless Toilet

AW HALL

Product Description

The LUSEC comprises of a 25L bucket fitted to a standard toilet and lid. Ventilation pipes are attached to the toilet lid. Air flows from outside, through the solids container, up the discharge pipe, vertically through an inverted T piece within the bucket and through the ventilation pipe on the toilet seat and/or the back of the toilet seat and exit the top of the cubicle vertically. The inverted 110mm T-piece within the bucket transports and deposits waste away from the seat into a metal chamber heated by sunlight. A flexible deflection plate surrounds the inverted t-piece and direct liquids to the floor of the bucket. A galvanised spiral auger also moves the deposits rearwards, while simultaneously accelerating the drying process. Dried solids are removed from the metal container into bags.

Operation & Maintenance

The auger can be manually or electrically operated to move solids to back. The toilet must be lifted up about 60 degrees to move waste into the metal chamber. Solids are emptied into bags and the bags are stomped upon to pulverise the solids into a manageable fertiliser. Liquid is removed by lifting the toilet and leaning it towards the discharge point, using a pump, or both.

- Every 30 days: Waste is emptied.

Health and Hygiene Benefits

Ventilation of the toilet ensures that odours leave through the ventilation pipe. Fly screens on the vent pipe help to manage vector related diseases.

First Installation

August 2015

(Prototype Development)

Total Number of Units

1

Location

KwaZulu-Natal Province

Product Components

Plastic Pedestal

Vent Pipe

Steel tilting mechanism

Collection bags

Budget Cost

To be confirmed by Supplier

Supplier Contact Details

Alan Hall
082 602 3046

P.O. Box 238 Winterton,
3340, KwaZulu Natal

shorty@megawif.co.za

Functionality Assessment

The design makes provision for the initial collection and composting of faecal waste and the periodic removal of partially composted waste. Normal volume of sludge removed is 50 litres, which can reasonably be carried by two operators. The urine diversion will prevent the build up of liquids in the collection bags and will aid the composting process. A subsequent composting stage is required to complete the treatment process.

Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

An extended field trial of the technology is required to verify its performance potential and the wear on mechanical components

The galvanised auger is likely to become corroded over time in this harsh environment.

WATER RESEARCH COMMISSION

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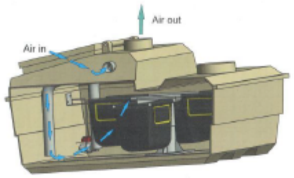
Household Sanitation Technology Assessment and Evaluation

v 1.0
16/02/16

Waterwise toilet

Madibeng Water Services



Product Description

The Waterwise toilet is a urine-diverting desiccation toilet, which utilizes heat from the sun and a wind turbine to expedite the process of drying. The sealed unit contains 4 woven mesh baskets, which faeces drop into from the urine-diverting toilet bowl. The baskets are on a carousel, which is turned by the users or servicers, allowing for nearly 24 months of drying treatment of faeces. The unit is equipped with a UV-treated manhole, which provides the user access for servicing and maintenance and aids in increasing the temperature inside the unit.

Operation & Maintenance

The urine diversion toilet bowl allows faeces to drop into the baskets and urine to be diverted, either to the bottom of the sealed unit or to a soak away pit. A wind turbine forces air from the rear of the toilet to pass over the liquid and up through the faeces baskets. In the manhole, the basket that has had the longest treatment is removed at this time, producing dry faecal matter, which should be safe for transfer to a compost pile or other location for use or disposal. In the event that too much liquid builds up in the bottom of the unit, the Waterwise toilet is equipped with an overflow valve, which is also accessed through the manhole at the top. This valve will release excess liquid and direct it to be leached into the ground.

- Every 4 to 6 months: Carousel inside the manhole is turned 90 Degrees for the next basket to be filled or for Removal of basket with the longest treatment.

Health and Hygiene Benefits

The ventilation system prevents odours building up inside the cubicle. The toilet opens directly onto the collected faeces although the dark container and this from being observed. The potential hygiene benefits afforded by access to this sanitation system are good. The dry waste being removed from the system may contain E.*coli* and should not be considered as sterile during handling.

First Installation

Prototype Development

Total Number of Units

0

Location

N/A

Product Materials

Polyethylene Tank

Stainless steel

Woven mesh polyethylene

Budget Cost

To be confirmed

R180.00 p.a (Cost of maintenance)

Supplier Contact Details

Malcolm Morris

0122525628

waterwise@mweb.co.za

Functionality Assessment

Faeces will collect in the bags and will be dried over time. The developer has made provision for 24 months drying time inside the container. With effective ventilation to keep humidity levels down, this process should enable effective drying of the waste. The separation and batching of faeces in the baskets will prevent the risk of contamination with fresh faeces during the drying process. The inclusion of a urine diversion toilet will help to minimise liquids in the chamber. The excess liquid drained from the baskets is likely to have a high turbidity and will not be suitable for discharge into infiltration systems. However the dry process and urine diversion may help to prevent the build-up of excess liquids.

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Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

The unit needs to be effectively demonstrated in the field for at least a year (ideally 2 years) of operation.

The effluent faecal matter should be tested for pathogens and moisture content to demonstrate effectiveness of the treatment process. Careful monitoring of the excess liquids is also required to verify the need for additional liquid handling. The long term performance of the rotating mechanism must be monitored to ensure free rotation and corrosion prevention.

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Household Sanitation Technology Assessment and Evaluation

v 1.0
16/02/16

Clarus Fusion

Maskam Water



Product Description

The Clarus Fusion is a package plant system that could be integrated with a flush toilet and possibly water recycling to provide a complete household sanitation technology. The Clarus Fusion is a domestic sewage treatment plant (STP) with full nitrification and de-nitrification processes used in conventional municipal STPs. Designed for urban areas, the Clarus Fusion is a compact three stage activated sludge treatment plant, where the recycling of water and sludge for the nitrification and de-nitrification processes is valve-operated and aeration is controlled by a pump, which may be powered by solar or mains electrical connection. Waste goes into the sedimentation chamber or anaerobic zone which separates solid and grease waste. From there, the wastewater moves into the anoxic zone is filled with suspended media, and then into another aeration chamber with membranes that enlarge the surface area for bacteria activity. Wastewater then moves through to the clarifier. UV, chlorine or a combination of both is used post-treatment to sterilise the water. Effluent is then discharged into a natural stream, used for irrigation or greywater reuse.

Operation & Maintenance

The system requires a secure electrical supply to operate the air pump:

- Every 6 months: One hour service
- Every 5 years: Replacement of air pump diaphragm
  Sludge removal

Health and Hygiene Benefits

The plant is sealed, which ensures that there is no opportunity for flies or other potential disease carrying organisms to thrive. The odour of the wastewater is managed on-site through the aerobic treatment process. The operation and maintenance of the system avoids human contact with undigested faecal matter.

First Installation

2010

Total Number of Units

90+

Location

- Botswana
- Eastern Cape Province (SA)
- Gauteng Province (SA)
- Ghana
- Kenya
- Limpopo Province (SA)
- Mauritius
- Mozambique
- Mpumalanga Province (SA)
- Namibia
- Nigeria
- United Arab Emirates
- Western Cape Province (SA)

Product Components

- Solar panel (optional)
- Fibreglass tank
- Polyurethane media
- PVC internal piping
- Air Pump
- GRP Electrical panel

Budget Cost

Depends on number of Households served

Supplier Contact Details

Gerhard Cronjé

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+27 21 988 8807

gerhard@maskam.co.za

Functionality Assessment

The package treatment plant works on a batch processing principle with anaerobic and aerobic treatment stages. The anaerobic chamber incudes filter media with a high surface area to support the attached growth of anaerobic bacteria. The aerobic chamber utilises an air lift pump and filter media to reduce the pump demand and to provide increased surface area for attached biofilm growth. Agitation of this media by the air lift pump will help to prevent clogging of the media. The design of this system is based on sound waste water treatment practice and should function reasonable well while there is a reliable power source.

Site Verification

The ZF450 model was installed at a guesthouse and restaurant in Franschhoek, Western Cape where the system services 4 cottages. The system had been operational for more than 4 years and had been running without any challenges and no components had yet been replaced. At the time of the site visit, the system was operational and had a connection to a mains electrical supply. Solids and scum were observed in the 'fat trap' chamber, the liquid effluent in the subsequent chambers had some discolouration.

Parameter	Unit	Target	Observed Effluent
E.coli	No./100mℓ	<1000	10 100
COD	mg/ℓ	<75	23
pH		5.5 – 9.5	7.2
Ammonia	mg/ℓ	<6	11
Nitrate as N	mg/ℓ	<15	0.6
Suspended Solids	mg/ℓ	<25	54
Electrical Conductivity	mS/m	<150	60

Recommendations

The package plant performed reasonably well in the controlled environment of the Franschhoek site. The observed effluent characteristics generally met the required standard with the exception of the E.*coli* levels which were high on the observed sample, indicating the requirement for disinfectant to be added to the final chamber.

Where disinfectant is used, monthly maintenance is required by trained personnel to ensure the effective operation of this system. Continual monitoring of the system is required to ensure that the E.coli and Ammonia limits are with the required limits. Effective design of the downstream infiltration system is required (where relevant), to ensure that the suspended solids do not lead to clogging over time.

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Nano Recycling Bio Digestor

Waste Intrique Services

Product Description

The Nano Recycling Bio Digestor System serves households using a flush toilet. It consists of four separate chambers where sedimentation, aeration, settling and filtration occur. An anaerobic process tank followed by an aerobic tank after which the liquid passes through polymeric membranes as part of the ultrafiltration process (0.1 to 0.4µm) before being disinfected and discharged, or reused for flushing. The system requires electricity (via mains or PV Cells) to provide the aeration and pumping. An ultrafiltration membrane claims to sterilise the wastewater.

Operation & Maintenance

WIS offers a monthly maintenance service in addition to an emergency call out service. This comprises the following activities:

Monthly Service:

- Preventative maintenance
- Check plumbing and power supply
- Reactivation of Bio-Augmentation products
- Test pumps and diffuser
- Assess membranes

Major Service (12 to 36 months):

- De-sludge
- replace membrane
- service pump

Health and Hygiene Benefits

The Nano Recycling Bio Digestor System enables the convenient use of a conventional flush toilet generally free from odour. The O&M requires some handling of faecal sludge, but this is external from the user and presents a low risk of contamination. The disinfection of recycled flush water will minimise risk of contact with faecal coliforms for the user.

First Installation

2013

Total Number of Units

15

Location

- Gauteng
- North West Province
- Limpopo

Product Materials

- Roto-moulded PE tank
- uPVC pipe and fittings
- Filter Media
- Recirculation Pump
- Air Compressor

Budget Cost

Depends on number of households served

Supplier Contact Details

Lentswe Mpete

076 710 6531

lentswe.mpete@wisgroup.co.za

Functionality Assessment

The system will combines conventional wastewater treatment steps (anaerobic, aerobic, filtration, chlorination), and also include a bio augmentation additives to apparently boost the bacteriological processes. The volume of the units is scaled according to the number of users with the suppliers literature indicating that the volume of 2 to 3 kl is used for household systems. This would give adequate retention time for the specified treatment processes for household toilet flushing.

Site Verification

The Site verification included a visit to two sites in the North West Province. Both at municipal clinics. The first installation (Thwulwe Clinic) was applicable to a domestic household system (pictured) and included a water recirculation pump to pump treated effluent back into the toilet cistern. The second site (Kutlawanong Health Centre) was a larger scale package solution that treated water from the kitchen and showers and did not recycle the water.

The maintenance agreement with the supplier had ended 9 months prior to the visit, and a lack of maintenance since this time had led to the Clinic directing patients to the VIP toilets. Despite the lack of maintenance, the system was partially operational, although no air compressor or chlorination step was observed, and the recycled water had a dark green/brown discoloration. The Kutlawaong system was fully operational with a good clarity of effluent water.

The visited installations did not match the supplied information and showed signs of differential settlement with some of the tanks tilting slightly and exposed drainage pipework.

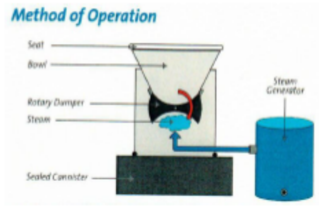
Parameter	Unit	Target	Observed Effluent
E.coli	No./100mℓ	<1000	*0 (disinfected)*
COD	mg/ℓ	<75	188 to 300
pH		5.5 – 9.5	7.9 to 8.1
Ammonia	mg/ℓ	<6	23 to 135
Nitrate as Nitrogen	mg/ℓ	<15	43 to 138
Ortho Phosphate as P	mg/ℓ	<10	9.9 to 25.8
Electrical Conductivity	mS/m	<150	127 to 236

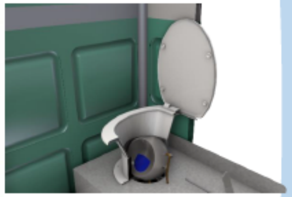
Recommendations

Regular maintenance (monthly) is required by trained personnel, the impact of good maintenance on the proper functioning of the system could be seen from the field verification. Continual monitoring of the system is required to ensure that the Faecal Coliforms, COD, N and P are achieving the required limits. The tanks must be installed on a well compacted base and should be backfilled and compacted in layers, where shallow groundwater conditions exist concrete anchors may be required to prevent floatation. All above ground pipework to be UV stabilised.

Steam Cleaning Toilet (SCT)

Sanitech





Product Description

The Steam Cleaning Toilet uses minimal water where a prefabricated toilet bowl is rotated after use and cleaned underneath with steam. The bowl is coated with Nano which creates a non-stick surface and also seals waste inside, separated from the user. The Nano technology prevents debris from sticking to bowl, and the rotating bowl covers opening to also prevent disposal of foreign objects. The system can be connected to a 110V or 220V power source, however It does not need to be connected to a main line sewer system. After the rotating bowl is turned, steam cleans the underside of the bowl ready for subsequent users.

Operation & Maintenance

The rotating bowl is rotated by pulling the lever situated on the right side of the toilet unit. Concealed at the bottom back of the structure is an 80 litre waste cartridge for collection of the waste. This canister is replaced at a predetermined service frequency, typically twice a week depending on loading rate

- 1-2 Service intervals per x10 users recommended.

Health and Hygiene Benefits

The toilet bowl is self-cleaning (with steam); The potential hazard from the steam is child safe as it is tamper proof. The user and operator has little to no exposure to waste due to the sealed storage inside the container. It has an integrated hand wash basin for improved hygiene.

First Installation

June 2015

Total Number of Units

240

Location

Gauteng Province

Product Components

Plastic Cubicle
Rotating bowl
220V power source (1700W)
Hand Basin
Collection Cartridges
20 Watt bulb in the unit

Budget Cost

Depends on location and number of units

Supplier Contact Details

John banks
011 823 6060
johnb@sanitech.co.za

Functionality Assessment

The SCT requires a small amount of stored water to turn into steam. The process of using steam to sanitise the surfaces is sound but requires a secure electrical supply for operation. The power demand (1700W to 3400W) to generate the steam will increase the operational cost of the unit.

The non-stick surfaces should help to prevent smearing of surfaces provided they do not become scratched. The rotating bowl is positioned sufficiently below the toilet seat that slight smears from previos users will not present and immediate health risk. The toilet bowl above the rotating component is also likely to become soiled and does not benefit from the steam cleaning action. The risk of soiling is reduced by the large diameter of the rotating bowl.

The technology must be accompanied by an appropriate collection and disposal service, together with a suitable treatment facility to keep the system operational

Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

A site verification of this technology should be undertaken now that it has been operation for several months. This investigation should consider:

- The cleanliness of the rotating bowl
- Whether the side of the bowl are becoming soiled
- The ease of operation
- The monthly power requirement
- The monthly water requirement
- The performance of the system in the event of power failure

The technology must also be coupled with an appropriate collection service as per the suppliers maintenance strategy.

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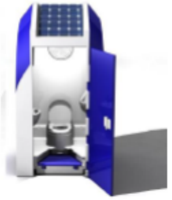
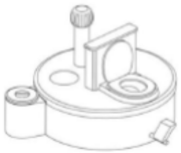
Savvyloo

Pennine Energy Innovation (Pty) Ltd





Product Description

The system comprises a toilet pedestal assembly fitted onto a circular housing, containing a conical rotating disc which incrementally rotates against a fixed spiral guide, which is a mechanism for drying and channeling dry waste into a receptacle, and a cover which is designed to use solar energy to accelerate drying, and a peripheral waste collection receptacle. Features also include liquids and urine separator linked to a container or soak-away, and a ventilation pipe with cowl to aid with the evaporation process, eradication of pathogens and reduction of odours. The dehydration process may be accelerated using an independent fan and/or heat source which may make use of photovoltaic energy.

The faeces is deposited through the chute onto the conical rotating disk, and is slowly rotated outwards along a spiral aerated conduit until the waste is dried and finally discharged into a waste collection receptacle positioned along the outer circumference of the housing.

Operation & Maintenance

The SavvyLoo requires normal cleaning and use of toilet paper. It does not require chemicals. Although it is a waterless toilet, to the extent that water is used for cleaning it will simply separate and drain into the liquids sump. Periodic emptying of the collection receptacle will be required depending on the loading rate. Subsequent Composting of waste may be required to complete the treatment process.

Health and Hygiene Benefits

The Savvyloo has a number of potential health benefits as would be provided by an improved sanitation facility. The drying process will help to reduce the pathogens in the dried faces, therefore presenting a low health risk to this handling process. The system claims to heat faeces above 60degrees centigrade which would kill most pathogens and protozoa.

First Installation

Prototype development

Total Number of Units

N/A

Location

N/A

Product Materials

Toilet Pedestal
Circular housing
Rotating disc
Collection receptacle

Budget Cost

To be confirmed by the supplier

Supplier Contact Details

Dr Dudley Jackson
082 880 1800

Functionality Assessment

Household sized dry sanitation system. The mixed excreta falls onto a large diameter disk which is incrementally turned. A rake system separates the solids from the liquid portion. The liquids discharge to a container or a soakaway. The solids dehydrate as they are scraped in a spiral fashion over the surface of the disk. The dried excreta then drops into plastic bag lined container.

The large surface area provided by system together with the separation from fresh faecses is expected to assist effective drying. The high temperatures claimed during development will assist sterilization of the waste. Additional loading will increase the rate that faeces passes through the desiccation system which could result in wetter faeces (and incomplete sterilization) entering the collection basket.

It is not clear whether the design will prevent contaminated liquids from washing past the drying faeces. The separated liquids are likely to be contaminated by faeces and may require additional treatment before discharging into an infiltration system.

Site Verification

Currently no site verification exercise completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	Currently no Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

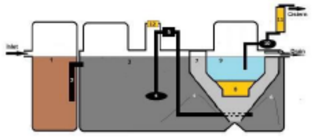
Recommendations

The unit needs to be effectively demonstrated in the field for at least a year (ideally 2 years) of operation.

The effluent faecal matter should be tested for pathogens and moisture content to demonstrate effectiveness of the treatment process and need for additional composting. Careful monitoring of the excess liquids is also required to verify the need for additional liquid handling.

SMARTSAN Recycle Reactor

Nano Water Technologies Africa (Pty) Ltd



Product Description

The SMARTSAN Technology is a variant of a sewage package plant which enables the connection and treatment of waterborne sewerage. The Recycle Reactor model incorporates the recirculation of treated effluent for toilet flushing and can therefore be connected to a conventional flush toilet. The core product is manufactured from roto-moulded polyethylene tanks which are usually installed below ground. The technology requires an electrical connection which may be provided by mains or PV Panels.

Two models are available for different household sizes:

- 1.6kl Single household model is designed to serve 1 to 6 people
- 2.5kl Double household model is designed to serve up to 12 people

The product utilises the combined processes of settling, anaerobic digestion, filtration, absorption and disinfection. The 'AIR' model incorporates a compressor to bubble air through the effluent to introduce an aerobic step for improved treatment performance.

The Technology has been awarded an Agrément Certificate (No. 214/466). This certification process considers the quality of materials and fabrication together with observations of the operational performance of the technology.

Operation & Maintenance

The SMARTSAN requires maintenance the following maintenance:

- Every month: - Replace Chlorine tablet (where applicable)
- Every 3 months: -top up the system with approximately 600 litres of fresh water (where required)
  add 500ml of NWTA Anaerobic biological additive.
- Every 12 months: - Replace Nano filter set and de-sludge from the sludge box if necessary using small mobile sludge pump

Health and Hygiene Benefits

The SMARTSAN Technology enables the convenient use of a conventional flush toilet generally free from odour. The O&M requires minimal handling of faecal sludge, which is well contained between emptying cycles. The disinfection of recycled flush water will minimise risk of contact with faecal coliforms for the user.

First Installation

Not provided

Total Number of Units

Not Provided

Location

- Western Cape (Knysna)
- Freestate (Clarens)

Product Components

- Roto-moulded Polyethylene
- uPVC pipe and fittings
- Filter Media
- Recirculation Pump

Budget Cost

Site Specific
Contact Supplier

Supplier Contact Details

Jurgen Graupe
082 453 6505
PO Box 1149 Knysna, 6570
graupe@mweb.co.za

Functionality Assessment

The treatment process utilises conventional settling, anaerobic and aerobic treatment processes common to conventional wastewater treatment, with some innovative features to promote the recirculation and digestion of sludge. The technology also includes absorption media and activated carbon in the 'Nano' filter that assist with nutrient removal, odour and discolouration of effluent. The design allows for approximately 7 day hydraulic retention time (based on one double household unit with 12 users and toilet flushing only), this is a long HRT and suggests that the loading could possibly be increased (subject to monitoring).

The Nano Filters do not have a Nano metre pore size and as such do not pose a clogging risk. The use of the absorption media in early stage filters is unlikely to have a prolonged benefit as this media will quickly become saturated. Recent modifications to this design include a sludge box to separate faecal matter from the filters. The filter size has also been increased to 19kg to increase the operation life of the filters. The media does however provide a good surface for fixed biofilm, whereby beneficial bacteria will contribute to the biological processes.

Site Verification

The Site verification included a visit to the George factory and three installations in the Knysna area (crèche, school and informal settlement). Two of the three visited sites were operational, with the informal settlement site failing due to lack of electricity and insufficient maintenance. The visited installations showed signs of differential settlement with some of the tanks tilting slightly, in extreme cases this could interfere with the connection between the tanks.

Parameter	Unit	Target	Observed Effluent
E.coli	No./100mℓ	<1000	ZERO
Protozoa & Helminths	No./100mℓ	ZERO	No Parasites Seen
COD	mg/ℓ	<75	107 to 127
pH		5.5 – 9.5	6.8 to 7.6
Ammonia	mg/ℓ	<6	10.0 to 17.2
TKN	mg/ℓ	<15	12.6 to 17.2
Total P	mg/ℓ	<10	2.4 to 4.0
Suspended Solids	mg/ℓ	<25	11 to 20
Electrical Conductivity	mS/m	<150	44 to 55

Recommendations

Regular maintenance (monthly) is required by trained personnel. The tanks to be installed on a well compacted base and should be backfilled and compacted in layers, where shallow groundwater conditions exist concrete anchors may be required to prevent floatation. The maintenance interval for the Nano filtration media and disinfection processes (where applicable) to be kept under close monitoring. If zero *E.coli* is required it is expected that chlorine tablets will need to be replaced every 1-2 weeks (or similar disinfectant must be regularly replenished). The absorbent filtration media is likely to become quickly saturated with ammonia and phosphates, the high nutrient loads of faecal waste are likely to require more frequent replacement of Nano Filters. The incorporation of urine diversion will significantly reduce the ammonia and phosphate load and will prolong the life of the filters. Relocation of the filters to the final chamber will also prolong the filter life.

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My Fast 16.0

Tupelovox (PTY) Ltd.

Product Description

My Fast is a wastewater treatment product which can mostly be stored underground. The system is an aerobic, fixed film packed bed reactor with 100% submerged media. It treats wastewater from toilets or houses flow to the treatment system in the tank for treatment. The treated water can be disposed of in the soil through a drain field and is often reused for irrigation. There is one moving part above the ground that blows air into the system.

Operation & Maintenance

- Every 6 months: Inlet filter to the blower is cleaned by shaking free of Debris.
- Every 1-5 years: Solids are emptied out of the vessel.
- Every 5 years: Metal element of the inlet filter is replaced if corroded.

Health and Hygiene Benefits

There is a simple air inlet filter to keep out large rodents and insects out. The facility enables connection of flush toilets to provide a complete sanitation solution.

First Installation

Total Number of Units

Location

Nigeria

Kenya

Product Components

Package Treatment Plant

Budget Cost

To be confirmed

Supplier Contact Details

Eugene Sihle Ngcobo
011 8496746
P.O. Box 785698 Sandton,
2146, Johannesburg
sihle@tupelovox.co.za

Functionality Assessment

This technology is based on proved package sewage treatment design and has not been specifically evaluated in this study.

Site Verification

No site verification exercise has been completed for the technology

Parameter	Unit	Target	Observed Effluent
Faecal Coliforms	No./100mℓ	<1000	No Lab analysis completed for the technology
COD	mg/ℓ	<75	
pH		5.5 – 9.5	
Ammonia	mg/ℓ	<6	
TKN	mg/ℓ	<15	
Suspended Solids	mg/ℓ	<25	
Electrical Conductivity	mS/m	<150	

Recommendations

The technology needs to be coupled with a suitable user interface (toilet) to present a household treatment solution.

The functionality of the technology should be evaluated in accordance with the SEWPACKSA assessment procedure which promotes self-regulation of the package plant industry. The technology is general outside the scope of this study for Household sanitation technologies.

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v 1.0
16/02/16

ZerH20 waterless toilet

ZerH₂O Waste Management Pty Ltd

Product Description

The ZerH₂O toilet is a urine-diverting dehydrating toilet. Faeces drop down onto a disk, which is rotated after each use by a user operated manual advance mechanism. While on the disk, the faeces are dried out by a combination of heat from the sun and ventilation through the vent pipe supplied. The faeces spend approximately 2 weeks on the disk before being dumped into the sump basket in the center of the disk. The dried product is removed when the basket is approximately half full and transferred to a compost pile for further treatment and reuse. After the faeces have been around one rotation of the disk, a wall constructed of flexible plastic directs the faeces into a slotted sump basket inside a sealed container. The sealed container prevents any leaching of effluent into the surrounding soil. However, in the case where excess water or other liquid builds up in the sealed container, adjustments must be made to remove the liquid and maintain the drying process.

Operation & Maintenance

Removal of the sump basket after two weeks is relatively simple, with an accessible handle in the centre of the unit. After removal, the basket can easily be carried by one person to a compost trench or added to a vermicompost pile with a small amount of water to produce nutrient-rich compost.

Sump basket needs to be emptied every two weeks under normal loading.

Health and Hygiene Benefits

The ZerH₂O has a number of health benefits, including: reduction in flies, reduction in faecal pathogens due to the drying process; isolation of faeces from human contact.

First Installation

June 2011

Total Number of Units

12 (to July 2015)

Location

Gauteng

Limpopo

Product Materials

Rotomoulded polyethylene

PVC vent pipe

Budget Cost

Contact Supplier

Supplier Contact Details

Janice Whitehead

+27(0)72 819 2060

janice@zerho.co.za

Functionality Assessment

The large surface area provided by the plastic tank is expected to assist effective drying. Potential operational issues revolve mostly around user behaviour. Not advancing faeces after use can cause odour in the toilet units. Additionally, improper use of the urine-diverting toilet pan can cause urine to enter the faeces drying unit, increasing time necessary for drying and causing odours. Furthermore, as noted in one of the visited toilets, faeces can get stuck onto the urine-diversion pan, bringing it close to the user. Additional loading will increase the rate that faeces passes through the desiccation system which could result in wetter faeces entering the collection basket. In the case where excess water or other liquid builds up in the sealed container, adjustments can be made to remove the liquid and maintain the drying process.

Site Verification

The discs for the two toilets were facing north. There was no smell in the women's toilet, which did not seem to be used often because the basket and the turn-table were almost empty. There was also a small amount of faeces on the urine section of the pedestal, which demonstrates the potential for misuse of the UD toilet. Users had not properly advanced their faeces after use in the men's toilet, which caused the smell inside the superstructure and the rubber wall on the turn-table had been dislocated, such that it blocked removal of the basket. The inspectors had to move the rubber wall in order to remove the basket, which made it slightly non-ideal to remove. However, the overall removal process appeared to be very simple and easy. The compost pile on the site appeared to be very active with worms, further breaking down the faecal matter. Although the faeces were dry and hard in texture upon collection, the *E.coli* count was above authorisation limits.

Parameter	Unit	Target	Observed Effluent
E.coli	No./100mℓ	<1000	965
pH		5.5 – 9.5	8.11 to 8.38
Electrical Conductivity	mS/m	<150	416 to 568
Moisture Content	%		19.5 to 20.4
Volatile Solids	g/g dry		0.80 to 0.84
Fixed Solids (Ash)	g/g dry		0.16 to 0.20

Recommendations

The liquid collected in the urine diversion system is likely to be contaminated with faeces and should be handled with caution. Excess liquid could possibly wash through the drying system which in turn would contaminate the faeces in the collection basket. This liquid would also build up over time below the collection basket. In light of the above, and the above lab results, the dried faecal waste will require the subsequent composting step before it can be considered sterile. Careful consideration of this manual handling process is required to minimise the potential health risk. The lab results indicate that the decomposition of the waste is not complete, (indicated by the low ash:volatile solids ratio). This results from the rapid dry process. Improved design of the urine diversion component should be considered to prevent risk of blockage and contamination of collected urine.

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ANNEXURE G – Workshop Feedback Responses

From your perspective, what has been the most useful and relevant aspect of the Protocol?

1. I think it is the beginning of the setting of standards which would guide innovators and suppliers in terms of developing technologies which would assist the country in terms of solving water and sanitation problems.
2. The sampling protocol and the importance of the requirement for sampling to obtain a representative sample to give emphasis of safety, health and environment.
3. Discussions.
4. Provide some basis for designing specification and evaluating technologies.
5. Methodology.
6. The beginning of a National programme that can inform decision-making! Objective dossiers to be shared and promoted.
7. The flowchart of the protocol gave an overview of what the project is about in summary.
8. The importance of suitability of the technology, including how the attitude of the users to be considered.
9. Understanding the way, the tool works as well as how it is applied.
10. Informing the sector about the tool and what is happening next.
11. Feedback on the inspected technologies.
12. Objectives, intent and overview of the protocols. Knowing how stakeholders will evaluate systems going forward.
13. That there is finally a tool in place to assess the effective functioning of the technologies.
14. The protocol is important for this industry.
15. I would say that the protocol in general is/could be very useful-in particular if this can be introduced to a higher level for recommendations/tool to all municipalities.
16. The fact that there is some reference point, albeit it is still at infancy.
17. Direction and focus of our product; especially in terms of the communities impacted.
18. The protocol has been scientifically scrutinized, therefor it is a credible reference source.

Was there anything from the day that requires further explanation?

1. As explained, this is an ongoing process, so I am satisfied that everything was explained sufficiently and more will unfold in due time.
2. Clarity on the way forward, additional tasks and stakeholder involvement to develop standards.
3. No.
4. Suitability (context specific) assessment.
5. Evaluation method based on desktop research.
6. How can other products or technologies now get reviewed? What is the role of industry associations in advancing ad supporting the protocol? Immediate next steps?
7. What the standards should specifically cover in order to match the sanitation technology industry and user.
8. Most of the broader sanitation technologies were covered, i.e.: dry, chemical and waterborne. Happy with all explanation given by the presenters.
9. The issue of mandates. I.e.: where would SABS, AGREMENT SA, etc. fall within the protocol, if at all?

10. –
11. Which are the preferred technologies used by municipalities so far? Where are the markets for which technologies, e.g. which municipalities have an urgent need for?
12. –
13. How the tool is going to be fed to the decision makers who were not at the workshops, municipalities and province.
14. The extent to which municipalities, who would independently adopt any technology are involved in the development of the protocol.
15. No.
16. How is it that certain technologies are not funded by the WRC while tax payers' money is used?
17. Congratulations for an exemplary interaction between suppliers and Gov. role players that would otherwise be out of reach.
18. How do/did you test for false positive regarding the presence/no presence of the helminth in the sample analysis? What is there were no helminths in the people making use of the system?

In your opinion, is there anything missing from the Protocol that should be added?

1. Clear-cut recommendations on particular technologies. I find that there could have been more said about which technologies are best received by the evaluators.
2. The protocol framework is complete and well done, it will serve well as a basis for standard development with input from a wide stakeholder base.
3. No.
4. –
5. Good process to start with.
6. I cost included-CAPEX & OPEX? What benchmarks do we have for these?
7. No.
8. Not for today.
9. No.
10. Process map/decision making table that helps municipalities in narrowing down technology options from 30-5, for example, based on environment, demographics, etc.
11. None.
12. –
13. The actual application of the tool in the field will tell, overtime, if there is anything missing, so far so good.
14. It is akin to over-the-fence-engineering, where the feedback from the ultimate customer will be determined at the end of the finalisation of the protocol.
15. Only that the protocol is currently only looked at as an informative tool, rather than an authoritative implementation paper or alike.
16. Yes, it should advocate use of National Treasury's Practice Note No.11 of 2008/2009.
17. –
18. No, however the site inspection component which was one day only (as I understood), will need to be re-visited for future undertakings.

Do you have any further comments related to the Protocol or the Workshop?

1. I think the protocol is very good and will become better with time and more experience
2. Important note: SABS does not function as a regulator-standards are voluntary, unless taken-up in legislation by a regulatory Department.
3. Consider certification programme for sanitation technologies.
4. Besides standard certification, need to look at how it is framed in municipal regulatory and institutional context.
5. It would have been useful to have had more interaction with the assessment team.
6. Could the toll include an indicator for the ideal marketplace the technology is suited for or targeted at?
7. No.
8. Not for today.
9. Generally, this is an extremely comprehensive workshop.
10. When report is finished, send it to Minister directly requesting formal confirmation that DWS commits in taking forward. She will then instruct the D Sanitation to implement.
11. What next? Could there be Provincial workshops to popularise the tool?
12. There is a lack of emphasis of the centrality of the end users (as would be represented by municipalities).
13. Please try and look into making the tool available and shared by all municipalities in an attempt to guide the municipalities to make more informed decisions. Further, to actually visit Municipalities in need, where there might be a lack of expertise.
14. The VIP monopoly was not addressed.
15. I would like to see on-going interaction with the government role players-with emphasis on communities.
16. Great study. Good to have a reference tool.

General Comments and Questions

"The workshop was well organized and the hospitality great! As a service provider in the water and energy savings field we gained valuable information on the status of small sanitation systems. On a negative note; we experienced some hostility between service providers which did not help the aim of the workshop. We look forward to participate in future workshops and wish your organization much future success in the regulation on off-grid sanitation systems".

"…my main question related to the Context Specific Suitability Evaluation stage. I noticed that for the other stages tools had been developed to assist, but not for this particular stage. Is that still under development? Also, I know that the evaluation protocol is geared towards decision-makers who are professionals in the field, but in terms of participation from users, I assume that is part of the 'acceptability' criteria, perhaps this is where developing a tool to assist with this may be of use or referring people to existing sanitation 'software' such as CLTS? The sanitation technology dossiers were good summaries, but just a note, I noticed that the last paragraph of several of them was cut off short so I would suggest checking the formatting again. Good work overall and thank you again for inviting me to the workshop."