Long-Term Monitoring and Assessment of Pour Flush Technology in South Africa

Report to the

Water Research Commission

prepared by

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Executive summary

The purpose of this project was to monitor and evaluate existing pour flush toilets and assess their applicability within the South African context. With the growth of uptake of pour flush toilets in South Africa, it is important that ongoing monitoring and evaluation contribute to improving the technology in order to promote it at a larger scale. By uncovering some of the key practical difficulties faced with the technology thus far, improvements can be made to how it is implemented, which will only lead to more success and ultimately, more safe, healthy, and dignified sanitation for communities. Through research-based monitoring, this research provides a critical look at the potential of the technology and contributes to guidelines for municipalities to pursue it with success. In the context of a country with enormous backlogs of household sanitation, pour flush has potential to generate improved outcomes, as long as lessons are learned early on to ensure successful implementation.

In 2009 the Water Research Commission (WRC) commissioned a study investigating the feasibility of the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush was needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and most of these have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. Thus, the current number of pour flush toilets in South Africa is now above 16 000.

The specific aims of this project as described in the project proposal were as follows:

1. Compile comprehensive data of all pour flush uptake to date (not restricted to WRC demonstration projects only)
2. Survey attitudes towards pour flush technology in South Africa
3. Using large data sets, refine estimates of pit filling rates of pour flush toilets compared to VIP toilets
4. Assess water consumption with particular reference to alternate P-trap designs
5. Evaluate the maintenance needs of pour/low flush toilets to produce an O&M schedule for the toilets

This study demonstrated how pour flush uptake in South Africa has increased exponentially in the last 8 years and that this increase in pour flush toilets is accompanied by positive user experiences in general. The increase in pour flush uptake has been due, in large part, to marketing efforts by manufacturers of pour flush toilets. While initial pilot projects had positive feedback from most users, many of them have not yet led to widespread municipal adoption, which is likely due to a lack of knowledge and knowledge sharing among municipal officials. Over the course of 8 years, pour flush

toilets in South Africa have gone from concept to prototyping, piloting, commercialisation, and medium-scale implementation.

This study demonstrates the general positive experiences of users across locations, with the greatest negative experiences being associated with extreme water shortages and inconvenience. To make pour flush toilets more accepted among rural householders, convenience should be improved, particularly with getting water to the toilet for flushing. This was by far the most common feedback received in this study. This study has presented some alternatives to carrying buckets of water to the toilet each time while also continuing to avoid creating a direct water connection between cistern and toilet pedestal.

Overall, pour flush toilets are currently the most practical alternative to VIP toilets in the rural sanitation landscape in South Africa. The addition of another viable technology option is a positive advancement, as it will allow municipalities and householders greater agency when implementing projects. This does, however, also require more critical thinking on the side of municipal decision-makers, since VIP toilets have for so long been the accepted standard. Though the pour flush technology has been successfully demonstrated, it is clear that there is still a long way to go in educating municipal officials about its potential and ensuring that standards and specifications enable wider spread implementation of pour flush toilets.

Acknowledgements

The project team wishes to thank the Water Research Commission (WRC) for their support of this project and of sanitation technology development in general.

Partners in Development (PID) acknowledges all municipal officials and ward councillors who opened doors for our team to collect data in their communities, as well as those who provided feedback to the project team about pour flush toilets.

PID would like to thank Envirosan and Cemforce for the information provided about pour flush toilet installations throughout South Africa.

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1 Introduction

The purpose of this project was to monitor existing pour flush toilets and assess their applicability within the South African context. With the growth of pour flush toilets in South Africa, it is important that ongoing monitoring and evaluation contribute to improving the technology in order to promote adoption at a larger scale. By uncovering some of the key practical difficulties faced with the technology thus far, improvements can be made in how it is implemented, which will only lead to more success and ultimately, more safe, healthy, and dignified sanitation for communities. Through research-based monitoring, this study provides a critical look at the potential of the technology and contributes to guidelines for municipalities to pursue it with success. In the context of a country with enormous backlogs of household sanitation, pour flush has potential to generate improved outcomes, as long as lessons are learned early on to ensure successful implementation.

1.1 History of Pour Flush development in South Africa

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to the South African context. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush was needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. Thus, as of 2018, the total number of pour flush toilets in South Africa exceeded 16,000.

1.2 Aims of this project

The specific aims of this project as described in the project proposal were as follows:

1. Compile comprehensive data of all pour flush uptake to date (not restricted to WRC demonstration projects only)
2. Survey attitudes towards pour flush technology in South Africa
3. Using large data sets, refine estimates of pit filling rates of pour flush toilets compared to VIP toilets
4. Assess water consumption of pour flush toilets
5. Evaluate the maintenance needs of pour/low flush toilets to produce an O&M schedule for the toilets

The accomplishment of these aims will lead to practical recommendations for the implementation of pour flush toilets.

2 Pour flush assessment methodology

2.1 Compiling data on pour flush projects in South Africa

Compilation of data on pour flush projects in South Africa required discussion with various stakeholders who have been involved in the growth of pour flush in South Africa. A list was compiled in mid-2018 to include all larger scale pour flush installations to date, excluding single pilot installations in dispersed communities. From this information, figures were generated depicting the spread of the technology in South Africa over the 8 years since its inception in South Africa. Figures were generated using Quantum GIS (1.8.0) to depict the spread of pour flush toilets across the various provinces in South Africa.

2.2 User surveys

In order to assess a number of aspects of pour flush toilets, structured surveys with users were conducted. User surveys were conducted with households in as many communities and provinces as possible based on the budgetary constraints. The final survey used in data collection is presented in Annexure A, and the methodology for developing the questions is described below. The questions are divided into the following sub-topics: household information, toilet information, toilet user information, hygiene supplies, maintenance needs, and feedback about the toilet.

2.2.1 Household information

Household information simply includes details of the interviewed individual and the location of the household. Collection of these specifics allows for linking the results of the survey with the results of the inspection and measurements, photos of the toilet, and, if possible, any past assessments that were carried out. For the most part in the WRC demonstration projects, reference numbers were established for each toilet constructed. In situations where no reference numbers have been used, other numbers, such as the post office record number or address, are used in its place. At the very least, the household family name, first name of interviewee, and location of the toilet should be sufficient for linking data.

2.2.2 Toilet information

The important toilet information collected includes when the toilet was built, whether the installation uses twin or single pits and whether there are other toilets on site. If there are other toilets on site, the user was asked how frequently the pour flush toilet is used compared to the other option(s). This information is useful in assessing the pit filling rate as well as general acceptance of pour flush toilets. For instance, in a case where a household has a VIP toilet and a pour flush toilet and uses both options equally, the volume of sludge in the pour flush pit may be relatively low. When calculating pit filling rates (ℓ/capita.year), it is most useful to report them assuming that the pour flush toilet is used 100% of the time. Data can be adjusted based on how frequently the pour flush is used.

2.2.3 Toilet user information

When determining sludge accumulation rate, it is important to know how many individuals use the toilet on a regular basis. This can only practically be determined by asking the householder. However, misreporting of this number can lead to gross inaccuracies in calculated pit filling rates. Thus, a series of questions were included in the survey to determine the most probable number of toilet users. Householders were asked to report on how many people lived in the house when the toilet was built and how many live in the house permanently now. The householder was then asked to report how many of those people use the toilet and then describe how many people *do not* use the toilet. This series of questions provides two answers to the question of the number of toilet users, which ideally will line up. Where these numbers are not equal, some assumptions must be made by the researcher assessing sludge accumulation rates.

$$No.\,toilet\ users_1 = Reported\ no.\,people\ who\ use\ the\ toilet$$

$$No.\,toilet\ users_2 = No.\,people\ living\ in\ the\ house - No.\,people\ not\ using\ the\ PF\ toilet$$

Subsequent questions regarding the ages of those who do not use the toilet and their reasons for not using it provide some insight into the applicability of the technology as well as adjustments that may be needed to ensure that the technology benefits are realised across age groups.

2.2.4 Hygiene Supplies

Provision of hygiene supplies is the responsibility of homeowners. Particularly since the present pour flush installations have taken place in impoverished communities, it is useful to assess the family's abilities and priorities around purchasing these materials. The main hygiene supplies relevant to pour flush toilets include a wiping material and soap for washing hands. By assessing householders' ability to purchase these materials and choices when purchasing, one can determine the maintenance costs to households. Additionally, though pour flush toilets have been proven to not be prone to blockages whether toilet paper or newspaper is used for wiping, the use of newspaper for wiping may have implications with regards to water usage and frequency of blockages.

2.2.5 Maintenance needs

The core of the household survey centres on maintenance needs of the pour flush toilet. The key aspects of maintenance assessed include: water usage, pit emptying and switching pit plumbing (for double pits), blockages, leakages, and replacement parts. Each aspect is addressed through a series of questions to assist in determining the overall cost and schedule for maintenance of pour flush toilets. In instances where individuals report an issue, they are asked a series of questions to determine the cause, nature, and frequency of this issue. They are then asked whether a member of the household was able to fix the problem or if they had to hire an outside person. If an outside person was hired, they are asked for the approximate cost.

2.2.6 Feedback about the toilet

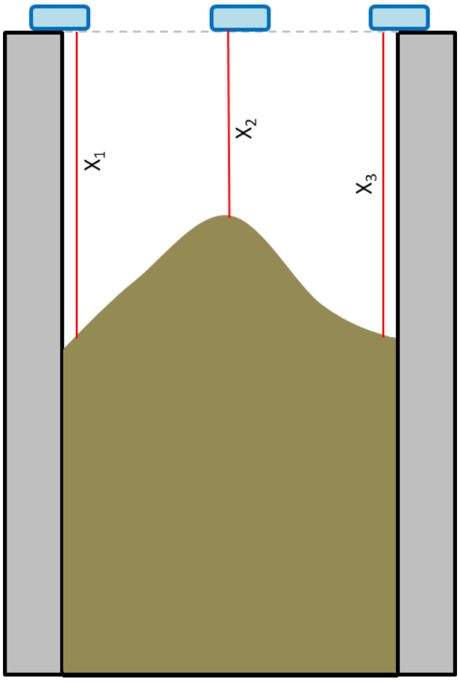
The final section of the survey gathers general feedback about users' attitudes towards pour flush toilets, an important aspect of technology success. Householders are asked if they made any upgrades to their toilets and if they have experienced any difficulties. They are asked to report what they like and dislike about the pour flush toilet. They are then asked if they would recommend the pour flush to anyone else and then asked why/why not, followed by a question about what they would change about it. Finally, they are asked whether they would consider upgrading their pour flush toilet to a low flush toilet (if they have not already done so). Each of these questions provides useful information regarding user acceptance of the technology *and* feedback for consideration in future design and implementation of the technology.

2.3 Physical inspections

In addition to discussing pour flush toilets with users, the researchers conducted physical inspections of each pour flush toilet. The goals of the physical inspections were to assess the condition of the pour flush toilet and measure the sludge depth in the pour flush pit(s). At each site the researcher assessed the condition of the door, pedestal, seat, structure and roof. Responses to these questions shed light on the durability of materials used and provide suggestions for any replacements or repairs that may be imminent in the near future. The full list of questions for physical inspections is provided in Annexure B.

If possible, the researcher then removed the pit cover from the pits and took 2-3 measurements of sludge depth in the pit. Measurements were taken using the Bosch DLE40 Professional laser measure, which can measure from the top of the pit to the top level of the sludge. The three measurements spanned the width of the pit and therefore provided some indication of the shape of the sludge in the pit. Where the dimensions of the constructed pit were known, the volume of sludge in the pit was simply the total volume of the pit minus the volume of the void. However, it is important to note that not all pits match the design drawings or specifications exactly. For instance, in areas with rocky conditions, some pits may not have been dug to the full depth specified. This would mean that estimates of sludge depth would be greater than the actual depth.

When assessing the sludge accumulation rate in a pit, it is important to distinguish between water and sludge. Some pits may be full of water, with a layer of water covering the sludge. This is not uncommon in cases with a high groundwater table or poorly-draining soils. Researchers were asked to note the contents of the pit (dry sludge, wet sludge, layer of water on top).



$$Approximate\ void\ height = \frac{X_1 + X_2 + X_3}{3}$$

$$Approximate\ sludge\ depth = (Pit\ depth) - (Approx.\ void\ height)$$

$$Sludge\ volume = (Approx.\ sludge\ depth) \times (Pit\ cross-sectional\ area)$$

$$Pit\ filling\ rate\ (litres\ per\ user\ per\ year) = \frac{Sludge\ volume\ in\ litres}{(2018 - year\ built) \times (PF\ users)}$$

Figure 1: Setup of pit depth measurements and associated equations

2.4 Field data collection, capture, and analysis

Data from user surveys and physical inspections was collected using a mobile application developed with the Open Data Kit (ODK) suite. For flexibility, a combined survey/inspection form was also created in addition to the separate forms for surveys and inspections. This allowed the researchers the flexibility to work alone in the field on one form or to work with a partner. To prepare the survey, it is entered into Excel in a specific format and then converted to .xml format through the online ODK application. The XML file can be used with web and mobile application data collection. The Open Data Kit mobile application is called ODK Collect and can be used by any Android device.

Using the mobile application has a number of benefits, including the ability to skip irrelevant questions based on interviewees' answers, which can cut down time of the survey and reduce confusion. The use of a mobile application for data collection also makes data capture considerably simpler than using paper surveys. Data collected using ODK Collect is uploaded to an ODK Aggregate server operated using the Google Cloud platform. From ODK Aggregate, data is directly exported as a .csv file and is ready to be analysed in MS Excel. This removes the need to capture the collected data manually in an electronic format and thus removes the human error often associated with data capture.

Each data set from the various locations is exported to its own MS Excel spreadsheet for analysis. A standard sheet for analysing numbers and percentages and calculating pit filling rates was created. This allowed for standard, comparable data which could be analysed for each site and overall for pour flush toilets in South Africa. All data from these sheets was then combined into one summary sheet of all data collected from all locations.

2.5 Interviews with municipal officials

Certain municipalities were selected to answer specific questions about their experience with pour flush toilets, in order to better understand the enabling environment for pour flush toilets. Municipalities were selected based on feedback from the user surveys as well as widespread adoption (or lack thereof) of pour flush toilets. Interviews were generally conducted over the phone or over e-mail with a series of unstructured questions. Collecting this information was difficult due to municipal employees being busy and difficult to get a hold of.

3 Compilation of Pour Flush projects in South Africa

3.1 Pour flush projects currently installed

Table 1 lists the major pour flush installations in South Africa as of July 2018. This includes the initial demonstration projects carried out by the WRC (including installations in schools) as well as projects where municipalities have specified and funded the installation of pour flush toilets. This does not include single pilot/demonstration units installed or low flush toilets. The installations are plotted on the map in Figure 7, and each is given a unique code in order (shown in Table 1) to simplify the display. A more detailed A3 version of the map is provided in Annexure C. As can be seen in Figure 2, the Eastern Cape has had the greatest number of pour flush installations to date, which includes both initial WRC demonstrations and municipal-funded projects. Zoomed-in maps of areas throughout the country are provided in Figure 3 through Figure 6, and the Eastern Cape and KwaZulu-Natal (KZN) are described in more detail below.

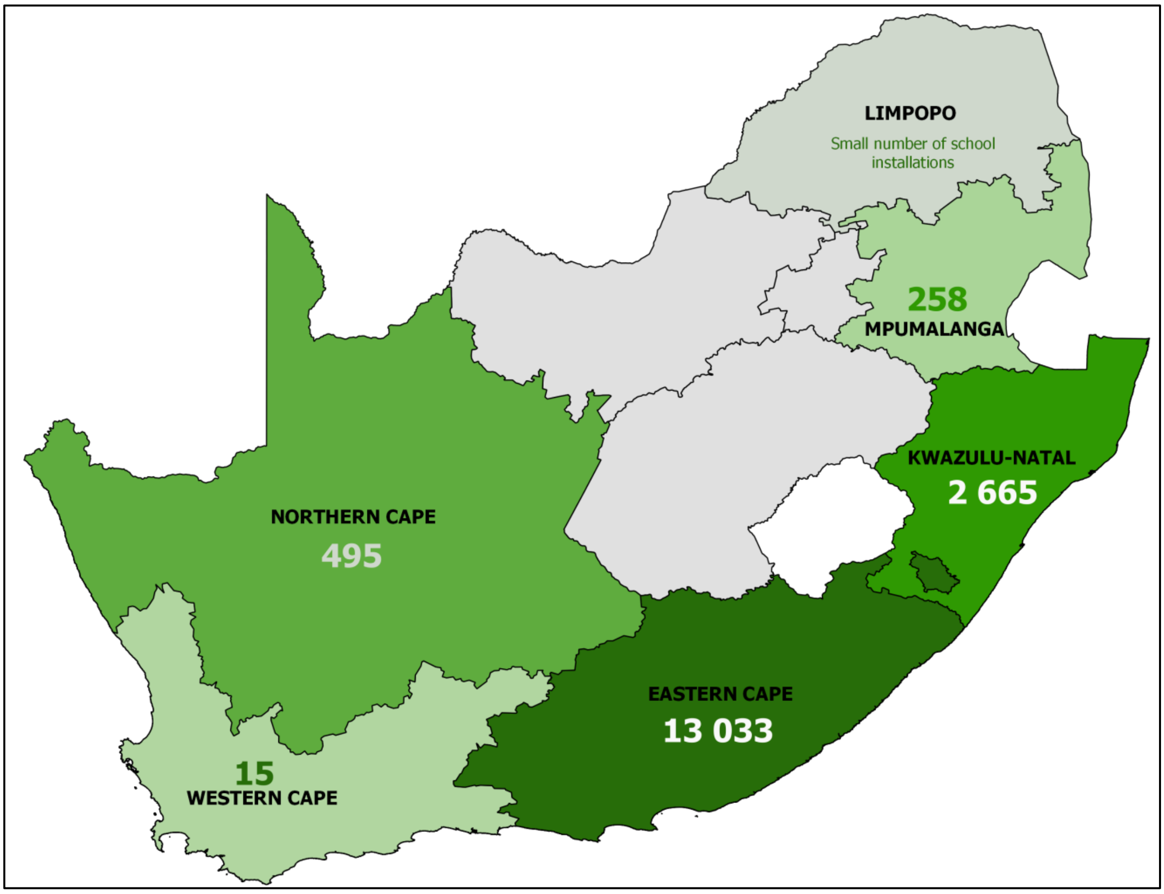


Figure 2: Pour flush installations in South African provinces

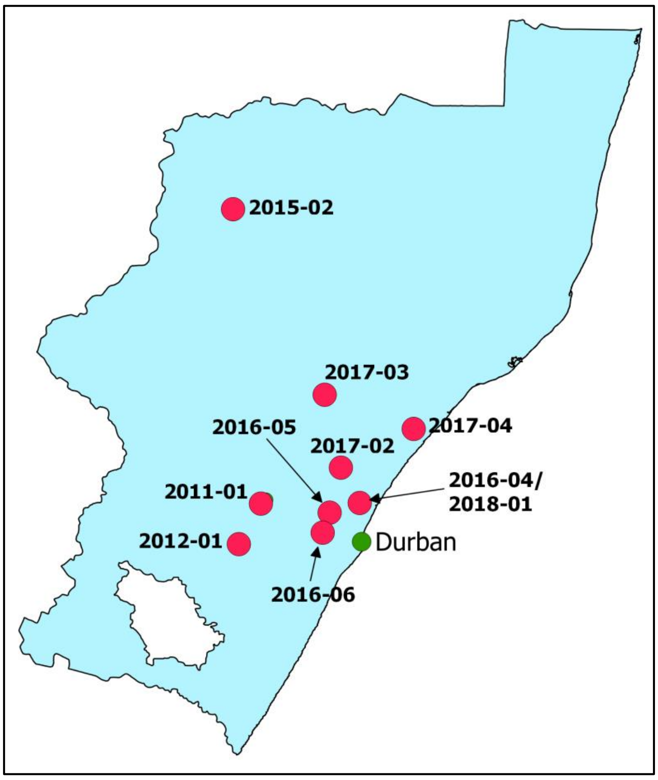


Figure 3: Pour flush installations in KwaZulu-Natal

As of July 2018, 2,065 pour flush toilets were installed in KZN at the domestic level. The status of the additional 600 planned for the Oakford Priory Reconstruction and Development Programme (RDP) housing project is unknown, since construction was delayed due to some negative feedback from local politicians. The pool of KZN installations includes the earliest WRC pilot projects of pour flush toilets as well as construction of 1,650 pour flush toilets in Ilembe District Municipality in 2017, which was completely funded by the municipality. The increasing uptake in KZN is likely due to the fact that the work originated in this province, including the beginning of commercial production of pour flush pedestals and P-traps by Envirosan, based in Durban. There are, however, many areas in KZN which have not yet considered pour flush. The large scale installation in Ilembe DM (2017-02, 2017-03, and 2017-04) is of particular interest, as this demonstrates initiative from a municipality without the promise of demonstration units.

Eastern Cape domestic pour flush installations are shown in Figure 4. As of July 2018, 13,033 domestic pour flush toilets were installed in the Eastern Cape, in addition to toilet blocks at 5 schools. The first set of 125 domestic pour flush units in Jerseyvale was constructed through the WRC as part of the same demonstration project which was carried out in Nellieville, KZN in 2015. WRC demonstration projects were also carried out in Bongolethu (Chris Hani DM, 150 units in 2016) and Mount Fletcher (Joe Gqabi DM, 122 units in 2017). In addition to the demonstration projects, Chris Hani District Municipality has demonstrated the greatest level of initiative to implement pour flush toilets using its own funding. Between 2015 and 2018, Cemforce installed approximately 12,246 single pit units at households in numerous villages in 4 of Chris Hani's local municipalities. Due to the large number of installations carried out in Chris Hani, these installations have a different code convention, with "CH" denoting Chris Hani, followed by a 2-letter code for each local municipality and a two-digit number.

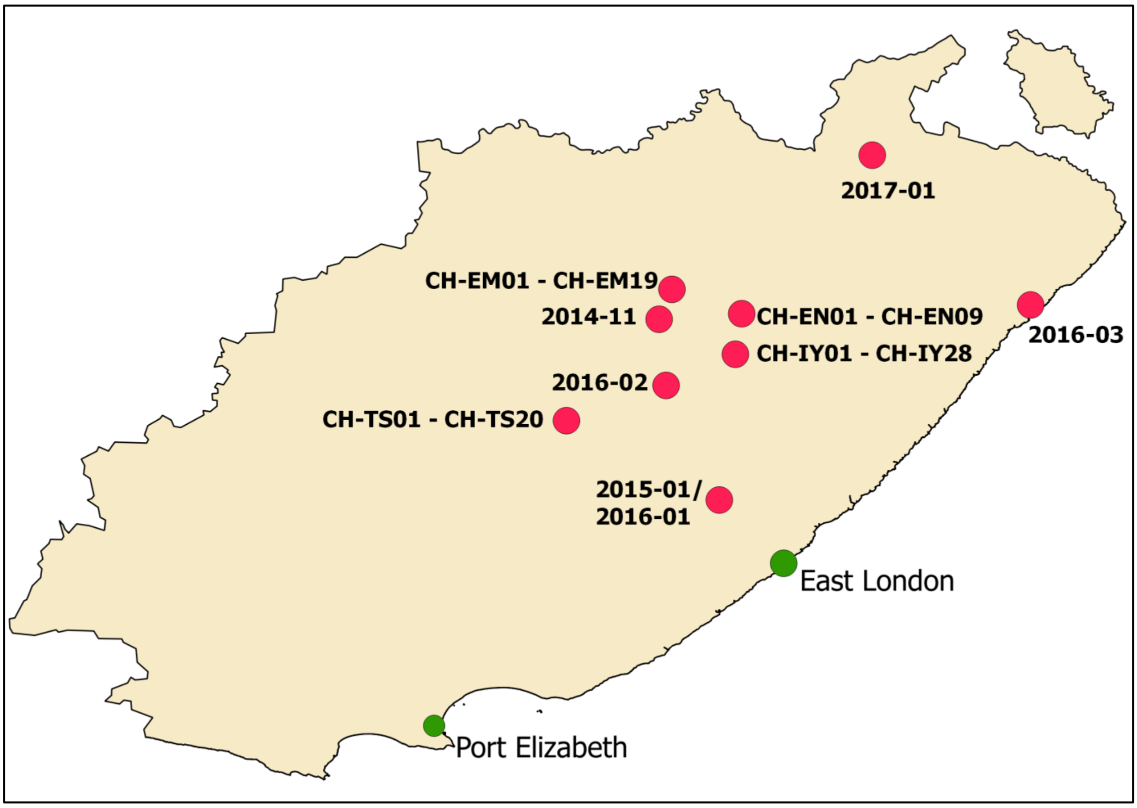


Figure 4: Pour flush installations in Eastern Cape

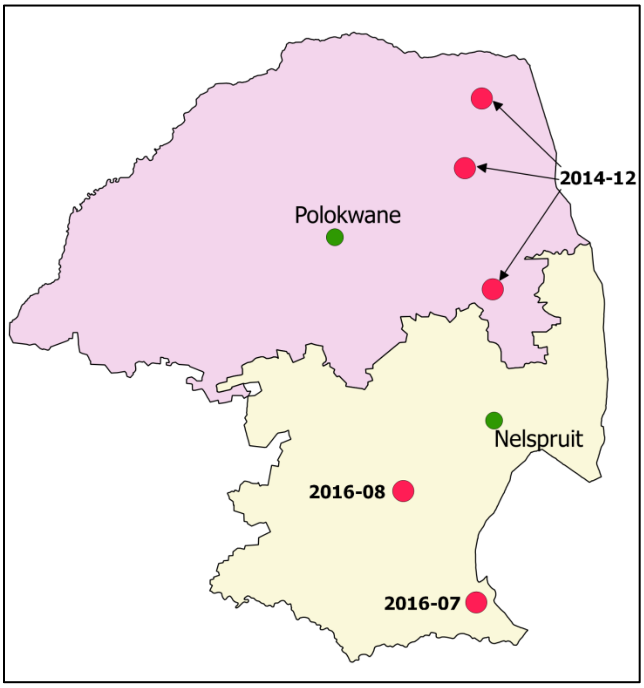


Figure 5: Pour flush installations in Limpopo Province (schools) and Mpumalanga Province (WRC demonstrations)

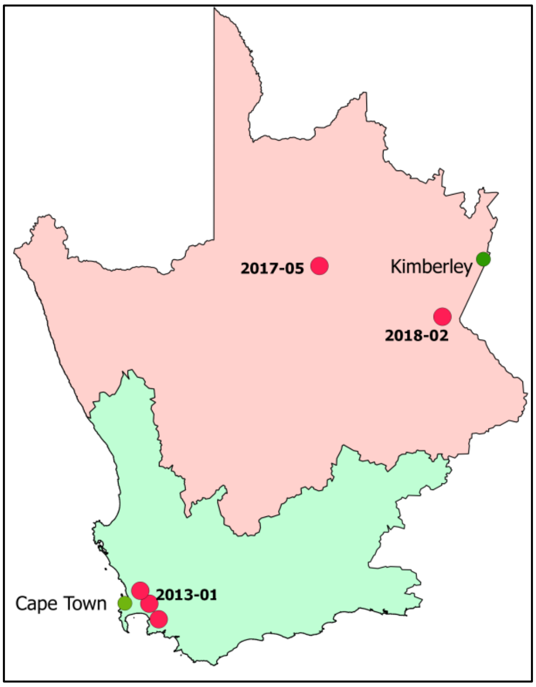


Figure 6: Pour flush installations in the Western and Northern Cape to date

Table 1: Pour flush installation database (as of August 2018)

REF. NUMBER	LOCATION	PROVINCE	DISTRICT MUNICIPALITY	PROJECT DATE	NO. POUR FLUSH UNITS INSTALLED	FUNDING SOURCE
2011-01	Greater Edendale	KZN	uMgungundlovu	2011	20	WRC
2012-01	Richmond	KZN	uMgungundlovu	2012	5	WRC
2013-01	Klipheuwel, Enkasini, Grabouw	WESTERN CAPE	Western Cape	2013	15	WRC
2014-11	Queenstown	EASTERN CAPE	Chris Hani	2014	5 schools	WRC
2014-12	Various	LIMPOPO	Vhembe, Sekhukhune, Mopani	2014	6 schools – 15 blocks, 44 toilets in total	DEA
2015-01	Jerseyvale	EASTERN CAPE	Amathole	2015	125	WRC
2015-02	Nellieville	KZN	Amajuba	2015	125	WRC
2016-01	Jerseyvale	EASTERN CAPE	Amathole	2016	150	WRC
2016-02	Bongolethu	EASTERN CAPE	Chris Hani	2016	150	WRC
2016-03	Port St Johns	EASTERN CAPE	OR Tambo	2016	240	Municipal
2016-04	Oakford	KZN	eThekwini	2016	90	WRC
2016-05	Molweni	KZN	eThekwini	2016	75	Municipal
2016-06	Mariannhill	KZN	eThekwini	2016	100	Municipal
2016-07	Piet Retief Area	MPUMALANGA	Mkhondo	2016	129	WRC
2016-08	Carolina area	MPUMALANGA	Chief Albert Luthuli	2016	129	WRC
2017-01	Mt Fletcher	EASTERN CAPE	Joe Gqabi	2017	122	WRC
2017-02	Ndwedwe (Wards 2, 9, 16)	KZN	Ilembe	2017	550	Municipal
2017-03	Maphumulo (Wards 2 and 8)	KZN	Ilembe	2017	550	Municipal
2017-04	Mandeni	KZN	Ilembe	2017	550	Municipal
2017-05	Wegdraai Village	NORTHERN CAPE	!Kheis	2017	120	WRC
2018-01	Oakford	KZN	eThekwini	2018 (in progress)	600	Municipal
2018-02	Hopetown	NORTHERN CAPE	Pixley Ka Seme	2018 (in progress)	375	Municipal

REF. NUMBER	LOCATION	PROVINCE	DISTRICT MUNICIPALITY	PROJECT DATE	NO. POUR FLUSH UNITS INSTALLED	FUNDING SOURCE
EMALALAHLENI LM, CHRIS HANI						
CH-EM01	Bongolwethu	EASTERN CAPE	Chris Hani	2015	547	Municipal
CH-EM02	Lower maqashu	EASTERN CAPE	Chris Hani	2016	404	Municipal
CH-EM03	Upper maqashu	EASTERN CAPE	Chris Hani	2016	772	Municipal
CH-EM04	Phelandaba	EASTERN CAPE	Chris Hani	2016	22	Municipal
CH-EM05	Tiwana	EASTERN CAPE	Chris Hani	2016	66	Municipal
CH-EM06	Tiwana Farms	EASTERN CAPE	Chris Hani	2016	5	Municipal
CH-EM07	Upper Mnxe - A	EASTERN CAPE	Chris Hani	2016	91	Municipal
CH-EM08	Upper Mnxe - B	EASTERN CAPE	Chris Hani	2016	172	Municipal
CH-EM09	Danatyiphu	EASTERN CAPE	Chris Hani	2016	255	Municipal
CH-EM10	Lahlangubo	EASTERN CAPE	Chris Hani	2016	90	Municipal
CH-EM11	Qithi	EASTERN CAPE	Chris Hani	2016	157	Municipal
CH-EM12	Siphafeni	EASTERN CAPE	Chris Hani	2016	22	Municipal
CH-EM13	Ndambane	EASTERN CAPE	Chris Hani	2017	145	Municipal
CH-EM14	Gadlume	EASTERN CAPE	Chris Hani	2017	135	Municipal
CH-EM15	Thaleni	EASTERN CAPE	Chris Hani	2017	48	Municipal
CH-EM16	Heluche	EASTERN CAPE	Chris Hani	2017	309	Municipal
CH-EM17	Waterfalls	EASTERN CAPE	Chris Hani	2017	48	Municipal
CH-EM18	Dedesiya(Tshamazimba)	EASTERN CAPE	Chris Hani	2018	155	Municipal
CH-EM19	Kwa Stocks	EASTERN CAPE	Chris Hani	2018	109	Municipal
ENGCOBO LM, CHRIS HANI						
CH-EN01	Hlophekazi	EASTERN CAPE	Chris Hani	2016	25	Municipal
CH-EN02	Majija	EASTERN CAPE	Chris Hani	2016	271	Municipal
CH-EN03	Madodase	EASTERN CAPE	Chris Hani	2016	56	Municipal
CH-EN04	Nginwayo	EASTERN CAPE	Chris Hani	2016	121	Municipal
CH-EN05	Tafeni	EASTERN CAPE	Chris Hani	2016	130	Municipal

REF. NUMBER	LOCATION	PROVINCE	DISTRICT MUNICIPALITY	PROJECT DATE	NO. POUR FLUSH UNITS INSTALLED	FUNDING SOURCE
CH-EN06	Ndungwana	EASTERN CAPE	Chris Hani	2016	117	Municipal
CH-EN07	Upper Luxeni	EASTERN CAPE	Chris Hani	2016	87	Municipal
CH-EN08	Lower Luxeni	EASTERN CAPE	Chris Hani	2016	26	Municipal
CH-EN09	Xhokonxa	EASTERN CAPE	Chris Hani	2017	36	Municipal
INTSIKA YETHU LM, CHRIS HANI						
CH-IY01	Mahlatini	EASTERN CAPE	Chris Hani	2016	350	Municipal
CH-IY02	Gcina	EASTERN CAPE	Chris Hani	2016	212	Municipal
CH-IY03	Mkhululani	EASTERN CAPE	Chris Hani	2016	148	Municipal
CH-IY04	Nyamankulu	EASTERN CAPE	Chris Hani	2016	159	Municipal
CH-IY05	Main	EASTERN CAPE	Chris Hani	2016	104	Municipal
CH-IY06	Mission	EASTERN CAPE	Chris Hani	2016	137	Municipal
CH-IY07	KwaMaya	EASTERN CAPE	Chris Hani	2016	138	Municipal
CH-IY08	Madlotsheni	EASTERN CAPE	Chris Hani	2016	131	Municipal
CH-IY09	Mahlungulu	EASTERN CAPE	Chris Hani	2016	82	Municipal
CH-IY10	Qolweni	EASTERN CAPE	Chris Hani	2016	68	Municipal
CH-IY11	Bulawayo	EASTERN CAPE	Chris Hani	2016	32	Municipal
CH-IY12	Elusizini	EASTERN CAPE	Chris Hani	2016	45	Municipal
CH-IY13	Majwareni	EASTERN CAPE	Chris Hani	2016	52	Municipal
CH-IY14	Mamfengwini	EASTERN CAPE	Chris Hani	2016	66	Municipal
CH-IY15	Maqwathini	EASTERN CAPE	Chris Hani	2016	187	Municipal
CH-IY16	Mfihlelweni	EASTERN CAPE	Chris Hani	2016	22	Municipal
CH-IY17	Mome	EASTERN CAPE	Chris Hani	2016	35	Municipal
CH-IY18	Dudumashe	EASTERN CAPE	Chris Hani	2016	246	Municipal
CH-IY19	Tshayelela	EASTERN CAPE	Chris Hani	2016	28	Municipal
CH-IY20	Nongqayi	EASTERN CAPE	Chris Hani	2017	29	Municipal
CH-IY21	Tsakana	EASTERN CAPE	Chris Hani	2017	438	Municipal

REF. NUMBER	LOCATION	PROVINCE	DISTRICT MUNICIPALITY	PROJECT DATE	NO. POUR FLUSH UNITS INSTALLED	FUNDING SOURCE
CH-IY22	Lubisi	EASTERN CAPE	Chris Hani	2017	223	Municipal
CH-IY23	Hala	EASTERN CAPE	Chris Hani	2018	178	Municipal
CH-IY24	Lower Seplan	EASTERN CAPE	Chris Hani	2018	401	Municipal
CH-IY25	Rwantsana	EASTERN CAPE	Chris Hani	2018	285	Municipal
CH-IY26	Qolweni	EASTERN CAPE	Chris Hani	2018	116	Municipal
CH-IY27	Zingquthu	EASTERN CAPE	Chris Hani	2018	215	Municipal
CH-IY28	Halalane	EASTERN CAPE	Chris Hani	2018	64	Municipal
CH-IY29	Ndungwana	EASTERN CAPE	Chris Hani	2018	69	Municipal
TSOLWANA LM, CHRIS HANI						
CH-TS01	Lower Zangqokhwe (PF)	EASTERN CAPE	Chris Hani	2015	37	Municipal
CH-TS02	Upper Zangqokhwe (PF)	EASTERN CAPE	Chris Hani	2016	138	Municipal
CH-TS03	Cimezile	EASTERN CAPE	Chris Hani	2016	226	Municipal
CH-TS04	Nonibe	EASTERN CAPE	Chris Hani	2016	344	Municipal
CH-TS05	Thornhill	EASTERN CAPE	Chris Hani	2016	368	Municipal
CH-TS06	Ensame	EASTERN CAPE	Chris Hani	2016	269	Municipal
CH-TS07	Machibini	EASTERN CAPE	Chris Hani	2016	419	Municipal
CH-TS08	Yonda	EASTERN CAPE	Chris Hani	2016	295	Municipal
CH-TS09	Madakeni	EASTERN CAPE	Chris Hani	2016	576	Municipal
CH-TS10	Lower Didimana	EASTERN CAPE	Chris Hani	2016	203	Municipal
CH-TS11	Mitford	EASTERN CAPE	Chris Hani	2017	75	Municipal
CH-TS12	Zola	EASTERN CAPE	Chris Hani	2017	149	Municipal
CH-TS13	Imvani	EASTERN CAPE	Chris Hani	2017	32	Municipal
CH-TS14	Khayelethu	EASTERN CAPE	Chris Hani	2017	11	Municipal
CH-TS15	Baldpoint	EASTERN CAPE	Chris Hani	2017	32	Municipal
CH-TS16	Eaderley	EASTERN CAPE	Chris Hani	2017	119	Municipal
CH-TS17	Khwezi	EASTERN CAPE	Chris Hani	2017	62	Municipal

REF. NUMBER	LOCATION	PROVINCE	DISTRICT MUNICIPALITY	PROJECT DATE	NO. POUR FLUSH UNITS INSTALLED	FUNDING SOURCE
CH-TS18	Springroove	EASTERN CAPE	Chris Hani	2017	84	Municipal
CH-TS19	Thembalethu	EASTERN CAPE	Chris Hani	2017	1	Municipal
CH-TS20	Tylden	EASTERN CAPE	Chris Hani	2017	125	Municipal

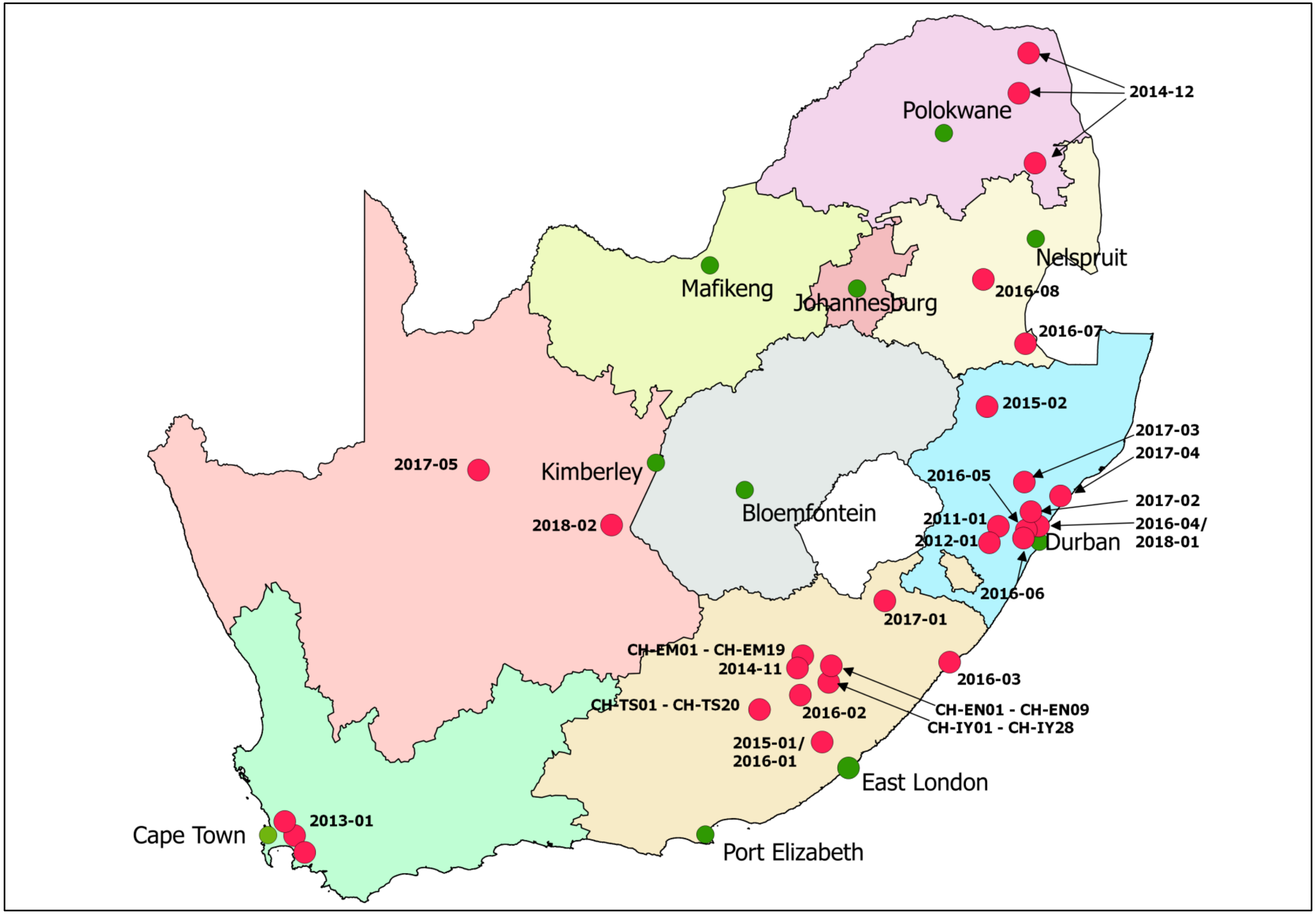


Figure 7: Pour flush installations in South Africa as of August 2018

3.1.1 Pilot units by Envirosan

Envirosan has to date installed upwards of 150 pilot pour flush and low flush units in various municipalities throughout South Africa. Most of these units were installed in municipalities as demonstrations for government officials wanting to see the technology in action. The hope is that these units will demonstrate the technology to communities that are unfamiliar with it so that they can adopt it. There are demonstration units in every province in South Africa.

3.2 Discussion on uptake of the technology over the first 7 years

Considering all installations of the pour flush since the initial WRC work to develop the technology for South Africa, uptake has steadily grown. Pour flush toilets have grown from an idea to a specified technology in government tenders over a relatively brief period, representing a small shift in the binary thinking of most officials in the country. The increasing uptake in South Africa is likely the result of a number of factors, including but not limited to: backing of the technology by businesses, such as Envirosan and Cemforce, who have invested considerable amounts of time and funding in marketing; some success of demonstration projects; and simply the need to find alternative solutions where the old ways of doing things have proven unsuccessful or unacceptable.

There are a few different ways to look at the degree of uptake of pour flush toilets in South Africa. Figure 8 displays the number of domestic pour flush toilets installed between 2011 and 2018. As shown in Figure 9 the total number of pour flush units in South Africa at the end of 2018 was approximately 16,466. Adoption of pour flush toilets has steadily risen since the initial pilots and demonstration projects. While the initial increase represents larger demonstration projects by the WRC, there is a good mix of installations in 2016 and 2017 that were also municipal-funded, as well as all projects happening in 2018. This is demonstrated in Figure 10 and Figure 11. Outside of KwaZulu-Natal and Eastern Cape, only one other municipally-funded project is known: the current project in Hopetown in the Northern Cape, which includes 375 households. There has been, however, considerable uptake of low flush technology, particularly in the Western Cape, but this is not included in this discussion.

Furthermore, the spread of pour flush toilets spatially is shown in Figure 12. This graph demonstrates how pour flush toilets have spread from the first demonstration in Msunduzi Local Municipality in KwaZulu-Natal to 14 different municipalities in 5 provinces. This graph does not account for the dominance of particular provinces or municipalities, but it does demonstrate that information about pour flush toilets is gradually being disseminated to a wider audience of provincial and municipal officials across South Africa. In 5 provinces in South Africa, there is an opportunity for decision makers to witness a relatively large scale installation of pour flush toilets in their province and possibly even in their municipality. While this only includes relatively large installations of pour flush toilets, it does not account for the fact that Envirosan has also installed single demonstration units across all provinces in South Africa, providing even more access for decision-makers to see this technology in action.

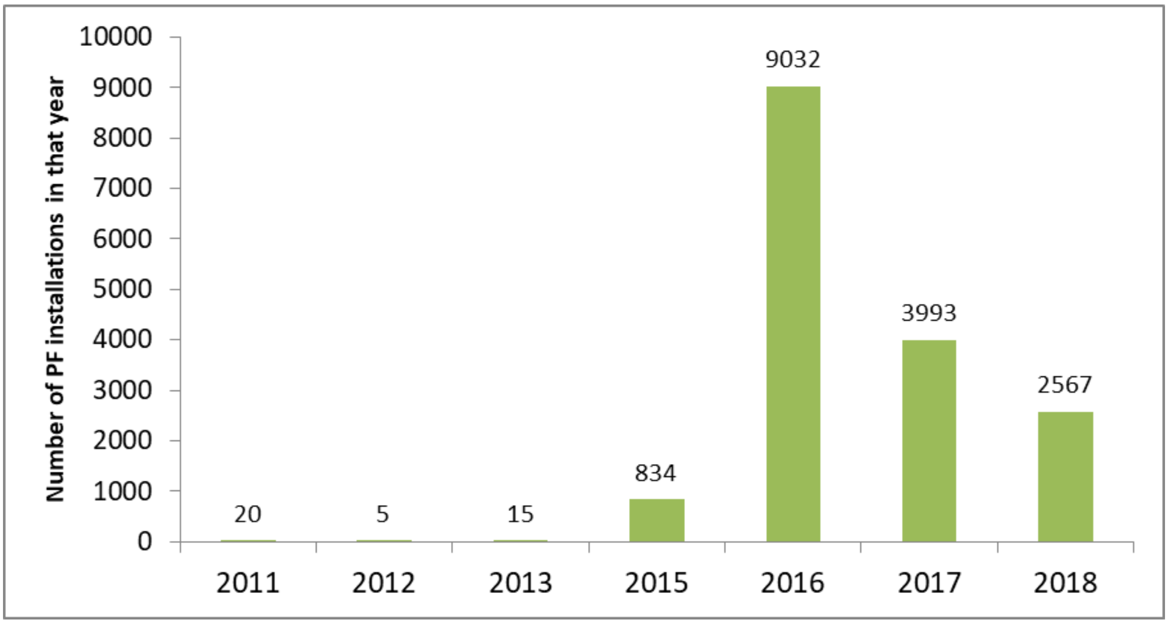


Figure 8: Number of domestic pour flush units installed per year throughout South Africa

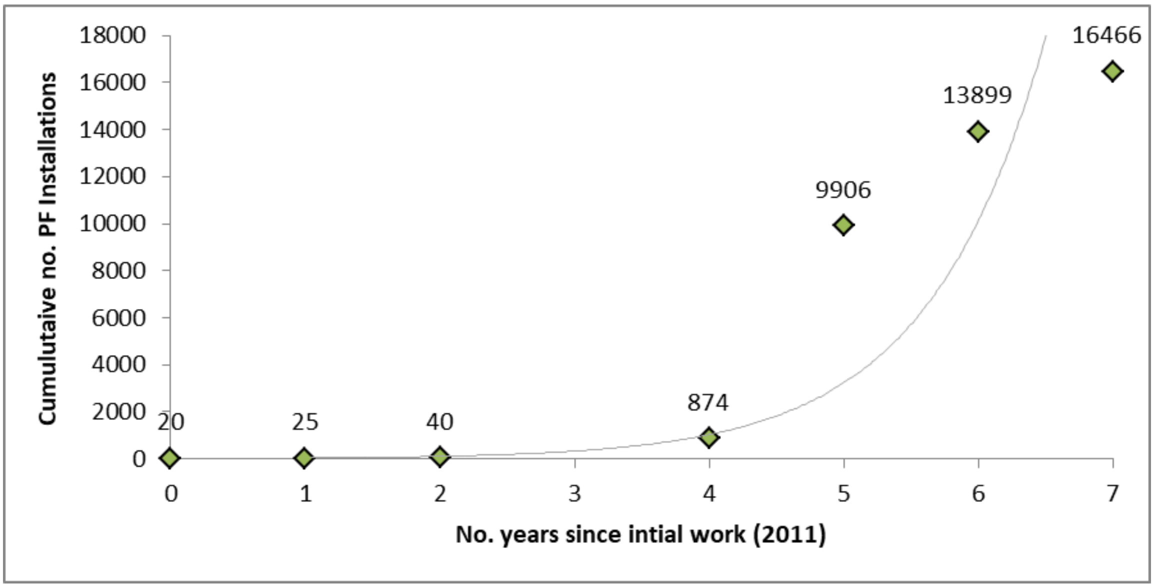


Figure 9: Cumulative numbers of domestic pour flush toilets in South Africa since the first installations in 2011

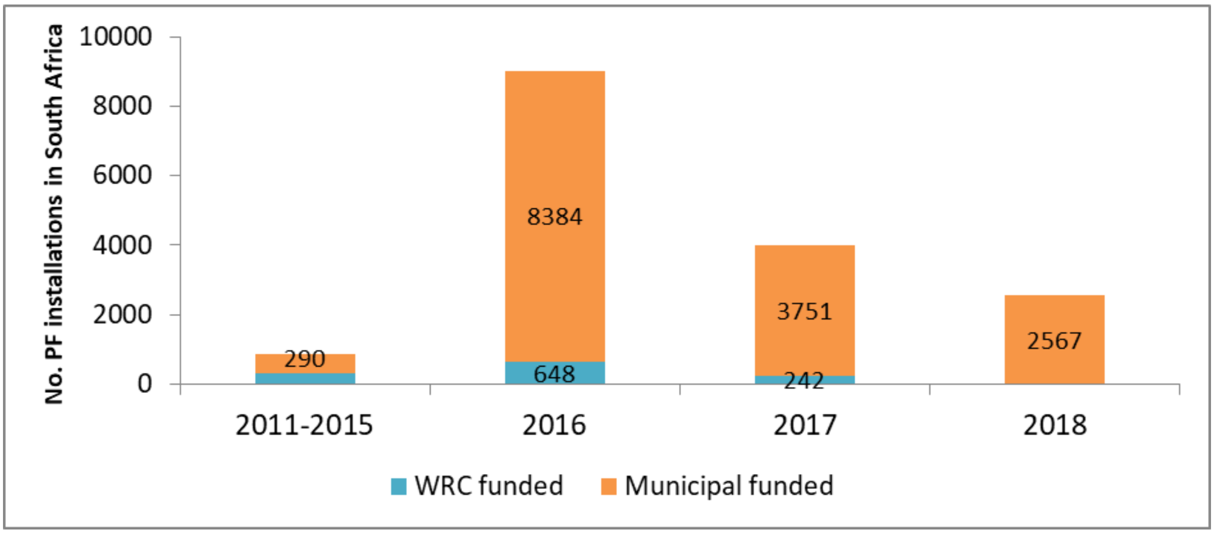


Figure 10: Funding sources for various domestic pour flush projects in South Africa

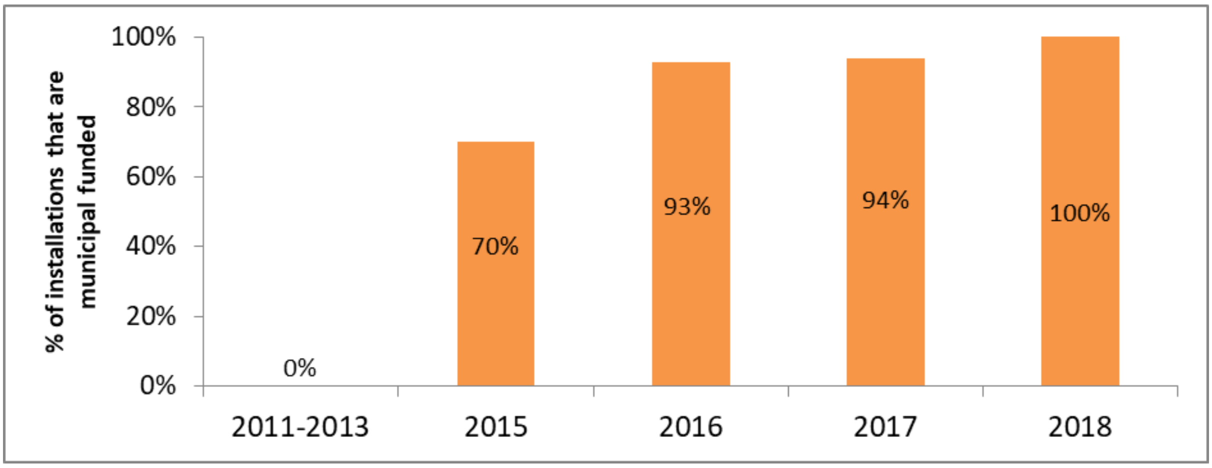


Figure 11: Percentage of domestic pour flush installations in South Africa funded by municipalities

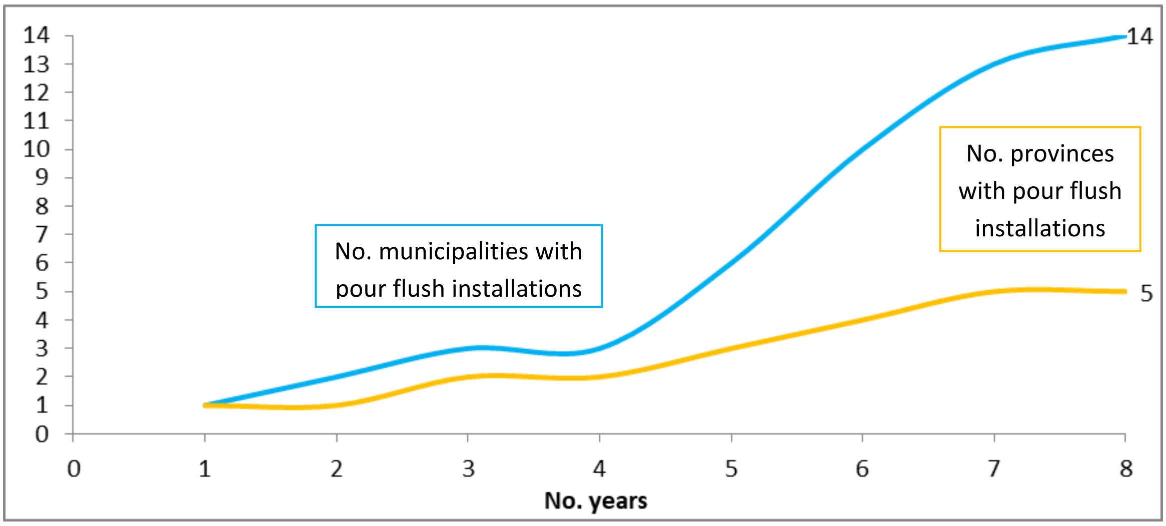


Figure 12: Spread of larger-scale pour flush toilet installations across provinces and municipalities in South Africa over time

Though single demonstration units are still under construction as necessary by companies promoting the technology, large-scale demonstrations of pour flush toilets plateaued in 2017 at 1180. These demonstrations were carried out in 5 provinces: most prominently in Eastern Cape and KwaZulu-Natal but also in Northern Cape, Mpumalanga, and Western Cape. Municipalities began taking the initiative to fund pour flush projects in 2015, four years after the initial small-scale pilot projects in KwaZulu-Natal. Figure 13 shows the growth of municipal-funded pour flush projects from 2015 to 2018, demonstrating relatively constant growth of the technology since the demonstrations. A linear curve has been fitted to this data to project the continued growth of pour flush implementation in South Africa over the coming years. This projection is shown to year 2031 in Figure 14. It is important to note that this trajectory will be greatly impacted by a number of things including: pace of backlog-eradication programmes with other technology options; the success of pour flush toilets; effectiveness of marketing; and technical capacity of municipalities to specify pour flush toilets.

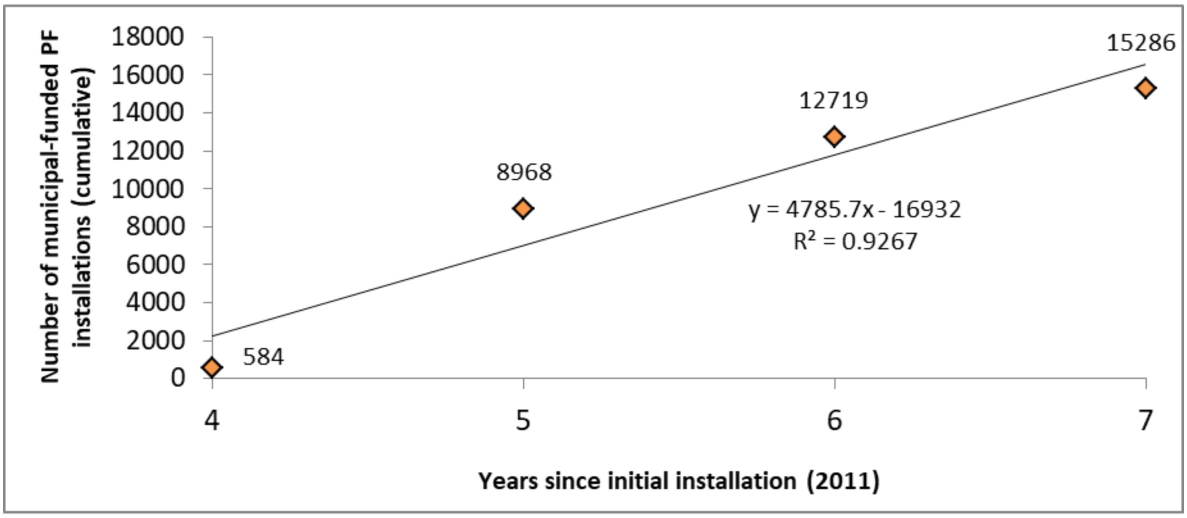


Figure 13: Cumulative number of municipal-funded domestic pour flush installations over time

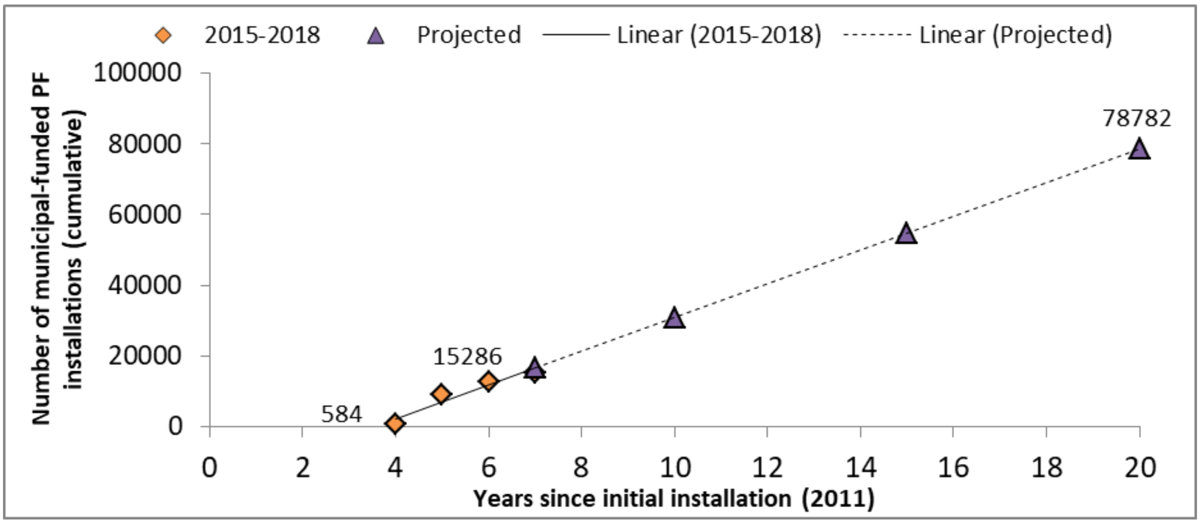


Figure 14: Projected growth of pour flush toilets based on growth between 2015 and 2018

The municipal-funded pour flush projects are made up of a mix of municipalities which received initial pilot projects and those that did not. To date, the only two municipalities that have large-scale demonstrations and municipal-funded initiatives are eThekwini Municipality and Chris Hani District Municipality. eThekwini received 90 pour flush demonstration units in an RDP development in Oakford. eThekwini has also installed units on their own initiative in Molweni (75) and Marianhill (100). These were installed in the same year as the Oakford demonstration units, and therefore, it does not appear that the Oakford demonstration units impacted the decision making on the Molweni/Marianhill project. Chris Hani District Municipality had a total of 12,396 pour flush toilets in July 2018, 95 percent of all pour flush toilets in the Eastern Cape. Only 150 of these units were demonstration units installed in 2016, thus demonstrating a significant investment by Chris Hani DM in pour flush toilets. Aside from Chris Hani and eThekwini, the following municipalities received large scale demonstrations but have not yet specified pour flush toilets in their municipal sanitation programmes: Amathole DM, Amajuba DM, Mkhondo DM, Chief Albert Luthuli DM, Joe Gqabi DM, and !Kheis DM.

Equally interesting and important is the number of municipalities that have pursued pour flush without having received a large-scale demonstration project. These projects include a large scale project (1650) in Ilembe District Municipality; 375 units installed in Hopetown (Northern Cape) in 2018; and 240 units installed in OR Tambo DM (Eastern Cape) in 2016.

4 Introduction to data collection locations

This section provides a description of the various projects and locations where data was collected from households. This provides context to the data reported in the following section and describes specific challenges encountered in the various locations. A summary of the locations and data points collected is provided in Table 2.

Table 2: Summary of household data collection

Project location	Household Interviews	PF Inspections	Sludge measurements
Vulindlela, KZN	10	10	3
Amajuba District Municipality, KZN	101	99	66
Jerseyvale, Eastern Cape	95	95	68
Bongolethu, Eastern Cape	129	129	34
Mt Fletcher, Eastern Cape	68	68	5
Mkhondo and Chief Albert Luthuli DMs, Mpumalanga	60	60	51
Mariannhill and Molweni, KZN	38	38	17
Oakford, KZN	29	29	9
Ilembe DM, KZN	24	24	0
Thornhill, Eastern Cape	41	41	0
Port St John's, Eastern Cape	44	44	16
OVERALL	**639**	**637**	**269**

4.1 Msunduzi LM, KwaZulu-Natal

A number of units were built during the initial pour flush development near Pietermaritzburg (KZN), including 15 in Msunduzi Local Municipality and 5 in Richmond Local Municipality. At the time of the assessment, these units were 8 years old and thus represent the longest-term installation and test for the success of pour flush toilets. These projects included mostly households as well as one church and one primary school. The construction also included a mix of double and single pit systems, though double pit systems were most common. Of the units in the Msunduzi area, 10 were visited and assessed. One has since been demolished and 2 were not locatable. Furthermore, one unit installed at a church was locked during the visit, and the lock appeared rusted, suggesting that the toilet had not been in use for some time. All 10 where inspections and interviews were carried out are all still in use.

Figure 15: Pour flush unit in Msunduzi

Figure 16: Dirty pour flush toilets in Msunduzi

Figure 17: Unit in Azalea before (left) and after (right) upgrade to low flush unit

Figure 18: Pedestal from demolished unit in Msunduzi

4.2 Nellieville, Amajuba DM, KwaZulu-Natal

The first set of data was collected in Nellieville, Amajuba District Municipality (KZN), as this was the site of the first medium scale installation of pour flush toilets in South Africa. The 150 units were built in 2015 by PID and local sub-contractors, through funding from the Department of Science and Technology (DST) (in partnership with the WRC). This data collection exercise not only provided a large data set (101 interviews in total) but also provided an initial test of the data collection materials and logistical challenges. One challenge in this area was locating the pits for measurements as well as uncovering them, as the pits were covered by a layer of soil which had subsequently been covered by grass. Local labour was hired for this purpose, but this did demonstrate that opening pits for measurements could potentially require more time than initially anticipated. From this experience the goal for each subsequent site visited was to collect pit measurements at only half of the toilets assessed.

Furthermore, this set of data demonstrated some areas in which the survey was lacking. For instance, some questions with a list of possible answers did not include some common answers and thus these were added in later versions of the survey. On the question about water usage for flushing, more options were added to the volumes of water used in order to better capture the variety of reported answers.

Overall, usage of the pour flush toilets in Nellieville is high, though many users expressed a lack of knowledge about how the toilets actually work. Some were unaware that they had two pits, let alone that they could switch the pipework once the one pit filled up. One additional concern was the small number of users who had converted their toilets to full flush toilets, when the leach pits have not been designed for full flush toilets. The water usage in these toilets is undoubtedly higher.

Figure 19: Standard pour flush units in Nellieville

Figure 20: Excess soil and grass removed from pit cover slab for opening

Figure 21: Worker removing pit cover slab for measurements

4.3 Jerseyvale, Eastern Cape

In 2016, 150 twin pit pour flush toilets were constructed in Jerseyvale in Amathole District Municipality in the Eastern Cape, as part of the initial medium-scale WRC pilot project. The top structures were built of precast concrete panels, and the leach pits were built with precast concrete rings. Handwashing units were made using 2-litre bottles and installed on the outside of the toilet cubicles. Reported usage of the pour flush toilets was relatively high, with 86% of households (82/95) saying that their pour flush is in use. Seventy-six percent of households have another toilet on site, with a vast majority reporting this as a home-built pit toilet. In general, those who do not use their pour flush toilet are waiting for their pit toilet to fill up first.

Figure 22: Typical pour flush construction in Jerseyvale

Figure 23: Typical leach pit design in Jerseyvale

4.4 Bongolethu, Chris Hani DM, Eastern Cape

The Bongolethu area in the Chris Hani District Municipality has 597 pour flush units that were all built in 2015/2016. Most of these (447) are single pit units built by Cemforce (the "Cemflush"), while 150 are twin pit systems also built by Cemforce but through funding from the DST (in partnership with the WRC). In this area, the single and twin pit units are evenly spread throughout the community, and the units are much closer together than in other areas. This made travelling between households efficient.

Despite some resistance from participants (Xhosa-speaking) to talk with the researchers (Zulu-speaking), people were generally cooperative and there were no barriers to understanding the questions and answers.

The Cemflush single pit units are built such that the top structure sits directly above the pit. Despite there being a slab extending from the back of the toilet, there is no access point to the pit without removing the pedestal. The long-term plan with these units is for the entire top structure to be moved to another location on the property when the pit fills up. This may not be sustainable in the long run as space becomes more limited. Additionally, if households prefer to have their pit emptied, they must either remove the pedestal or break the slab at the back of the toilet. From a data collection point of view, this meant that the researchers could not measure sludge depth without damaging (and subsequently repairing) the toilet slab. Thus, it was decided that only twin pit systems in Bongolethu would be measured, as the cover slabs were easily accessible.

In some parts of Bongolethu, leach pits become flooded during large rain storms. In certain instances, this had led to overflowing pits. One householder complained about their pit overflowing, only to discover when the cover was removed that the pit was completely full. Luckily, this unit was a twin pit system and the research team assisted in switching the pipework. However, it is clear that many householders were not aware of the maintenance needs of pour flush and, furthermore, many do not feel that they should be responsible for maintenance needs such as switching the pipework, emptying the pits, or moving the top structure.

Figure 24: Standard pour flush unit in Bongolethu

Figure 25: Single pit (left) and twin pit (right) pour flush units with pit cover slabs

Figure 26: Household tap installed adjacent to pour flush unit

Figure 27: Decorated pour flush unit in Bongolethu

Figure 28: Researchers assisting a householder to switch to the unused pit

4.5 Mt Fletcher, Eastern Cape

In 2017, 122 pour flush toilets were built in Mt Fletcher in Joe Gqabi District Municipality as part of a WRC project. The toilets installed here utilised goose neck shaped p-traps made of fibreglass, following more closely the p-trap design used during the initial WRC research project. The cubicles in this project were larger than typical household systems in order to accommodate an indoors handwashing station. The outlet pipe from the handwashing basin is directed into the bucket of flushing water to encourage water recycling. During construction of these units, the groundwater level in the area was high, and this was confirmed during the monitoring visits, in which many pits were full of groundwater.

Figure 29: Typical pour flush installation in Mt Fletcher, complete with handwashing basin

Figure 30: Top structures built at Mt Fletcher

Most households with pour flush toilets in Mt Fletcher also have multiple other toilets on site, which has led to overcrowding of relatively small yards, as shown in Figure 31. At the time of construction, most households in the project had an unimproved pit toilet on site and the pour flush was the second toilet constructed. During monitoring, it was confirmed that most households received new VIP toilets since the 2017 construction of pour flush toilets. This municipal programme led to confusion among some householders as to whether they should be using the pour flush toilets. Only 40% of interviewed households (27/42) indicated that their pour flush toilet is currently in use. Eight households said that they were waiting until their pit toilet filled up to start using either of the new toilets, as one household reported that pit toilets were emptied by the municipality in 2016 for free. Furthermore, a few households reported water challenges and a lack of motivation to fetch water for flushing.

Figure 31: Three toilets installed for one household, thus overcrowding the household yard

4.6 Mkhondo and Chief Albert Luthuli, Mpumalanga

In 2016, the WRC funded 129 pour flush toilets in Mkhondo Local Municipality and 129 pour flush toilets in Chief Albert Luthuli Local Municipality, both located in Mpumalanga province. These toilets were also part of the second round of domestic installations carried out by the WRC, in addition to Mt Fletcher described above. All households in this project are located in rural areas where water is either supplied by a borehole or delivered by a tanker. This installation utilised twin pits, with the same larger structure and handwashing system used at Mt Fletcher.

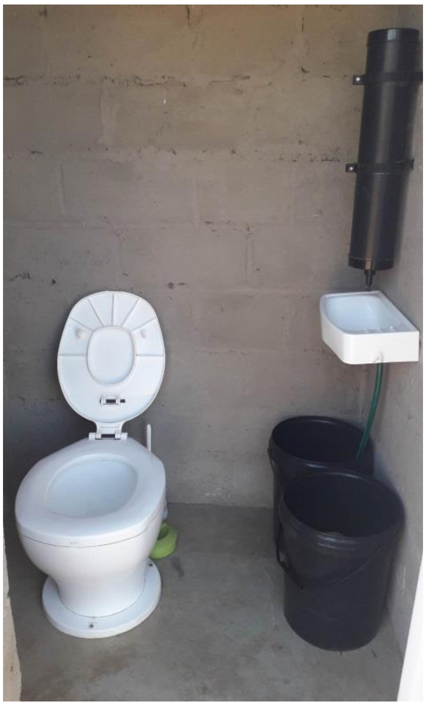


Figure 32: Typical pour flush installation in Mkhondo/Chief Albert Luthuli

All interviewed households in Mpumalanga reported that their pour flush toilet is in use, which is consistent with the apparent reliability of water. No families indicated that they ever go without water, despite the primary sources of water being communal taps, boreholes, surface water, and delivery by tankers. Furthermore, unlike in Mt Fletcher, only 22% of interviewed households indicated that they have another toilet on site, all of which ware home-built pit toilets.

4.7 Mariannhill and Molweni, eThekwini, KwaZulu-Natal

In 2016, 175 single pit pour flush units were installed in Mariannhill and Molweni (Wards 9 and 14) in eThekwini (KZN). This was a municipal programme in which Rocla and Conloo were contracted for construction. The toilets are scattered over the wards, but as Envirosan was involved in the construction an Envirosan representative assisted the researchers to locate the units. Though these are single pit systems, the pits are offset from the superstructures, unlike the Cemflush version described above. This meant that the researchers could open some pits to take measurements. Data was collected from only 38 households here due to the difficulty of locating the pour flush toilets.

Figure 33: Standard pour flush unit in Mariannhill

Figure 34: Unit in Mariannhill with child friendly seat

Figure 35: Pit cover slabs and a leak from the pit

4.8 Oakford, eThekwini, KwaZulu-Natal

In 2016, an RDP housing area was constructed in Oakford, north of Durban (KZN). The specified technology for these units was pour flush toilets, located inside the home, complemented by a greywater recycling system. PID constructed the first 90 units and trained a local contractor to finish the remaining units.

This is an interesting case study, given that this was a brand new housing development where each household has only one sanitation system. Although the choice of the system was approved by community representatives prior to commencement (after seeing pour flush toilets in Edendale), residents later complained that they did not get full flush toilets with cisterns in their new houses. eThekwini had been unwilling to provide full waterborne sanitation due to the high cost, and to the fact that the area was subject to water supply constraints. Thus, even with pour flush toilets which use less water, some householders are forced to use public mobile toilets provided by the municipality.

During data collection, some challenges were faced with locating pits and measuring sludge depth. Firstly, householders were not present during the construction of their toilets and did not know where the pits were located. The markers set in place to indicate the pit locations had been removed. Some pit covers were covered as deep as 500 to 700 mm by soil after site landscaping was done subsequent to the completion of the toilets. In other cases, households have paved over their pits due to a lack of knowledge about the pit location, making the pits inaccessible without breaking the pavement.

During data collection, it was especially difficult to find people in this area to interview, as many were at work. This was a challenge in many areas and is simply the result of collecting data during normal working hours.

Figure 36: Pour flush unit in Oakford

Figure 37: New pedestal and cistern installed at Oakford (full flush conversion)

4.9 Ilembe District Municipality, KwaZulu-Natal

In 2017, 1 650 pour flush units were built in the Ilembe District Municipality. This includes 550 each in Ndwedwe, Maphumulo, and Mandeni. After struggling to make contact with the councillors, researchers visited 10 houses in Maphumulo and 14 houses in Mandeni for a total of 24 in Ilembe DM.

Most of the municipality consists of rural settlements with dispersed settlements. Large distances between houses made data collection inefficient. The area does not have a potable water supply. There are pipes in the ground and communal standpipes, but water has not yet been made available. Thus, people fetch water from the local river for domestic use. The lack of water supply in the area means that households with pour flush toilets often resort to open defecation. This is not good for public health due to the community's reliance on the local river for all household uses, including consumption, and the location of the settlement in a valley with large catchment areas on both sides. Open defecation likely leads to pollution of this water source and can contribute to diarrhoeal disease in the area. It would be far better for householders to use VIP toilets than to resort to open defecation.

Figure 38: Photo of the valley at Maphumulo

Two types of pour flush toilets were constructed in this area. All toilet structures are built of precast concrete, and the toilets are either connected to a septic tank and soak pit or pits lined with concrete blocks. Some toilets have an external water tank connected to the cistern in the toilet, but these tanks are not full since there is no water supply. Cisterns were installed by the contractor even though there is no water in the area. This was a decision made by the municipality, due to future plans to connect the area to a water supply.

Approximately 50% of people in the area were not yet using their pour flush toilets for different reasons, including:

1) Some say they are still using VIP toilets and they will only switch to the pour flush toilet when their VIP is full.
2) Some use the bush (open defecation) since they are not used to the toilets and do not have a piped water supply.

Figure 39: Standard pour flush unit in Maphumulo

Figure 40: Single pit units in Maphumulo

Figure 41: Septic tank + soak pit pour flush unit in Maphumulo

Figure 42: Access road in Maphumulo

4.10 Thornhill, Eastern Cape

In 2016, Cemforce constructed 368 single-pit pour flush (Cemflush) toilets as part of a municipal sanitation programme in Thornhill, located in the Chris Hani District Municipality in the Eastern Cape. These toilets have the typical Cemflush construction, with the top structure located directly above the single pit. Usage of pour flush toilets in Thornhill was relatively low, with only 40% of interviewed households (16/41) confirming that the pour flush toilet is in use. In some cases, this was due to the presence of old pit toilets on site, and in others, this was due to lack of water or dissatisfaction with the construction.

Figure 43: Typical pour flush toilet in Thornhill

4.11 Port St John's, Eastern Cape

In 2016, 240 single pit pour flush toilets (Eaziflush) were constructed in Port St John's in the Eastern Cape as part of an OR Tambo DM sanitation project. These single pit toilets have off-set single pits. Ninety-one percent (40/44) of householders interviewed said that their pour flush toilet was in use. This is a positive outcome, especially given that the primary water sources in the area are communal taps and rainwater (for houses located too far from communal taps). Though 64% of interviewed households said that they sometimes do not have water, the households demonstrated resilience, with 7 saying they use greywater to flush and 5 saying they use rainwater to flush.

Figure 44: Typical pour flush toilet in Port St John's

Figure 45: Single leach pit in Port St John’s

5 Results

This chapter presents the general outcomes of the study across all communities visited. Case studies from each location are provided in the appendices and can be utilised by municipalities to assess the success of pour flush toilets in their specific location. As shown above, data was collected at 629 households in 11 project locations, distributed between three different provinces. This included a mixture of single pit and twin pit systems, municipal and pilot projects. Any low flush or full flush toilets included in the assessment were those that were converted by the householders.

Table 3: Toilet types in each area surveyed

Location	Pour flush	Low flush (converted)	Full flush (converted)	Single pit	Twin pit
Vulindlela, KZN	8	2	0	3	7
Nellieville, Amajuba District Municipality, KZN	95	2	4	0	101
Jerseyvale, Eastern Cape	95	0	0	0	95
Bongolethu, Eastern Cape	123	4	2	88	41
Mt Fletcher, Eastern Cape	68	0	0	0	68
Mkhondo and Chief Albert Luthuli DMs, Mpumalanga	59	0	1	0	60
Mariannhill and Molweni, KZN	38	0	0	38	0
Oakford, KZN	16	11	2	1	28
Ilembe DM, KZN	17	7	0	24	0
Thornhill, Eastern Cape	40	0	1	41	0
Port St John's, Eastern Cape	44	0	0	44	0
TOTAL	**603**	**26**	**10**	**239**	**400**

5.1 Use of pour flush toilets

Overall, usage of pour flush toilets was high, with 84% (537/639) of households reporting that their pour flush toilet was in use. In a majority of communities, this percentage was in excess of 90%; however, in both Mt Fletcher (n=68) and Thornhill (n=41), reported usage was only 39%, as shown in Figure 46. When considering usage, it is important to note that data collection may have been biased towards households that were using their pour flush toilets, even though fieldworkers were asked to conduct household interviews even if the toilets were not in use. For example, during the first visit to Ilembe DM, only households using their toilet were interviewed. Thus, the relatively large number of households visited that were not using their toilets is not included in the data below. It is estimated that during the first visit to Ilembe DM, 10 out of 20 of the households visited were not using their pour flush toilets due to water shortages in the area.

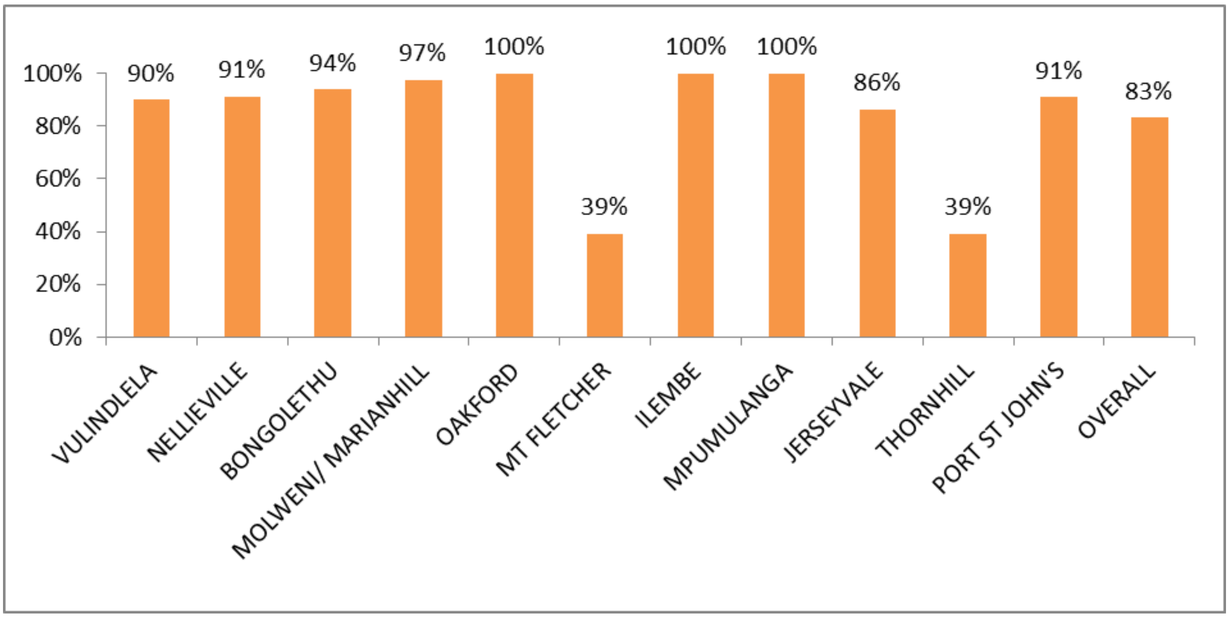


Figure 46: Usage of pour flush toilets in each area surveyed

5.1.1 Other toilets on site

Households were asked to report on whether they had other toilets at their house, which was confirmed during inspections. This information helped to understand people's preferences for pour flush toilets and behaviours around usage. Overall, 56% of households (304/547) have another type of toilet on their property. This was most often a home-built pit toilet (38%), but also included VIP toilets (15%) and full flush toilets (3%). Of those who have another toilet on site, 49% (149/304) said that they use the pour flush toilet 100% of the time. In many cases, households with pour flush and a dry sanitation option resort to using the dry sanitation option when there is no water available.

This reality varied widely across the different project locations visited, as shown in Figure 47. Mt Fletcher was the community with the highest percentage of households with more than one toilet on site, and the majority of those were VIP toilets. Large percentages of households in Amajuba, Jerseyvale, and Thornhill also had other toilets on their property, though the majority of those were home-built pit toilets. As discussed above, use of pour flush toilets in Mt Fletcher and Thornhill was relatively low, which could be partly due to the availability of other options on site, compounded with water scarcity.

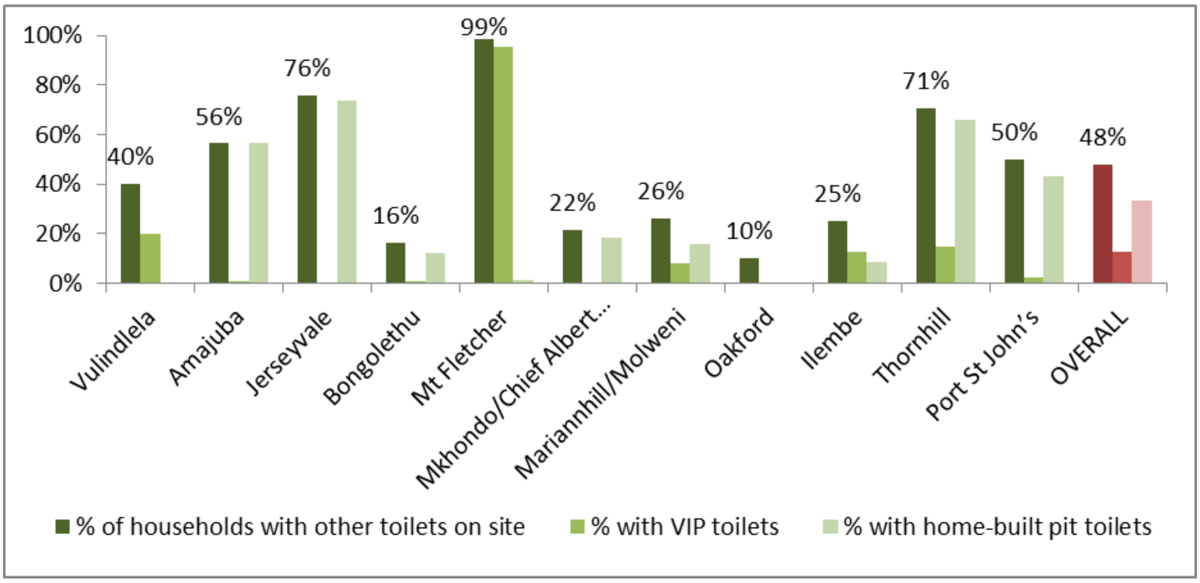


Figure 47: Households with other toilets on site, for each location

5.1.2 People who don't use the toilet

Participants were asked to report on any household members who do not use the pour flush toilets in order to understand ways in which pour flush toilets exclude users. Overall, 34% (184/547) of respondents said that there are people in their household who do not use the pour flush toilet. As shown in Figure 48, babies, children, and adults are the most likely to not use the pour flush toilet. For babies and children, this is usually because they are too young to use the toilet properly. Some children may be big enough to use the toilet, but they do not want the responsibility of filling a bucket and carrying water to the toilet. Most adults who do not use the pour flush toilet do so out of preference for their other options (usually VIP), unwillingness to carry water to the toilet, or the fact that they can see their faeces before they flush the toilet. Typically, lack of use among elderly users is due to ergonomics of the pedestal (i.e. too low to sit comfortably on) or unwillingness or inability to carry water to the toilet.

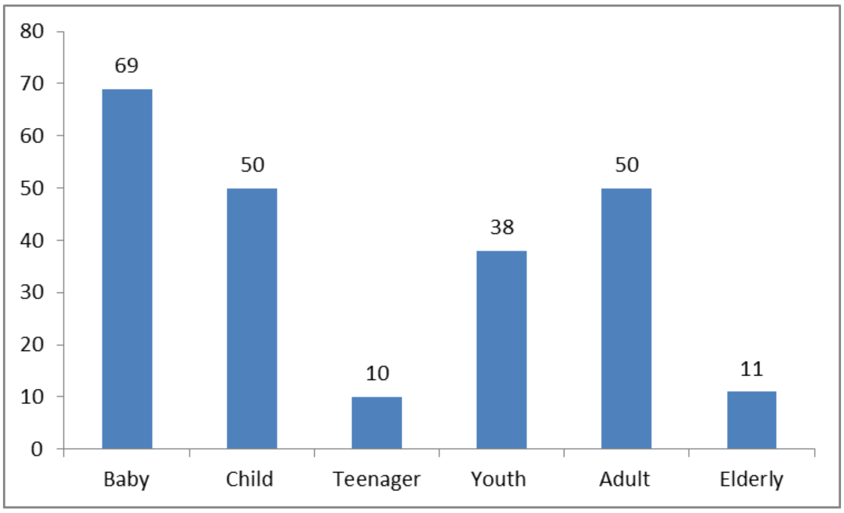


Figure 48: Householders that do not use the pour flush toilet

5.2 User feedback on the technology

In general, pour flush toilets are widely accepted among the communities visited in this study, with 87% (476/547) users saying that they would recommend pour flush toilets to other people. The main reasons that people like pour flush toilets are presented in Figure 49. Notably, 64 users (12%) said that there is nothing they like about pour flush toilets. This appears consistent with the percentage (~13%) of people who said that they would not recommend pour flush toilets to other people. The results in Figure 49 and Figure 50 paint similar pictures about what is preferable about pour flush toilets, with responses commonly focusing on safety, ease of use, cleanliness and lack of odours. Interestingly, a relatively large percentage of respondents also said that they would recommend pour flush toilets because they are "better than VIP toilets".

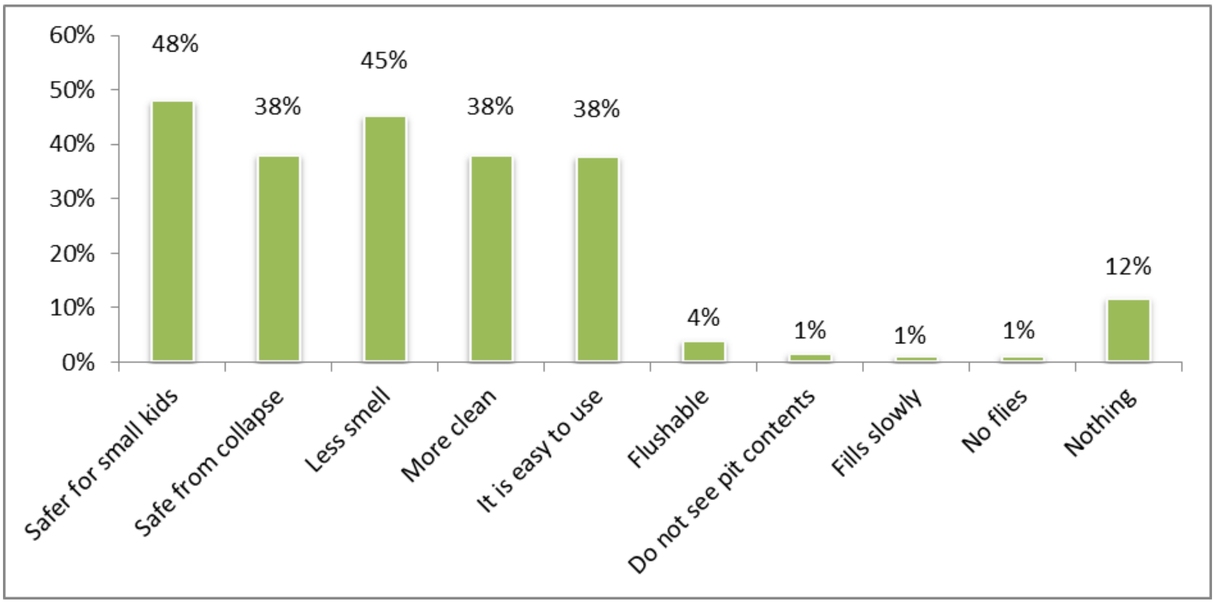


Figure 49: What do householders like about pour flush toilets?

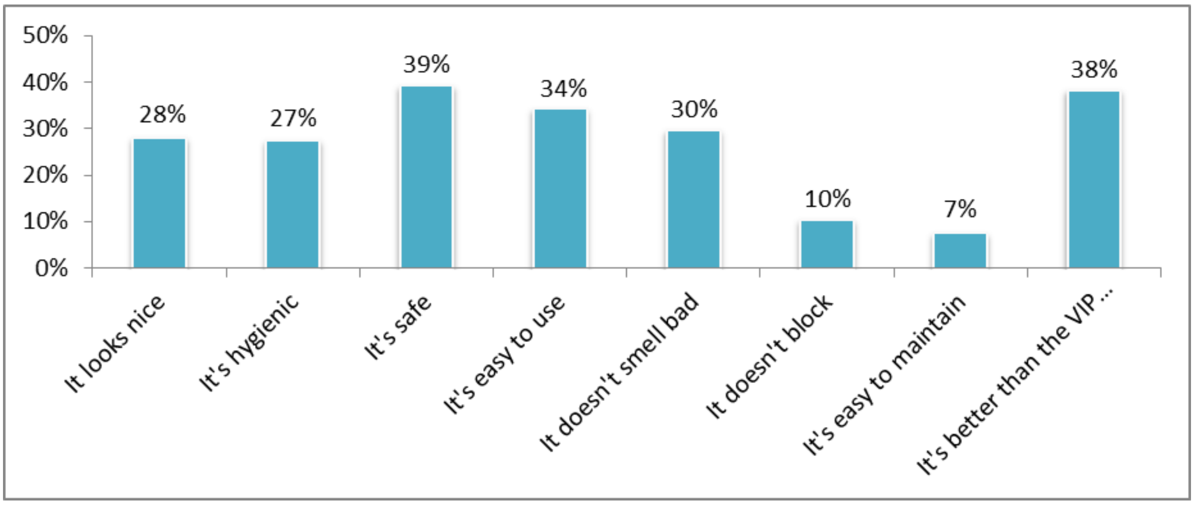


Figure 50: Responses from users about why they would recommend pour flush toilets

Similarly, users were asked what they do not like about pour flush toilets, and the most consistent feedback was that refilling the bucket for flushing was too difficult (186/547; 34%). This is important feedback, because while many users appreciate that the use of water for flushing makes pour flush toilets better than VIPs, others do not think that the effort is worth the benefits. Further, some people said they would consider installing a cistern to convert their toilet in order “to make it flushable”. This suggests that some people do not see the pour flush system as a flushing toilet, despite the reality that water is used to flush human waste away. It appears that some people believe a toilet is only flushable if the flushing is not done manually (i.e. with a jug or bucket). The next most common aspect that people do not like is that there is not enough water in the community for pour flush toilets to be successful (7%).

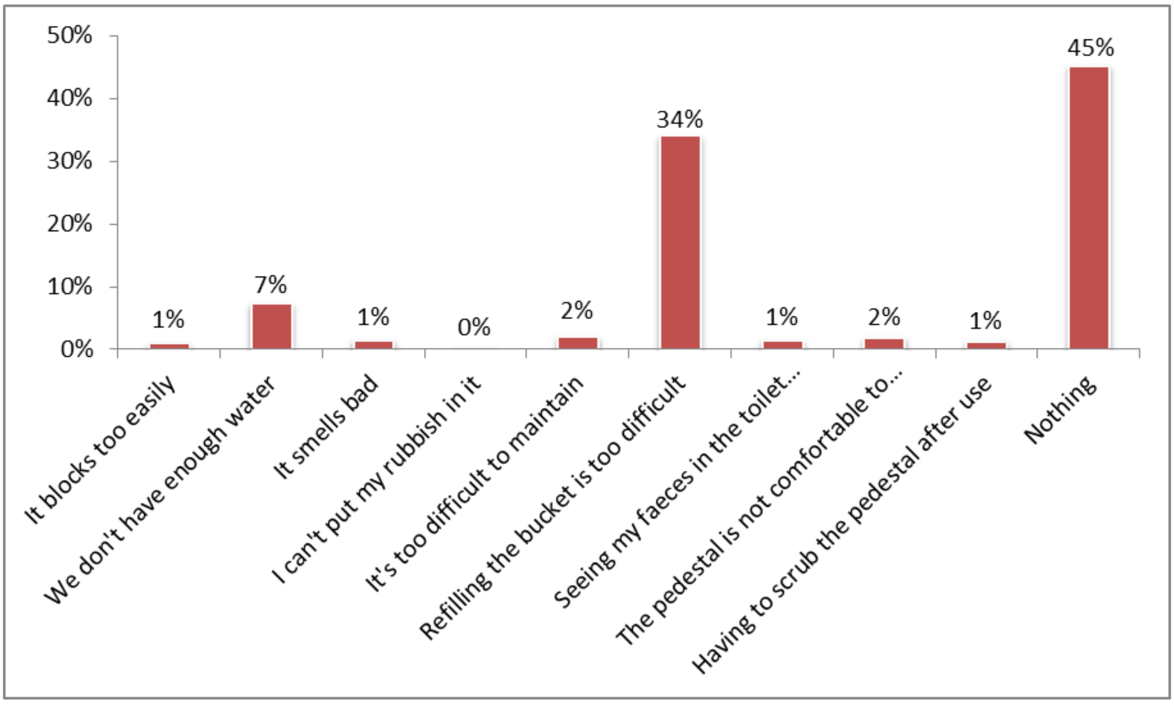


Figure 51: What do users dislike about pour flush toilets?

When asked whether they would recommend pour flush toilets to other people, 76 users (14%) said that they would not recommend pour flush toilets. When asked why they would not recommend pour flush toilets, responses generally echoed those aspects of pour flush toilets disliked by users, shown above. Of those who would not recommend pour flush toilets, 46% gave the reason that it is too much work to refill the bucket, and 28% said that it cannot be used when there is no water. The dependence on water is also the reason 16 users said in their final comments that they prefer pit toilets over pour flush toilets. The majority of these users (13) came from Bongolethu. As shown above, only a limited number of households in Bongolethu have other toilets on site, which means that an unreliable water supply leaves them with no alternative for sanitation during water shortages.

5.2.1 Variations in user feedback based on participant characteristics

Responses were assessed based on the gender and age of the participants in order to determine whether these traits influence people's feelings towards and experience of pour flush toilets. While the differences were very small, some notable differences were observed.

Most notably when comparing men and women, the only significant difference was that women generally demonstrated a higher priority for safety. This was evidenced by the fact that 41% of women said they believe pour flush toilets are safer for small kids, as compared to 31% of men. In addition, 49% of women said that they would recommend pour flush toilets because they are safe, compared to 31% of men. Not only do women see pour flush toilets as safe for children; they also recognise the impact of having the toilet closer to their household (due to lack of odour), which makes it safer to use at night.

When comparing respondents older than age 50 with those younger than age 50, the most significant differences ($p < 0.05$) were in response to the question: "what do you dislike about pour flush toilets?" As shown in Table 4, those respondents above the age of 50 generally like pour flush toilets more than those below 50, with over 50% saying they dislike nothing about pour flush toilets. The only issue that was pointed out significantly more by those over 50 is that the pedestal is not comfortable, which highlights the need to design sanitation hardware that is accommodating to people of all ages and abilities. Further, though only two respondents said that they would change the pour flush toilet by making the pedestal bigger, both of these respondents were older than 50 years of age. Respondents below age 50 were significantly more critical of the need to refill the bucket with water and also the fact that they see their faeces in the toilet bowl before flushing.

Table 4: Responses to the question "what do you dislike about pour flush toilets" which were significantly different between users older and younger than 50 years old

	Age <50	Age >50	p-value
Refilling bucket is too difficult	39.2%	24.4%	0.0004
Seeing my faeces before I flush	15.3%	8.46%	0.0220
Pedestal is not comfortable to use	2.10%	5.47%	0.0359
Nothing	39.5%	54.2%	0.0009

5.2.2 Variations in user feedback based on project

Another way to consider variations is by looking closely at the differences based on various project characteristics (e.g. location, single/double pit, municipal or pilot project). To assess overall satisfaction with the technology, it is useful to look at how many households would recommend the technologies to others as well as those that stated they either like or dislike *nothing* about pour flush toilets. Figure 52 presents the percentages of households that would recommend pour flush toilets to others, based on location and excluding Msunduzi and Ilembe due to low sample sizes. Figure 53 presents the percentages of each community that like or dislike nothing about pour flush toilets.

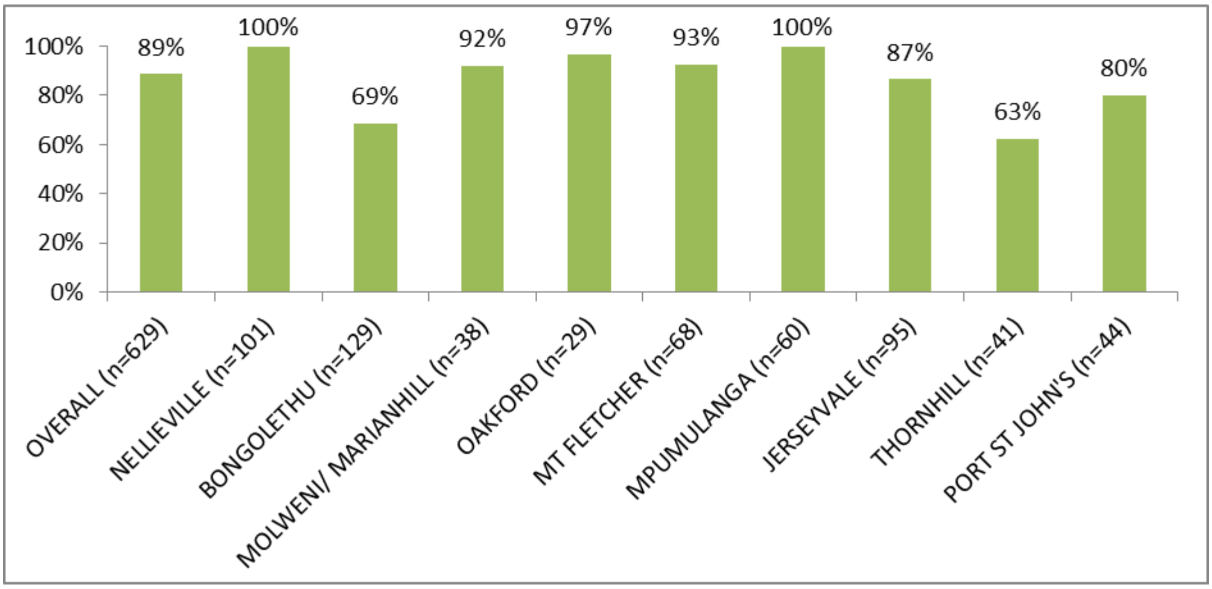
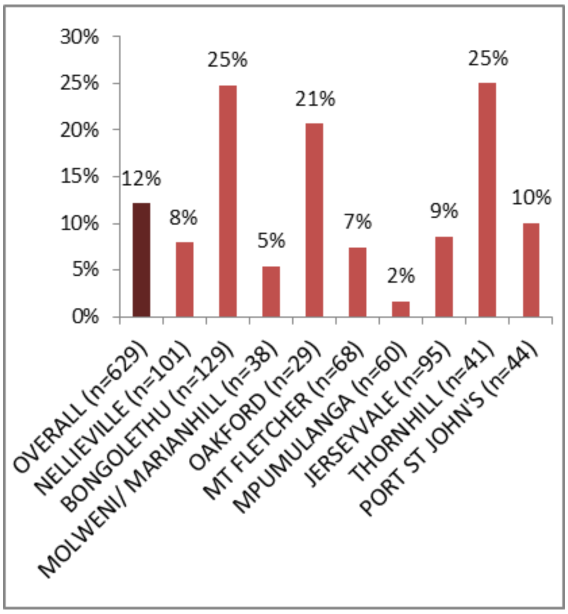


Figure 52: Percentage of households that would recommend pour flush toilets, by location



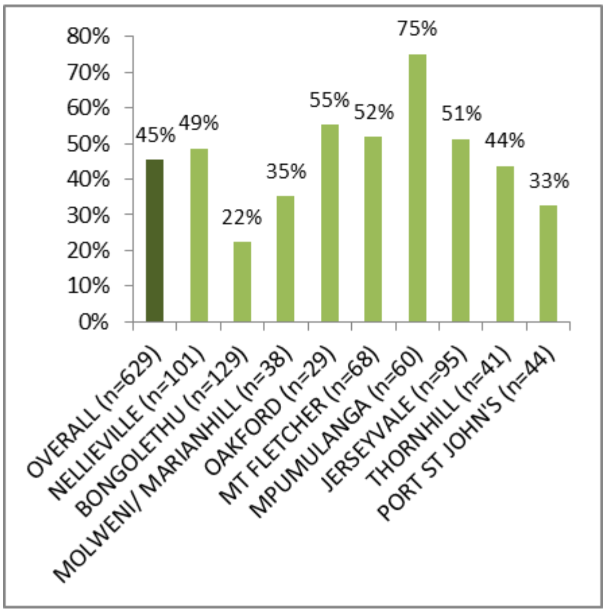


Figure 53: Percentages of users in each location that like (left) or dislike (right) nothing about pour flush toilets

The above figures suggest that the most positive experiences with pour flush toilets have been in the two projects in Mpumalanga province and the early large-scale pilot in Nellieville (Amajuba DM, KZN). Both Nellieville and Mpumalanga had 100% recommendation rates, which is significantly higher than the overall rate of 88% ($p < 0.00001$). Furthermore, Mpumalanga residents had significantly lower percentages who like nothing about pour flush toilets (2%, $p = 0.0142$) and significantly higher percentages who dislike nothing about pour flush toilets (75%, $p = 0.000013$). It is important to note that the percentage of households in Mpumalanga who have other toilets on site (22%) is significantly lower than the overall average of 48%, which could contribute to the overall satisfaction when compared to the alternative of having no toilet at all. Both of these projects were double pit systems implemented as pilot projects.

On the other hand, Bongolethu (69%, $p<0.00001$), Thornhill (63%, $p<0.00001$), and Port St John's (80%, $p=0.0175$) all had significantly lower recommendation rates than the overall rate. It appears that satisfaction with the project was lowest in Bongolethu, given that a significantly larger percentage reported liking nothing about pour flush toilets (25%, $p = 0.000366$) and a significantly smaller percentage reported disliking nothing about pour flush toilets (22%, $p < 0.00001$). A portion of households in Bongolethu and all those in Thornhill and Port St John's were part of municipal projects that utilised single pit systems.

In comparing all single pit systems with all double pit systems, the recommendation rate for single pit users (77.2%) was significantly lower than the recommendation rate for double pit users (91.7%). It is difficult to ascertain the reason behind this difference, since each project and location has its own unique characteristics. One aspect that is consistent is that all twin pit systems built were done so with donor funding as part of a large-scale pilot, while those with single pit systems are all municipally-funded programmes. Single pit systems seem to be preferred by municipalities, likely due to the lower capital cost, particularly for those with the pit located directly beneath the superstructure. However, this short-sighted way of thinking does not consider the long-term maintenance needs of pour flush toilets (e.g. pit emptying or relocating the toilet structure).

The difference in satisfaction between single and double pit system users in Bongolethu community was also analysed as a way to ascertain more about single vs. double pit users with everything else being the same (e.g. location, contractor). In general, despite recommendation rates being similar between the two populations, the satisfaction with the system was higher from those with double pit systems as compared to the single pit systems, as shown by the variety of significantly different responses shown in Table 5. Given the fact that all of these households are located in the same area and their toilets were built at the same time with the same materials and contractors, these differences may be due to the different technologies (single vs. double pits).

It is interesting to point out that a significantly larger percentage of single pit users said that they dislike pour flush toilets because they do not have enough water to use them. However, no significant difference was observed between single and double pit users on the reliability of their water supply or the source of their water (mostly communal or household outside taps). During final comments, Bongolethu single pit users were the most likely respondents to say that they prefer pit toilets (13/16) and that they fear the pit is too small (6/7). Anecdotally, during site visits, fieldworkers were told by single pit users that their pits were full of rainwater due to excessive runoff from a nearby hill. These users were worried about this situation and were also unsure what was going to be done to empty their pits.

Table 5: Significantly different responses from single pit and double pit users in the Bongolethu community

		Single pit	Double pit	p-value
Has had difficulties		23.2%	12.8%	*Not significant:* 0.20200
Likes	Less smell	14.6%	35.9%	0.00685
	Cleaner	9.8%	30.8%	0.00320
	Easy to use	11.0%	30.8%	0.00638
Dislikes	We don't have enough water	29.3%	7.7%	0.00948
	Refilling the bucket is too difficult	51.2%	30.8%	0.04780
	Prefer pit toilet	15.9%	0.0%	0.00945
	Nothing	17.1%	33.3%	0.03999

5.3 Maintenance needs

5.3.1 Water usage

Water availability

Water availability is important to determining water usage, because if there is no water available, no water can be used. Overall, a vast majority of households (79%) reported that there are times that they go without water, as demonstrated in Figure 54. It is striking to note that in 7 of the 11 communities visited, over 90% of the householders reported that there are times they go without water. Figure 55 presents how frequently householders reported that they go without water. In Nellieville, 82% of households reported that they go without water most days in the week. Interestingly, as shown previously in Figure 46, usage of pour flush toilets in this community is still very high (91%). In Mt Fletcher and Thornhill, all participants reported that they go without water periodically. A majority of Mt Fletcher residents (67%) reported that this happens once or twice a month, while a majority of Thornhill residents (60%) reported that this happens once a week. As described above, these two communities also had very low usage rates compared to the other communities. The unreliability of the water supply in the communities visited is characteristic of many rural communities throughout South Africa.

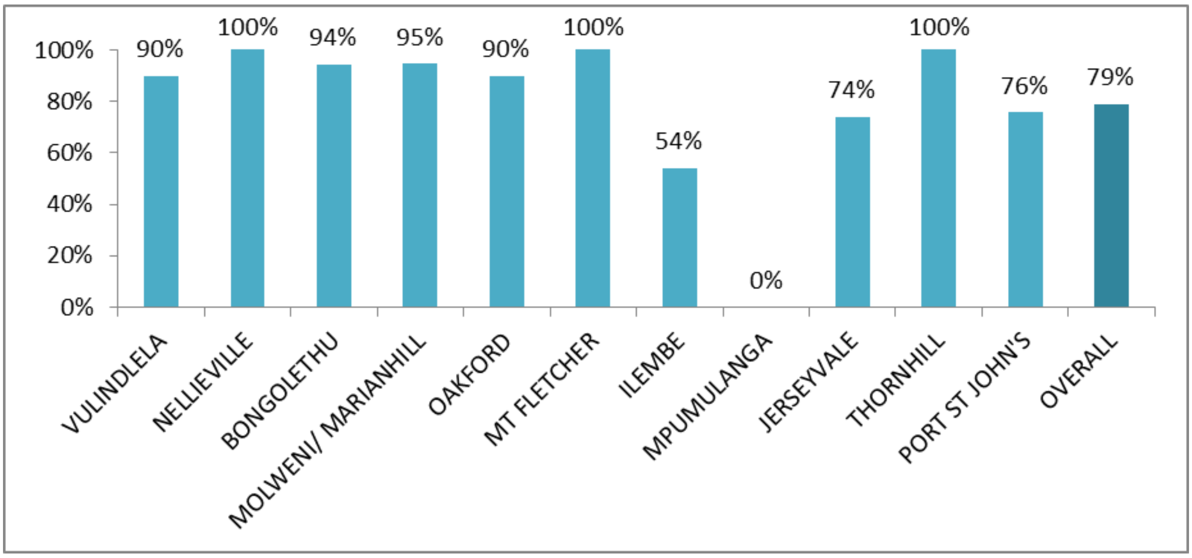


Figure 54: Percentages of households reporting that there are times they do not have water

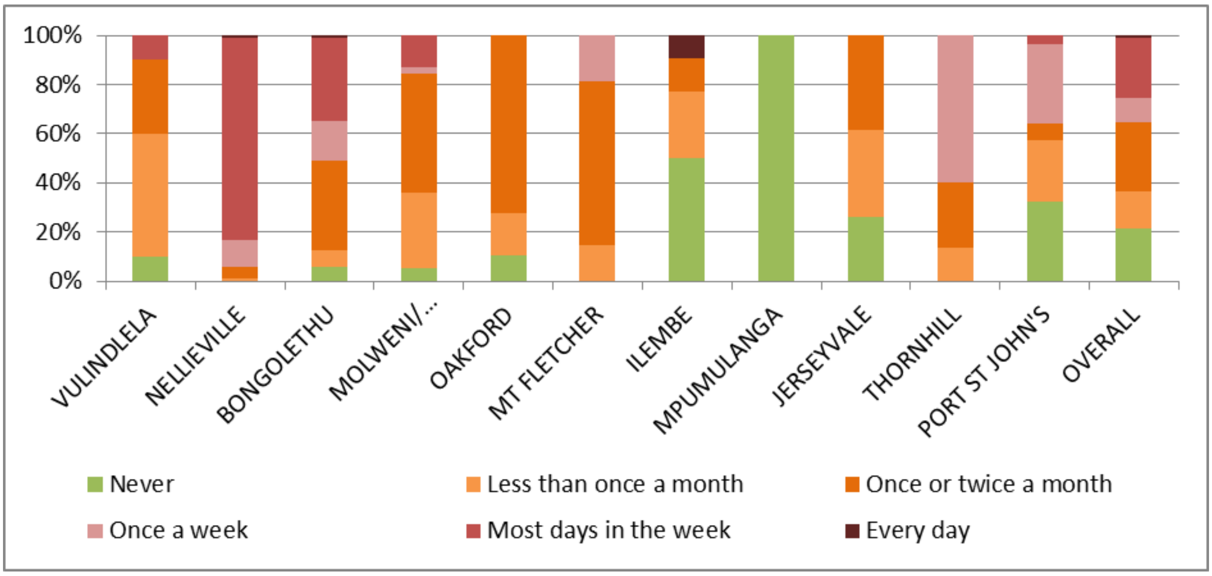


Figure 55: Reported frequency that areas do not have water

Even when there are water shortages, all people need somewhere to relieve themselves; therefore, communities that have waterborne toilets and experience water shortages must have strategies for coping when there is no water. Households were asked what they do when there is no water available, and the responses varied widely, as shown in Figure 56. While a large portion of households simply do not use the toilet and resort to an old pit toilet or the bush, a substantial portion of households (55%) indicated that they use an alternative water source, including greywater, rainwater, stored tap water, or water from a nearby river.

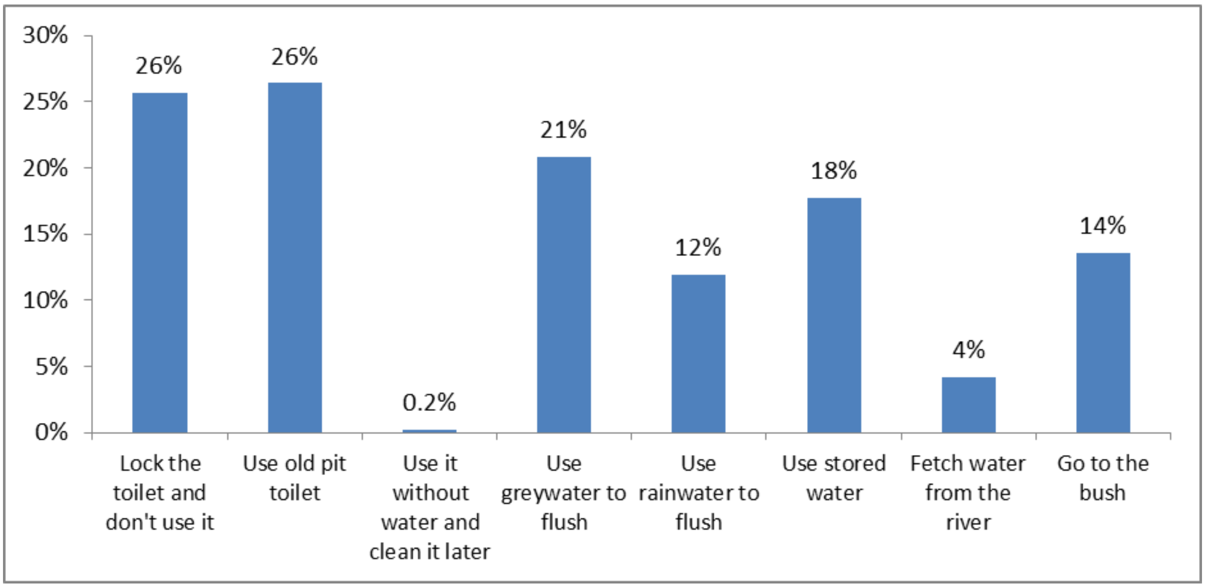


Figure 56: What do you do when there is no water available?

Using greywater for flushing is a strategy of resilience in areas with water shortages, as it reduces the burden on already-limited potable water supplies. Therefore, households were asked in general whether they use greywater for flushing their pour flush toilet, along with how frequently. Given the unreliability of water and the resourcefulness of the communities visited, as shown above, it is not surprising that 55% of households interviewed use greywater for flushing at least occasionally. Fifty percent of those who use greywater for flushing only use it when there is no water available, but 26% use greywater all the time for flushing. In communities where water is scarce, many households choose to use their potable water for activities such as cooking, bathing, and cleaning, and then use recycled water for flushing. This is a positive practice that should be encouraged in projects where pour flush toilets are used.

Water volumes used for flushing

This study provided an opportunity to understand how behaviour influences the amount of water used to flush urine and faeces in a toilet that, as demonstrated in a controlled study, can be completely flushed with 1-2 litres of water regardless of whether newspaper or toilet paper are used. Pour flush toilets differ from low flush toilets, in which the volume used is regulated by the size of the cistern and the level to which it fills up. With pour flush toilets, users pour in water to flush their waste according to their own preference. Figure 57 shows the user-reported volumes used for flushing urine and faeces. The median volume used to flush urine is 2 litres, while the median reported volume for faeces is 5 litres.

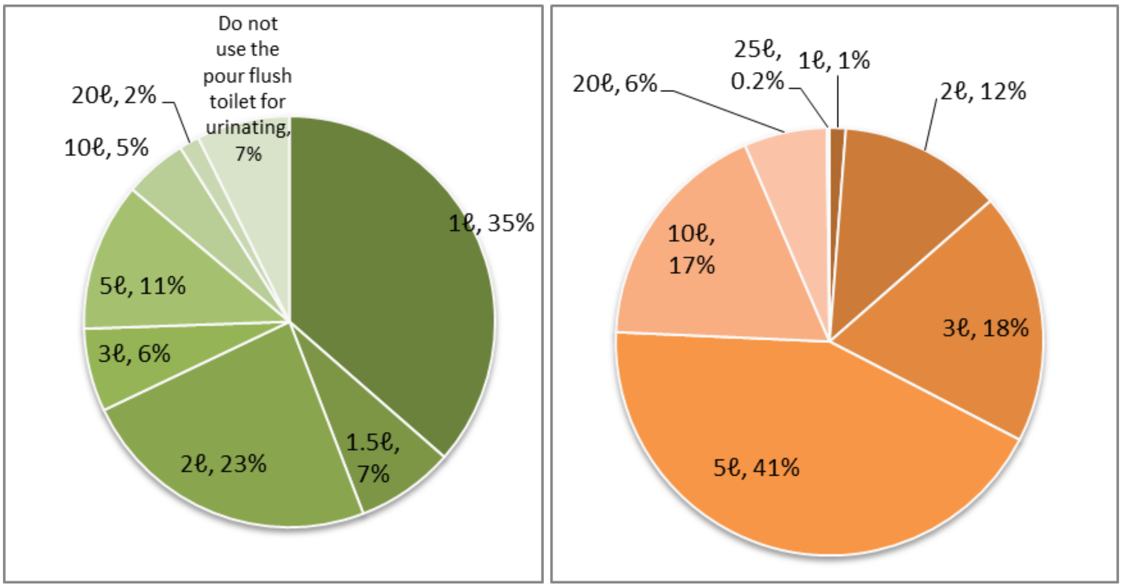


Figure 57: Reported volumes of water used for flushing urine (left) and faeces (right)

The fact that the volumes are higher than required for the technology (based on tests) highlights the impact of user behaviour in practice. A relatively strong positive correlation (correlation coefficient = 0.604) was found between reported volume used to flush urine and volume to flush faeces. This suggests that users who use the most water for flushing urine would also flush faeces with relatively large volumes. For many users, large volumes are used to flush urine down the toilet simply because that is the size of the container that they use for flushing. In these cases, each user will take a full bucket of water with them to the toilet and then pour it all into the toilet after urinating or defecating. During inspections, only 56% of toilets (356/637) had a bucket in the cubicle, confirming that it is relatively common for people to carry the bucket with them to the toilets. Furthermore, only 18% of toilets had a jug in the cubicle, suggesting that the practice of flushing with a small 1-2 litre jug is not common (even though buckets and jugs were often supplied at the handover). Interestingly, the need to carry water to the toilet was one of the most criticised aspects of pour flush toilets, which could be made simpler by having a large bucket in the toilet cubicle with a smaller jug for flushing.

5.3.2 Hygiene supplies

Households were asked about whether or not they purchase toilet paper and handwashing soap as their contribution to improving hygiene. Seventy-one percent (386/547) of respondents said that they use toilet paper exclusively for wiping when using their pour flush toilet. A further 152 respondents (28%) indicated that they use both toilet paper and newspaper for wiping, which is likely due to budgetary constraints (when they can't afford toilet paper anymore, newspaper is used). Households were also asked to report how frequently and in what quantities they purchase toilet paper. Overall, households which exclusively use toilet paper for wiping purchase a median of 4.8 rolls per user per month. Assuming a cost of R2.00 per roll, this translates to a monthly budget for the household of R9.60 per user per month for toilet paper.

Twenty-four percent (130/547) of households reported that they purchase hand soap, with 69 saying they purchase liquid soap and 60 purchasing bar soap. The median quantity of liquid soap purchased buy is 188 mℓ per user each month, while those buying bar soap purchase a median of 0.25 bars per user each month. Assuming a cost of R50 per litre of liquid soap and R20 per bar of soap, this translates to a median cost to the householder of R9.38 per month and R2.50 per user per month for liquid and bar soap, respectively.

5.3.3 Occurrence of blockages

Blockages are one of the main concerns when implementing waterborne sanitation systems in areas that have always had dry sanitation; however, feedback from this study demonstrates that pour flush toilets do not block as easily as assumed. Overall, 91 percent of participants said that they have *never* had a blockage of their pour flush toilet. A summary of the frequency of blockages experienced is presented in Figure 58. While only 8 percent of households overall reported that they have experienced a blockage, 16% of households in Nellieville have experienced blockages (p-value = 0.008). This is a significant difference and may be due to the length of time that the toilets have been installed in Nellieville when compared to the other locations. However, only 3.7% of households in Jerseyvale have reported any blockages over the lifetime of the pour flush toilets, and these were constructed in the same year as the Nellieville ones.

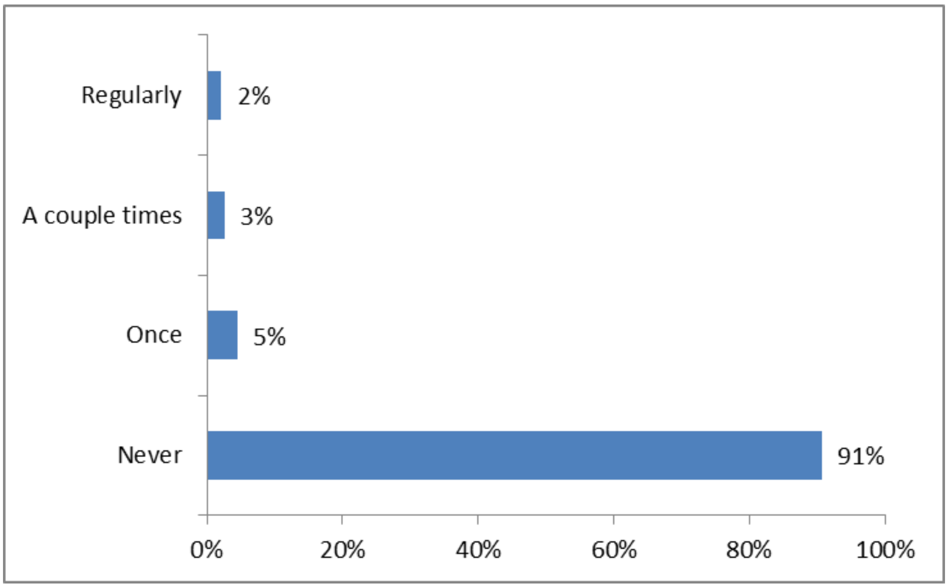


Figure 58: Frequency of blockages of pour flush toilets reported by householders

When pour flush toilets do get blocked, the most important consideration is whether households are able to fix the problem themselves. Overall, 31 out of 46 households that have experienced blockages were able to fix the problem themselves. Of those who said the household could not fix the problem, one said that their neighbour helped, while 4 said that they just left it and eventually it unblocked. No households reporting blockages hired a plumber to unblock the toilet, suggesting that there was no cost to the household.

5.3.4 Occurrence of leakages

Implementation of waterborne sanitation increases the chances of water wastage and leakages, which is especially problematic in water-scarce areas. However, pour flush toilets should not leak as frequently as full flush toilets with cisterns, as the majority of leakages take place in leaky cisterns that are constantly full of water. This was confirmed by householders, 81% (442/549) of which reported that they have never had a leak in their pour flush toilet. Nineteen households (3%) reported that they regularly experience leakages. These households were in Nellieville (6/101), Oakford (5/29), Bongolethu (4/121), Marianhill/Molweni (2/37), and Mt. Fletcher (2/27). Leakages occur either where the pedestal meets the floor, where the pipework connects to the pedestal, or at other pipe joins. These leakages are likely due to poor installation and can be easily remedied. While some households report that they can fix the problem, others have just left the toilets to leak. The key benefit of pour flush toilets is that when leakages are not dealt with, it does not lead to constant loss of water, since no water is stored in the system except in the p-trap.

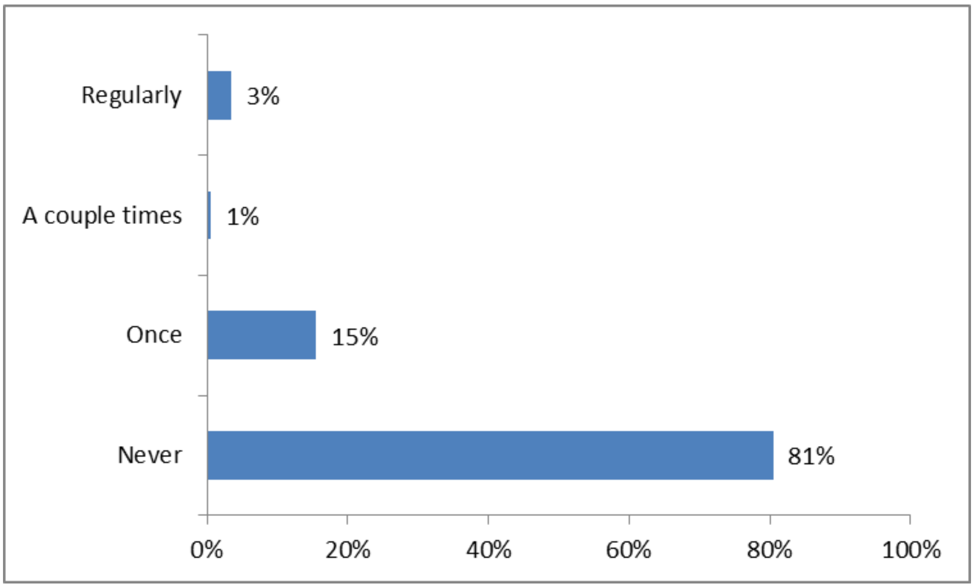


Figure 59: Reported frequency of leakages

5.3.5 Sludge accumulation rates

In total, 269 sludge measurements were taken, representing 43% of all households visited. While this represents a significant data set, only 129 points are included in the analysis of sludge accumulation rates, shown in Table 6. This excludes outliers, pits with layers of water on top of the sludge, and points with incomplete or incomprehensible data. Where a layer of water exists above the sludge, the measured level does not necessarily represent sludge that has accumulated over time. The data presented in Table 6 and Figure 60 represents results from 8 different communities with a wide range of conditions and includes 28 single pit toilets and 101 double pit toilets. The imbalance in single vs. double pits is due to the lack of accessibility of most single pits due to the way the Cemflush pits were designed. The single pit systems in which the toilet structure is directly above the pit were not accessible for measurements. The two communities that had off-set single pits (Port St John's and eThekwini) were accessible for measurements and have been included here. It is important to note that these calculations are based on dimensions of the pits specified in design drawings, rather than the measured volume of each pit on site. This introduces some level of error into the analysis below.

Sludge accumulation rates varied widely overall and within the different communities, and this variation is consistent with results presented in a number of other studies. The median accumulation rate observed in this study was 27.2 ℓ/capita.annum, with an average of 30.1 ± 19.5 ℓ/c.a. The median accumulation rate in Chief Albert Luthuli Municipality was 41.4 ℓ/c.a, which was significantly larger (p=0.0065) than the overall median. In both Mkhondo and Port St John's, the median rate was significantly lower than the overall median, at 15.5 ℓ/c.a (p=0.0240) and 15.3 ℓ/person/year (p=0.0227), respectively.

Table 6: Sludge accumulation rate results

Site	No. Households	Median accumulation rate (ℓ/c.a)	Average accumulation rate (ℓ/c.a)	Average no. of users	p-value
Amajuba	25	27.2	35.3 ± 19.5	8.2	0.0833
Bongolethu	21	35.2	35.1 ± 16.2	3.2	0.1267
Chief Albert Luthuli	12	41.4	46.2 ± 17.2	3.1	0.0065
eThekwini	17	24.4	30.9 ± 22.3	6.9	0.5833
Jerseyvale	15	30.1	32.9 ± 16.9	3.0	0.5773
Mkhondo	24	15.5	17.8 ± 12.9	5.0	0.0240
Msunduzi	3	19.5	20.9 ± 14.5	4.7	0.1403
Port St Johns	12	15.3	18.4 ± 15.2	7.3	0.0227
Overall	**130**	**27.2**	**30.1 ± 19.5**	**5.9**	

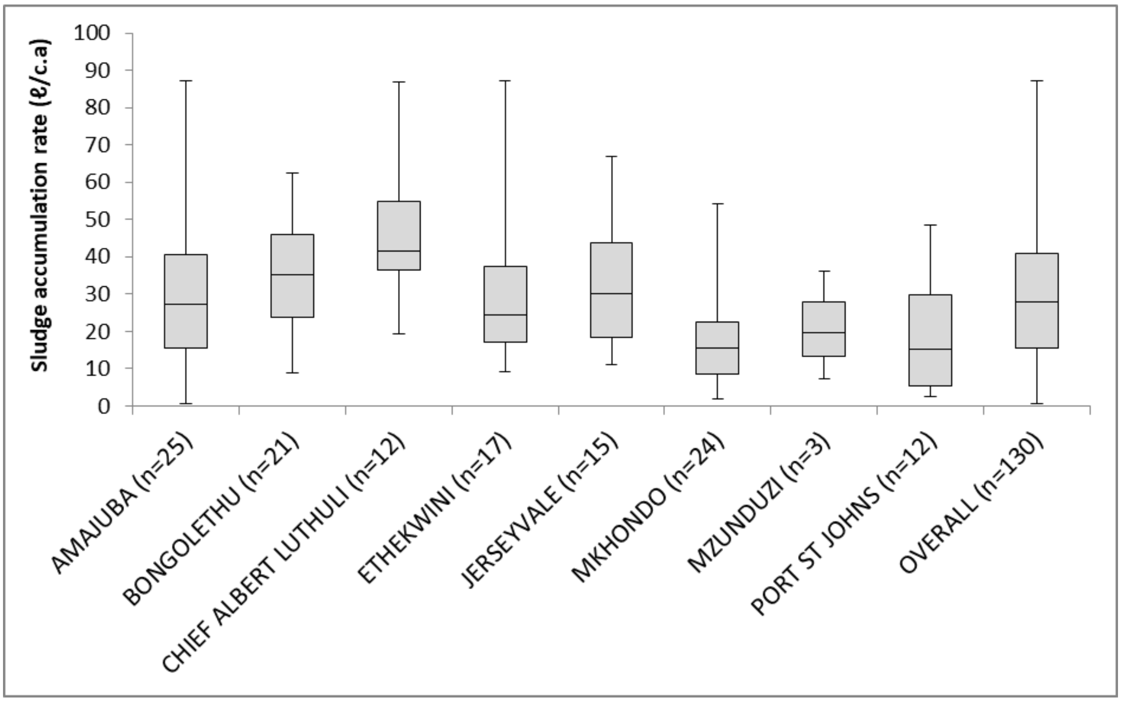


Figure 60: Graph of sludge accumulation rate results

What influences sludge accumulation rate?

A number of variables can be checked against sludge accumulation rates to determine what influences the sludge accumulation rate in pour flush pits. The variables investigated here include: number of users, double/single pit configuration, soil type, wiping material, pit contents, toilet age, and volume of water used for flushing faeces and urine.

A very slight negative correlation was observed between sludge accumulation rate and number of users, which was also observed in previous studies (Bakare, 2011). This may be due to households misreporting the number of users but may also suggest that higher usage of the toilet leads to a decreased accumulation of sludge, due to the fact that microorganisms in the pit are fed fresh sludge more frequently. Figure 61 presents all sludge accumulation rate data points, showing a general decreasing trend with increasing number of users. The correlation coefficient calculated for filling rate and number of users is -0.275, representing a weak negative correlation (i.e. when one increases, the other decreases).

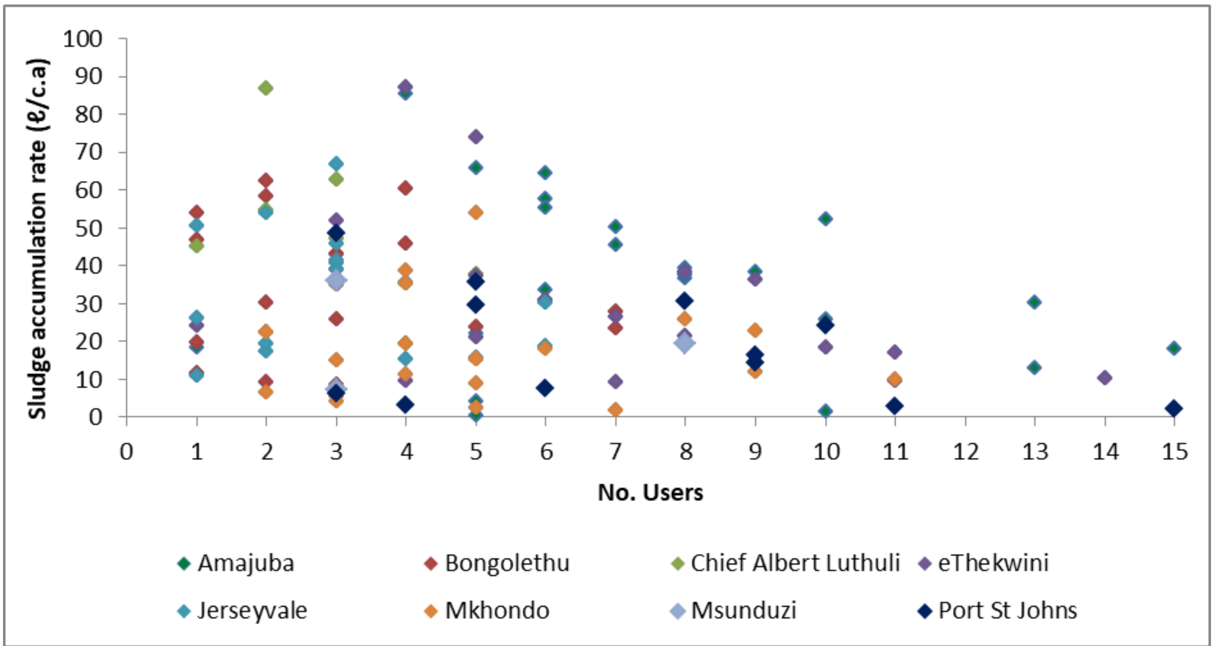


Figure 61: Calculated sludge accumulation rates vs. number of users reported

The accumulation rate in single pit systems was then compared to double pit systems, but this data is irrelevant given that a vast majority of double-pit households (all but 1) had not yet begun using their second pit. When pipework is switched to the second pit, it gives the first pit time to rest and decompose, which usually leads to some decrease in moisture content and volume of sludge. Thus, once the second pit was completely full, the volume in the first pit would have decreased substantially. This suggests that the overall sludge accumulation in the system over time would be lower than a system where the full volume is collected in a single pit. The dryer sludge could also likely be emptied manually, as the contents would be easy to dig out. On the other hand, single pit systems can likely be easily emptied with pumping technology when they fill up, due to the sludge at the top being fresher and therefore having a higher moisture content.

Soil conditions are likely to have a large impact on sludge accumulation rate due to infiltration of water into soil. Thus, sandy soils are expected to drain more water and lead to lower sludge accumulation rates when compared to clayey soils. Unfortunately, this study did not include detailed analysis of soil conditions aside from fieldworkers being asked to comment on the soil type, indicated sandy, clayey, or rocky. A vast majority of data points were taken in sandy soils (98/127), and with very small sample sizes for clayey and rocky soils (n=12 for each), the results presented in Figure 62 cannot be taken as conclusive. The results do show a slightly higher average accumulation rate in clay soils when compared to sandy soils. Furthermore, the average accumulation rate in rocky soils is lower than both of the other soil types. It would be beneficial to collect more detailed data on soil conditions in future studies, as it is expected that soil conditions will have an impact, especially given the water input to pour flush pits.

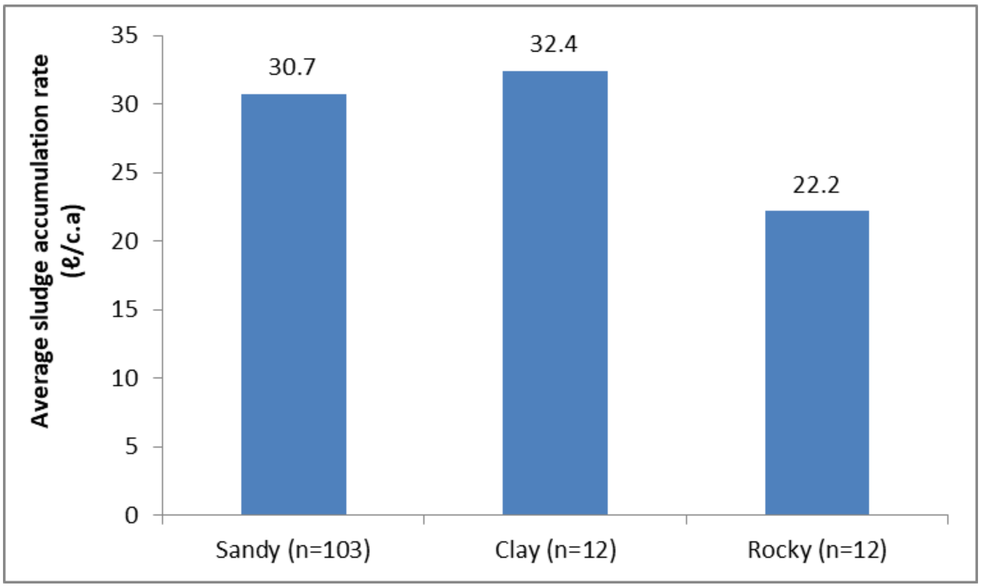


Figure 62: Average sludge accumulation rates in different soil types

Householders typically use toilet paper or newspaper for wiping, and since newspaper is generally bulkier than toilet paper, it is assumed that sludge accumulation would be higher where households use newspaper. Unfortunately, only 3 households included in the pit measurement analysis reported using exclusively newspaper for wiping. Thus, though the average sludge accumulation rate for those 3 households was 39.9 ℓ/c.a as compared to 30.2 ℓ/c.a for toilet paper users, due to a small sample size this result cannot be regarded as particularly significant. Forty households reported using both newspaper and toilet paper for wiping; however, the difference in sludge accumulation between those households and those using only toilet paper was not significant.

After measuring the pit contents, researchers were asked to comment on the contents of the pit, noting whether sludge was wet or dry and whether or not it contained rubbish. As noted by Still and Foxon (2012), disposal of solid waste in pits can lead to a 10-20% increase in sludge accumulation in VIP pits. While it is less likely that households will dispose of rubbish in pour flush toilets, there is still a chance that wrappers and other small rubbish items can be flushed with human waste. Further, wetter sludge indicates either that the sludge is newer or that the liquid in the sludge is not draining freely from the pit. It is therefore assumed that wet pits would have a higher sludge accumulation rate. The results from this analysis are presented in Figure 63. Though the number of pits with rubbish in them is low (n=8), there does appear to be an impact of rubbish on the sludge accumulation rates. It is therefore encouraging that the number of pits with rubbish in them was so low. As municipalities are responsible for pit emptying activities, this is an important consideration for them since rubbish in pits can make pit emptying extremely inefficient, especially when vacuum trucks are used. Further, with any sludge beneficiation and reuse schemes, rubbish can be a serious hindrance that must be removed before processing. Wider implementation of pour flush toilets would likely lead to sludge with lower rubbish content and improve both of these important activities. When comparing wet and dry pits, it is clear that wet pits have a higher average sludge accumulation rate than dry pits, as hypothesised above.

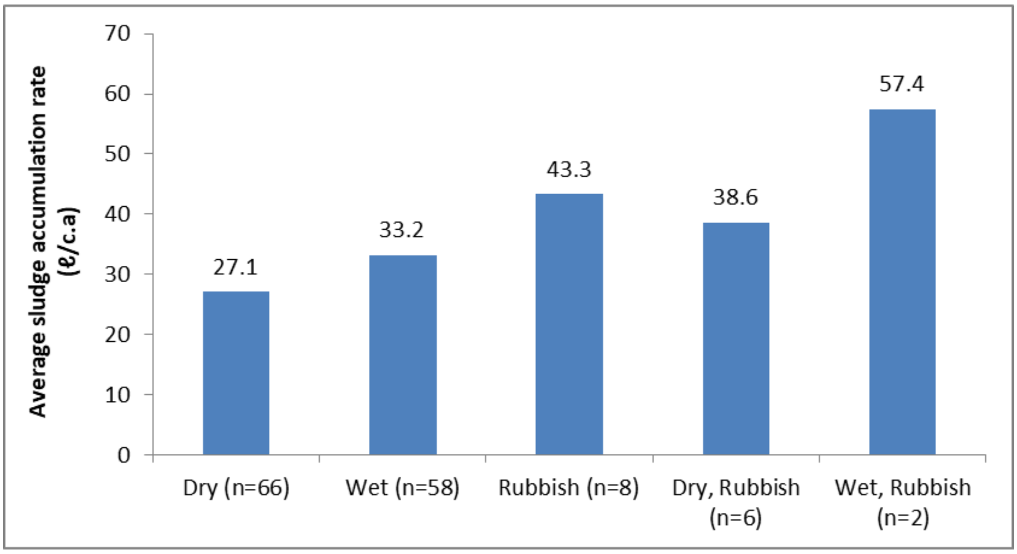


Figure 63: Comparison of sludge accumulation rates based on pit contents

As alluded to when discussing pit contents, sludge is expected to dry out and decompose in pits over time, which suggests that older pits should have lower sludge accumulation over time than younger pits. Unfortunately, the range of ages included in this study is very narrow, since pour flush toilets are still a relatively new addition to the South African landscape. The oldest installations included in this study are from Msunduzi and were approximately 8 years old during measurements. Though only 3 toilets from this project were included in this analysis, Figure 64 seems to confirm the hypothesis that sludge accumulation rate will decrease over time, as the sludge has time to decompose. This exercise should be done again when the larger pilot projects from 2015 and 2016 are at least 7 years old, in order to gain a better understanding of how time impacts sludge accumulation rate. This exercise should also be conducted once the second pit is in use and almost full in twin pit systems. This will provide greater insight into the impact of a resting period on sludge accumulation.

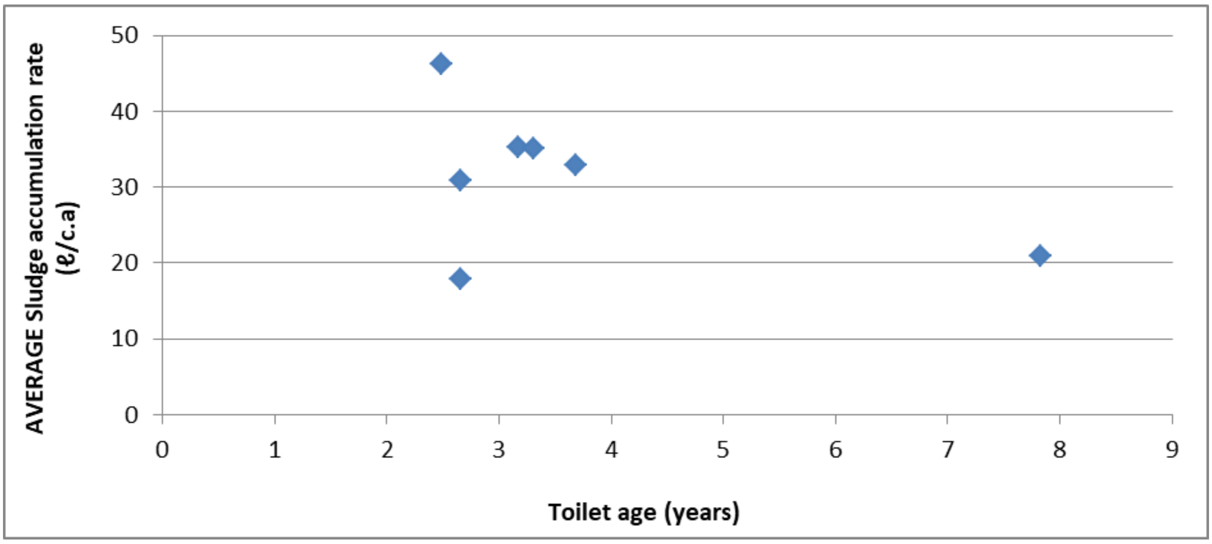


Figure 64: Average sludge accumulation rates vs. toilet age

The addition of water for flushing increases the overall volume entering the pit. However, given the biological and physical processes that take place within pits, it is unlikely that this extra moisture volume would increase sludge accumulation. This was confirmed by the data, as no correlation exists between filling rate and reported flushing volumes. It is interesting to note that Bakare (2011) stated that increased moisture content can quicken the establishment of anaerobic conditions in a pit, which would decrease the sludge accumulation rate. This suggests that the addition of water to the pit may actually decrease sludge accumulation over time, but again, this would need to be assessed once the pits in this study are older.

5.4 Suggested improvements for pour flush toilets

Users were asked to suggest improvements to pour flush toilets, which would improve their experience using them. Overall, 36% of users said that they would want to change something about pour flush toilets, and by far the most common suggestion was to add a cistern (24.5% of all pour flush users). Other responses shown in Figure 65 were not suggested by more than 5% of participants. Additional responses not shown here include, among others: construction issues, such as gaps in the slabs or precast structure that allow water in; the orientation or location of the toilet on site; and increasing the structure size. One user in Thornhill who suggested installing a cistern then said "or change to pit and stop using the pour flush". This is an interesting response, since the two options are completely opposite in terms of the amount of water they will require, and this user consistently complained about the unreliability of the water supply. Users likely do not understand the implications of installing a cistern on the overall water consumption of the toilet.

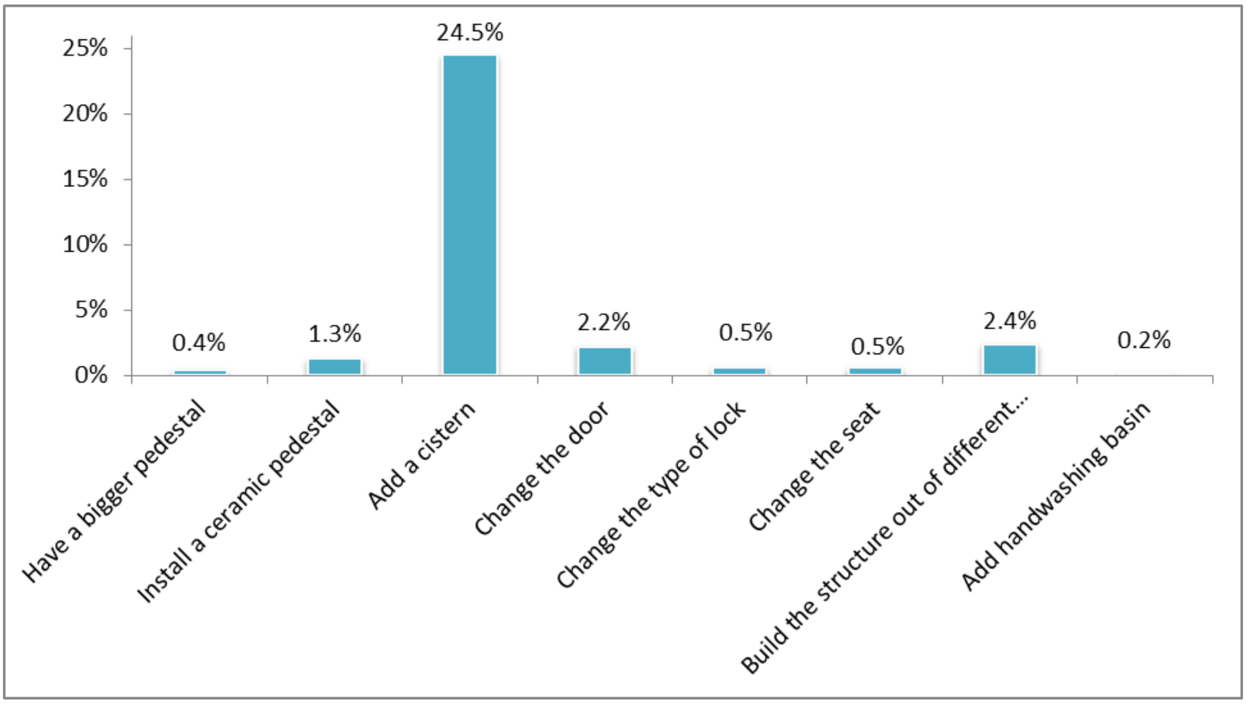


Figure 65: What would users change about pour flush toilets?

The feedback above is consistent with the responses to the question of whether households would consider changing their pour flush toilet to a low flush toilet. Seventy-seven percent of all respondents said that they would consider changing to a low flush toilet, whereas only 33% knew that it was possible to do so. Communities that were significantly more interested in doing this conversion included Nellieville (97%) and Oakford (100%). It is not surprising that Oakford residents were more interested in converting, given the more peri-urban nature of the neighbourhood when compared to the more rural locations included in the study. Further, some households in the Oakford community received low flush toilets during the initial construction (after the initial 90 units were constructed), which created an expectation among those who received pour flush toilets. The percentages of households considering changing to low flush were significantly lower in Bongolethu (67%), Mpumalanga (67%), and Port St John's (63%). These percentages do represent a majority of users but also suggest either a relatively higher satisfaction with pour flush toilets or greater understanding of the fact that low flush toilets will not address the water shortage issues in these communities.

6 Discussion

The results above demonstrate a high level of acceptance of pour flush toilets among users after at least 2 years of use. The toilets are in use across all included communities, and many people appreciate the improvements brought through pour flush toilets when compared to VIP toilets. These improvements include enhanced safety, reduced odours, and ease of use. Some of the key barriers or concerns identified in the user surveys include: water shortages in the project areas, unwillingness to carry water to the toilet, and lack of maintenance plans on the part of municipalities.

6.1.1 Dealing with water shortages

It is important that the implementation of pour flush toilets does not come with a decrease in resilience to water shortages that are common throughout the country. Since dry sanitation systems do not require water, they are able to continue providing dignified sanitation despite water challenges. Measures must be put in place to make sure that communities using pour flush toilets are not neglected when water shortages take place. These measures can be the same measures implemented to make households in general more resilient to water shortages, such as: rainwater harvesting, greywater recycling, and storage of potable water.

Greywater recycling for toilet flushing should be encouraged from the initiation of a pour flush project. For households without a water connection in their home, this reduces the volumes of water that must be fetched from communal taps or surface water. Further, using greywater for flushing provides an alternative disposal option for greywater, instead of the common practice of disposing of greywater on the ground surface or in the garden.

As mentioned above, installation of cisterns connected to toilets will make pour flush users more vulnerable to water shortages, as installations of low flush toilets will likely lead to higher wastage of a precious and limited resource. Users' desire for easier use and provision of flushing water in the toilet cubicle should be addressed in other manners that do not require a direct connection from cistern to pedestal in order to avoid excessive water usage.

6.1.2 Limiting the need to carry water to the toilet

By far the most common negative feedback received about pour flush toilets in this study was that carrying water to the toilet is too much work. The original concept for pour flush toilets was that each cubicle would be equipped with a larger bucket (25-50 litres), which would be manually filled with water, and a 2-litre jug for flushing the toilet. This 2-litre jug would be sufficient for flushing all contents down, and if it were not, the user could simply add another jug. As described above, this set up was not present in many pour flush toilets, suggesting that this practice has been abandoned (probably the bucket had been moved into the house). As an alternative, many households have adopted a practice of each user carrying their own bucket of water to the toilet for each use. It is not surprising that users dislike this aspect of the toilet, due to the weight of water and the inconvenience of carrying it to the toilet.

Various options exist for bringing water closer to the toilet without installing a cistern with a direct connection to the toilet and/or to the municipal water supply. Some ideas for improvements are provided below:

- A cistern can be installed on the inside of the toilet cubicle without a connection to the toilet, which means that constant leakage will not occur. That cistern can be fed by a larger external tank, which is filled manually as needed. Envirosan has developed this system, which utilises a 50 litre tank, mounted on the outside of the cubicle. For a family of 4, this tank would likely need to be filled approximately once per day to meet the flushing water needs. Thus, the number of times water is carried to the toilet is dramatically decreased, and using the toilet is overall less of an inconvenience.

- Recycled greywater could be stored in the same way and either added to the large tank manually or pumped from the main greywater storage area with a manual pump. This setup was proposed and implemented in Oakford for the initial 90 homes; however, few households use the greywater in this way.
- For households that have an outdoor tap on their property, their pour flush toilet could be built near to these taps, which will reduce the distance that people must carry their flushing water.
- A small amount of rainwater can be harvested from the roof of toilet cubicle itself and stored in a small tank adjacent to the toilet. Users could then fill their bucket or jug using this rainwater when it is available.
- Pour flush toilets can be built closer to or even inside households, as the water seal prevents odours that are common with VIP toilets. This drastically reduces the distance that people must walk from their home to the toilet and thus the distance that they must carry the water. For some householders, this would be a great improvement from VIP toilets due to safety concerns. However, some householders have a preference for their toilet being located outside, which is likely due to a perception of toilets being dirty, or the small size of homes making it preferable to have the toilet separate.

Figure 66: Pour flush toilet with 50 litre tank installed on the outside and connected to a cistern inside the toilet, located in Maphumulo, Ilembe DM

6.1.3 Planning for maintenance of pour flush toilets

As with any sanitation system, maintenance should be planned for from the outset of implementation. Various maintenance considerations are described below, and these will be considered in more detail in a Master's thesis, which will compare the life cycle costs of pour flush toilets and VIPs. This includes comparing double pit and single pit systems with VIPs and considering capital costs along with operations and maintenance costs. This study will provide a larger picture for municipalities that are deciding between various technologies.

Dealing with full pits

For on-site systems, the primary maintenance activity is dealing with full pits or septic tanks *before* they fill up. Once a system is full, it is unusable and the household becomes part of the sanitation backlog. One method of estimating the interval for pit emptying services is to utilise the median sludge accumulation rate shown above (27.8 ℓ/person/year), along with the design pit volume and the median number of users of each toilet. In this study, the median number of users reported was 5, and quintile 3 was 7. Both of these have been used below to provide both a more conservative and a less conservative estimate. Table 7 shows a sample calculation of the years it will take for pits to fill up, using the total pit volumes from this study and the median accumulation rate. This calculation can be repeated for each municipality based on an average number of householders per toilet and the design pit volume used.

Table 7: Sample calculation of number of years for pits to fill up

Construction	Combined pit volume	Years to fill (assuming 5 users)	Years to fill (assuming 7 users)
Twin pit, PID	2.0 m^3	14.5 years	10.4 years
Single pit, Envirosan	1.3 m^3	9.5 years	6.8 years
Twin pit, Cemforce	1.2 m^3	9.0 years	6.4 years

As expected, a larger total pit volume means that pit emptying will have to take place less frequently. This is an important consideration for municipal managers when selecting what type of system to use. Whereas single pit systems may have a lower capital cost up front, their operational costs will be higher due to the need for more frequent emptying. It is important to note again that the calculation for double pit systems does not account for sludge decomposition that will take place when the pipework is switched from the first pit to the second pit. The main effect of this is that when both pits are full, the actual volume that has to be removed from the first pit is likely to be only half the pit volume, as the sludge will have dried and decomposed.

The emptying frequency required for pour flush toilets should be compared to that of VIP toilets to properly assess the differences in maintenance requirements. Sludge accumulation rates in VIPs have been assessed by numerous sources, generally with large variation. Still and Foxon (2012) reported that 40 ℓ/c.a is a good figure to use in designing VIP toilets but that accumulation rates up to 60 ℓ/c.a are common where trash content is high. This is consistent with data collected as part of another study in Vulindlela (n = 112) in 2019 using the same methodology described in this project. In this study, the median sludge accumulation rate was 42 ℓ/c.a, with an average of 50 ℓ/c.a (±33 ℓ/c.a). Using the medians of 42 ℓ/c.a for VIPs and 28 ℓ/c.a for pour flush toilets, the estimated frequency for pit emptying can be compared. Assuming an average of 6 users per toilet, a 2 m^3 VIP pit would require emptying every 7.9 years, and a 2 m^3 pour flush pit would require emptying for the first time after

11.9 years. Based on these two data sets, it is clear that there is a significant reduction in sludge accumulation rate in pour flush toilets when compared to VIPs, which therefore suggests that overall maintenance costs will be lower for pour flush toilets than for VIPs. While this is not captured in the initial capital cost of the toilet, it will impact on the overall life-cycle cost of the technology, which municipalities should consider due to the mandate to provide long-term improved sanitation to all people.

Dealing with full pits either requires emptying the pits or relocating the toilet to another location on the same site. Emptying pits is advantageous, as it allows for continual use of the initial investment and also allows for beneficiation of sludge. Emptied sludge can either be buried on site (after which a tree can be planted over the sludge) or transported off-site to a faecal sludge processing facility, either a specially designated faecal sludge treatment plant or a wastewater treatment plant. Particularly in rural areas with large travel distances, emptying and burial on site is generally the most economical option. In urban areas or areas with a high demand for beneficiated sludge products (e.g. compost), transport and treatment of faecal sludge may be advantageous.

The use of precast concrete top structures in on-site sanitation has become a common practice in South Africa, with the aim of providing householders with a structure that can easily be relocated when the pits fill up. The Cemflush pour flush toilet is designed to be used in this way. Once the pit fills up, it would be abandoned and the top structure moved to another location above a new pit. Municipalities must not forget that this comes with its own costs. If this is the model adopted, the sanitation provider is required and will be expected to provide a pit for disposal, a new lined pit for the toilet and will then have to take down and reconstruct the top structure. Some households may take the initiative to do this, but this is not ideal as the integrity of the construction cannot be ensured. This model is also only applicable in rural areas where households have relatively large plots. For example, this would not work in Mt Fletcher where, as shown above, the plots are small and are already overcrowded with other sanitation systems.

Switching pipework (double pit systems)

One minor maintenance requirement that is unique to double pit systems is the switching of pipework when the first pit fills up in order to start utilising the second pit. Pipework should be installed from the beginning to allow for this to be a simple operation. The pipe that is not in use must be sealed with an end cap to keep soil from getting into the pipe and causing blockages. One method for switching pipework is to use a flexible pipe fitting to switch between the two lines. To make this method even simpler, a bucket can be installed around the flexible fitting (similar to a manhole), rather than burying the pipe underground. This would make switching the pipework extremely simple. Another method for switching is the use of an elbow, which is rotated 180 degrees when it is time to switch pits (see Figure 67). The PID researchers assisted one family with switching their pipework that had the elbow option, and it was found to be relatively awkward and difficult. It is unlikely that a household would do this switching, and they would like have to hire someone to take care of it for them. A small number of householders (4) expressed dissatisfaction with the fact that they would be required to switch the pipework themselves and insisted that it should be the municipality's job. If the municipality did take this responsibility, this would need to be done as soon as the first pit fills up and would require little more than a worker going to site with a spade to dig up the pipework and switch it.

In addition to making it simple to switch pipework, householders must be made aware of the fact that they have two pits and that switching will be necessary at some point. Of the 239 householders asked, only 55 (23%) said that they know about switching between the pits in their double pit systems. This demonstrates the lack of knowledge about how the system works, which is a failure in user education. If families are made aware from the beginning that they will be required to switch the pipework and how to do so, they might be more willing to do the job themselves.

Figure 67: Pipework switching option using an elbow

Addressing blockages and leakages

As demonstrated in this study, blockages and leakages in pour flush toilets are extremely uncommon, and very seldom do householders get plumbers involved to fix these problems. Nevertheless, it is still wise to be aware of this potential maintenance need and plan accordingly, whether that means municipalities making their maintenance teams available to respond to calls reporting such issues or households knowing who to call in the event of a blockage or leakage (e.g. a local plumber).

6.1.4 Project implementation issues

No matter what technology is used, the manner of implementation of a project from beginning to end has a large impact on the reception of the intervention. This includes involving households in decision-making so that they feel empowered to use the technology. In Thornhill, a number of households expressed some dissatisfaction that they were forced to have pour flush toilets when they would have been happier with VIP toilets. This is especially true due to water shortages in the area, which led to dissatisfaction with pour flush toilets. In this case, if householders had actually chosen to have pour flush toilets, the outcomes may have been better even if the water reliability did not improve.

During implementation, each householder should be consulted regarding where their pour flush toilet should be built. In some project locations, it was found that the contractors placed the toilets on the opposite end of the household property than that requested. Other householders reported that they did not like the orientation of their pour flush toilet and would prefer if the door faced a different way. These requests should be note up front and acted upon to avoid householders resenting the intervention from the time it is built.

It is also important to consider how the project implementation method creates unreasonable expectations for householders. Creating these expectations can lead to dissatisfaction, as users think that what they have been given is an interim solution and not a final solution. For example, in Ilembe District Municipality, cisterns were installed with all pour flush toilets, because the municipality had plans to install water connections at a later point. This, coupled with the numerous buried water pipes with no water running through them, created an expectation that water was coming soon to the community. As a result, some users reported not using the pour flush toilet, as they were waiting for it to be "completed". Another example of this is that in Oakford, a portion of houses received low flush toilets instead of pour flush toilets. As a result, those that received pour flush toilets insisted that they should also get low flush toilets. However, water supply in this project is very limited and the current water system could not support low flush or full flush toilets.

7 Conclusions

This study demonstrated how pour flush uptake in South Africa has increased exponentially in the last 8 years and that this increase in pour flush toilets is accompanied by positive user experiences in general. The increase in pour flush uptake has been due, in large part, to marketing efforts by manufacturers of pour flush toilets. While initial pilot projects had positive feedback from most users, many of them have not yet led to widespread municipal adoption, which is likely due to a lack of knowledge and knowledge sharing among municipal officials. Over the course of 8 years, pour flush toilets in South Africa have gone from concept to prototyping, piloting, commercialisation, and large-scale implementation.

This study demonstrates the general positive experiences of users across locations, with the greatest negative experiences being associated with extreme water shortages and inconvenience. To make pour flush toilets more accepted among rural householders, convenience should be improved, particularly with getting water to the toilet for flushing. This was by far the most common feedback received in this study. This study has presented some alternatives to carrying buckets of water to the toilet each time while also continuing to avoid creating a direct water connection between cistern and toilet pedestal.

Overall, pour flush toilets are currently the most likely alternative to VIP toilets in the rural sanitation landscape in South Africa. The addition of another viable technology option is a positive advancement, as it will allow municipalities and householders greater agency when implementing projects. This does, however, also require more critical thinking on the side of municipal decision-makers, since VIP toilets have for so long been the accepted standard. Though the pour flush technology has successfully been demonstrated, it is clear that there is still a long way to go in educating municipal officials about its potential and ensuring that standards and specifications enable wider spread implementation of pour flush toilets.

Works cited

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Still, D. and Foxon, K. (2012). *Tackling the Challenges of Full Pit Latrines: Volume 2 How fast do pit toilets fill up? A scientific understanding of sludge build up and accumulation in pit latrines.* WRC Report No. 1745/2/12. Pretoria, South Africa.

ANNEXURE A: User Survey

WRC POUR FLUSH ASSESSMENT, USER INTERVIEW

QUESTION		TYPE	OPTIONS										
			General information of this assessment										
1	Interviewer's name	SELECT ONE											
2	Household family name	TEXT											
3	Name(s) of interviewee	TEXT											
4	Gender of interviewee	SELECT ONE	*MALE*	*FEMALE*									
5	Age of interviewee	NUMBER											
6	Municipality	SELECT ONE											
7	Neighborhood name or ward number	TEXT											
8	Post office reference number	TEXT											
9	Toilet reference number	TEXT											
	Toilet information												
10	Do they have a pour flush or low flush toilet?	SELECT ONE	*POUR*	*LOW*	*NEITHER*								
11	Is it a single or double pit?	SELECT ONE	*SINGLE*	*DOUBLE*									
12	When was the pour flush toilet built?	DATE											
13	Is the pour flush toilet in use?	SELECT ONE	*YES*	*NO*									
14	Has a pour flush toilet ever been used at this household?	SELECT ONE	*YES*	*NO*									
15	Why is the pour flush toilet not used?	TEXT											
16	Since when has it not been in use?	DATE											
17	Why is it not used anymore?	TEXT											
18	Since when has the PF toilet been in use?	DATE											
19	Are there other toilets on site?	SELECT ONE	*YES*	*NO*									
20	How many?	NUMBER											
21	What kind of toilets are they?	SELECT ONE	*VIP toilet*	*Home-built pit toilet*	*Full flush toilet*								
22	How frequently is the pour flush toilet used compared to the other options?	SELECT ONE	*25% of the time*	*50% of the time*	*75% of the time*	*100% of the time*							

	QUESTION	TYPE	OPTIONS										
			Toilet user information										
23	How many people lived in the house when the toilet was first built?	NUMBER											
24	How many people, including babies and children, currently live in the house permanently?	NUMBER											
25	Out of those people, how many people normally use the toilet?	NUMBER											
26	Is there anyone that does not use the toilet?	SELECT ONE	*YES*	*NO*									
27	Who doesn't use the pour/low flush toilet?	SELECT ONE	*Baby (0-2 years old)*	*Child (2-12 years old)*	*Teenager (13-19 years old)*	*Youth (20-35 years old)*	*Adult (36-70 years old)*	*Elderly (70+ years old)*					
28	How many babies/toddlers don't use the pour/low flush toilet?	NUMBER											
29	Why doesn't the baby/toddler use the pour/low flush toilet?	SELECT ONE	*The toilet is too small/cramped*	*The toilet ceiling is too low for them*	*The pedestal is too high*	*The pedestal is too low*	*They do not want to go outside to use the toilet*	*They are too young to use the toilet properly*	*They just don't like it*				
30	What do they use instead?	SELECT ONE	*Nappies*	*Use old toilet*	*Go outside in the bush*	*Use public toilet*	*Use neighbor's toilet*						
31	How many children don't use the pour/low flush toilet?	NUMBER											
32	Why doesn't the child(ren) use the pour/low flush toilet?	SELECT ONE	*The toilet is too small/cramped*	*The toilet ceiling is too low for them*	*The pedestal is too high*	*The pedestal is too low*	*They do not want to go outside to use the toilet*	*They are too young to use the toilet properly*					
33	What do they use instead?	SELECT ONE	*Nappies*	*Use old toilet*	*Go outside in the bush*	*Use public toilet*	*Use neighbor's toilet*						
34	How many teenagers don't use the pour/low flush toilet?	NUMBER											
35	Why doesn't the teenager(s) use the pour/low flush toilet?	SELECT ONE	*The toilet is too small/cramped*	*The toilet ceiling is too low for them*	*The pedestal is too high*	*The pedestal is too low*	*They do not want to go outside to use the toilet*	*They are too young to use the toilet properly*					
36	What do they use instead?	SELECT ONE	*Nappies*	*Use old toilet*	*Go outside in the bush*	*Use public toilet*	*Use neighbor's toilet*						
37	How many youth don't use the pour/low flush toilet?	NUMBER											
38	Why doesn't the youth use the pour/low flush toilet?	SELECT ONE	*The toilet is too small/cramped*	*The toilet ceiling is too low for them*	*The pedestal is too high*	*The pedestal is too low*	*They do not want to go outside to use the toilet*	*They are too young to use the toilet properly*					
39	What do they use instead?	SELECT ONE	*Nappies*	*Use old toilet*	*Go outside in the bush*	*Use public toilet*	*Use neighbor's toilet*						
40	How many adults don't use the pour/low flush toilet?	NUMBER											
41	Why doesn't the adult(s) use the pour/low flush toilet?	SELECT ONE	*The toilet is too small/cramped*	*The toilet ceiling is too low for them*	*The pedestal is too high*	*The pedestal is too low*	*They do not want to go outside to use the toilet*	*They are too young to use the toilet properly*					

	QUESTION	TYPE	OPTIONS										
42	What do they use instead?	SELECT ONE	*Nappies*	*Use old toilet*	*Go outside in the bush*	*Use public toilet*	*Use neighbor's toilet*						
43	How many elderly adults don't use the pour/low flush toilet?	NUMBER											
44	Why doesn't the elderly adult(s) use the pour/low flush toilet?	SELECT ONE	*The toilet is too small/cramped*	*The toilet ceiling is too low for them*	*The pedestal is too high*	*The pedestal is too low*	*They do not want to go outside to use the toilet*	*They are too young to use the toilet properly*					
45	What do they use instead?	SELECT ONE	*Nappies*	*Use old toilet*	*Go outside in the bush*	*Use public toilet*	*Use neighbor's toilet*						
					Hygiene supplies								
46	What do you use for wiping?	SELECT ONE	*Toilet paper*	*Newspaper*	*Rubbish*								
47	How often do you buy toilet paper?	SELECT ONE	*Every day*	*Once a week*	*Once every two weeks*	*Once a month*	*Never*						
48	When you buy toilet paper, how many rolls do you usually buy?	NUMBER											
49	Do you ever purchase handwashing soap?	SELECT ONE	*YES*	*NO*									
50	What kind do you usually buy?	SELECT ONE	*Bar*	*Liquid*									
51	How often do you buy soap?	SELECT ONE	*Every day*	*Once a week*	*Once every two weeks*	*Once a month*	*Never*						
52	How many bars do you usually purchase at a time?	NUMBER											
53	How much soap do you usually buy (millilitres)	NUMBER											
					Maintenance needs								
54	What is your household's primary water source?	SELECT ONE	*Inside tap*	*Outside tap (household)*	*Outside tap (communal)*	*Outside tap (neighbour's tap)*	*Surface Water*	*Rainwater*	*Greywater*				
55	What water do you usually use for flushing the toilet?	SELECT ONE	*Inside tap*	*Outside tap (household)*	*Outside tap (communal)*	*Outside tap (neighbour's tap)*	*Surface Water*	*Rainwater*	*Greywater*	*Municipal water directly connected to toilet*			
56	How much water do you use to flush number 1?	SELECT ONE	*1 litre*	*1.5 litres*	*2 litres*	*3 litres*	*5 litres*	*10 litres*	*20 litres*	*25 litres*	OTHER		
57	How much water do you use to flush number 2?	SELECT ONE	*1 litre*	*1.5 litres*	*2 litres*	*3 litres*	*5 litres*	*10 litres*	*20 litres*	*25 litres*	OTHER		
58	What size bucket do you use to hold flushing water?	SELECT ONE	*2 litres*	*5 litres*	*10 litres*	*20 litres*	*25 litres*						
59	How often do you refill the bucket?	SELECT ONE	*1 time per day*	*2 times per day*	*3 times per day*	*4 times per day*	*Each person takes a full bucket when the use the toilet*						
60	Do you ever not have water?	SELECT ONE	*YES*	*NO*									
61	How frequently do you not have water?	SELECT ONE	*Less than once a month*	*Once or twice a month*	*Once a week*	*Most days in the week*	*Every day*						
62	What do you do about the pour flush toilet when there is no water?	SELECT ONE	*Lock the toilet and don't use it*	*Use old pit toilet*	*Use it without water and clean it later*	*Use greywater to flush*	*Use rainwater to flush*	*OTHER*					
63	Where do you dispose of your greywater (from washing dishes, clothes, and bathing)?	SELECT ONE	*Pour into the new toilet*	*Pour into the old toilet*	*Pour into the yard*	*Pour on the vegetables*							

	QUESTION	TYPE	OPTIONS										
64	Do you ever use greywater for flushing?	SELECT ONE	*YES*	*NO*									
65	How often?	SELECT ONE	*All the time*	*Sometimes*	*When there is no water*								
66	Where do you get your greywater from?	SELECT ONE	*Kitchen (dishwashing)*	*Bathing*	*Cleaning/floo r mopping*	*Clothes washing*	*Handwashing basins*						
67	Why do you use greywater for flushing?	SELECT ONE	*Water shortage*	*To save water*	*I don't know where else to dispose of my greywater*								
68	Please describe how you capture greywater and use it in the toilet.	TEXT											
69	How easy is it to clean your pour flush toilet after use?	SELECT ONE	*1 - Difficult*	*2 - Easy*	*3 - Very easy*								
70	Do you know how to switch the plumbing between your two pits?	SELECT ONE	*YES*	*NO*									
71	Have you used the second pit?	SELECT ONE	*YES*	*NO*									
72	Approximately when did you switch to the second pit?	DATE											
73	Did you your someone else in your household switch the plumbing?	SELECT ONE	*YES*	*NO*									
74	Who helped you switch the plumbing?	SELECT ONE	*Neighbor*	*Local plumber*	*Municipal employees*								
75	How much did it cost you (in Rands)?	NUMBER											
76	Where do you dispose of rubbish?	SELECT ONE	*Old toilet*	*Burn*	*Bury*	*Throw in dump*	*Municipal collection*						
77	Have the pits been emptied before?	SELECT ONE	*YES*	*NO*									
78	How many pits were emptied?	NUMBER											
79	When?	DATE											
80	By whom?	SELECT ONE	*The householders*	*Municipal contractor*	*Private contractor*								
81	How was it emptied?	SELECT ONE	*Manually (shovel/buck ets)*	*Vacuum truck*	*OTHER*								
82	How much did it cost you (in Rands)?	NUMBER											
83	How much did it cost you (in Rands)?	NUMBER											
84	Have you used any chemicals in attempt to lower the sludge level?	SELECT ONE	*YES*	*NO*									
85	What did you use?	TEXT											
86	How often do you use it?	SELECT ONE	*I just used it once.*	*Every two years*	*Once a year*	*Twice a year*	*Every month*						
87	Do you think it helps reduce the sludge level?	SELECT ONE	*YES*	*NO*									
88	How many times have you experienced a blockage?	SELECT ONE	*Never*	*Once*	*A couple times*	*Regularly*							
89	When did the blockage happen?	DATE											
90	What caused the blockage?	TEXT											
91	Where did the blockage happen?	SELECT ONE	*Toilet pedestal*	*P-trap*	*Pipework to leach pit*	*Leach pit*							
92	Were you or someone else in your household able to fix the problem?	SELECT ONE	*YES*	*NO*									
93	Who helped you fix the blockage?	SELECT ONE	*Neighbor*	*Local plumber*	*Municipal employees*								
94	How much did it cost you (in Rands)?	NUMBER											

	QUESTION	TYPE	OPTIONS										
95	About how many times do you think it's happened?	NUMBER											
96	Do you remember when it happened the first time?	DATE											
97	When did it most recently happen?	DATE											
98	In the most recent time, what caused the blockage?	TEXT											
99	Where did the blockage happen?	SELECT ONE	*Toilet pedestal*	*P-trap*	*Pipework to leach pit*	*Leach pit*							
100	Were you or someone else in your household able to fix the problem?	SELECT ONE	*YES*	*NO*									
101	Who helped you fix the blockage?	SELECT ONE	*Neighbor*	*Local plumber*	*Municipal employees*								
102	How much did it cost you (in Rands)?	NUMBER											
103	How frequently does it happen?	SELECT ONE	*Annually*	*Monthly*	*Weekly*	*Daily*							
104	What usually causes the blockage?	TEXT											
105	Where does the blockage usually happen?	SELECT ONE	*Toilet pedestal*	*P-trap*	*Pipework to leach pit*	*Leach pit*							
106	Are you or someone else in your house usually able to fix the problem?	SELECT ONE	*YES*	*NO*									
107	Who usually helps you fix the blockage?	SELECT ONE	*Neighbor*	*Local plumber*	*Municipal employees*								
108	How much does it usually cost you (in Rands)?	NUMBER											
109	Is your toilet currently leaking?	SELECT ONE	*YES*	*NO*									
110	Where is it leaking?	SELECT ONE	*Cistern*	*P-trap/ pipework*	*OTHER*								
111	How often have you experienced leakages?	SELECT ONE	*Never*	*Once*	*A couple times*	*Regularly*							
112	What was leaking?	SELECT ONE	*Cistern*	*P-trap/ pipework*	*OTHER*								
113	When did it start leaking?	DATE											
114	About how long was it leaking for?	SELECT ONE	*Less than a day*	*For a few days*	*For a week*	*For a few weeks*	*For a few months*	*For a year*	*For more than a year*	*It is still leaking.*			
115	Is there something specific that caused the leakage?	SELECT ONE	*YES*	*NO*									
116	Please describe.	TEXT											
117	Were you or someone else in your household able to fix the problem?	SELECT ONE	*YES*	*NO*									
118	Who helped you fix the leakage?	SELECT ONE	*Neighbor*	*Local plumber*	*Municipal employees*								
119	How much did it cost you (in Rands)?	NUMBER											
120	About how many times do you think it's happened?	NUMBER											
121	Do you remember when it happened the first time?	DATE											
122	When did it most recently happen?	DATE											
123	In the most recent time, about how long was it leaking for?	SELECT ONE	*Less than a day*	*For a few days*	*For a week*	*For a few weeks*	*For a few months*	*For a year*	*For more than a year*	*It is still leaking.*			
124	What was leaking?	SELECT ONE	*Cistern*	*P-trap/pipework*	*OTHER*								
125	Was there something specific that caused the leakage?	SELECT ONE	*YES*	*NO*									
126	Please describe.	TEXT											
127	Were you or someone else in your household able to fix the problem?	SELECT ONE	*YES*	*NO*									
128	Who helped you fix the leakage?	SELECT ONE	*Neighbor*	*Local plumber*	*Municipal employees*								
129	How much did it cost you (in Rands)?	NUMBER											
130	How frequently does it happen?	SELECT ONE	*Annually*	*Monthly*	*Weekly*	*Daily*							

	QUESTION	TYPE	OPTIONS										
131	What usually causes the leakage?	TEXT											
132	What usually leaks?	SELECT ONE	*Cistern*	*P-trap/ pipework*	*OTHER*								
133	Are you or someone else in your house usually able to fix the problem?	SELECT ONE	*YES*	*NO*									
134	Who usually helps you fix the leakage?	SELECT ONE	*Neighbor*	*Local plumber*	*Municipal employees*								
135	How much does it usually cost you (in Rands)?	NUMBER											
136	Which items (if any) have you replaced?	SELECT ONE	*Pedestal*	*Seat*	*Bucket*	*Jug*	*Door*	*Lock*	*Roof*	*Nothing*	OTHER		
137	How many times have you replaced your pedestal?	NUMBER											
138	Where do you usually get your replacement pedestal from?	TEXT											
139	How many times have you replaced your toilet seat?	NUMBER											
140	Where do you usually get your replacement seat from?	TEXT											
141	How many times have you replaced your bucket?	NUMBER											
142	How many times have you replaced your flushing jug?	TEXT											
143	How many times have you replaced your door?	NUMBER											
144	How many times have you replaced your door lock?	TEXT											
145	How many times have you replaced your roof?	NUMBER											
146	Where do you usually get your replacement parts from?	TEXT											
147	Is there anything you're planning to replace?	SELECT ONE	*Pedestal*	*Seat*	*Bucket*	*Jug*	*Door*	*Lock*	*Roof*	*Nothing*	OTHER		
148	Why do you want to replace your pedestal?	TEXT											
149	Why do you want to replace your toilet seat?	TEXT											
150	Why do you want to replace your bucket?	TEXT											
151	Why do you want to replace your flushing jug?	TEXT											
152	Why do you want to replace your door?	TEXT											
153	Why do you want to replace your door lock?	TEXT											
154	Why do you want to replace your roof?	TEXT											
	Final comments on the toilet												
155	Have you made any upgrades to your toilet?	SELECT ONE	*YES*	*NO*									
156	What upgrades have you made?	SELECT ONE	*Added a cistern*	*Added tiles*	*Painted it*	*Added mats or rugs*	*Added other accessories (e.g. mirror)*	*Installed a septic tank*	*Replaced the pedestal*	*OTHER*			
157	Did you know that you could convert your toilet to a low flush toilet by adding a cistern?	SELECT ONE	*YES*	*NO*									
158	Briefly describe to the householder some pros and cons of converting to a low flush toilet.												
159	Would you consider adding a cistern to your toilet and converting to a low flush or full flush system?	SELECT ONE	*YES*	*NO*									
160	Why would you convert your pour flush toilet?	TEXT											
161	Have you experienced any difficulties with the toilet?	SELECT ONE	*YES*	*NO*									
162	Please explain.	TEXT											
163	Is there anything you like about the toilet?	SELECT ONE	*Safer for small kids*	*Safe from collapse*	*Less smell*	*More clean*	*It is easy to use*	*Nothing*	*OTHER*				
164	Is there anything you dislike about the toilet?	SELECT ONE	*It blocks too easily*	*We don't have enough water*	*It smells bad*	*I can't put my rubbish in it*	*It's too difficult to maintain*	*Refilling the bucket is too difficult*	*Seeing my faeces in the toilet before I flush them down*	*The pedestal is not comfortable to use*	*Having to scrub the pedestal after use*	*Nothing*	*OTHER*
165	Would you recommend the pour/low flush toilet to others?	SELECT ONE	*YES*	*NO*									

QUESTION		TYPE	OPTIONS										
166	Why would you would recommend it?	SELECT ONE	*It looks nice*	*It's hygienic*	*It's safe*	*It's easy to use*	*It doesn't smell bad*	*It doesn't block*	*It's easy to maintain*	*It's better than the VIP toilet*	*OTHER*		
167	Why would you not recommend it?	SELECT ONE	*It's too much work to clean after use*	*Cannot always afford toilet paper*	*Too much work to refill the bucket*	*Cannot use when there is no water*	*It breaks too often*	*OTHER*					
168	Is there anything you would change about the toilet or structure?	SELECT ONE	*YES*	*NO*									
169	What?	SELECT ONE	*Have a bigger pedestal*	*Have a smaller pedestal*	*Install a ceramic pedestal*	*Add a cistern*	*Change the door*	*Change the type of lock*	*Change the seat*	*Build the structure out of different materials*	*Add handwashing basin*	*Nothing*	*OTHER*
170	Please provide more specifics if applicable.	TEXT											
171	Comments regarding home owner attitude towards the toilet.	TEXT											

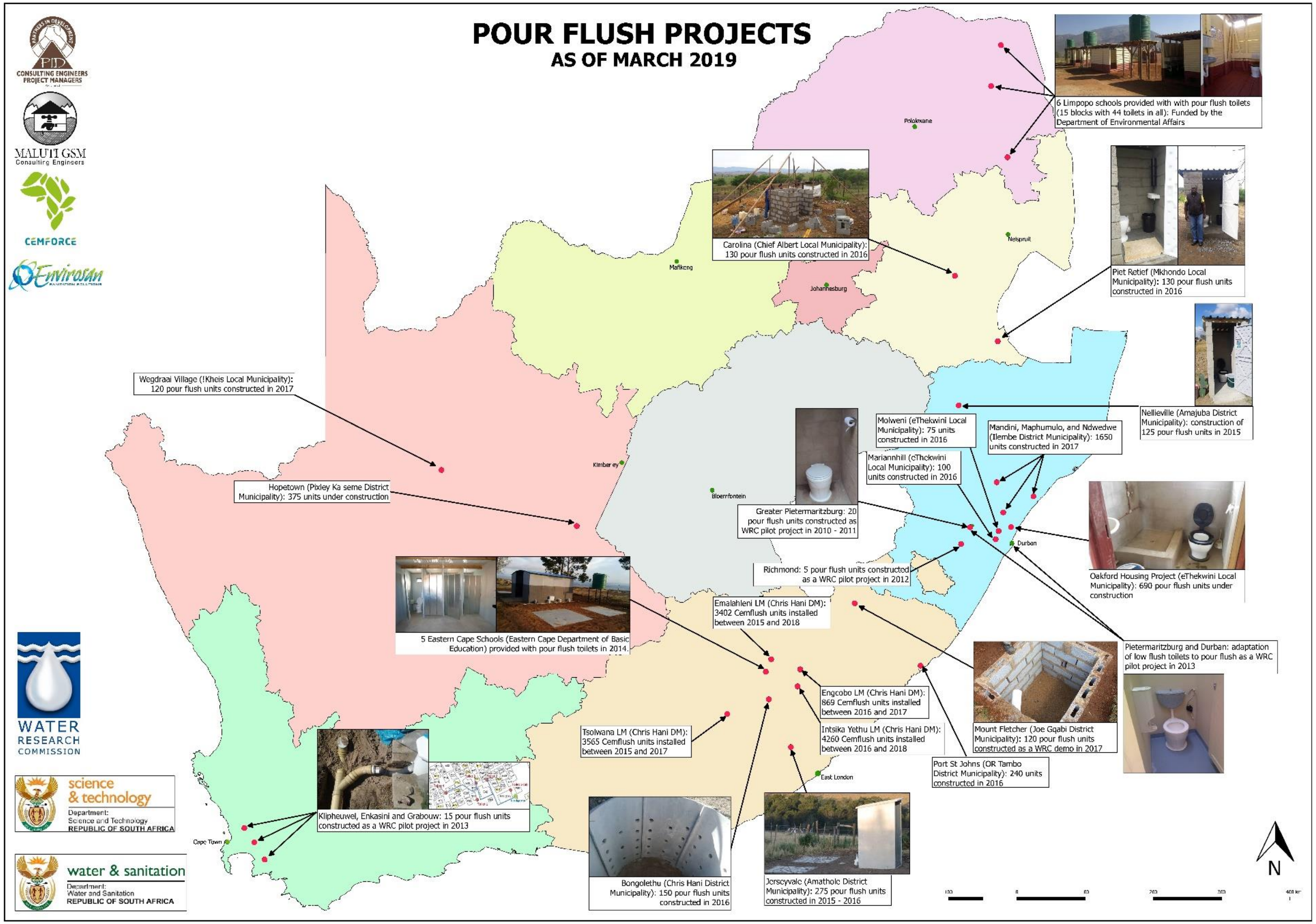
ANNEXURE B: Pour flush toilet inspection

WRC POUR FLUSH ASSESSMENT, TOILET INSPECTION

	QUESTION	TYPE	OPTIONS							
1	Where is the pour flush toilet located?	SELECT ONE	*Inside the house*	*In the yard of the house*						
2	Has the toilet been converted to low flush or full flush toilet?	SELECT ONE	*YES*	*NO*						
3	Has the toilet been upgraded in any way?	SELECT ONE	*Added a cistern*	*Added tiles*	*Painted it*	*Added mats or rugs*	*Added other accessories (e.g. mirror)*	*Installed a septic tank*	*Replaced the pedestal*	*OTHER*
	Remove pit cover(s) for the pit(s) that are or have been in use									
	Take measurements of the sludge depths									
4	Pit 1, sludge depth number 1	NUMBER								
5	Pit 1, sludge depth number 2	NUMBER								
6	Pit 1, sludge depth number 3	NUMBER								
7	Describe the contents of pit 1	SELECT ONE	*Dry sludge*	*Wet sludge*	*Layer of water on top*	*A lot of rubbish*				
8	Please provide general comments on the contents of Pit 1	TEXT								
9	Has the second pit been used?	SELECT ONE	*YES*	*NO*						
10	Pit 2, sludge depth number 1	NUMBER								
11	Pit 2, sludge depth number 2	NUMBER								
12	Pit 2, sludge depth number 3	NUMBER								
13	Describe the contents of pit 2	SELECT ONE	*Dry sludge*	*Wet sludge*	*Layer of water on top*	*A lot of rubbish*				
14	Please provide general comments on the contents of Pit 2	TEXT								
15	What is the toilet structure built out of?	SELECT ONE	*Concrete blocks*	*Precast concrete*	*OTHER*					
16	What condition is the toilet structure in?	SELECT ONE	*Stable, good condition*	*Cracked in some places*	*Some holes in the structure*	*Unstable/ falling apart*				
17	Is there a door?	SELECT ONE	*YES*	*NO*						
18	Does it close?	SELECT ONE	*YES*	*NO*						
19	Does it lock?	SELECT ONE	*YES*	*NO*						
20	What condition is the door in?	SELECT ONE	*Intact*	*Lockable*	*Broken*	*Rusted*	*Dirty*	*Detached from the structure*		
21	Is there a pedestal?	SELECT ONE	*YES*	*NO*						
22	Does the pedestal have a seat?	SELECT ONE	*YES*	*NO*						
23	Is there a child friendly seat installed?	SELECT ONE	*YES*	*NO*						
24	What condition is the seat in?	SELECT ONE	*Stable, working*	*Broken*	*Loose*	*Detached from the pedestal*				
25	Does the pedestal have a cover that's connected?	SELECT ONE	*YES*	*NO*						
26	What condition is the pedestal in?	SELECT ONE	*Stable, working*	*Broken*	*Unstable*	*Dirty*				
27	Is there a roof?	SELECT ONE	*YES*	*NO*						
28	What condition is it in?	SELECT ONE	*Good condition*	*Cracked or has a hole in it*	*Loose/not well connected*	*Falling off*				
29	Check if these items are present	SELECT MULTIPLE	*Toilet paper*	*Water bucket*	*Jug for flushing*	*Toilet brush*	*Soap*	*Poster*		
30	How big is the bucket for water?	SELECT ONE	*2 litres*	*5 litres*	*10 litres*	*20 litres*	*25 litres*	*OTHER*		

	QUESTION	TYPE	OPTIONS							
31	Rate the overall toilet cleanliness	SELECT ONE	*3 - Clean*	*2- A bit dirty*	*1 - Very dirty*					
32	Rate the toilet odour	SELECT ONE	*3 - No odour*	*2 - Some odour*	*1 - Too much odour*					
33	Please explain why there might be an odour. (examples: toilet hasn't been flushed; greywater used for flushing; urine on the floor; etc)	TEXT								
34	Note the soil conditions of the area.	SELECT ONE	*Sandy*	*Clay*	*Rocky*					
35	General comments regarding the toilet state and observed condition.	TEXT								

ANNEXURE C: Map of domestic pour flush toilet installations in South Africa


POUR FLUSH PROJECTS
AS OF MARCH 2019
CONSULTING ENGINEERS PROJECT MANAGERS
MALUTI GSM
Consulting Engineers
CEMFORCE
Envirosan
WATER RESEARCH COMMISSION
science & technology
Department: Science and Technology REPUBLIC OF SOUTH AFRICA
water & sanitation
Department: Water and Sanitation REPUBLIC OF SOUTH AFRICA
6 Limpopo schools provided with with pour flush toilets (15 blocks with 44 toilets in all): Funded by the Department of Environmental Affairs
Polokwane
Carolina (Chief Albert Local Municipality): 130 pour flush units constructed in 2016
Nelspruit
Mafikeng
Johannesburg
Piet Retief (Mkhondo Local Municipality): 130 pour flush units constructed in 2016
Nellieville (Amajuba District Municipality): construction of 125 pour flush units in 2015
Wegdraai Village (!Kheis Local Municipality): 120 pour flush units constructed in 2017
Molweni (eThekwini Local Municipality): 75 units constructed in 2016
Mandini, Maphumulo, and Ndwedwe (Ilembe District Municipality): 1650 units constructed in 2017
Kimberley
Mariannhill (eThekwini Local Municipality): 100 units constructed in 2016
Hopetown (Pixley Ka seme District Municipality): 375 units under construction
Bloemfontein
Greater Pietermaritzburg: 20 pour flush units constructed as WRC pilot project in 2010 - 2011
Durban
Oakford Housing Project (eThekwini Local Municipality): 690 pour flush units under construction
Richmond: 5 pour flush units constructed as a WRC pilot project in 2012
5 Eastern Cape Schools (Eastern Cape Department of Basic Education) provided with pour flush toilets in 2014.
Emalahleni LM (Chris Hani DM): 3402 Cemflush units installed between 2015 and 2018
Pietermaritzburg and Durban: adaptation of low flush toilets to pour flush as a WRC pilot project in 2013
Engcobo LM (Chris Hani DM): 869 Cemflush units installed between 2016 and 2017
Mount Fletcher (Joe Gqabi District Municipality): 120 pour flush units constructed as a WRC demo in 2017
Tsolwana LM (Chris Hani DM): 3565 Cemflush units installed between 2015 and 2017
Intsika Yethu LM (Chris Hani DM): 4260 Cemflush units installed between 2016 and 2018
Port St Johns (OR Tambo District Municipality): 240 units constructed in 2016
East London
Klipheuwel, Enkasini and Grabouw: 15 pour flush units constructed as a WRC pilot project in 2013
Cape Town
Bongolethu (Chris Hani District Municipality): 150 pour flush units constructed in 2016
Jerseyvale (Amathole District Municipality): 275 pour flush units constructed in 2015 - 2016
N

ANNEXURE D: Vulindlela Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in Msunduzi Municipality.

Case Study: Msunduzi, KwaZulu-Natal

A number of units were built during the initial pour flush development near Pietermaritzburg (KZN), including 20 in Msunduzi Local Municipality and 5 in Richmond Local Municipality. At the time of the assessment, these units were 8 years old and thus represent the longest-term installation and test for the success of pour flush toilets. These projects included mostly households as well as one church and one primary school. The construction also included a mix of double and single pit systems, though double pit systems were most common. Of the units in the area, 10 were visited and assessed. One has since been demolished and 2 were not locatable. Furthermore, one unit installed at a church was locked during the visit, and the lock appeared rusted, suggesting that the toilet had not been in use for some time. All 10 where inspections and interviews were carried out are all still in use.

Figure D68: Pour flush unit in Msunduzi with water stored in 2-litre bottles

Figure D69: Dirty pour flush toilets in Msunduzi

Figure D70: Unit in Azalea before (left) and after (right) upgrade to low flush unit

Figure D71: Pedestal from demolished unit in Msunduzi

Condition of PF toilets

During the assessments, all 10 toilets had no odour, according to fieldworker feedback. This demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure, even after a long period of use. Seven of the toilets were clean, 1 was a bit dirty, and 2 were very dirty. As shown above in Figure D69, the dirty toilets had a lot of trash thrown on the ground, which could be a symptom of a lack of solid waste collection in the area along with the fact that rubbish cannot be put down a pour flush toilet like it can in a VIP.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include the fact that they have less odour (5); they are cleaner (4); and they are flushable (2). Typically, respondents will answer this question relative to the status quo option, which is using their old, home-built pit toilet or the other options available in the municipality, such as VIPs. Six respondents said that there is nothing they dislike about pour flush toilets. A small number of households reported aspects that they don't like about pour flush toilets, including: it smells bad (2); refilling the bucket is too difficult (2); it blocks too easily (1); the pedestal is not comfortable (1); and scrubbing the pedestal after use is not nice (1).

It is interesting to note that the number of people who said that refilling their bucket is too difficult was low in this area when compared to other areas included in the assessment. The majority (9) of the users in this survey use their outside tap water for flushing their toilet, which suggests that they must carry water from the tap to the toilet. The wider satisfaction with this aspect of the technology may be due to education and support that was provided up front to the users as well as the comparative advantage of simply being able to flush the toilet as opposed to the alternative of VIP toilets. Two users had upgraded to a low flush unit by installing a pedestal, while 5 said that they would consider adding a cistern to have a low flush unit.

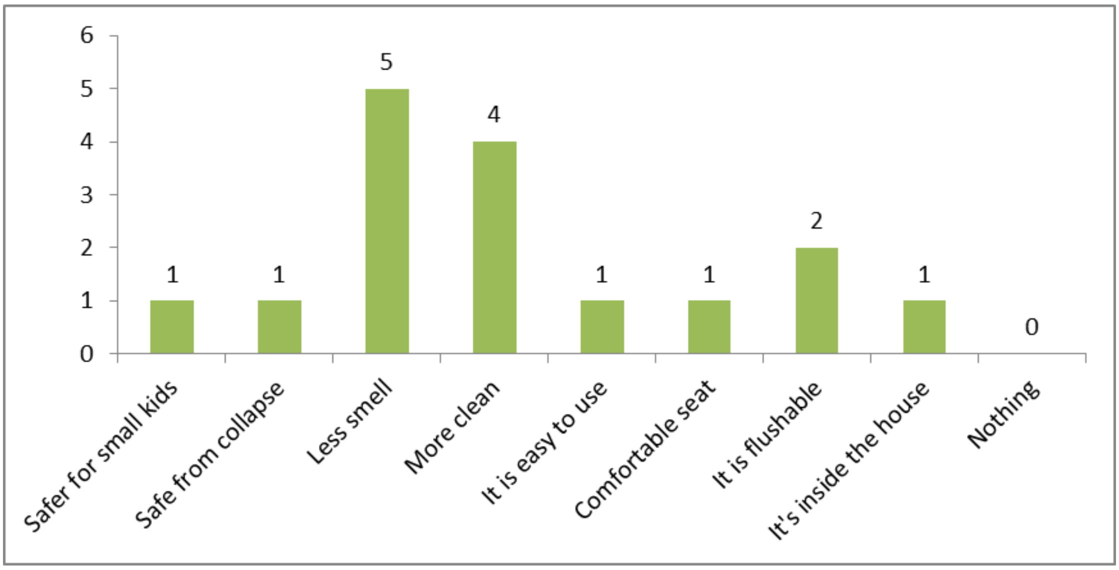


Figure D72: What do users like about pour flush toilets?

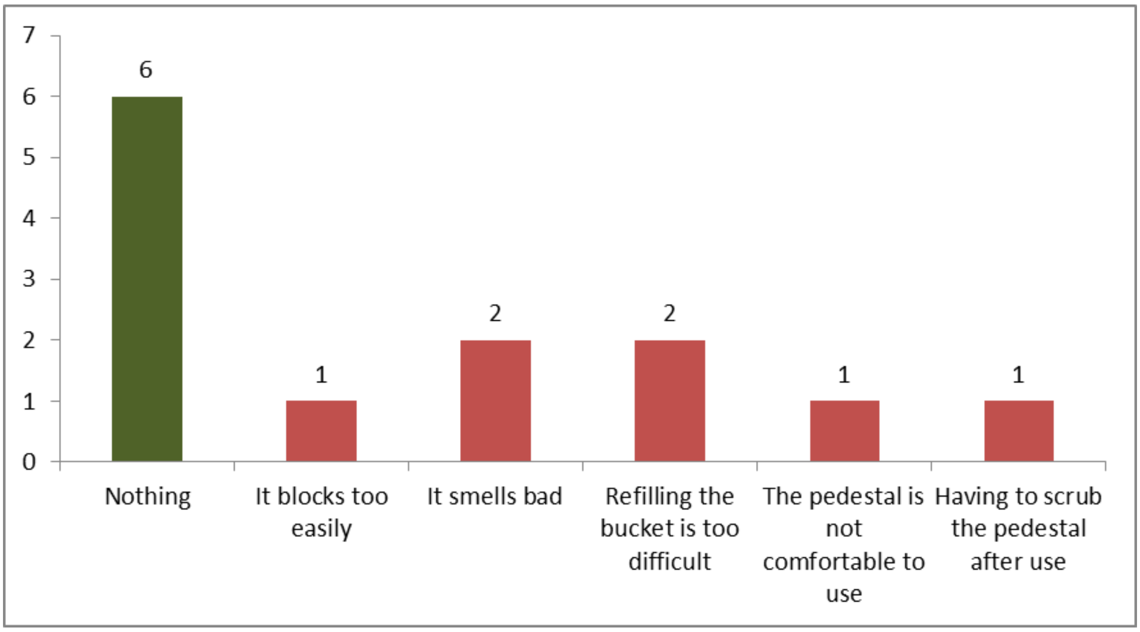


Figure D73: What do users dislike about pour flush toilets?

Users generally said that they would recommend pour flush toilets (8/10) to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets (Figure D72), including that it is easy to use (4) and safe (3). One user stated that his friends often ask why his family is the only one that has this type of toilet, because they like the technology. This suggests a small amount of knowledge transfer due to word of mouth as well as the potential for wider acceptance of pour flush toilets in this area.

Figure D74: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, flushing urine requires 1 to 2 litres (8/8 pour flush toilets). This includes one user who reported that they generally do not flush when they urinate and only when they defecate. Five pour flush users reported that they use 2 litres or less to flush faeces. According to the visual inspections, a larger number of pour flush toilets (7/8) had a bucket in their toilet, and 6 had their smaller jug as well. This suggests that the practice of pouring full buckets of water into the toilet for flushing is not as common in this area, which ultimately saves water and demonstrates the technical ability of the technology.

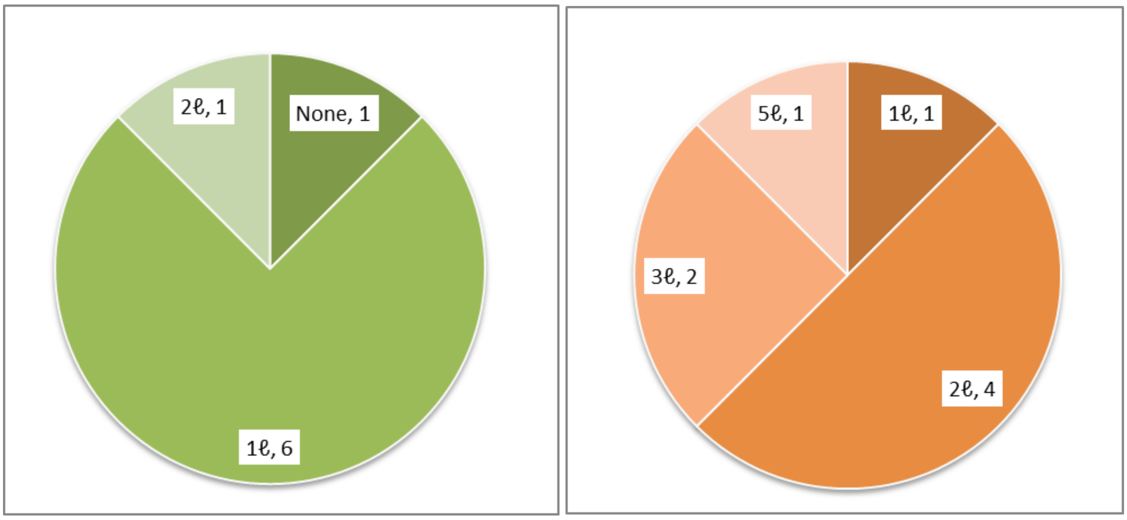


Figure D75: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In this area, 9 out of 10 respondents indicated that there are times when they do not have water. Of those, 5 indicated that it happens less than once a month; 3 said it happens once or twice a month; and 1 said that it happens most days in the week. When there is no water to flush, 5 users said that they use stored water to flush, and 3 said that they use greywater to flush. Both of these practices demonstrate a level of resilience to water shortages at the household level. One user said that they use their old pit toilet when there is no water, which demonstrates the potential synergies between dry and waterborne sanitation in areas with water shortages.

Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour flush toilets. As shown, 7 households have experienced a blockage at least once. In most instances, blockages occurred due to misuse of the toilet (e.g. flushing sanitary pads or rubbish down the toilet). Two users said that their toilets were blocked due to the pits being full, which would have led to a backup of sewage in the sewer. Generally, households are able to fix blockages when they occur. No households reported ever experiencing leakages in their pour flush toilets. This is a positive outcome of using a pour flush toilet without a cistern, as it reduces the opportunities for leakages.

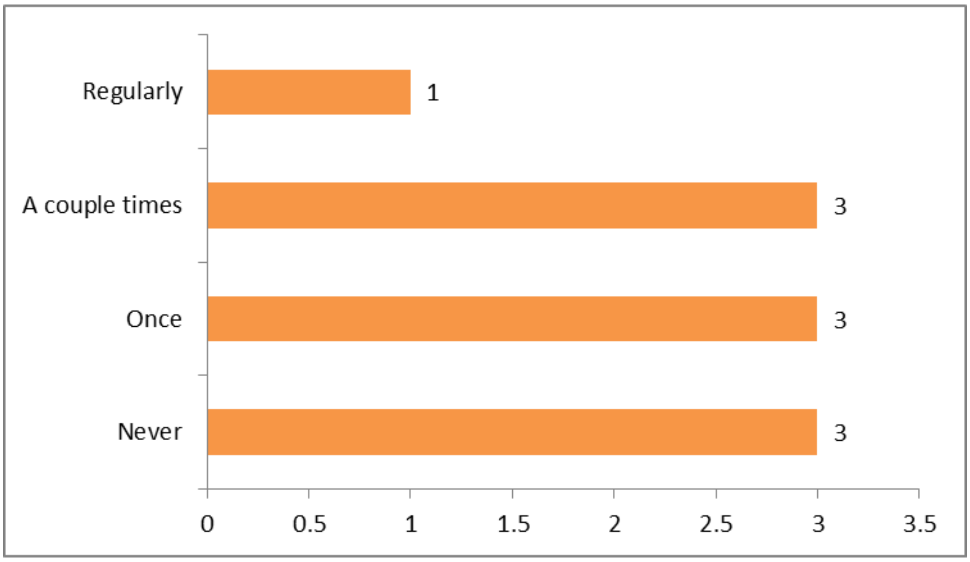


Figure D76: How often do households experience blockages of their pour flush toilet?

Sludge accumulation and pit emptying

Due to this area having the oldest pour flush toilets installed in South Africa, it is not surprising that 4 households have had their pits emptied at some point. Of those who have emptied their pits, 3 have used private contractors and one used a municipal emptier. Two pits were emptied with a vacuum truck and one was emptied manually. Furthermore, one household with a double pit system has switched their pit pipework due to the first pit filling up. Sludge measurements at this household should theoretically provide the greatest insight into the impact of using a twin pit system on sludge accumulation rate and, therefore, required emptying frequency.

Overall, 3 valid sludge measurements from this area can be used to determine a median pit filling rate. As shown in Table D8, sludge accumulation rates calculated in this area vary. Interestingly, the household with both pits used has a relatively low sludge accumulation rate when compared to the overall median from this project of 27.2 ℓ/c.a. This suggests the potential decrease in overall sludge accumulation when both pits are used. However, as this is the only point included in the study, no definitive conclusions can be drawn.

Table D8: Sludge accumulation rates observed in Msunduzi

Household	Sludge accumulation rate (ℓ/c.a)	No. pits used
1	7.12	1
2	36.1	1
3	19.5	2

Conclusions

Overall, householders in Msunduzi reported positive experiences with pour flush toilets. The fact that these toilets are still in use after 6-7 years is a positive outcome for the longevity of pour flush toilets. Further, while blockages may have been more frequent in this area than in others, households were generally able to fix the problem. This suggests that installation of pour flush toilets is unlikely to require extensive maintenance by municipalities, aside from pit emptying at regular intervals as needed.

ANNEXURE E: Nellieville Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

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The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in the Nellieville area in Amajuba District Municipality, Kwa-Zulu Natal.

Case Study: Nellieville, Amajuba DM

The first set of data was collected in Nellieville, Amajuba District Municipality (KZN), as this is one of the oldest large-scale installations of pour flush toilets in South Africa. The 150 units were built in 2015 by PID and local sub-contractors, through funding from the Department of Science and Technology (in partnership with the Water Research Commission). This data collection exercise not only provided a large data set (101 interviews in total) but also provided an initial test of the data collection materials and logistical challenges. One main issue in this area was locating the pits for measurements as well as uncovering them, as many were covered in a layer of soil. Local labour was hired for this purpose, but this did demonstrate that opening pits for measurements could potentially require more time than initially anticipated. From this experience the goal for each subsequent site visited was to collect pit measurements at only half of the toilets assessed.

Furthermore, this set of data demonstrated some areas in which the survey was lacking. For instance, some questions with a list of possible answers did not include some common answers and thus these were added in later versions of the survey. On the question about water usage for flushing, more options were added to the volumes of water used in order to better capture the variety of reported answers.

Overall, usage of the pour flush toilets in Nellieville was high (97%, 92/95), though many users expressed a lack of knowledge about how the toilets actually work. Some were unaware that they had two pits, let alone that they could switch the pipework once the one pit filled up. One additional concern was the small number of users who had converted their toilets to full flush toilets, when the leach pits have not been designed for full flush toilets. The water usage in these toilets is undoubtedly higher.

Figure E77: Standard pour flush units in Nellieville

Figure E78: Excess soil and grass removed from pit cover slab for opening

Figure E79: Worker removing pit cover slab for measurements

Condition of PF toilets

During the assessments, 84 percent of the toilets visited (82/98) had no odour, 13 percent had some odour and 3 percent had too much odour. This demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure. Sixty-one percent of toilets (60/98) were clean, whereas only 9% were very dirty. All pour flush toilets in Nellieville were constructed with concrete blocks, and 88% of them were in a good, stable condition. A small number (10/99) of the units were cracked in some places, but for the most part, the structures have withstood years of use.

Fifty-six percent (57/101) of respondents reported that they have other toilets on their household plot in addition to the pour flush toilets. All of these households have a home-built pit toilet, and these are generally in a bad condition. Only one household reported having a VIP toilet and 6 reported having full flush toilets in addition to their pour flush and unimproved pit latrine.

During inspections, it was noted that 6 households had converted their pour flush toilet either by adding a cistern or replacing the pedestal altogether with a ceramic full flush pedestal. Anecdotally, most households in Nellieville were not aware that it was possible to upgrade their pour flush toilet to a low flush toilet. Similarly, many households were not aware that their toilets had 2 pits and that the pipework for the pits would need to be changed at some point. As a result, questions were added to the survey after this data collection activity to assess householders' knowledge of their ability to upgrade and the need to switch pipework on their twin pit systems.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include the fact that they are cleaner (36%); and they are easy to use (31%); they are safer for small kids to use (28%); they have less smell (26%); and they are safe from collapse (13%). Typically, respondents will answer this question relative to the status quo option, which is using their old, home-built pit toilet. Forty-nine percent of respondents said that there is nothing they dislike about pour flush toilets, which demonstrates wide acceptance of the technology by households. Twenty-six percent of the respondents said that refilling the bucket for flushing is too difficult. Ninety-one percent of households interviewed reported that their main water source is an outside tap in their yard. Since the water supply is not located directly next to the toilet, filling a bucket and carrying it to the toilet becomes more of a task for some than they would like. On a similar note, 12 percent of households said that they do not like that pour flush toilets do not have a cistern.

A few solutions to improving this situation is installation of a yard tap just outside of the pour flush toilet, to remove the need to carry the bucket long distances, or conversion of the pour flush toilets to low flush toilets, with a cistern to hold the water. Including a water connection directly to the cistern is an option, but due to the potential for leakages, this is not advised in areas with an unreliable water source, such as in Nellieville. Despite water shortages, 55% of users (56/101) said that they would change something about the pour flush toilets, with 43/56 saying they would add a cistern. It is unlikely that many households understand how the pour flush configuration will ultimately save more water when compared to the low flush option.

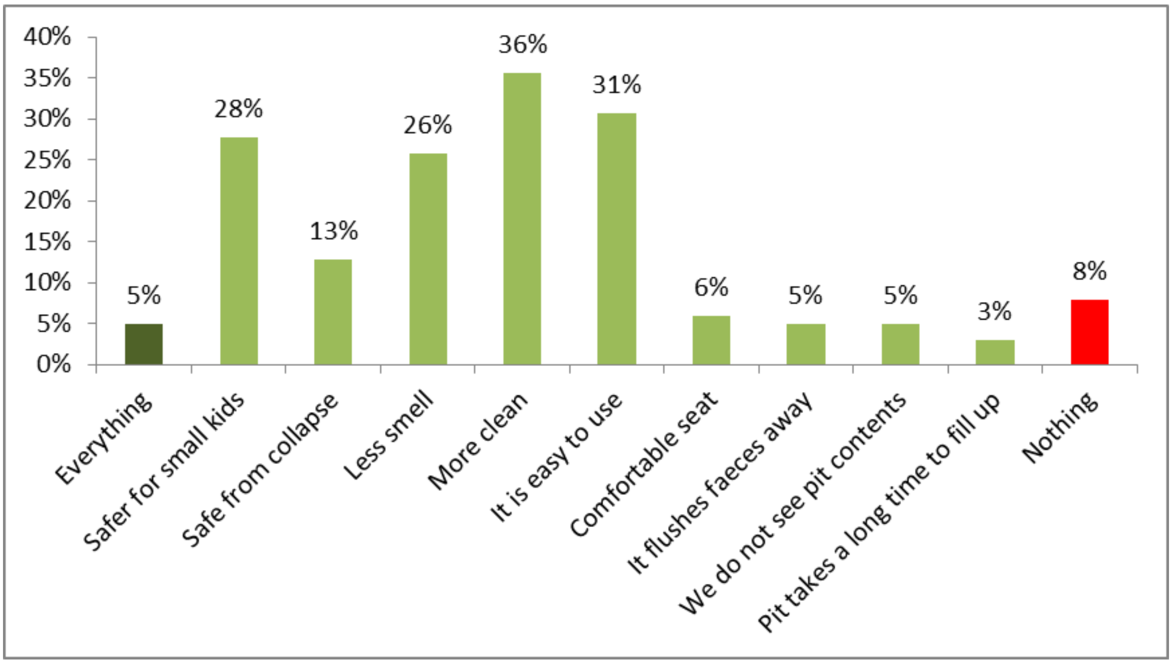


Figure E80: What do users like about pour flush toilets?

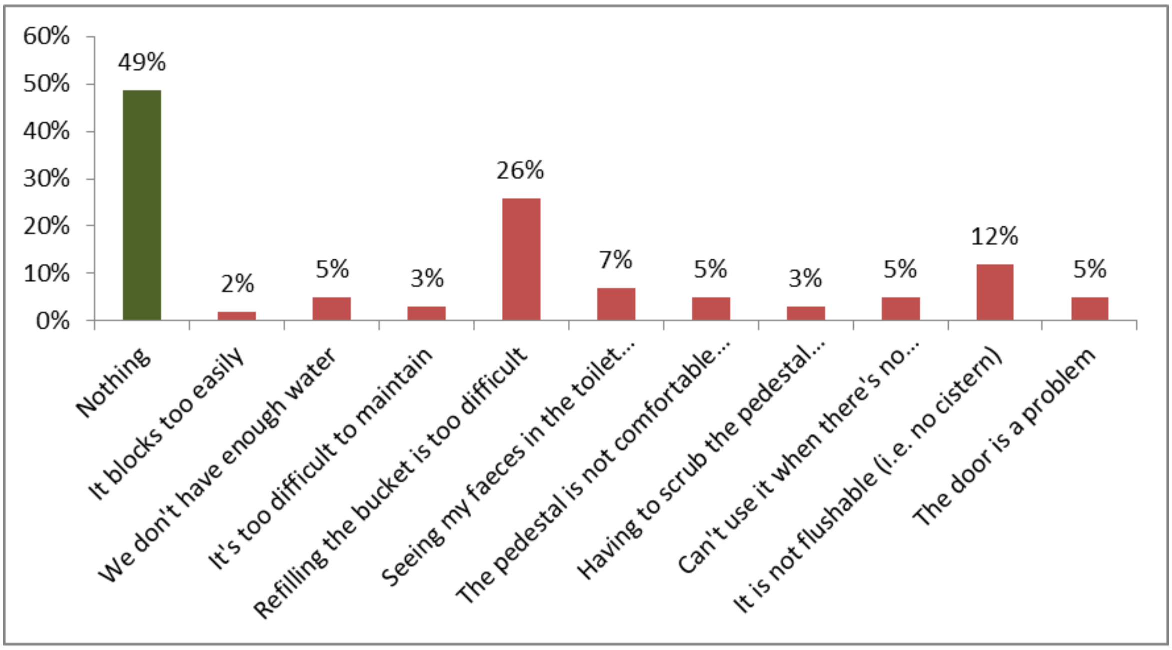


Figure E81: What do users dislike about pour flush toilets?

Ninety-nine users (98%) said that they would recommend pour flush toilets to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets (Figure D72). Forty-nine percent said they would recommend pour flush toilets because they are better than VIP toilets; 38% said it is safe; and 28% said it is easy to use. This is an important contribution to the comparison of VIP toilets versus pour flush toilets, which would likely be appropriate in similar contexts.

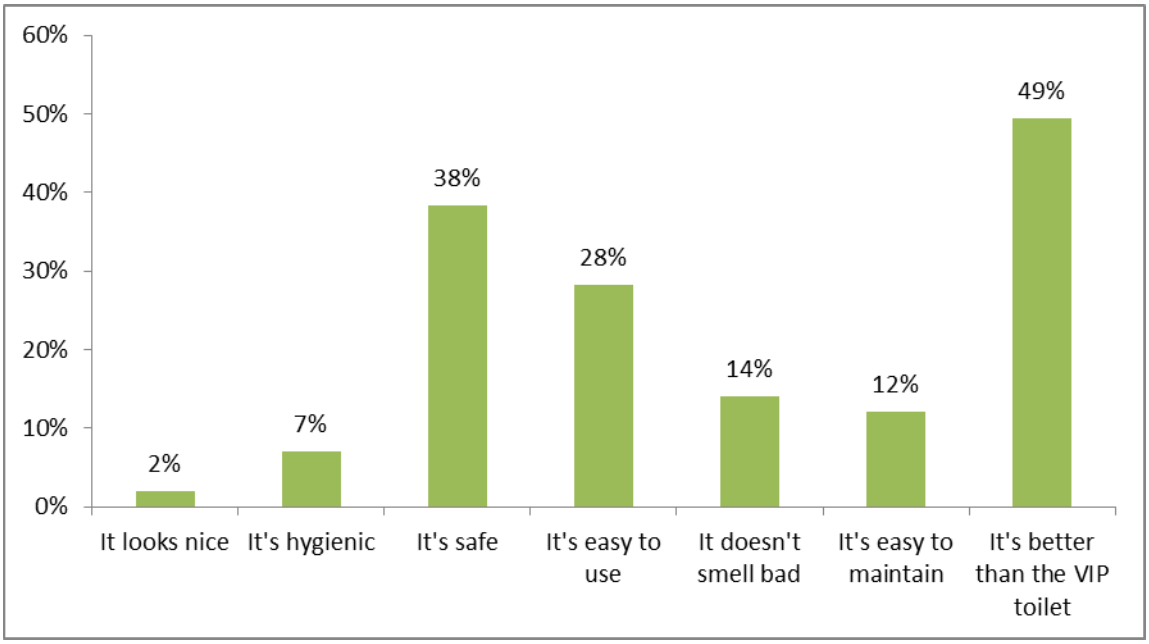
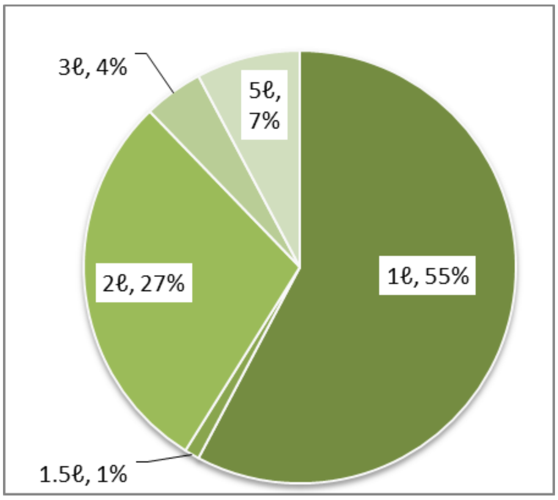


Figure E82: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, flushing urine requires 1 to 2 litres (83%). Alternatively, 60% of users said that they use 5 litres of water to flush faeces, which far exceeds the amount that should be needed, based on controlled tests with pour flush toilets. The discrepancy is most likely due to the common practice of users carrying full buckets of water with them and pouring the entire contents into the toilet for flushing.



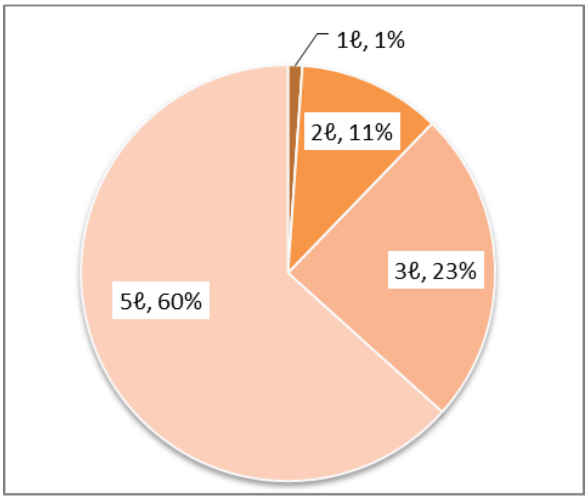


Figure E83: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In this area, 100% of respondents (101/101) indicated that there are times when they do not have water. Of those, 82% indicated that this occurs more than once each week, and a further 11% said that it happens once a week. This represents extreme water shortages in the area. When there is no water to flush, 39% of users reported that they use their old pit toilet and 20% said that they lock the pour flush toilet and do not use it. Seventeen percent of users said that they use greywater and 4% said that they use rainwater to flush when there is no water, both practices which demonstrate resilience among households.

Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour flush toilets. As shown, a vast majority (84%) have never had a blockage. Similarly, most households (98%) have never experienced a leakage of their pour flush toilet. This is a positive outcome of using a pour flush toilet without a cistern, as it reduces the opportunities for leakages.

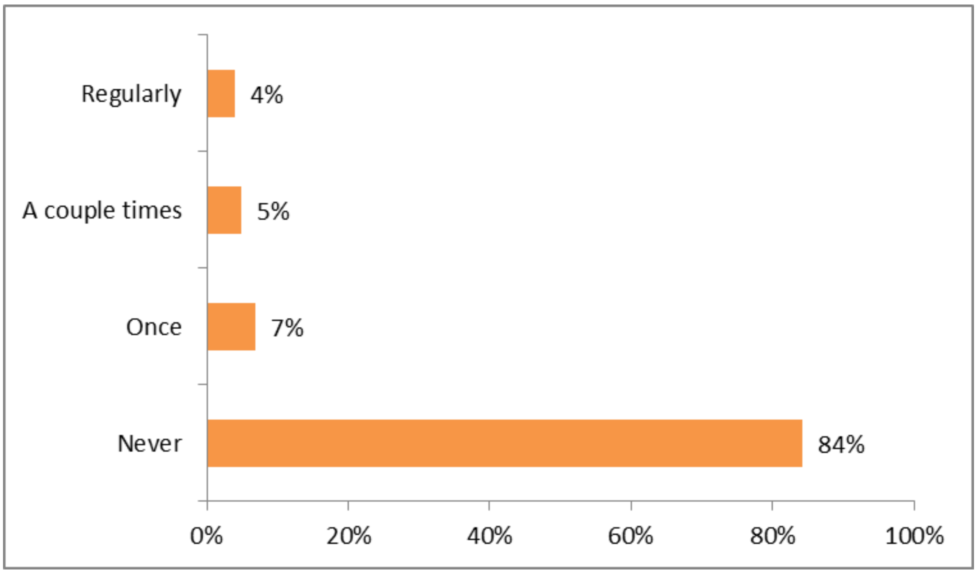


Figure E84: How often do households experience blockages of their pour flush toilet?

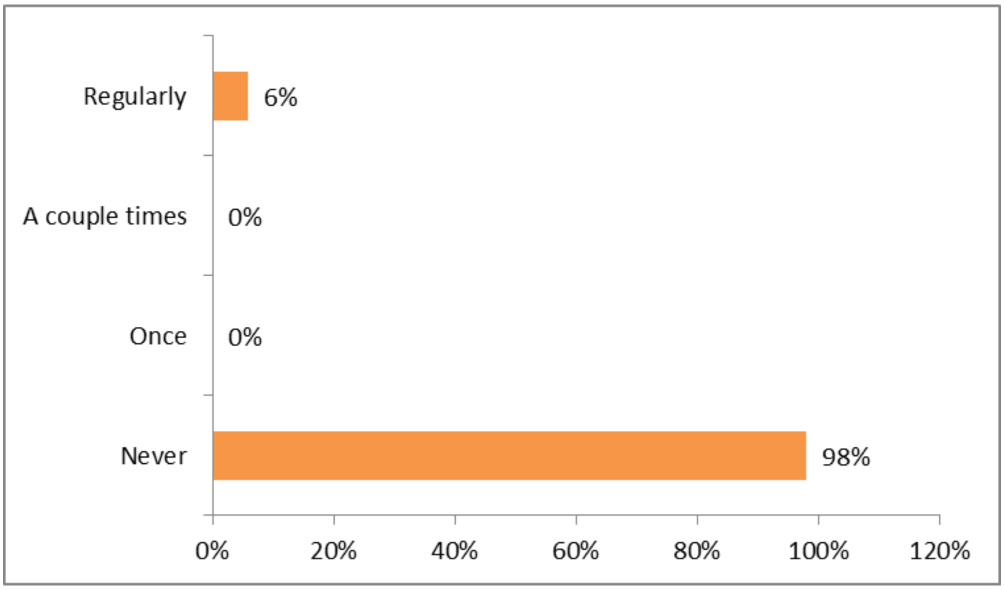


Figure E85: Frequency of leakages experienced by households

Sludge accumulation and pit emptying

A total of 66 sludge measurements were taken during fieldwork, though only 24 have been included in the analysis described here. The group of 24 excludes pits with a layer of water on top of the sludge as well as any with supporting data that was either missing or incomplete. Overall, the median sludge accumulation rate was 38 litres/capita.annum, which exceeds the overall median observed in this study of 27.8 ℓ/c.a. Of the 24 pits included, only 3 had rubbish in them. Further, 16 of 66 pits were at least 70% full, and 2 were at least 90% full, which demonstrates that a relatively large number are reaching the stage when pipework must be switched and the second pit used. In order to avoid overflowing pits, households must be made aware that they have two pits and that the pipework must be switched when the first pit fills up. Alternatively, the municipality could provide plumbers to do this for households as part of the basic sanitation provision.

Pit emptying can be planned using a median accumulation rate determined across all study areas (27.8 ℓ/c.a), the median of number of people per household (5), and the total pit volume available. In the case of Amajuba, each pit has a volume of 1.3 m^3, which translates to a cumulative pit volume of 2.6 m^3. This suggests that pour flush toilets built in Nellieville in 2015 will require emptying in approximately 2033, 18 years after installation. Similarly, it is likely that a majority houses will need to switch their pipework to use the second pit after 9 years of use. It is important to note that this does not adequately account of any reduction in sludge volume that will take place when the pipework is switched. Conservatively, it would be wise to plan for emptying to take place 10 years after installation to account for varying household sizes and to avoid overflowing pits and unhappy residents.

Conclusions

Overall, interviewed householders in the Nellieville area had a positive outlook on pour flush toilets after 3-4 years of usage. This is a positive outcome for the technology, as this is one of the longest-term, large-scale pilots of pour flush toilets in South Africa. Households in this area are resilient to the extreme water shortages, either through use of a dry sanitation option or use of an alternative water source for flushing.

Regarding the actual technology the primary negative feedback was that refilling the bucket for flushing is too difficult. Thus, adjusting the design to reduce the need for refilling the bucket would be ideal. This can be accomplished by installing a tap adjacent to the pour flush unit or by installing a larger tank/cistern in or near the pour flush unit. Ideally, this tank should not be connected directly to the toilet bowl in order to avoid excessive leakages.

Support from the local municipality is required to make such innovations a success in rural areas that are slowly developing and might be a solution that saves them funds. Despite the apparent success of this pilot project, it does not appear that the municipality has since taken initiative to specify pour flush toilets for on-site sanitation projects. The learnings and outcomes from this pilot must be shared with those with decision making power if further successful application of the technology is to be realised in Amajuba DM.

ANNEXURE F: Jerseyvale Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in the Jerseyvale area in Amathole District Municipality, Eastern Cape.

Case Study: Jerseyvale, Eastern Cape

In 2016, 150 twin pit pour flush toilets were constructed in Jerseyvale in Amathole District Municipality in the Eastern Cape, as part of the initial large-scale WRC pilot project. The top structures were built of precast concrete, and the double leach pits were built with precast concrete rings. Handwashing units were made of 2-litre bottles and installed on the outside of the toilet cubicles. Reported usage of the pour flush toilets was relatively high, with 86% of households (82/95) saying that their pour flush is in use. Seventy-six percent of households have another toilet on site, with a vast majority reporting this as a home-built pit toilet. In general, those who do not use their pour flush toilet are waiting for their pit toilet to fill up first.

Figure F86: Typical pour flush construction in Jerseyvale

Figure F87: Typical leach pit design in Jerseyvale

Condition of PF toilets

During the assessments, 91% (80/88) of the toilets had no odour, while 9% had at least some odour. This demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure, even after a long period of use. Forty-three percent of the toilets assessed were clean, while 47% were a bit dirty and 10% were very dirty. Overall, 85% said that pour flush toilets are easy to clean, while 15% said they were difficult to clean.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include that they are safer for small children (47%); they are safe from collapse (36%); they are easy to use (34%); and they have less odour (29%). Typically, respondents answer this question relative to the status quo option, which is in Jerseyvale is typically using their home built pit toilet. This explains the large emphasis placed on increased safety of pour flush toilets, as they do not put small children over a pit of sludge and there is no risk of children falling through the seat. A large percentage (44%) also said that there is nothing they dislike about pour flush toilets, which demonstrates relatively wide acceptance of the technology. The most common negative feedback about pour flush toilets was that refilling the bucket for flushing is too difficult (27%), and a small number (4%) said that they do not have enough water to use the toilet properly.

Feedback about the bucket being difficult to refill was the main negative feedback coming from all areas included in this study. Seventy-nine percent (65/82) of Jerseyvale respondents said that they would consider changing their pour flush toilet to a low flush toilet, with the main motivation being “to have a flushable toilet” (24). It is interesting to note the distinction made that some users do not see a pour flush toilet as a “flushable” toilet, as pouring water into the pedestal is a manual action. Other users (15) simply think that having a cistern will be more convenient than carrying water to the toilet for flushing. It is important to note that a vast majority of households in this area rely on a communal outdoor tap for their main water supply, which increases the inconvenience of having to collect water to use in the toilet. It also highlights that upgrading to low flush toilets would require considerable infrastructure to create water connections at the household level.

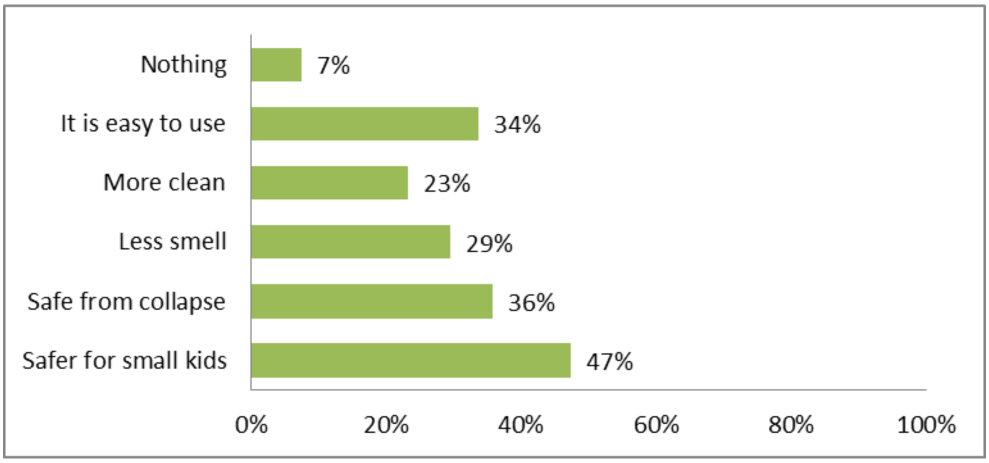


Figure F88: What do users like about pour flush toilets?

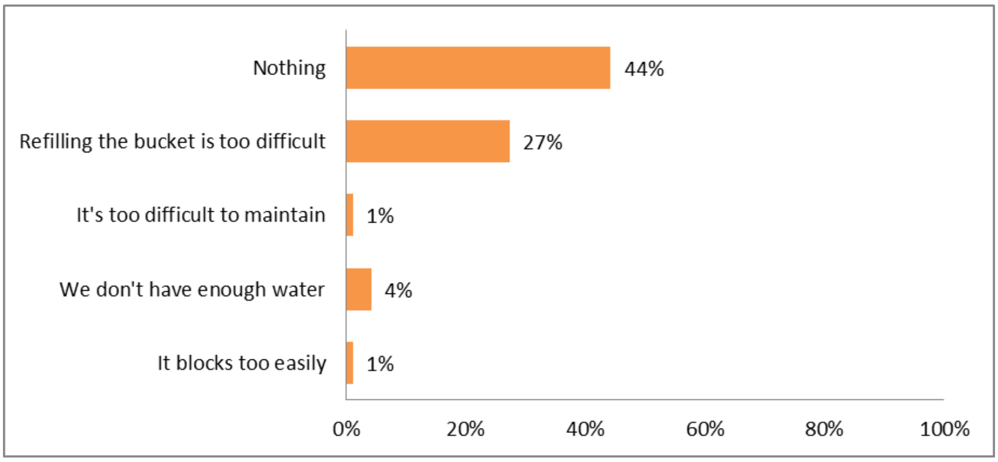


Figure F89: What do users dislike about pour flush toilets?

Users generally said that they would recommend pour flush toilets (71/82) to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets (Figure D72), including that it is easy to use (37%); it is safe (25%); and it doesn't smell bad (21%).

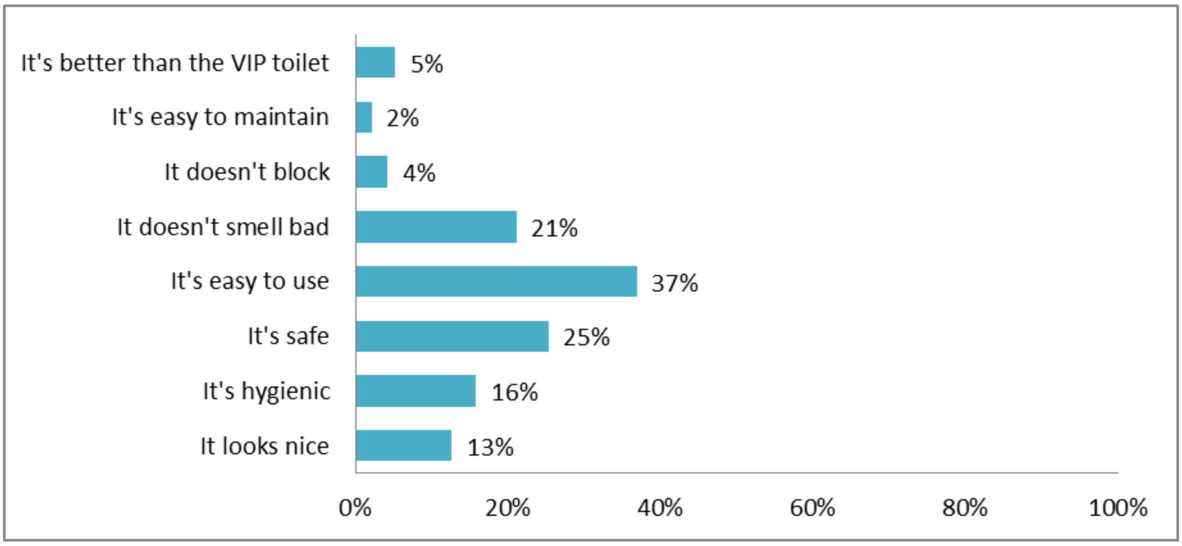


Figure F90: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, flushing urine requires 1 to 2 litres (80%), including 14 users who reported that they generally do not flush when they urinate and only when they defecate. In contrast, only 22% of users reported using 2 litres or less to flush faeces, which is not consistent with the requirements of the technology, as testing in a controlled setting. Most commonly, householders use between 3 and 5 litres to flush faeces (51%), but a small percentage use 10 litres or more (11%). This is likely due to the practice of each user taking a full bucket of water with them to the toilet and then pouring the entire contents in, rather than using a smaller jug provided during installation to flush the contents. This is further evidenced by results from the visual inspections, in which 66% of toilets had a water bucket in the toilet and only 25% had a smaller jug available for flushing.

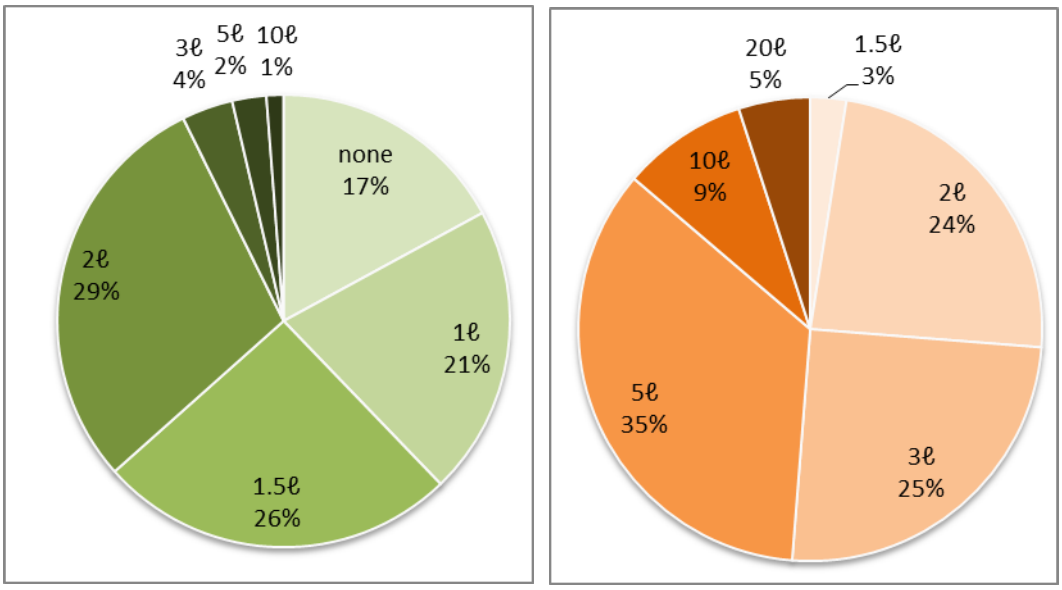


Figure F91: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In Jerseyvale, 74% of users said that there are times that they go without water. The reported frequency of water shortages was no more than once or twice a month, which suggests a relatively reliable supply. When there is no water to flush, 57% of users said that they sometimes use an alternative water source to flush, such as greywater (11/60), stored tap water (10/60), rainwater (6/60), or river water (7/60). This demonstrates some resilience to water shortages at the household level. Alternately, 72% of users said that they do not use the toilet at all, and either resort to using their old pit toilet or nothing at all.

Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour flush toilets. As shown, 96% of households have never experienced a blockage, which is a very positive outcome of this longer-term pilot project. Four percent (3/82) of households have experienced a blockage once, the cause of which was not known by any of these users. No households with pour flush toilets in use had ever experienced a leakage, which demonstrates how pour flush toilets are much less prone to leakages than toilets with a cistern connection, which conserves water.

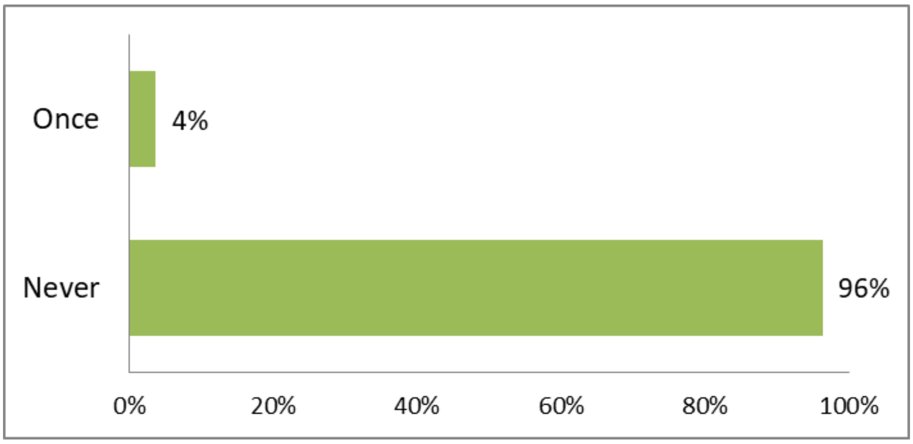


Figure F92: How often do households experience blockages of their pour flush toilet?

Sludge accumulation and pit emptying

During inspections of the pits, only 4 out of the 95 pits assessed were over 70% full. Of those, 2 have sludge within 200 mm of the top of the slab, which suggests that it will soon be time to switch the pipework to use the second pit. Given that these are all double pit systems, it is surprising that only 16 households knew that they would have to switch their pipework when the first pit fills up. Two households in total had done this once already and had managed to do it themselves. The large gap in knowledge (77% of households) on switching the pit pipework suggests that households were not made adequately aware of how the system works when it was installed.

While 95 sludge measurements were taken, a large number have been excluded due to various reasons, such as: pits that have a layer of water covering the sludge layer; pits with missing or incomplete data; pits with accumulation rates less than 10 ℓ/c.a or greater than 105 ℓ/c.a. Thus, 15 valid measurements have been included, which have led to a median sludge accumulation rate of 30.1 ℓ/c.a.

Pit emptying can be planned using a median accumulation rate determined across all study areas (27.8 ℓ/c.a), the median of number of people per household (5), and the total pit volume available. In the case of Jerseyvale, each pit has a volume of 0.79 m^3, which translates to a cumulative pit volume of 1.58 m^3. This suggests that pour flush toilets built in Jerseyvale in 2015 will require emptying in approximately 2026, 11 years after installation. Similarly, it is likely that a majority houses will need to switch their pipework to use the second pit after 5.5 years of use. It is important to note that this does not adequately account of any reduction in sludge volume that will take place when the pipework is switched. Conservatively, it would be wise to plan for emptying to take place at the latest 10 years after installation to avoid overflowing pits and unhappy residents.

Conclusions

Overall, householders in Jerseyvale reported positive experiences with pour flush toilets. The relatively high usage of pour flush toilets (82/95) is evidence that the technology is accepted, which is not surprising given that the most common alternative is a home-built pit toilet. Those who are not using their pour flush toilet are most often waiting for their pit toilet to fill up before switching to the pour flush toilet. Despite the success of this pilot project, it is unknown whether the municipality has plans to implement pour flush toilets at a larger scale.

ANNEXURE G: Bongolethu Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in Bongolethu area in Chris Hani District Municipality, Eastern Cape.

Case Study: Bongolethu, Eastern Cape

The Bongolethu area in the Chris Hani District Municipality has 597 pour flush units that were all built in 2015 and 2016. Most of these (447) are single pit units built by Cemforce (the "Cemflush"), while 150 are twin pit systems also built by Cemforce but through funding from the Department of Science and Technology, in partnership with the Water Research Commission. In this area, the single and twin pit units are evenly spread throughout the community, and the households are located close to one another. This made travelling between households efficient. Despite some resistance from participants (Xhosa-speaking) to talk with the researchers (Zulu-speaking), people were generally cooperative and there were no barriers to understanding the questions and answers. During a visit carried out by PID in March 2019, it was discovered that most pits were filled with rainwater. This includes pits that have not been connected for usage by the households. It was also suspected that the soil drainage is very poor and thus rainwater does not drain efficiently. The groundwater level in the area was observed to be high during construction, resulting in full pits.

Local Findings

On arrival at the municipality offices to meet with the Bongolethu ward councillor, the fieldworkers were introduced to the Mayor and had a brief conversation with her. They explained what they were there to do, and the mayor gave positive remarks regarding the pour flush toilets, advising that they are still advocating for scaling up the pilot project. She advised the team that some people would provide negative feedback as she has also addressed complaints from certain individuals about having to look at and handle their faeces when flushing. Her response to this was “looking at your own faeces forms a vital part of life/healthy living because even when one is sick the doctor would ask them what colour their faeces are”, so looking at the faeces should not bother people that much.

Ward committee members assigned to assist the researchers initially reported that most pour flush toilets were reported to be full by the community. Householders reported the matter to them and they forwarded it to the municipality, but nothing was done in response. They insisted that whatever survey that was to be done must start on those houses. They took the fieldworkers to the first house that had a full pour flush toilet crisis, which was a twin pit system. The fieldworkers assisted this household to switch their pipework to use the second pit and also demonstrated this to the ward committee.

The area is fairly flat with houses clustered together, and it is located at the foot of a mountain. During rain events, large amounts of runoff accumulate around the houses, flooding them, which includes the pour flush pits. The area was observed to be slowly developing with projects such as road paving found under construction during the visit. The RDP houses were constructed with internal full flush toilets. The community was instructed that they would be able to use their internal toilets once municipal sewer line construction was completed. It was discovered that some residents have gone ahead and connected to the municipal sewer line while others have removed/demolished their internal toilets. Apart from the internal full flush toilet, most houses only have the pour flush toilet in the yard, and a small number have a home built pit toilet.

Figure G93: Single pit (left) and double pit (right) pour flush toilets in Bongolethu

Figure G94: Typical leach pit design in Bongolethu

Condition of PF toilets

During the assessments, 74 percent of the toilets visited (96/130) had no odour; this demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure. However, 18 percent (23/130) had some odour and 8 percent (11/130) had too much odour. Further investigation done regarding the odour, it was discovered that the users left the urine and faeces unflushed in the pedestal. In one case where the odour was unbearable the floor slab was broken and odour from the vault came through the slab opening, there were also too many flies because of this. Internal structure cleanliness was observed: 35% (46/130) of the toilets (46/130) were clean, 43% (56/130) were a bit dirty and 22% (28/130) were very dirty. Toilets that were found very dirty include those that have never been used ever since they were constructed. Sixteen percent (21/132) of houses reported that they have another toilet on the yard, which was typically a home built pit toilet. Most commonly, households that were not using their pour flush toilet were still using their home built pit toilet and waiting for it to fill up before switching to the pour flush toilet.

Figure G95: Pour flush toilets that have never been used

Three percent (4/132) of households have converted their pour flush toilets to low flush toilets. Two percent (3/132) removed their pour flush pedestals and replaced them with ceramic pedestals. Those that have converted their pour flush toilets reported that they hired local plumbers to convert the toilet for them. Some of the households that have converted the toilets have a single pit. This was anticipated to be a problem as the area is normally flooded and the pits are mostly filled by rainwater. Householders with single pits also indicated that they do not know how their pits are supposed to be emptied as the superstructure is directly above the pit. One interviewed householder reported that she asked an individual working for the municipality about the plan for emptying their single pits when they get full. She reported that his response was that he is not sure what the initial plan was but according to his observation the pedestal would have to be removed. In reality, the single pit systems constructed by Cemforce are actually meant to be relocated when the pits fill up, digging a new pit, moving the precast structure, and then backfilling the old pit.

Figure G96: Households that have converted from pour flush to low flush toilets

Four percent (5/121) of households have made upgrades to their pour flush toilets. These upgrades are as shown below and include painting or decorating the toilet structure.

Figure G97: Households with upgraded pour flush toilets

Sixty-eight percent of households with the pour flush not in use were observed to be using the toilet structure to store their household material/equipment. These houses are using home built pit toilets.

Figure G98: Pour flush toilets that are not used for intended purpose

The toilet assessment included inspecting the condition of the structure. All pour flush toilet structures in the area were still stable and intact. A few households reported issues they have with the structure which have to do with rain getting in through the joints at the back of their toilet structure. The openings are as shown in Figure G99 below. The contractor did not properly seal the joints and thus there are openings, which obstruct access and comfortable usage of the toilet on a rainy day.

Cleanliness was observed and rated by the fieldworkers and some home were found to be taking good care of their toilets (Figure G100). Figure G101 show households that were found with their toilets very dirty.

Figure G99: Pour flush toilet structures with joints that were not sealed

Figure G100: Households with clean and well taken care of pour flush toilets

Figure G101: Households with dirty toilets that are not taken proper care of

One of the most common reported challenges was soil erosion around the toilet floor slab and the pit cover slabs. This is caused by rain and causes water to enter the pit. One householder with a single pit reported that after a rainy day and when the pit beneath the toilet superstructure is full she can feel the toilet structure slide when she enters to use the toilet. Also, pit contents sometimes flow through to the surface, which is sometimes very smelly. This is both unsafe unhealthy and she reported that sometimes she instructs family members not to use the toilet a day or two after a rainy day until water infiltrates and the water level in the pit is lowered. The figures below show results of erosion and a pit overflowing. Households with single pits that experience this erosion reported that sometimes the extent of erosion is so much that they can see the pit concrete rings beneath the toilet structure. This leaves the toilet superstructure resting on the concrete rings with no ground supporting the structure.

Figure G102: Households with eroded soil (left) and overflowing pit (right)

One pour flush toilet for a disabled user was constructed in the area, which has a larger structure and a handrail with a chain to assist with standing up. This design must be rethought and redesigned. In particular, the handrail with the chain was installed too high and access to the toilet was also a challenge for her (no path was provided). The interviewed householder also noted that she felt degraded by the toilet installation and felt she deserves something better. As a result, she uses her old, collapsing pit toilet instead.

Figure G103: Pour flush toilet structure built for a disabled user

Figure G104: Old home built pit toilet used by a disabled user

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include the fact that they are safer for small kids to use (28%); they are safe from collapse (22%); they have less smell (21%); a shares percentage said because they are cleaner and they are easy to use (17%). Twenty-five percent said they like nothing about the toilet and thirty-nine percent reported different unique reasons for this question. Typically, respondents will answer this question relative to the status quo option, which is using their old, home-built pit toilet or the other options available in the municipality, such as the internal toilet (the residents that have connected to the municipal sewer line). Twenty-two percent of respondents said that there is nothing they dislike about pour flush toilets. Forty-five percent of the respondents said that refilling the bucket for flushing is too difficult. Given that majority households do not have taps in the yard, their water sources are the centralised communal taps. Walking to fill the bucket and carry it to their pour flush toilet is something that many are lazy to do and some cannot physically do (e.g. elderly). It was observed that a number of people in the area practice open defecation, both to avoid carrying water to the toilet and also when water is not available. Further, 22% of households said that there is not enough water in their area for these toilets, making them inappropriate.

A few solutions to improving this situation is installation of a yard tap just outside of the pour flush toilet, to remove the need to carry the bucket long distances, or conversion of the pour flush toilets to low flush toilets, with a cistern to hold the water. Including a water connection directly to the cistern is an option, but due to the potential for leakages, this is not advised for water scarce areas. Thirty-four percent of users (41/121) said that they would change something about the pour flush toilets, of this percentage fifty-four percent (22/41) said that a cistern should be added.

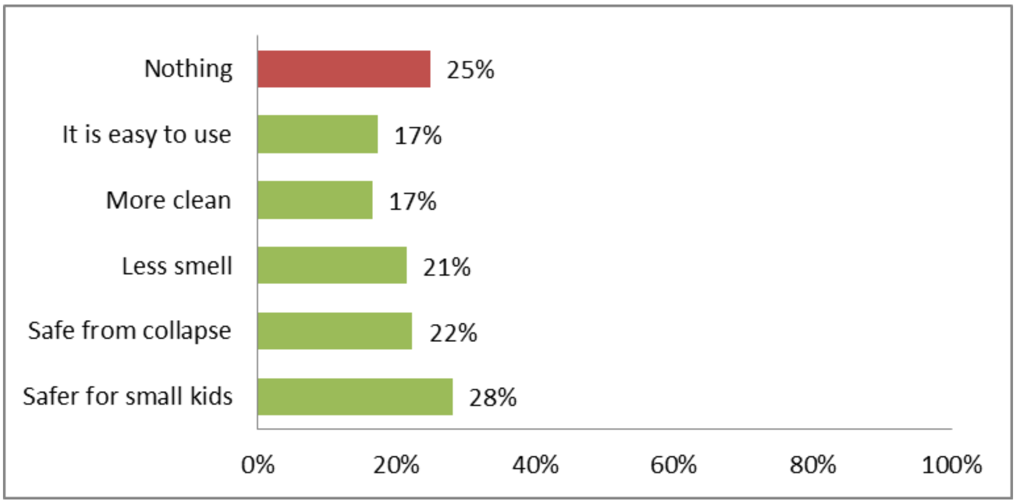


Figure G105: What do users like about pour flush toilets?

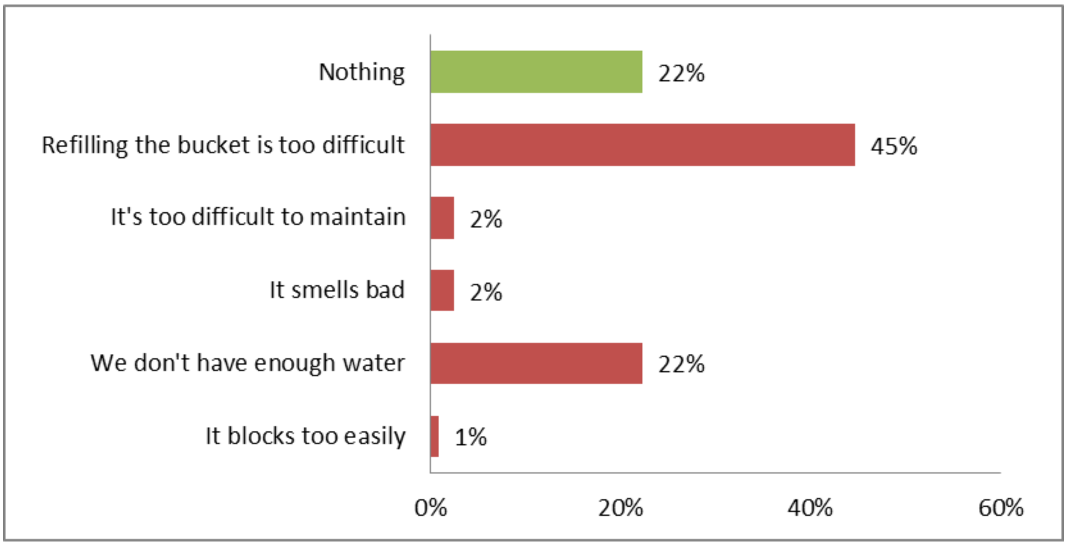


Figure G106: What do users dislike about pour flush toilets?

Sixty-nine percent (83/121) users said that they would recommend pour flush toilets to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets. Forty-two percent said that it is better than the VIP toilet; 25% said it looks nice; 20% said it is safe and a large percentage (55%) reported unique reasons based on their personal experienced and observations with the pour flush toilet.

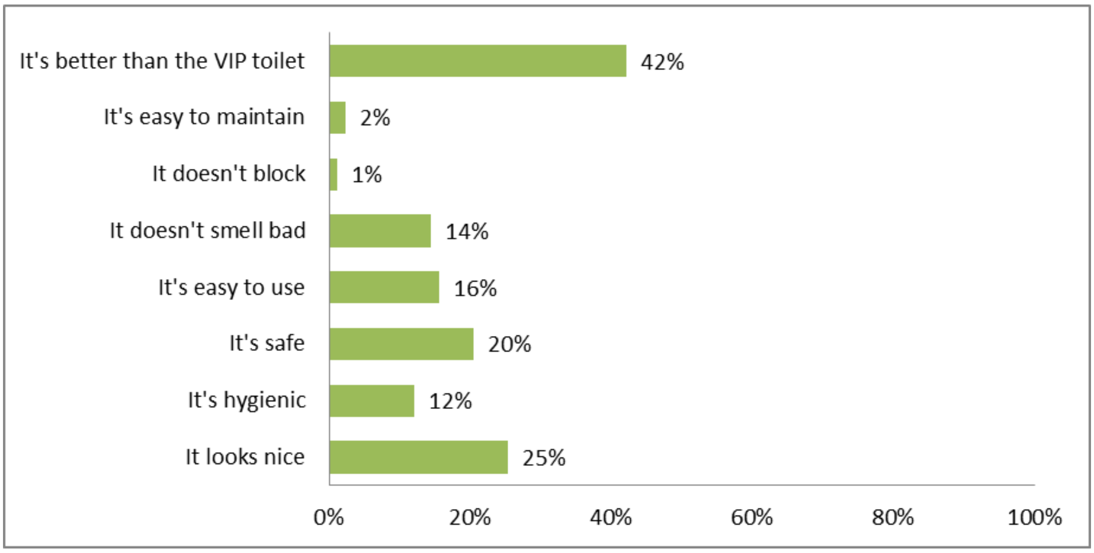


Figure G107: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. Water usage for flushing urine was generally high in Bongolethu area, with only 35% of users saying that they use the required 2 litres or less. The majority of participants use above 5 litres of water to flush urine, which is excessive. Seven percent of users reported that they do not use the pour flush toilet for urinating (they urinate in the yard or use the bush) and only use the pour flush toilet for defecating. Very few users (6%) use 2 litres or less to flush faeces. The majority of users (62%) use more than 10 litres of water to flush faeces, which hugely exceeds the amount of water *required* based on standard, controlled testing with the pedestal. This is due to the common practice of pouring the entire bucket amount into the pour flush toilet, regardless of whether it is necessary.

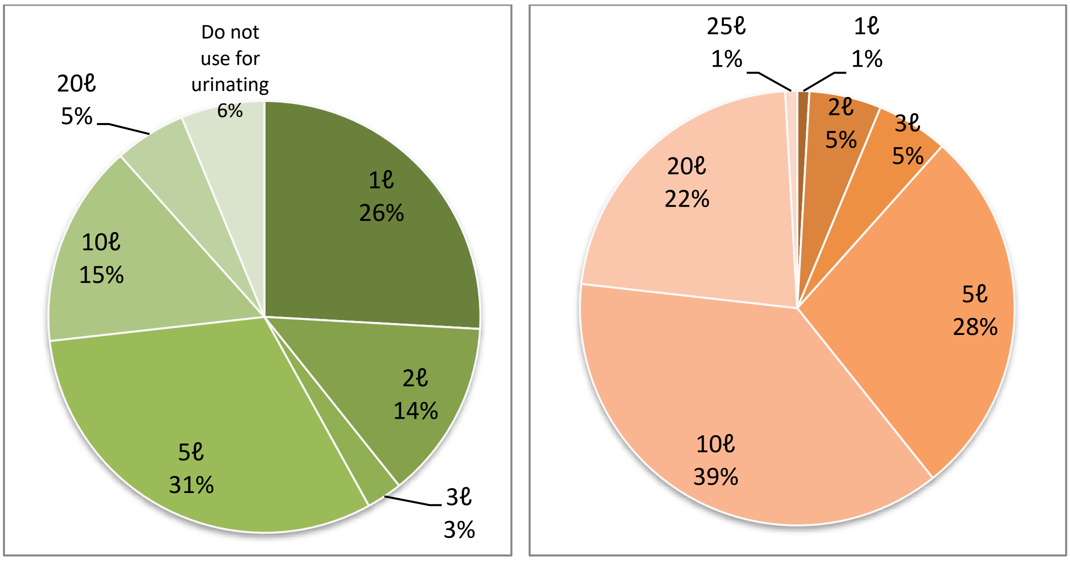


Figure G108: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In this area, 94% of respondents (114/121) indicated that there are times when they do not have water. Of those, 39% indicated that this occurs once or twice a month, and 7% said that it happens less than once a month. When there is no water to flush, a high number of 53% of users reported that they lock the pour flush toilet. Of these, only 4% reported they use the pit toilet while the rest use the bush. Twelve percent of householders reported they use greywater to flush their pour flush toilet, a behaviour that increases households' resilience to water shortages. This practice should be more widely encouraged to ensure that householders have a reliable sanitation option when water shortages occur, rather than using the bush.

Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour flush toilets. As shown, a vast majority (92%) have never had a blockage. Similarly, most households (93%) have never experienced a leakage of their pour flush toilet. This is a positive outcome of using a pour flush toilet without a cistern, as it reduces the opportunities for leakages. Further, this data highlights that the addition of water and sewers to the system does not necessarily increase the maintenance needs or fragility of the toilet.

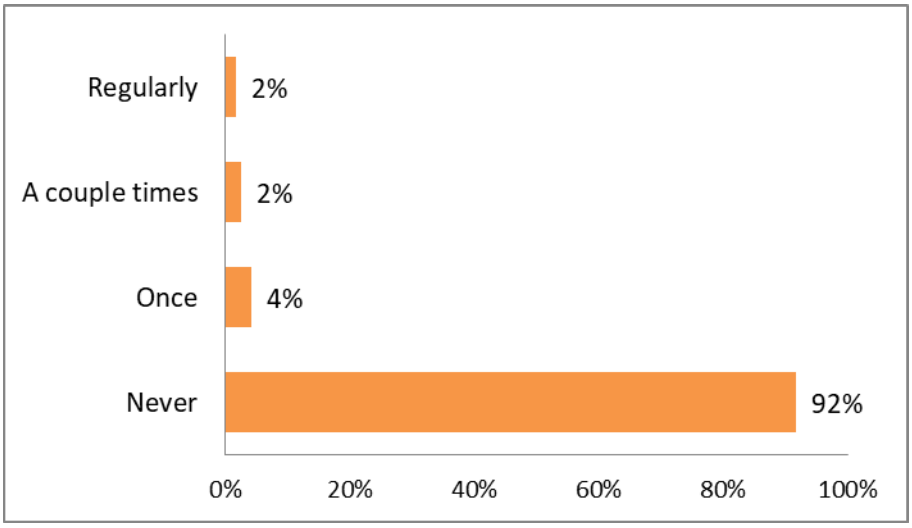


Figure G109: How often do households experience blockages of their pour flush toilet?

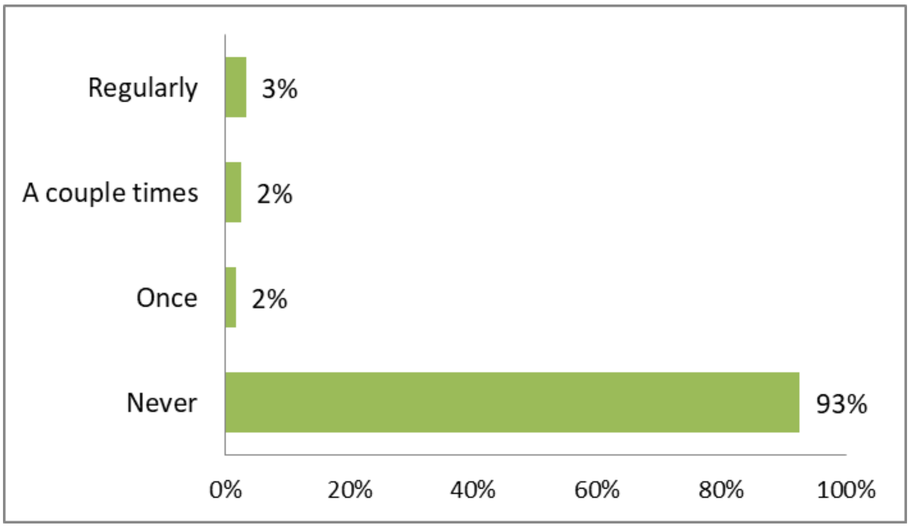


Figure G110: Frequency of leakages experienced by households

Sludge accumulation and pit emptying

In Bongolethu, sludge measurements were only taken of twin pit systems, as the pits in single pit systems were not accessible for measurements. A total of 34 measurements were taken, and 8 of these pits were over 70% full. Of those, 4 had sludge within 200 mm of the top of the slab, which suggests that it will soon be time to switch the pipework to use the second pit. Given that these are all double pit systems, it is surprising that only 4 out of 38 households knew that they would have to switch their pipework when the first pit fills up. At the time of assessment, no households had yet switched their pipework. The large gap in knowledge (89% of households) on switching the pit pipework suggests that households were not made adequately aware of how the system works when it was installed.

While 34 sludge measurements were taken, some were excluded due to various reasons, such as: pits that have a layer of water covering the sludge layer; pits with missing or incomplete data; pits with accumulation rates less than 10 ℓ/c.a or greater than 105 ℓ/c.a. Thus, 19 valid measurements have been included, which have led to a median sludge accumulation rate of 35.8 ℓ/c.a. This exceeds the overall median from the study of 27.8 ℓ/c.a, which may be due to poor draining soils.

Pit emptying can be planned using a median accumulation rate determined across all study areas (27.8 ℓ/c.a), the median of number of people per household (5), and the total pit volume available. In the case of Bongolethu, each pit has a volume of 0.79 m^3, which translates to a cumulative pit volume of 1.58 m^3. This suggests that twin pit pour flush toilets built in Bongolethu in December 2016 will require emptying in approximately 2027, 11 years after installation. Similarly, it is likely that a majority houses will need to switch their pipework to use the second pit after 5.5 years of use. It is important to note that this does not adequately account of any reduction in sludge volume that will take place when the pipework is switched. Conservatively, it would be wise to plan for emptying to take place at the latest 8 years after installation to account for varying house sizes and avoid overflowing pits and unhappy residents.

If a similar planning exercise is done for the single pit systems in Bongolethu and it is assumed that the single pit provided has a volume of 1.8 m^3 (according to Cemforce website on Cemflush toilets), this emptying exercise would have to take place after 13 years of use, in 2029. The sludge emptied from these single pit systems would include both fresh and old sludge. In contrast to the twin pit systems above, there would be little benefit observed in sludge volume reduction due to a resting period. Conservatively, it would be wise to plan for emptying to take place 9 years after construction to account for varying house sizes and avoid overflowing pits and unhappy residents. These systems are designed to be relocated rather than emptied, which requires digging a new pit on the property, providing a slab, relocating the precast structure, and then covering the old pit. It is not yet certain whether this is more cost-effective than emptying from a life-cycle cost point of view, but this will be investigated in more detail in a Master’s student study.

Conclusions

Compared to other areas in the wider monitoring study, acceptance of pour flush toilets in Bongolethu was relatively low, though it is still notable that over 50% of households would recommend this technology. Water scarcity was observed to be a challenge in the Bongolethu area. Additionally, some drainage issues were observed in the pits, as a number were overflowing with rainwater and some unused pits were half full of water. The concrete rings used for the leach pits are perforated with small holes, but this does not appear adequate for drainage. Providing river sand around the leach pits would assist at least partly with this drainage.

Residents saw pour flush toilets technology is a great solution and fills the gap that exists between the pit toilets and full flush toilets. However, they also recognised the benefit of having an alternative dry sanitation option (e.g. VIP toilet) to use in instances when there is no water. At the same time this would not be ideal as the area has very small yards, which would not accommodate numerous toilet structures well. An alternative to the water shortage issues is providing people with education on recycling greywater for flushing as well as harvesting rainwater which can be used when water shortages occur. These actions increase households' resilience to water shortages and can ensure that open defecation is not a reality in the community.

ANNEXURE H: Mt Fletcher Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in Mt. Fletcher area in Joe Gqabi Municipality, Eastern Cape.

Case Study: Mt. Fletcher, Eastern Cape

In 2017, 122 pour flush toilets were built in Mt Fletcher in Joe Gqabi District Municipality as part of a Water research Commission project. The toilets installed here utilised goose neck shaped p-traps made of fibreglass, following more closely the p-trap design used during the initial WRC research project. The cubicles in this project were larger than typical household systems in order to accommodate an indoors handwashing station. The outlet pipe from the handwashing basin is directed into the bucket of flushing water to encourage water recycling. During construction of these units, the groundwater level in the area was high, and this was confirmed during the monitoring visits, in which many pits were full of groundwater.

Figure H111: Standard pour flush unit in Mt Fletcher

Figure H112: Unit in Mt. Fletcher with child friendly seat

Figure H113: Pit cover slabs behind the toilet covered by grass

Local findings

Sixty-eight assessments were done in the Solomzi area. Forty percent (27/68) pour flush toilets were in use and sixty percent (41/68) were found not in use, which is an extremely low usage rate. Some reasons for not using the pour flush toilets were shared by individuals that were approached for interviews on day one of the assessments. They advised the fieldworkers that they would not get any positive response from the area regarding the pour flush toilets because residents were instructed not to use the toilets. When asked why this instruction was sent out and by whom the residents' response was that the pour flush toilets had failed and thus the entire community would receive new VIP toilets. VIP toilets were constructed shortly after the pour flush toilets were installed and the residents then believed that it meant the pour flush toilets really had failed. With the newly constructed VIP toilets, householders that received the pour flush toilets now had 3 toilets in the yard (the old pit toilet, the pour flush toilet and the new VIP toilet). In fact, one householder demolished her pour flush toilet in an attempt to create space in her yard. The interviews were done regardless of the discouraging start.

Figure H114: Typical household setup with multiple sanitation systems installed

Figure H115: Newly constructed VIP toilet (note elevated structure due to high groundwater table)

Condition of PF toilets

During the assessments, 95 percent of the toilets visited (62/65) had no odour, 2 percent had some odour and 3 percent had excessive odour. This demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure. Thirty-three percent of toilets (19/57) were clean, whereas 35 percent were very dirty. Most unused pour flush toilets were dirty and/or used for other purposes, such as storage of equipment.

Figure H116: Pour flush toilets that are either no longer used or used but not properly maintained

Figure H117: Pour flush toilets that are used as storage and have never been used for intended purpose

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include the fact that they have less smell (74%); they are safer for small kids to use (67%); they are safe from collapse (52%); they are cleaner (37%); and they are easy to use (33%). Typically, respondents answer this question relative to the status quo option, which is using their old, home-built pit toilet a VIP. Fifty-two percent of pour flush users (14/27) said that there is nothing they dislike about pour flush toilets. Thirty percent of the pour flush users (8/27) said that refilling the bucket for flushing is too difficult. Since households do not have taps in the yard, their water sources are the centralised communal taps, which for some are located far. Walking to fill the bucket and carry it to their pour flush toilet is something they do not like, and some are not able to do this. This includes the elderly or the sick, while some younger users reported they are mostly too lazy to do this and thus resort to using the old pit toilets or the bush. When asked further about aspects of the pour flush toilet that they dislike, some responded that they do not like being seen carrying the bucket to and from the toilet. It suggests to others that they are going to defecate, which can feel embarrassing and degrading.

A few solutions to improving this situation include: installation of a yard tap just outside of the pour flush toilet, to remove the need to carry the bucket long distances; installation of a larger storage tank outside the toilet cubicle to reduce the frequency of having to carry water to the toilet; or conversion of the pour flush toilets to low flush toilets, with a cistern to hold the water. Including a water connection directly to the cistern is an option, but due to the potential for leakages, this is not advised in areas with an unreliable water source. Nineteen percent of users (5/27) said that they would change something about the pour flush toilets, and 4 of those 5 respondents said that a cistern should be added. A larger number of respondents (22/27) said they would not change anything about the pour flush toilet. Their reasons include that water is very scarce in their area, which makes it difficult to use the pour flush toilet forcing them to prioritise water usage.

It was also discovered during the inspections that a number of houses in the area are being rented and are occupied by tenants. This created a gap in the pour flush toilet usage as most tenants were never introduced to the pour flush toilet and had no knowledge of how the technology works. This also contributed to low usage of the pour flush toilets. Some that had figured out how the toilet works reported that they like the technology a lot but it is not feasible to use due to water scarcity in their area. They reported that they believe the toilets will be used a lot once there is reliable water supply and also once taps are connected in the yards.

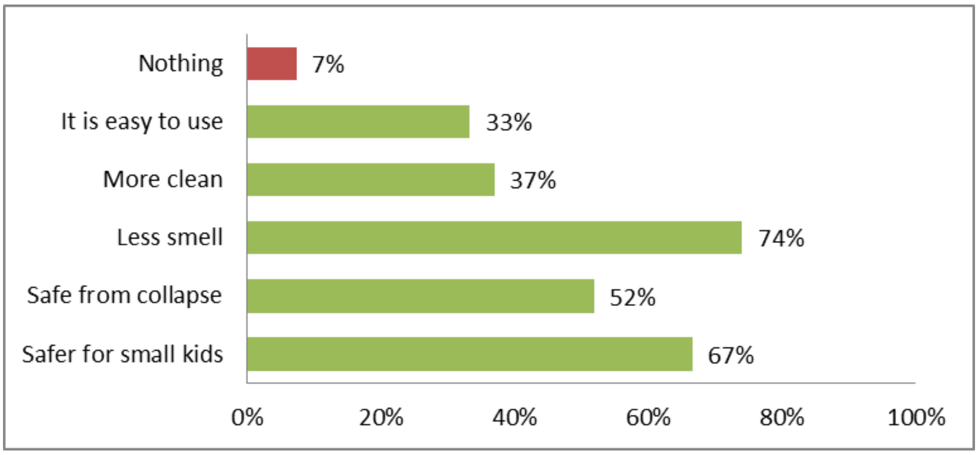


Figure H118: What do users like about pour flush toilets? (Percentage of reported users)

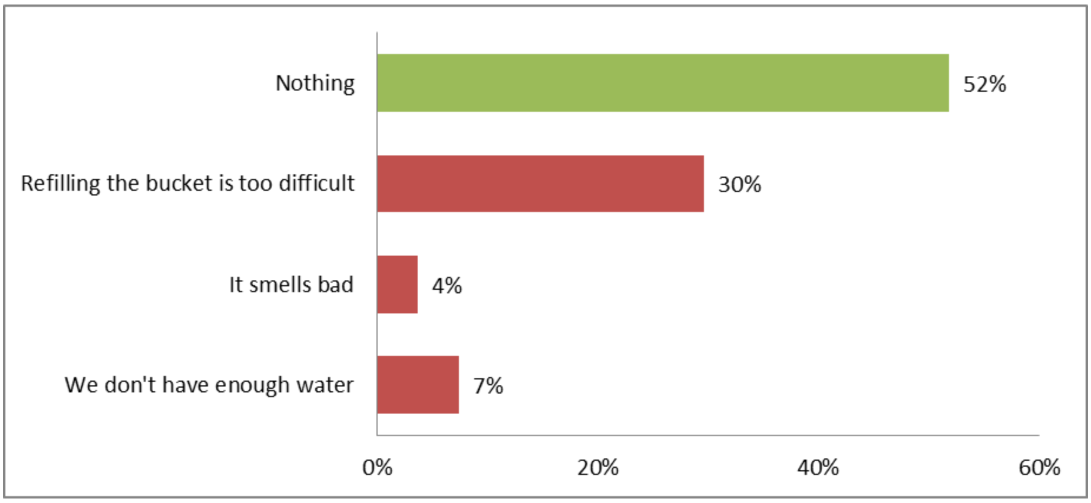


Figure H119: What do users dislike about pour flush toilets? (Percentage of reported users)

Users generally said that they would recommend pour flush toilets (93%) to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets (Figure D72), including the fact that they are safe (56%) and they do not smell bad (56%). Both of these are qualities that are not often associated with VIP toilets.

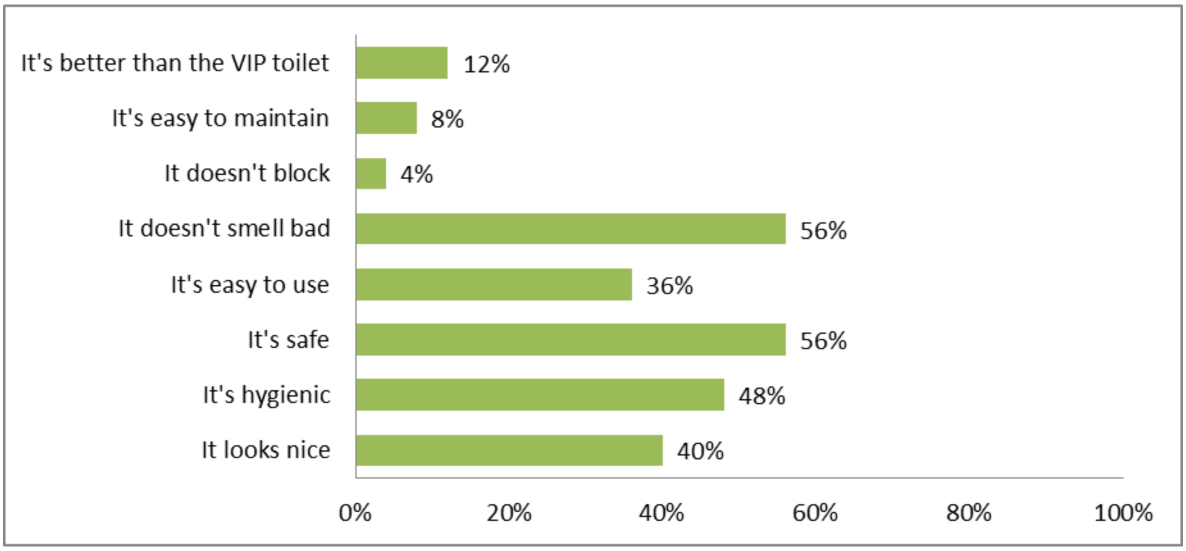


Figure H120: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, users reported that they use 1 to 2 litres (89%) to flush urine. Some users reported that they generally do not flush when they urinate or they do not use the pour flush toilet for urinating (they either use a bucket and dispose the urine in the yard or use the bush). Only 41% of householders reported using 2 litres or less to flush faeces down the toilet. Many users who use more than the required amount of 2 litres have established a system in which users fill and carry the bucket with them to the toilet every time they use it. As a result, some users simply pour the entire bucket amount into the pour flush toilet, regardless of whether it is needed. These results therefore highlight the water volumes used in practice, which differ from what is actually required based on controlled testing of pour flush toilets. Previous tests have shown that 1-2 litres is generally sufficient for flushing faeces, regardless of whether toilet paper or newspaper are used for wiping.

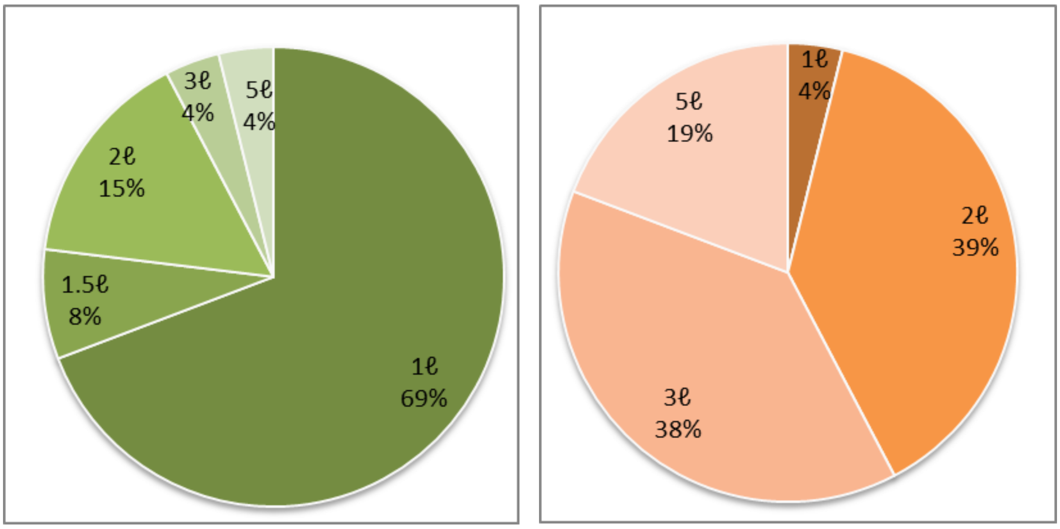


Figure H121: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In this area, 100% of pour flush users (27/27) indicated that there are times when they do not have water. Of those, 67% indicated that this occurs once or twice a month, and 15% said that it happens less than once a month. When there is no water to flush, 15% of users reported that they use greywater to flush their pour flush toilet, a behaviour that increases households' resilience to water shortages. Thirty percent of the householders reported that they do not use the pour flush toilet when there is no water. Twenty-one reported that they use their pit toilets when there is no water and other responded and said they sometimes use the bush. This highlights one of the benefits of households having multiple sanitation options on site.

Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour flush toilets. As shown, a vast majority (89%) have never had a blockage. Similarly, most households (93%) have never experienced a leakage of their pour flush toilet. This is a positive outcome of using a pour flush toilet without a cistern, as it reduces the opportunities for leakages. This also removes concerns about blockages and leakages of pour flush toilets, which are also not of concern when using VIPs.

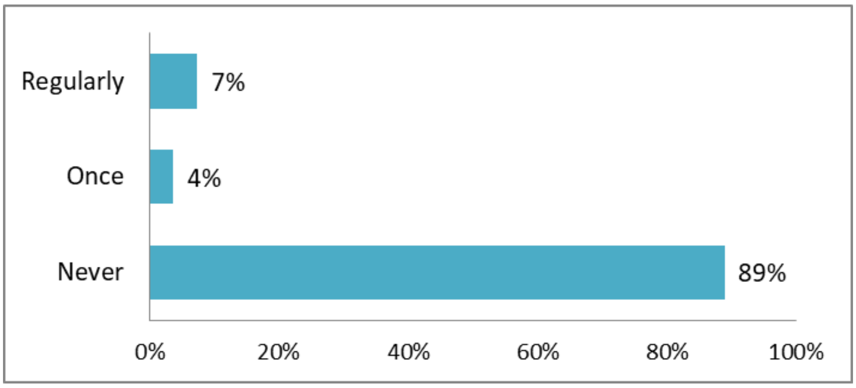


Figure H122: How often do households experience blockages of their pour flush toilet?

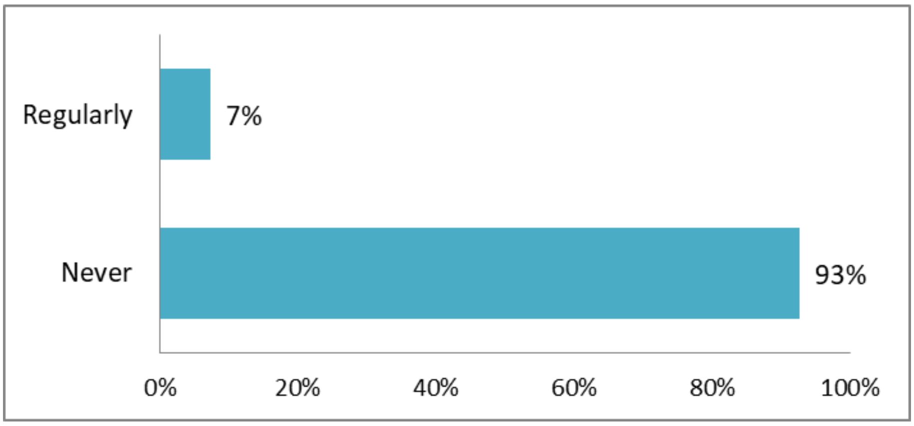


Figure H123: Frequency of leakages experienced by households

Conclusions

Overall, usage of pour flush toilets in Mt Fletcher was very low, but those who were using the toilets reported positive attitudes towards the technology. The main reasons for low usage include water shortages/unreliability and the fact that most households have more than one sanitation option in their yard. Users of pour flush toilets said that the technology is a great solution and fills the gap that exists between the pit toilets and full flush toilets. Pour flush toilets are considered a safe, easy-to-use, and odour-free alternative to other on-site technologies in rural and peri-urban areas.

The primary negative feedback was that refilling the bucket for flushing is too difficult. Thus, adjusting the design to reduce the need for refilling the bucket would be ideal. This can be accomplished by installing a tap adjacent to the pour flush unit or by installing a larger tank/cistern in or near the pour flush unit. Ideally, this tank should not be connected directly to the toilet bowl in order to avoid excessive leakages.

Support from the local municipality is required to ensure success of innovations like pour flush toilets in rural areas. Construction works were observed in the area and seem to include water reticulation, which could contribute to success of pour flush toilets in the future. Provision of water supply and the demand for dignified sanitation solutions create a perfect opportunity for pour flush toilets. Any further implementation of this technology should be accompanied by education campaigns so that users are made aware of how to use them, including water-saving strategies such as recycling rainwater and greywater.

ANNEXURE I: Mkhondo LM and Chief Albert Luthuli LM Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in Mkhondo Local Municipality and Chief Albert Luthuli Local Municipality in the Mpumalanga Province.

Case Study: Mkhondo LM and Chief Albert Luthuli LM, Mpumalanga

In 2016, the WRC funded construction of 129 pour flush toilets in Mkhondo Local Municipality and 129 pour flush toilets in Chief Albert Luthuli Local Municipality, both located in Mpumalanga province. These toilets were also part of the second round of domestic installations carried out by the WRC. All households in this project are located in rural areas where water is either supplied by a borehole or delivered by a tanker. This installation utilised twin pits, with a larger structure and handwashing system installed inside the structure. The effluent pipe from the handwashing basin was left open so that buckets for flushing could be refilled with recycled handwashing water.

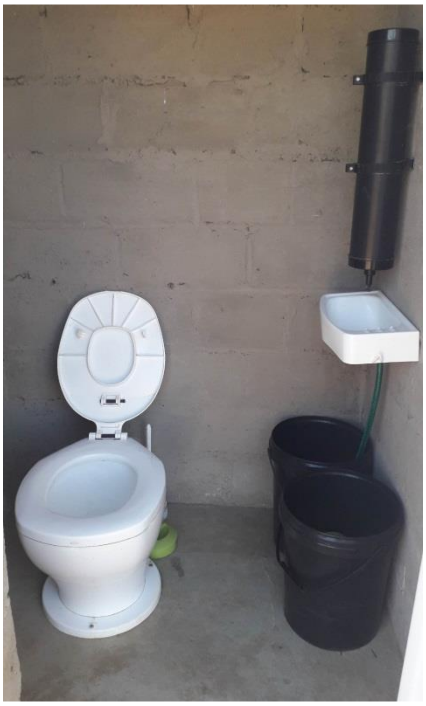


Figure I124: Typical pour flush installation in Mkhondo/Chief Albert Luthuli

All interviewed households (60) in Mpumalanga reported that their pour flush toilet is in use, which is consistent with the apparent reliability of water. No houses indicated that they ever go without water, despite the primary sources of water being communal taps, boreholes, surface water, and delivery on tankers. Furthermore, only 22% of interviewed households indicated that they have another toilet on site, all of which ware home-built pit toilets.

Condition of PF toilets

During the assessments, 100% (60/60) of the toilets had no odour, which demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure. Sixty-four percent of pour flush toilets were clean, 24% were a bit dirty, and 12% were very dirty.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. Users were generally satisfied with many aspects of pour flush toilets, most commonly: they are safe for children (98%); they are safe from collapse (95%); and they have fewer odours (95%). Typically, respondents answer this question relative to the status quo option, which for many in this area is nothing at all (78%) or a home-built pit toilet (18%). This explains the large emphasis placed on increased safety of pour flush toilets, as they do not put small children over a pit of sludge and there is no risk of children falling through the seat. A large percentage (75%) also said that there is nothing they dislike about pour flush toilets, which demonstrates wide acceptance of the technology. The only negative feedback gathered about pour flush toilets is that refilling the bucket for flushing is too difficult (20%), which is consistent with feedback from the other areas included in the study.

Sixty-seven percent of users said that they would consider converting their pour flush toilet to a low flush toilet for the same reason that they do not like carrying water to the toilet with them. Interestingly, one household seemed to believe that it would save them water to install a cistern, but practice demonstrates that addition of a cistern connection to the pedestal creates a key point for leakages. Despite expressing a desire to have a cistern installed, no users interviewed said that they have had any difficulties with the toilet, suggesting that this desired design change does not impact on householders' satisfaction and use of the pour flush toilet.

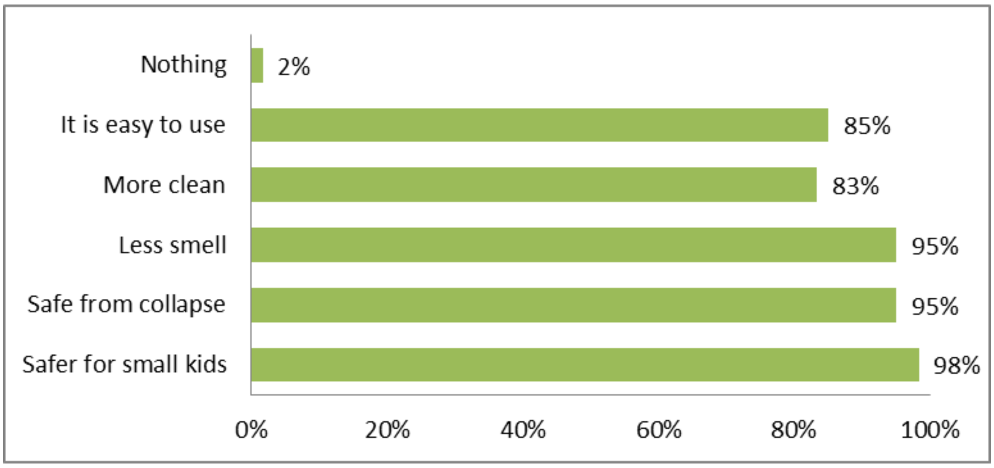


Figure I125: What do users like about pour flush toilets?

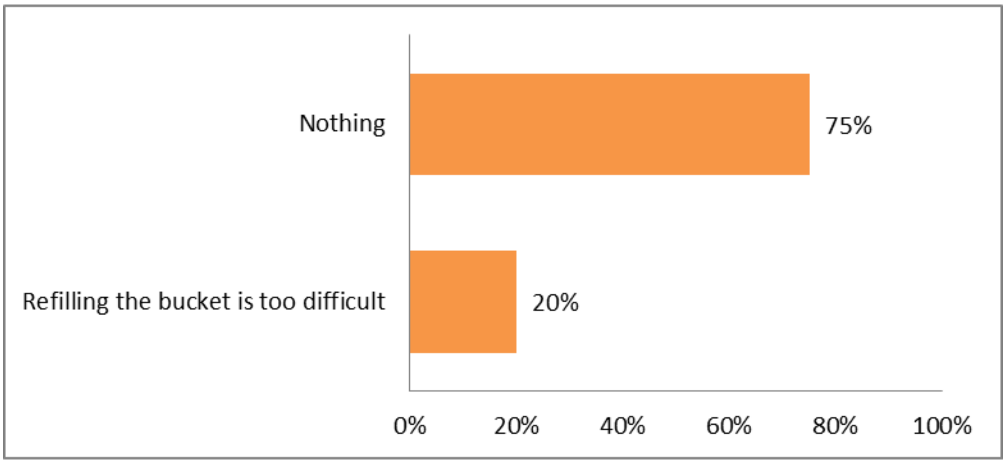


Figure I126: What do users dislike about pour flush toilets?

All 60 interviewed householders said that they would recommend pour flush toilets to others, and their reasons for recommending them are shown in Figure D72. It is interesting that 95% recognise pour flush toilets as better than VIP toilets, as none of these householders have VIP toilets on their property to compare with. Furthermore, many see pour flush toilets as hygienic (88%), safe (82%), nice looking (80%), and free from odours (77%).

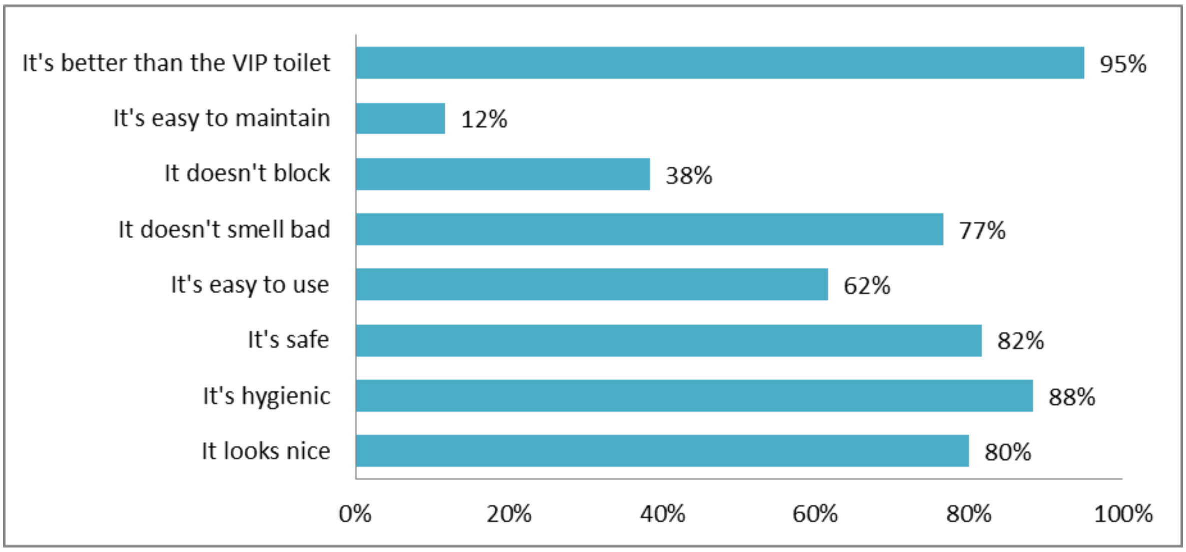
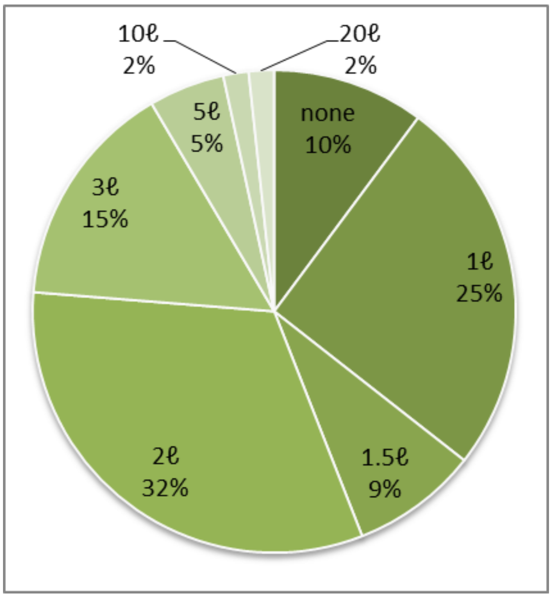


Figure I127: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, flushing urine requires 1 to 2 litres (66%), and 6 users said that they do not use the toilet at all for urinating. In contrast, only 4% of users reported using 2 litres or less to flush faeces, which is not consistent with the requirements of the technology, as testing in a controlled setting. Ninety-two percent of respondents use between 3 and 10 litres of water to flush faeces. It is unclear from the survey responses why water usage is higher than necessary, because only 1 household indicated that each user brings a full bucket with them to the toilet each time.



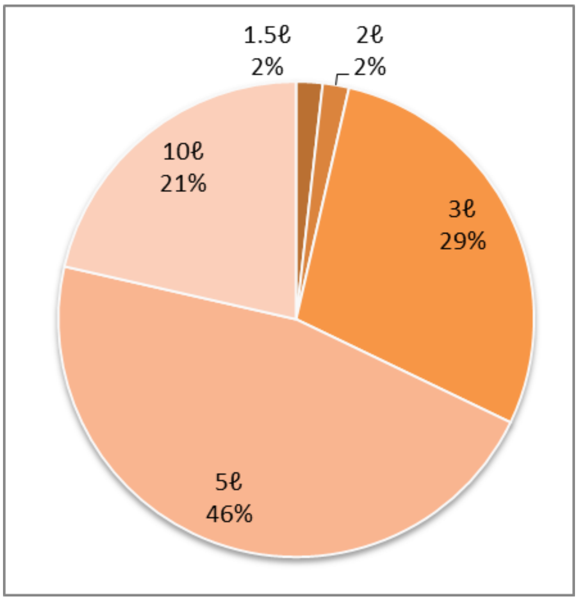


Figure I128: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In both Mkhondo and Chief Albert Luthuli, no users reported ever going without water. The water sources available to households, shown in Figure I129, are more inconvenient methods than each household having a tap in their yard or house. However, the water supplies are reliable, and this has allowed for wide usage and acceptance of pour flush toilets. Furthermore, 68% of households said that they do use greywater sometimes for flushing, with 9 households saying they always use greywater. This is a practice that makes households even more resilient to any water shortages and also reduces the need for households to fetch water for flushing from remote areas.

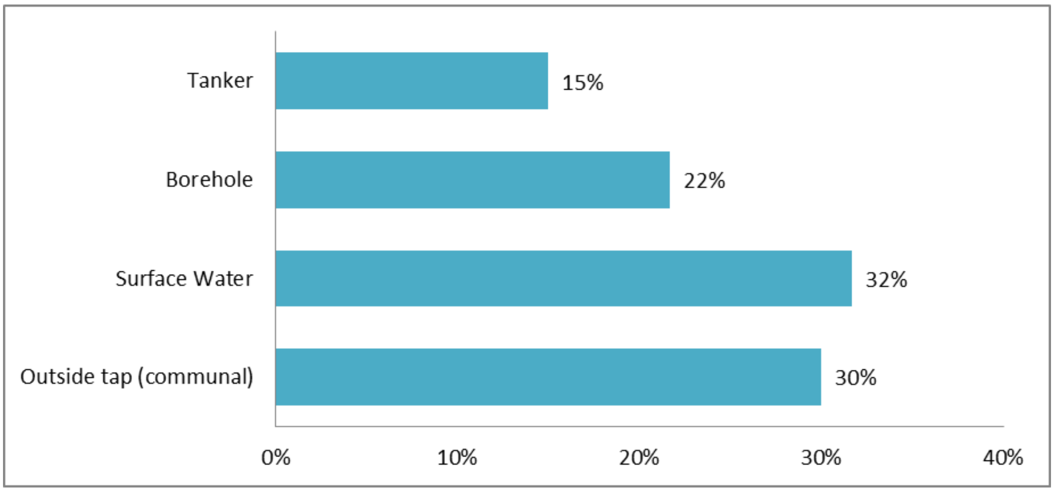


Figure I129: Primary water sources available in Mkhondo and Chief Albert Luthuli

Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour flush toilets. As shown, 98% of households have never experienced a blockage and only one household experienced a blockage once. This is a positive outcome that demonstrates the ability of pour flush toilets to function in communities despite concerns about blockages occurring. Furthermore, no households reported ever having leakages in their pour flush toilets. Both of these suggest that the addition of water and sewers to the system (when compared to a VIP) does not necessarily increase the maintenance needs for these households.

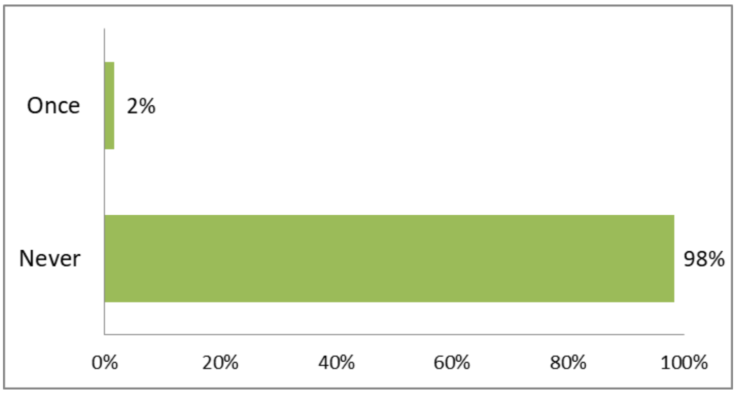


Figure I130: How often do households experience blockages of their pour flush toilet?

Sludge accumulation and pit emptying

In total, 50 sludge measurements were taken in Mkhondo and Chief Albert Luthuli. Any measurements taken on pits with a layer of water over the sludge and those with sludge accumulation rates less than 10 ℓ/c.a and greater than 105 ℓ/c.a have been excluded, and therefore the final number of pits included in analysis is 29. Overall, the median sludge accumulation rate in this area was 35.4 ℓ/c.a, which exceeds the overall median of 27.8 ℓ/c.a. The increase in sludge accumulation could be due to a number of factors, such as errors in reporting and measurements, age of the sludge, and soil conditions.

Pit emptying can be planned using a median accumulation rate determined across all study areas (27.8 ℓ/c.a), the median of number of people per household (5), and the total pit volume available. In the case of Mkhondo and Chief Albert Luthuli each pit has a volume of 1.3 m^3, which translates to a cumulative pit volume of 2.6 m^3. This suggests that pour flush toilets built in Mpumalanga will require emptying in 2034, or 18 years after the initial construction. Based on this estimate, it is likely that a majority houses will need to switch their pipework to use the second pit after 9 years of use. It is important to note that this does not adequately account of any reduction in sludge volume that will take place when the pipework is switched. Conservatively, it would be wise to plan for emptying to take place at the latest 15 years after installation to avoid overflowing pits and angry residents.

Conclusions

Overall, householders in both Mkhondo LM and Chief Albert Luthuli LM have had very positive experiences with pour flush toilets. All households are still using their toilets and are very satisfied with them, though a small number expressed dissatisfaction with having to carry water to their toilets. Households in this area do not have convenient water sources, but this does not deter them from preferring this option of the dry alternative, VIPs.

Despite the success of these pilots, pour flush toilets have not yet been installed by the municipalities in this area. When discussing with a local municipality representative from Mkhondo LM, he expressed that provision of sanitation has been moved to the District Municipality. Thus, it is likely that the officials making decisions about sanitation are not yet aware of the pilot project and its success. This should be shared with the municipal representatives so that they can add pour flush toilets to their toolbox of on-site sanitation technologies.

ANNEXURE J: Mariannhill and Molweni Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in Mariannhill and Molweni areas in eThekwini Municipality.

Case Study: Mariannhill and Molweni, eThekwini

In 2016, 175 single pit pour flush units were installed in Mariannhill and Molweni (Wards 9 and 14) in eThekwini Municipality. This was a municipal programme in which Rocla and Conloo were contracted for construction. These installations included a single pit, offset from the structure. In 2019, 38 households in the area were visited and interviewed about their pour flush toilets. The condition of each pour flush toilet was also assessed through inspection. Of those 38 households, 37 pour flush toilets were in use.

Figure J131: Standard pour flush unit in Mariannhill

Figure J132: Unit in Mariannhill with child friendly seat

Figure J133: Pit cover slabs and a leak from the pit

Condition of PF toilets

During the assessments, 83 percent of the toilets visited (30/36) had no odour and 17 percent had some odour. This demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure. Fifty percent of toilets were clean, whereas 17 percent were very dirty.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include the fact that they are safe from collapse (61%); they have less smell (58%);

they are cleaner (53%); they are safer for small kids to use (55%); and they are easy to clean (53%). Typically, respondents will answer this question relative to the status quo option, which is using their old, home-built pit toilet or the other options available in the municipality, such as VIPs and urine diversion toilets. Thirty-four percent of respondents said that there is nothing they dislike about pour flush toilets. Nearly half of respondents (45%) said that refilling the bucket for flushing is too difficult. Given that households typically have one household tap in their yard, they must fill the bucket and carry it to their pour flush toilet, which is sometimes located far away. This is particularly difficult for older users but can also be a challenge for younger users.

Ten users indicated that each user carries a full bucket of water with them to the toilet every time it is used, rather than having a large bucket inside the toilet at all times, with a jug for flushing. Another ten users indicated that they refill their bucket 2 times each day. These practices may explain why users report that refilling their bucket is too difficult. In addition to being difficult, some users said that they do not like being seen carrying the bucket. It suggests to others that they are going to defecate, which can feel embarrassing and degrading.

A few solutions to improving this situation is installation of a yard tap just outside of the pour flush toilet, to remove the need to carry the bucket long distances, or conversion of the pour flush toilets to low flush toilets, with a cistern to hold the water. Including a water connection directly to the cistern is an option, but due to the potential for leakages, this is not advised in areas with an unreliable water source. Forty-five percent of users said that they would change something about pour flush toilets, and 7 of those 17 respondents said that a cistern should be added. This was by far the most common feedback from users and is supported by the fact that 79 percent of interviewed users said that they would consider adding a cistern to their toilet to convert it to a low/full flush toilet.

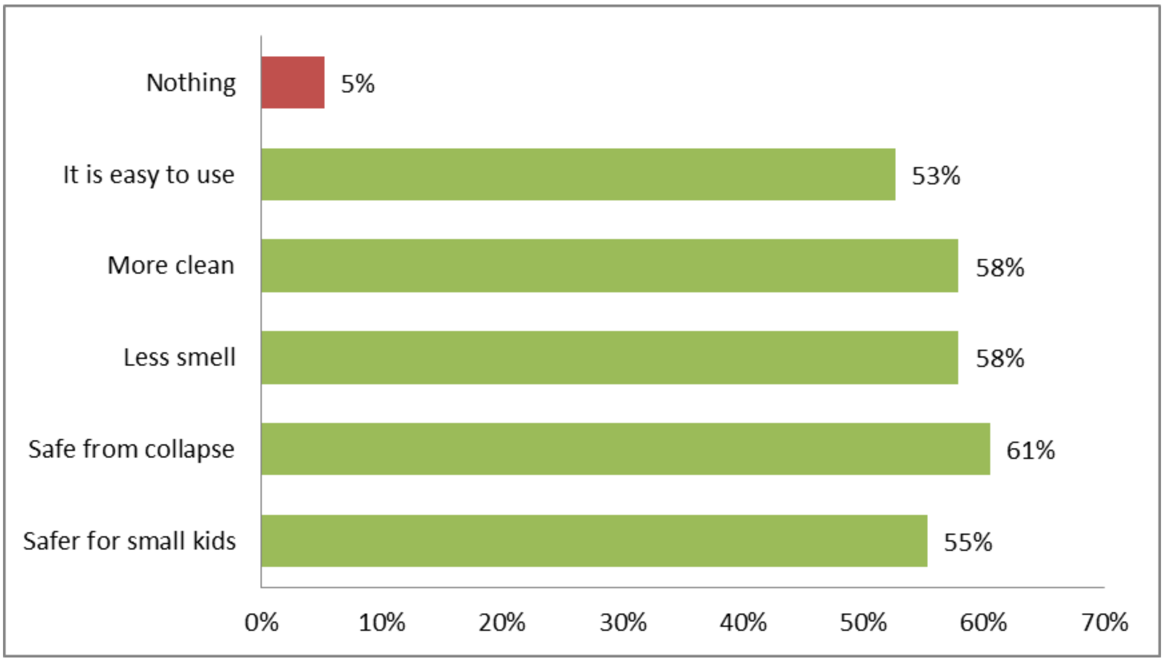


Figure J134: What do users like about pour flush toilets?

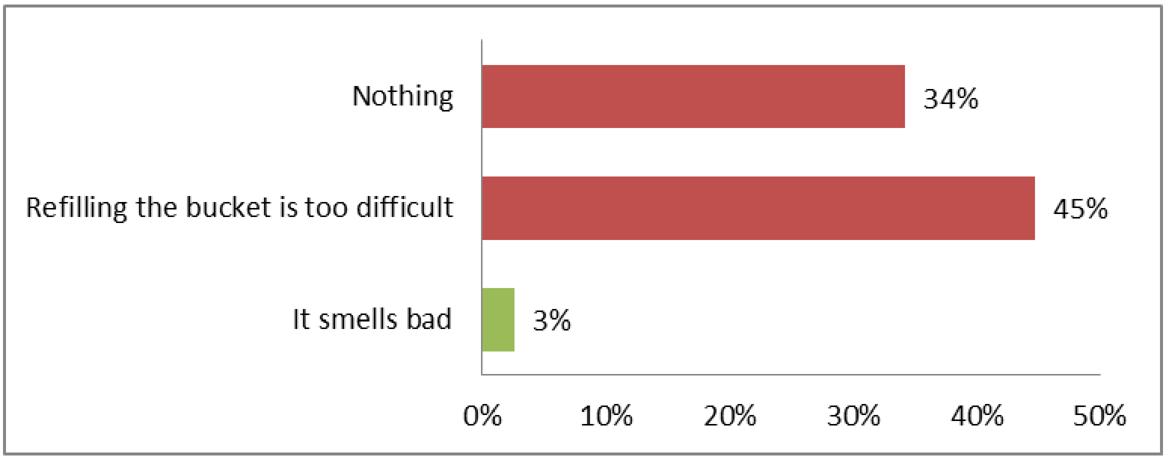


Figure J135: What do users dislike about pour flush toilets?

Users generally said that they would recommend pour flush toilets (89%) to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets (Figure D72), and a large percentage (62%) said that they would recommend it simply because they are better than VIP toilets. This is an important contribution to the comparison of VIP toilets versus pour flush toilets, which would likely be appropriate in similar contexts.

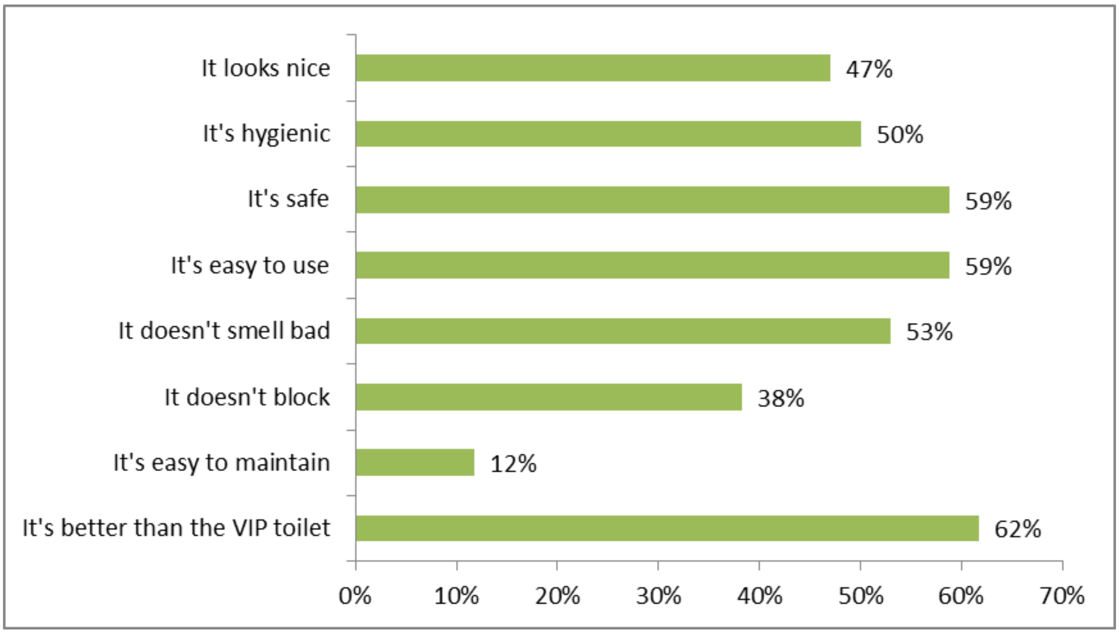


Figure J136: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, flushing urine requires 1 to 2 litres (71%). This includes some users who reported that they generally do not flush when they urinate and only when they defecate. Twenty-nine percent of users reported using 3 litres or less to flush faeces down the pour flush toilet. However, 68 percent said that they use 5 or more litres, including those who lose count of the amount of water used. As stated previously, many users have established a system in which users fill and carry the bucket with them to the toilet every time they use it. As a result, some users simply pour the entire bucket amount into the pour flush toilet, regardless of if it is needed.

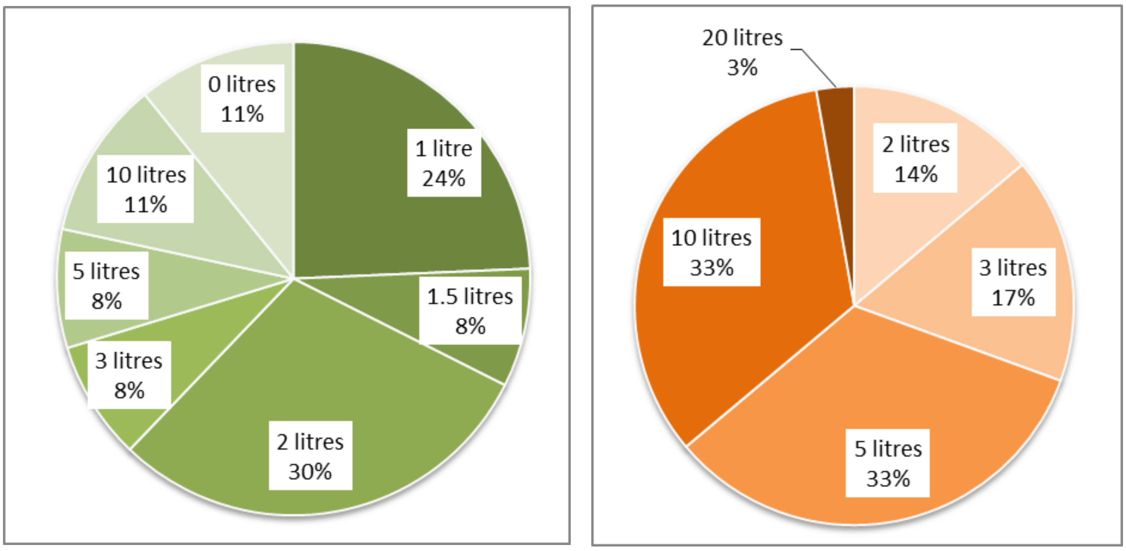


Figure J137: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In this area, 92% of respondents indicated that there are times when they do not have water. Of those, 54% indicated that this occurs once or twice a month, and 34% said that it happens less than once a month. When there is no water to flush, 60% of users reported that they use greywater to flush their pour flush toilet, a behaviour which increases households' resilience to water shortages. Only 4 households reported that they do not use the pour flush toilet when there is no water.

7.1.1 Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour flush toilets. As shown, a vast majority (97%) have never had a blockage. Similarly, most households (95%) have never experienced a leakage of their pour flush toilet. This is a positive outcome of using a pour flush toilet without a cistern, as it reduces the opportunities for leakages.

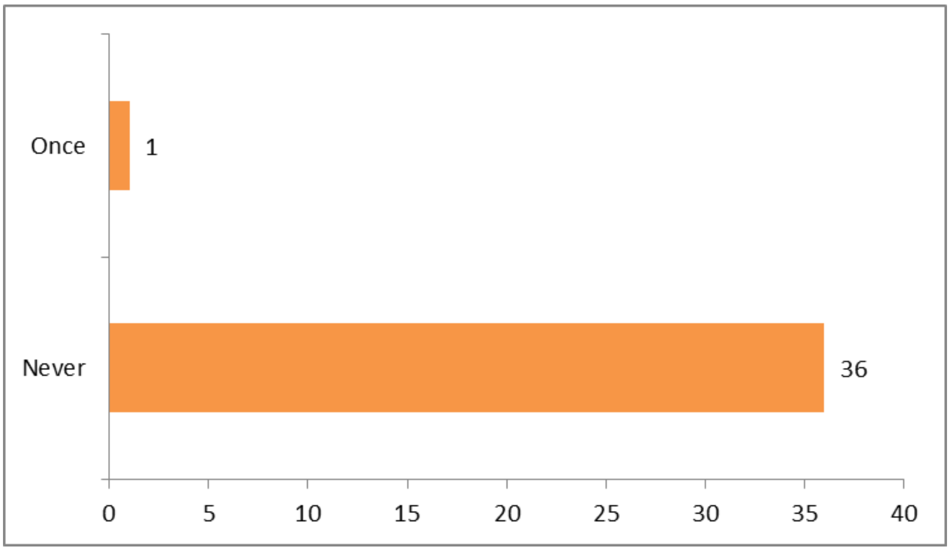


Figure J138: How often do households experience blockages of their pour flush toilet?

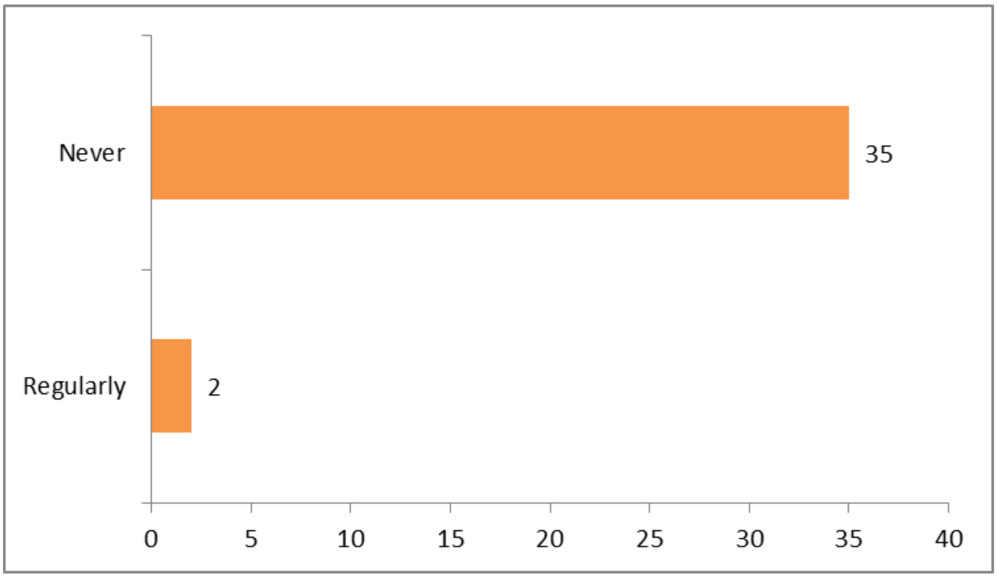


Figure J139: Frequency of leakages experienced by households

Conclusions

Overall, householders in Mariannhill and Molweni areas reported positive experiences with pour flush toilets. The primary negative feedback was that refilling the bucket for flushing is too difficult. Thus, adjusting the design to reduce the need for refilling the bucket would be ideal. This can be accomplished by installing a tap adjacent to the pour flush unit or by installing a larger tank/cistern in or near the pour flush unit. Ideally, this tank should not be connected directly to the toilet bowl in order to avoid excessive leakages.

Aside from this feedback, pour flush toilets are considered a safe, easy-to-use, and odour-free alternative to other on-site technologies in rural and peri-urban areas.

ANNEXURE K: Oakford Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in the Oakford area under eThekwini Municipality.

Case Study: Oakford, eThekwini

In 2016, construction of an RDP housing development began in Oakford, north of Durban (KZN). The specified technology for these units was pour flush toilets, located inside the home, accompanied by a greywater recycling system. PID constructed the first 90 units and trained a local contractor to finish the remaining units. Houses at Oakford are still under construction. The first 90 units installed were all pour flush toilets, but during inspections, it was clear that many toilets constructed after this initial 90 were low flush. Overall, 29 households were included in this study, 16 of which had pour flush toilets installed, 11 which had low flush toilets installed, and 2 which had converted their pour flush toilets to full flush toilets.

This is an interesting case study, given that this is a brand new housing area where each household has only one sanitation system. Anecdotally, there have been some complaints about the pour flush nature of these toilets, as residents feel that they should have full flush toilets with cisterns in their new houses. However, the houses have also been built in an area with water shortages. Thus, even with pour flush toilets which use less water, some householders are forced to use public mobile toilets provided by the municipality.

During data collection, some challenges were faced with locating pits and measuring sludge depth. Firstly, householders were not present during the construction of their toilets and did not know where the pits were located. Any markers set in place to indicate the pit location had been removed. Some pit covers were covered as deep as 500 to 700 mm by soil. In other cases, households had since paved over their pits due to a lack of knowledge about the pit location, making the pits inaccessible without breaking the pavement.

During data collection, it was also difficult to find people in this area to interview, as many were at work. This was a challenge in many areas and is simply the result of collecting data during normal working hours.

Figure K140: Pour flush unit with child-friendly seat in Oakford

Figure K141: New pedestal and cistern installed at Oakford (full flush)

Figure K142: Offset pits and concrete covers

Condition of PF toilets

During the assessments, ninety-seven percent of the toilets visited (28/29) had no odour and only 1 toilet had some odour. This demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure. Ninety-seven percent of toilets were clean, whereas 3% were found very dirty.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include the fact that they are cleaner (41%) and have less smell (24%). Twenty-one percent users reported different unique reasons as to what they like about the pour flush toilet technology. Fifty-five percent of respondents said that there is nothing they dislike about pour flush toilets, which demonstrates a high acceptance of the technology. Fourteen percent said the pedestal is not comfortable to use, when asked further one elderly user reported that she finds it too short as she is tall and has fragile knees. Ten percent said that refilling the bucket for flushing is too difficult, which was the most common negative feedback gathered across all sites.

Eighty-one percent (13/16) of the houses with pour flush toilets said that they would consider changing to low flush toilet and thirteen percent (2/16) said they would keep the toilet as a pour flush. A further 10% of users also said that they do not like having to scrub the pedestal after use of the toilet, but this would also be required in full flush toilets were provided.

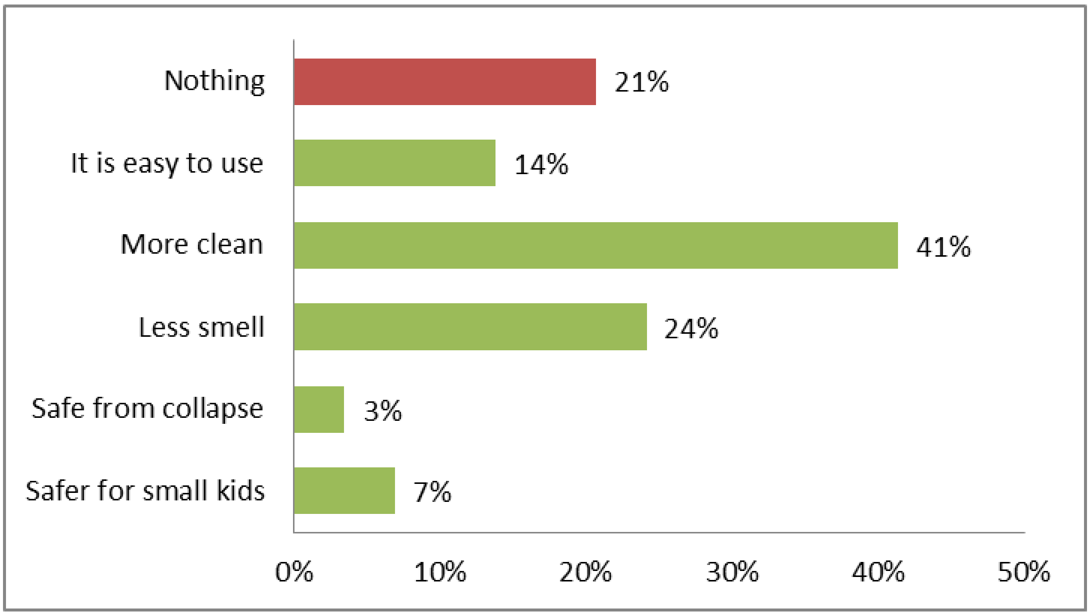


Figure K143: What do users like about pour flush toilets?

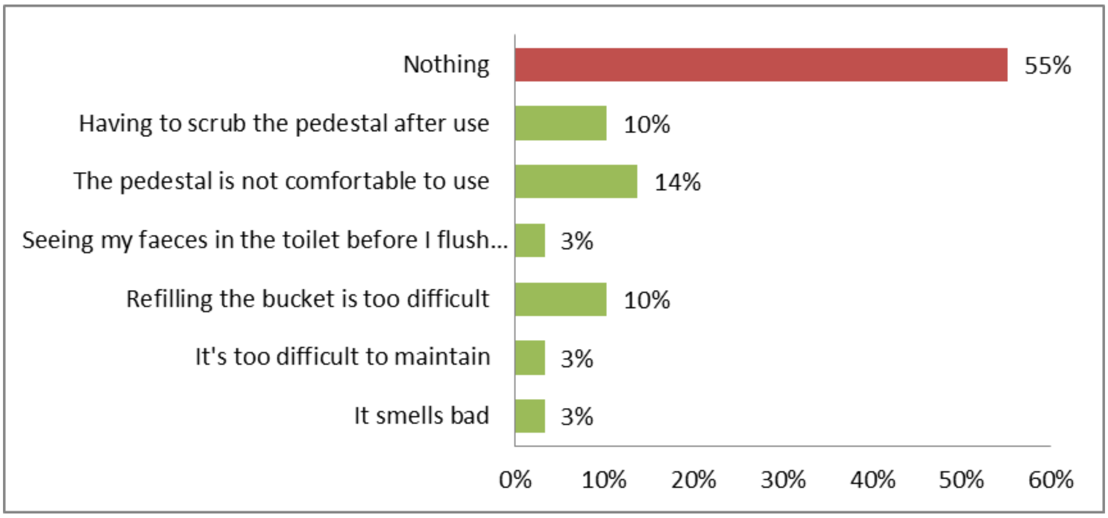


Figure K144: What do users dislike about pour flush toilets?

Users generally said that they would recommend pour flush toilets (76%) to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets (Figure D72). A shared percentage (27%) said that they would recommend it because it is hygienic and it does not smell bad. This was followed by users (23%) that said the toilet is better than the VIP toilet. Another shared percentage (18%) said that they would recommend the toilet because it is safe, easy to use and easy to maintain. Forty-one percent reported different unique reasons why they would recommend the pour flush toilet.

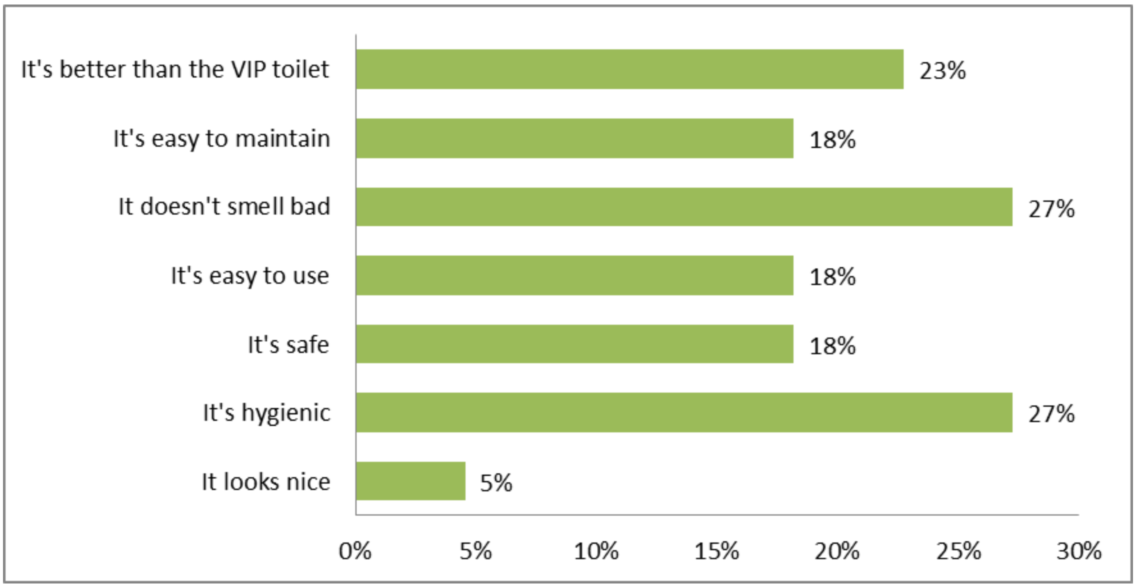


Figure K145: Why would users recommend pour flush toilets?

As described above, eleven (38%) of the assessed houses had low flush toilets constructed for them, which led to some dissatisfaction among those who received pour flush toilets. Householders in the area were not sure how those ones were selected or what the criteria was but they reported that they also wished for the same convenient system (low flush). In an effort to achieve a flushing system, 2 households had replaced their pour flush pedestal with a full flush system, while still using the leach pits designed for pour flush toilets. These leach pits are therefore likely receiving far more water than they were sized to receive. These householders did not know they could convert their pour flush toilet by simply connecting to the same pedestal.

Once switching of the pits was explained to the householders they complained that they would not have the money to hire individuals to switch for them. They reported that this should be in the municipality's plans to empty the community's full toilet pits.

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, flushing urine requires 1 to 2 litres (50%). This is only for users that have the pour flush toilets in their homes. On the other hand, no users reported using less than 3 litres to flush faeces down the toilet, and 31% said they use 10 litres or more, which represents excessive water used for flushing compared to what is required. This is due to users pouring the entire contents of their bucket into the toilet to flush.

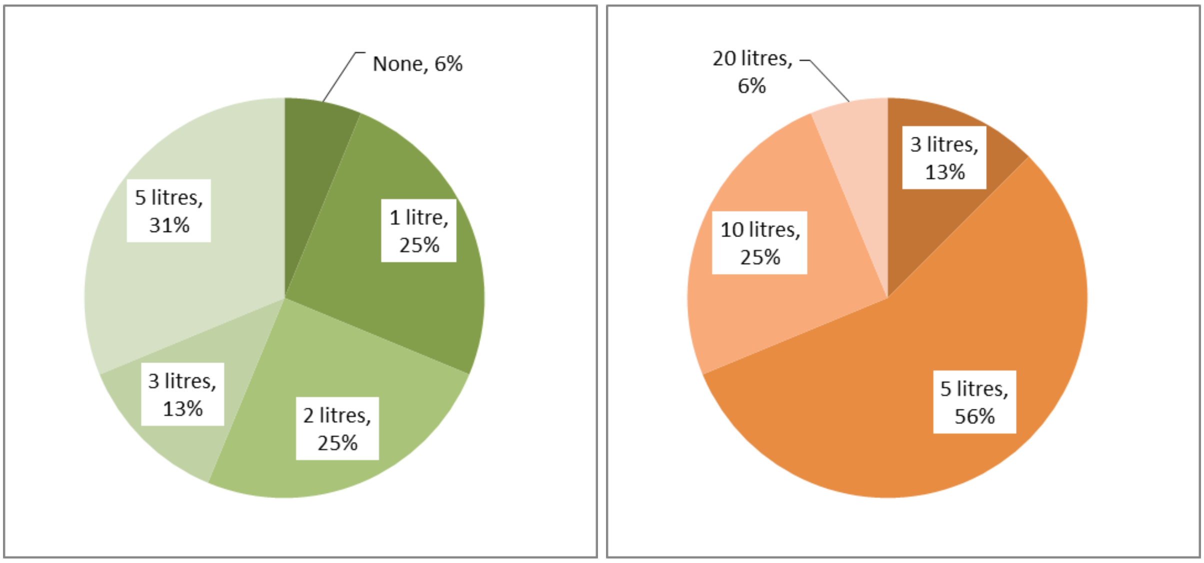


Figure K146: How much water do users (pour flush) use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour/low-flush toilets. In this area, 90% of respondents indicated that there are times when they do not have water. Of those, 81% indicated that this occurs once or twice a month, and 19% said that it happens less than once a month. When there is no water to flush, only 15% of users reported that they use greywater to flush their pour flush toilet. Eighty-five percent reported that they use rainwater stored in their JoJo tanks for the pour flush toilet, a behaviour that increases households' resilience to water shortages when there is no water in the area.

Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour/low flush toilets. As shown, a vast majority of ninety-three percent (26/28) have never had a blockage. Seventy-nine percent (22/28) of households have never experienced a leakage of their pour flush toilet, as shown in Figure K148. Four percent (1/28) experienced a leakage once and eighteen percent (5/28) experience leakages regularly. All reported leakages happened in households with low flush toilets, which is due to the installation of a cistern. The connection between cistern and pedestal is a common location for leakages in all flushing systems.

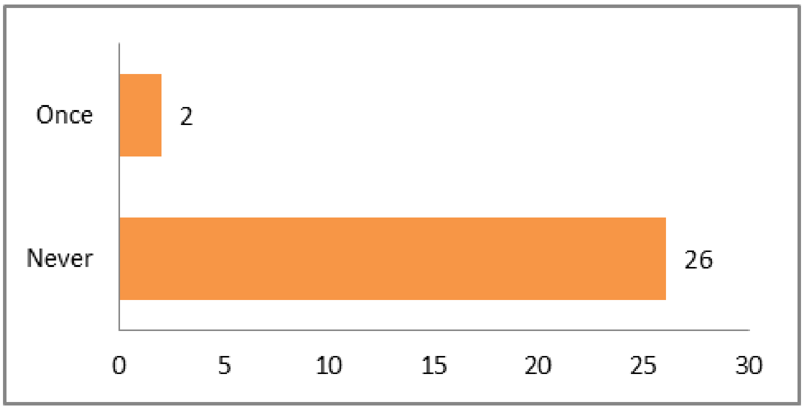


Figure K147: How often do households experience blockages of their pour flush toilet?

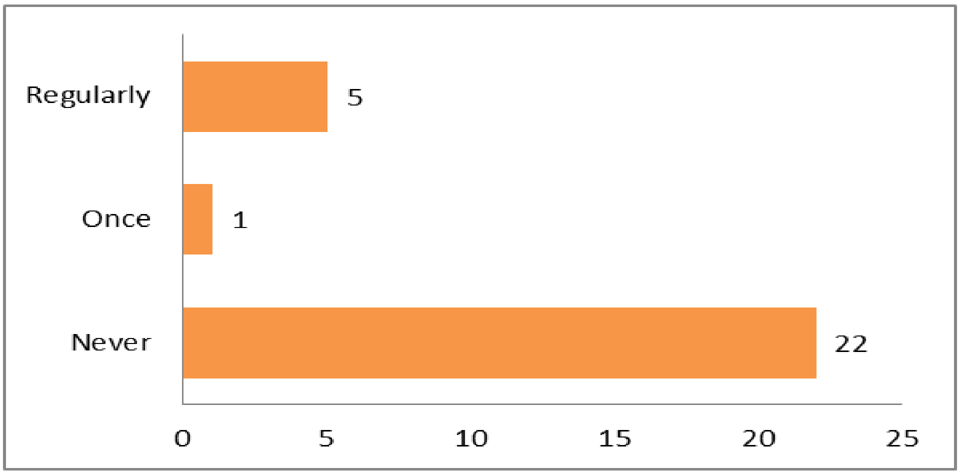


Figure K148: Frequency of leakages experienced by households

Feedback on greywater recycling system

Although this assessment is focused on the pour flush toilets, some feedback was also provided about the greywater system. Residents reported having challenges with the greywater harvesting system. There were faults when this system was constructed and as a result most people have never made proper use of that system or understand how they can make it work. Further, some reported that they prefer not to use the recycled greywater due to odours. This sometimes leads to greywater pooling on the surface when it is not pumped or cannot drain fast enough from the installed greywater system.

Figure K149: Example of greywater not properly draining and rather pooling on the surface

Feedback on construction issues

During the visits to site in May 2018 and October 2018, some issues were noted with toilets built after PID's involvement in construction ended, which are likely due to errors made during construction. For example, blockages in the pipes can be due to inadequate pipe slopes to allow gravity flow or if pipes with some soil in them were installed without cleaning. Two households were skipped and did not receive the low flush toilets (as their immediate neighbours did) and one of them reported that his house had incomplete services. The missing services included electrical and water connections as well as his cistern not being connected to the pedestal. He struggled with obtaining water for household and toilet use as he had to ask from his neighbours. He also reported that trenches around the pour flush toilet pits were left open and he backfilled them himself. He had to make his own means for both electrical and water connection and he reported that no one was willing to assist him after several attempts of reporting his matter.

In one household the owner reported that the contractor left the pits without concrete covers and she had to use planks (wood) to cover the deep pits. The interviewee reported this as unsafe as there is a risk of falling in if someone steps on top of the pits.

Another householder reported that the contractor had constructed a bigger pit than the covers, which led to the covers falling into the pit. He found a way to balance the covers the keep them from falling into the pit, but this was a precarious and short-term solution.

Two households reported that they once had faeces back up into their kitchen drain, which suggests that the pipework was improperly installed (with greywater separate from blackwater). Another household reported that their pour flush toilet was not fully installed. The pedestal is incomplete, as shown below, and no leach pits were ever constructed. This householder, therefore, has constructed his own leach pit behind the house and continues to use the uncomfortable pedestal.

Figure K150: Unfinished construction as evidenced by improper pedestal (left) and home-built septic tank (right)

Conclusions

Overall, householders in the Oakford area reported positive experiences with pour flush toilets. The primary negative feedback was that residents wish to have the low flush toilets. This adjustment to the design would reduce the need for refilling the bucket would be the most ideal. Interviewed residents were reminded of the general water scarcity and the challenge that lies in most municipalities of providing full water borne sanitation for all communities. This has massive cost implications and also currently impossible with the country's water shortage crisis. If householders were more open to using their greywater for flushing, it would reduce their reliance on potable water for flushing and therefore more water could be made available for flushing from a cistern.

Aside from this feedback, pour flush toilets are considered a solution for bridging the gap that exists between VIP and waterborne toilets. They have a number of advantages, which include the fact that they are a safe, easy-to-use, and odour-free alternative compared to other on-site technologies in rural and peri-urban areas. In projects such as this one, it is important to manage expectations of the householders and ensure that construction is done well so that users' experiences will be positive.

ANNEXURE L: Ilembe DM Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in Ilembe District Municipality, Kwa-Zulu Natal.

Case Study: Ilembe DM, KwaZulu-Natal

In 2017, 1650 pour flush units were built in the Ilembe District Municipality. This includes 550 each in Ndwedwe, Maphumulo, and Mandeni. After struggling to make contact with the councillors, 10 households were visited in Maphumulo and 14 were visited in Mandeni for a total of 24 in Ilembe DM.

Both areas visited are rural with scattered houses. Large distances between houses made data collection inefficient. The area does not have a potable water supply. There are pipes in the ground and communal standpipes, but water has not yet been made available. Thus, people fetch water from the local river for domestic use. The lack of water supply in the area means that households with pour flush toilets often cannot use their toilets and resort to open defecation. This is concerning due to the community's reliance on the local river for all household uses, including consumption, and the location of the settlement in a valley with large catchment areas on both sides. Open defecation likely leads to pollution of this water source and can contribute to diarrhoeal disease in the area. It would be far better for householders to use VIP toilets than to resort to open defecation.

Figure L151: Photo of the valley at Maphumulo

Two types of pour flush toilets were constructed in the area. All toilet structures are built with precast concrete and then connected to either a septic tank and soak pit or pits lined with concrete blocks. Some toilets have an external water tank connected to the cistern in the toilet, but it does not work since there is no water supply. Cisterns were installed in each toilet by the contractor even though there is no water in the area. This was a decision made by the municipality, due to future plans to connect the area to a water supply.

During the visit to Maphumulo, it was estimated that approximately 50% of people in the area are not yet using their pour flush toilets for different reasons, including:

3) Some say they are still using VIP toilets and they will only switch to the pour flush toilet when their VIP is full.
4) Some use the bush (open defecation) since they are not used to the toilets and do not have access to water.

Figure L152: Standard pour flush unit in Maphumulo

Figure L153: Single pit units in Maphumulo

Figure L154: Septic tank + soak pit pour flush unit in Maphumulo

Figure L155: Pour flush toilet with large water storage tank installed outside toilet structure, connected to the cistern

Figure L156: Access road in Maphumulo

Condition of PF toilets

During the assessments, 91% (21/23) of the toilets had no odour, which demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure. Twenty-two percent were clean, while 57% were a bit dirty and 22% were very dirty.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. Users were generally satisfied with many aspects of pour flush toilets, most commonly: they are safe for children (96%); they are easy to use (88%); and they have fewer odours (88%). Typically, respondents answer this question relative to the status quo option, which for many in this area is nothing at all (75%), a VIP toilet (13%), or a home-built pit toilet (8%). This explains the large emphasis placed on increased safety of pour flush toilets, as they do not put small children over a pit of sludge and there is no risk of children falling through the seat. A large percentage (63%) also said that there is nothing they dislike about pour flush toilets, which demonstrates wide acceptance of the technology. The only negative feedback gathered about pour flush toilets is that refilling the bucket for flushing is too difficult (33%), which is consistent with feedback from the other areas included in the study.

In this area, converting to a low flush toilet would simply require connecting the installed cisterns to the pedestal, which 7 households have already done. A further 9 households said that they would consider converting their pour flush toilet to a low flush toilet for the same reason that they do not like carrying water to the toilet with them. However, since household water connections do not yet exist, this configuration still requires households to manually fill the cistern for flushing, which would not get rid of this inconvenience. Furthermore, should water connections be made available to each low flush toilet, there is a large chance of water wastage due to leakages.

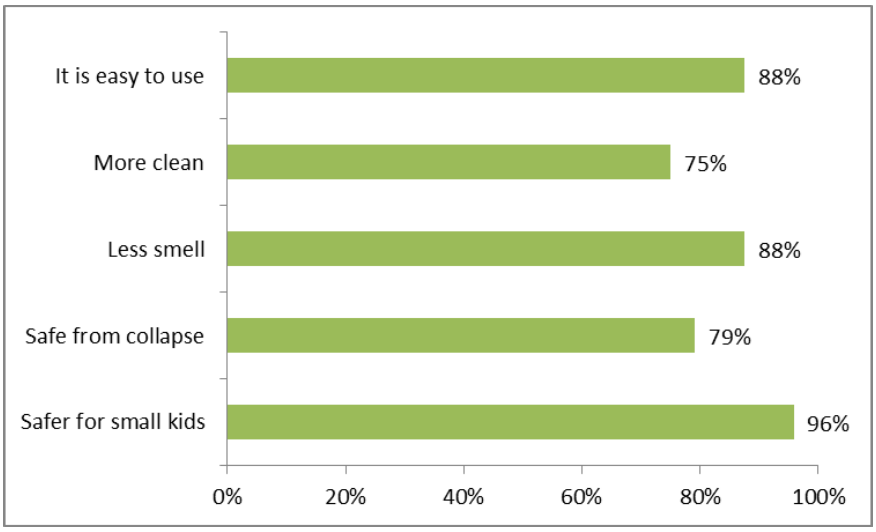


Figure L157: What do users like about pour flush toilets?

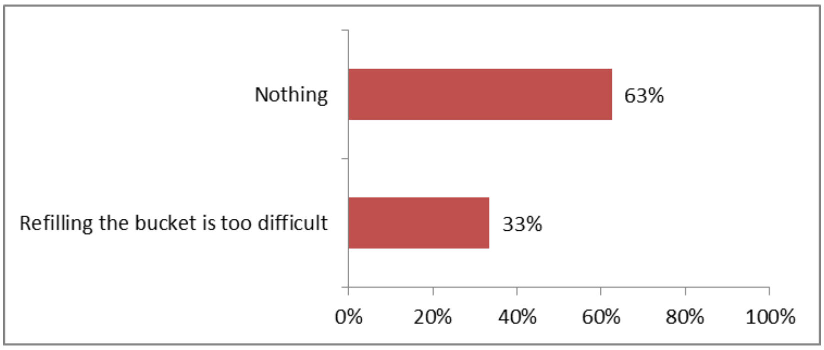


Figure L158: What do users dislike about pour flush toilets?

All 24 interviewed householders said that they would recommend pour flush toilets to others, and their reasons for recommending them are shown in Figure L159. Again, the most reported positive aspect was the safety of pour flush toilets (79%). Furthermore, 71% said that it is better than a VIP toilet.

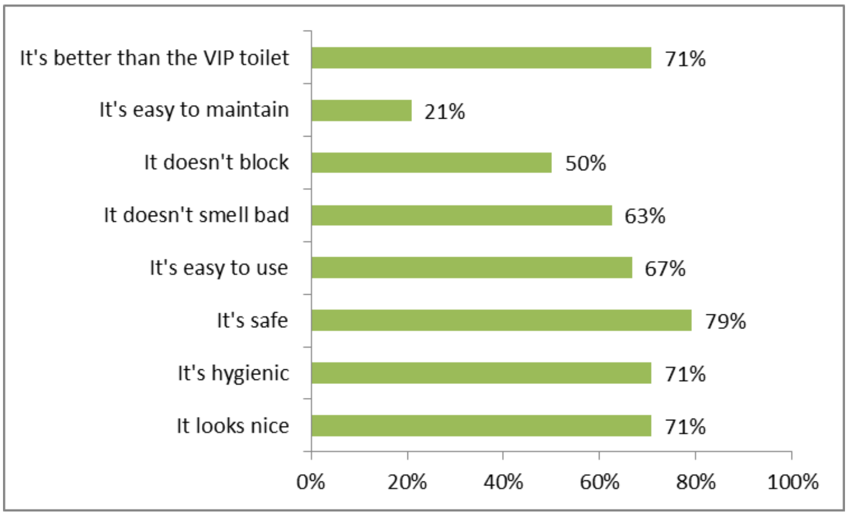
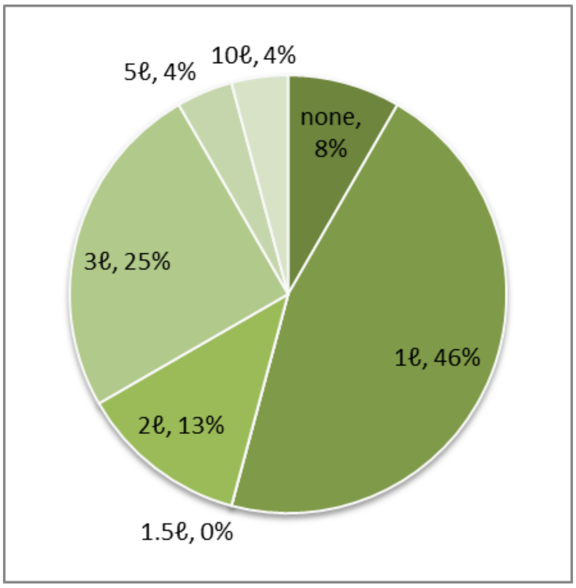


Figure L159: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, flushing urine requires 1 to 2 litres (67%), including 2 users who said they do not use the toilet for urinating. In contrast, only 8% of users reported using 2 litres or less to flush faeces, which is not consistent with the requirements of the technology, as testing in a controlled setting. Seventy-nine percent of users said that they use at least 5 litres to flush faeces, with 21% saying they use as much as 10 litres. It is unclear why so much water is used to flush the toilet, as very few people said that people take a full bucket with them to the toilet when using it.



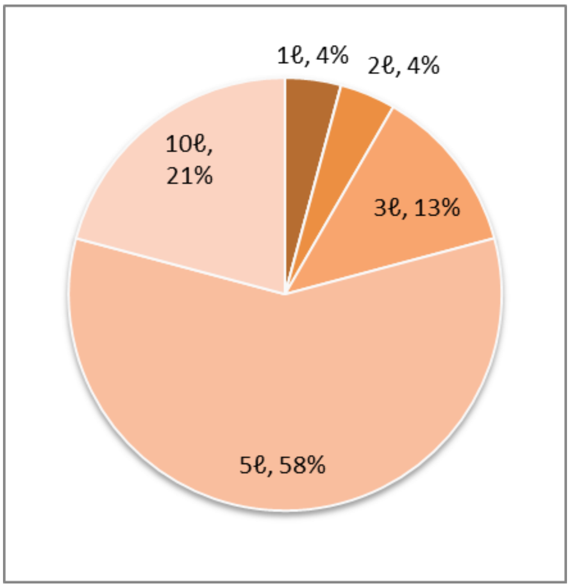


Figure L160: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In Ilembe DM, 13/24 users said that there are times when they do not have water. The majority of these (9) said that this does not happen more than once or twice a month, but 2 said that it happens every day. Ten households (42%) have a tap in their house, while 3 use an outdoor tap and 11 people use surface water. When there is no water, 7 users said that they use an alternative water source such as greywater, rainwater, stored water, or river water, and 2 said that they use their old pit toilet.

Occurrence of blockages and leakages

No participating households in Ilembe have experienced blockages. This is a positive outcome that demonstrates the ability of pour flush toilets to function in communities despite concerns about blockages occurring. Furthermore, only one household has experienced a leakage once in the pipework of the toilet. In this instance, the household was able to fix the problem. Both of these suggest that the addition of water and sewers to the system (when compared to a VIP) does not necessarily increase the maintenance needs for these households.

Conclusions

Despite the relatively small sample size, it appears that users in Ilembe have had positive experiences with pour flush toilets. The water shortages are of concern in this area, along with the provision of cisterns but no water connection to the cisterns. This decision in the project may create expectations among householders, despite the fact that the chance of the existing units being upgraded to low flush units with a water connection may be slim.

This project is particularly interesting due to the large-scale implementation carried out by the municipality, without any large scale pilot being done in this area. The large-scale implementation is, therefore, likely purely due to effective marketing efforts by Envirosan.

ANNEXURE M: Thornhill Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in Thornhill area in Chris Hani District Municipality, Eastern Cape.

Case Study: Thornhill, Eastern Cape

In 2016, Cemforce constructed 368 single-pit pour flush (Cemflush) toilets as part of a municipal sanitation programme in Thornhill, located in Chris Hani District Municipality in the Eastern Cape. These toilets have the typical Cemflush construction, with the top structure located directly above the single pit. Usage of pour flush toilets in Thornhill was relatively low, with only 40% of interviewed households (16/41) confirming that the pour flush toilet is in use. In some cases, this was due to the presence of old pit toilets on site, and in others, this was due to lack of water or dissatisfaction with the construction.

Figure M161: Typical pour flush toilet in Thornhill

7.2 Local findings

Overall, 41 assessments were done in the Thornhill area, but one had since upgraded their pour flush to a full flush toilet. Forty percent (16/41) pour flush toilets were in use, highlighting that usage in Thornhill was very low. Some reasons that people were not using their toilets included that there is not enough water in the area or they were still using their pit toilets until they fill up.

Condition of PF toilets

During the assessments, 76 percent of the toilets visited (22/29) had no odour, 7 percent had some odour and 17 percent had excessive odour. This demonstrates the general effectiveness of the water seal to prevent odours from entering the toilet structure. Only 10% of toilets (3/30) were clean, whereas 57 percent were very dirty. Most unused pour flush toilets were dirty and/or used for other purposes, such as storage of equipment.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include the fact that they are easy to use (44%) and they are cleaner (25%). Typically, respondents answer this question relative to the status quo option, which for most households is using their old, home-built pit toilet. Forty-four percent of pour flush users (7/16) said that there is nothing they dislike about pour flush toilets. Nineteen percent of the pour flush users (3/16) said that refilling the bucket for flushing is too difficult. A majority of households using pour flush toilets use communal taps for their primary water source and only 6 out of 16 have a household tap in their yard. Walking to fill the bucket and carry it to their pour flush toilet can be a burdensome task for some, especially if water is not stored on site in larger quantities for the purpose of flushing the toilet.

A few solutions to improving this situation include: installation of a yard tap just outside of the pour flush toilet, to remove the need to carry the bucket long distances; installation of a larger storage tank outside the toilet cubicle to reduce the frequency of having to carry water to the toilet; or conversion of the pour flush toilets to low flush toilets, with a cistern to hold the water. Including a water connection directly to the cistern is an option, but due to the potential for leakages, this is not advised in areas with an unreliable water source. Fifty percent of users (8/16) said that they would change something about the pour flush toilets, and 7 of those 8 respondents said that a cistern should be added, but it is unclear whether residents understand the implications of installing a cistern with water connection on the available water supply.

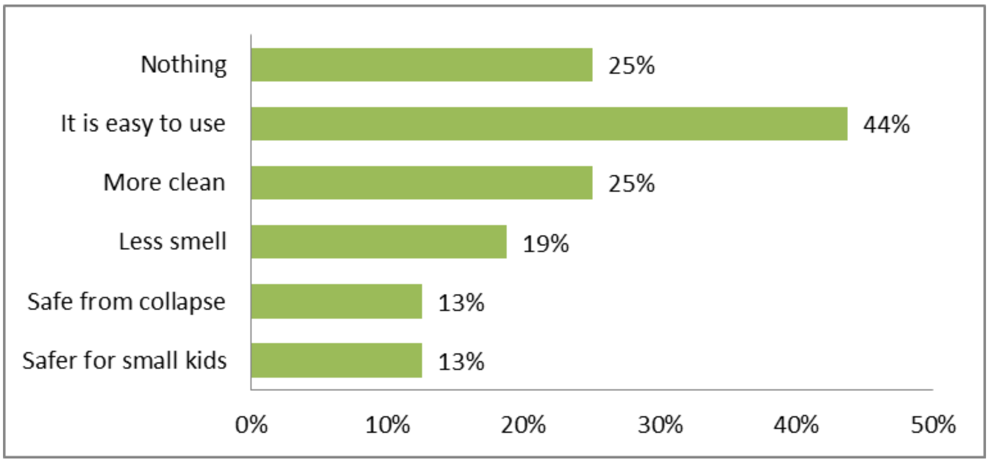


Figure M162: What do users like about pour flush toilets? (Percentage of reported users)

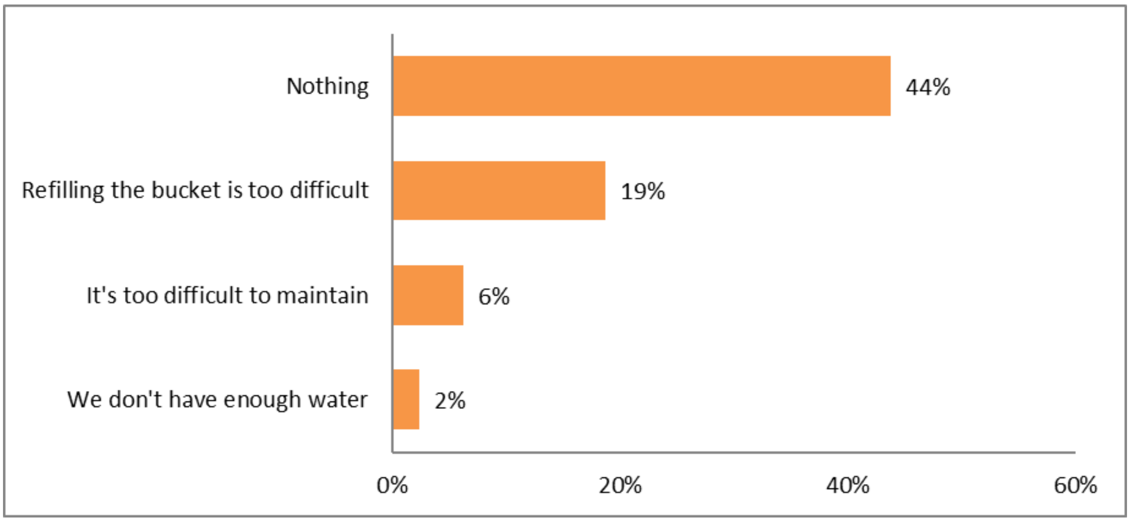


Figure M163: What do users dislike about pour flush toilets? (Percentage of reported users)

Most users said that they would recommend pour flush toilets (63%) to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets (Figure D72), including the fact that they are easy to use (70%).

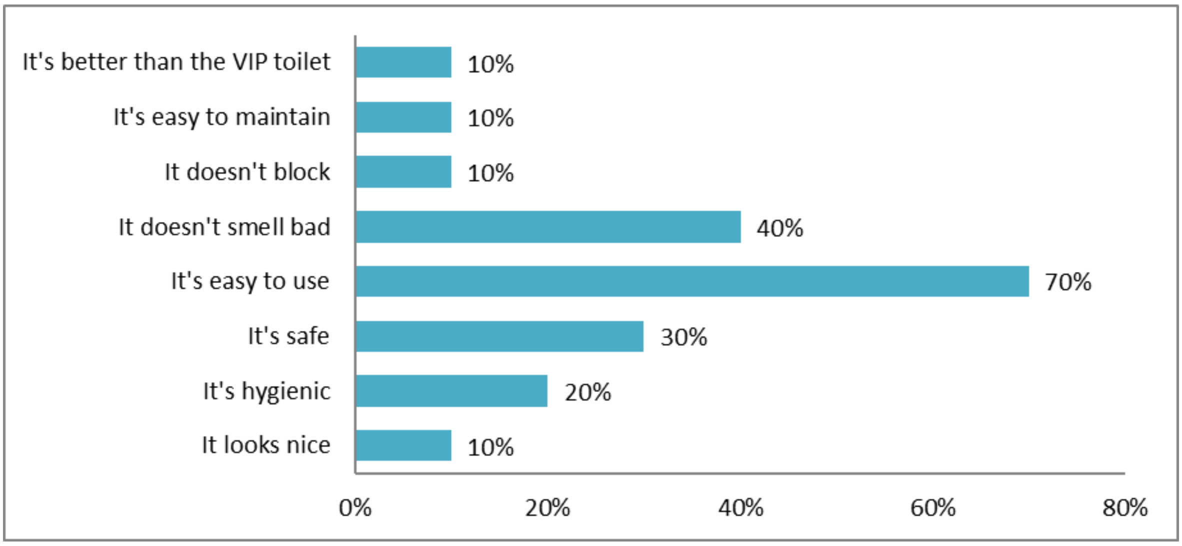


Figure M164: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, users reported that they use 1 to 2 litres (76%) to flush urine. Some users reported that they generally do not flush when they urinate or they do not use the pour flush toilet for urinating (they either use a bucket and dispose the urine in the yard or use the bush). On the other hand, only 28% of users reported using 2 litres or less to flush faeces down the pour flush toilet, though prior testing of pour flush toilets suggests that faeces can be flushed with 2 litres or less. Sixty-five percent of users use between 3 and 5 litres of water to flush faeces. This highlights that the volume of water used in practice is often higher than what is *necessary* or that what is *necessary* in practice is actually more than what was determined during testing.

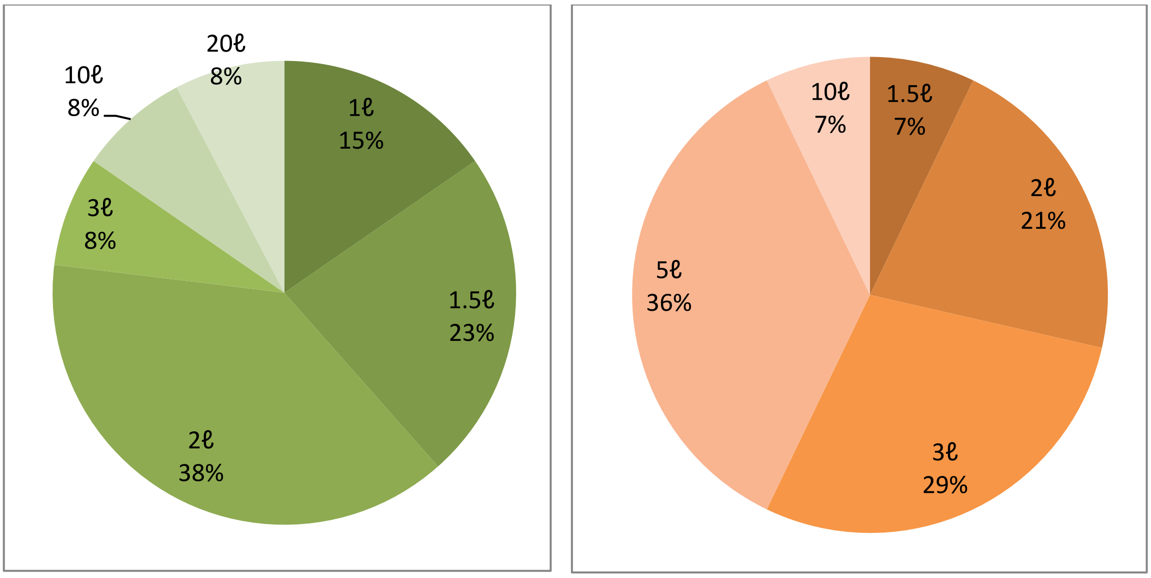


Figure M165: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In this area, 15 out of 16 pour flush users said that there are times that they do not have water. Of those, 9 said that this happens most days in the week, which demonstrates severe water shortages in the area. When there is no water to flush, 6 users said that they use their old pit toilet, which highlights the usefulness of having two options where waterborne solutions are used in water scarce areas. In contrast, 3 users said that they go to the bush to defecate when there is no water. All 3 of these households do not have another toilet on site, and this highlights the potential negative ramifications of providing only waterborne sanitation in water scarce areas. Further, 5 users said that they use an alternative flushing water source, such as rainwater or greywater.

Occurrence of blockages and leakages

Figure D76 displays how often users reported experiencing blockages of their pour flush toilets. As shown, most households have never had a blockage. Of the two houses that have experienced blockages, one says that it is newspaper which blocks the toilet. Both of the households said that the household can fix the problem and does not have to call a plumber. No households reported ever having experienced a leakage of their pour flush toilets. This is a positive outcome of using a pour flush toilet without a cistern, as it reduces the opportunities for leakages. This also removes concerns about blockages and leakages of pour flush toilets, which are not of concern when using VIPs.

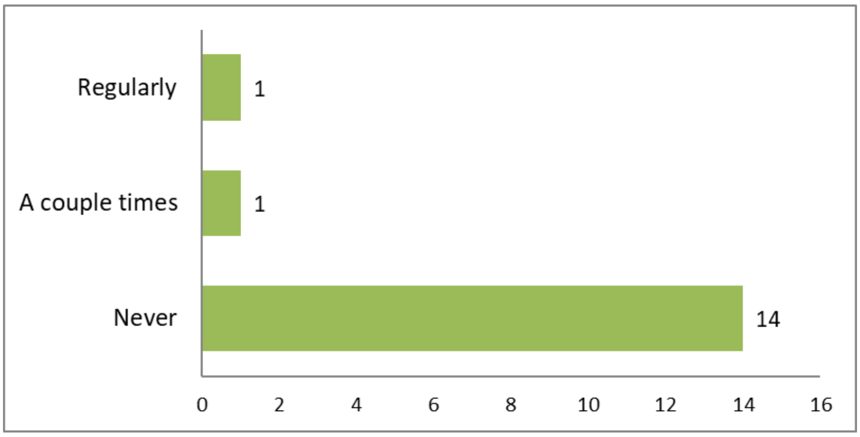


Figure M166: How often do households experience blockages of their pour flush toilet?

Conclusions

Overall, usage of pour flush toilets in Thornhill was very low, but those who were using the toilets reported positive attitudes towards the technology. The main reasons for low usage include water shortages/unreliability and the fact that some households have more than one sanitation option in their yard. Anecdotally, some users reported that they wish they had a say in what type of toilet was built for them, rather than simply being given pour flush toilets. This is an interesting point to make, as it may be that providing users with an option up front will make them more satisfied later on, because it was seen as their decision, rather than an imposed solution. It would be interesting to investigate if having a choice up front makes users more satisfied and willing to refill their bucket for flushing.

This project emphasised the importance of creating resilience among communities that have both waterborne sanitation and frequent water shortages. Resilience can be created either by providing other options (e.g. VIP toilets) that can be used during water cuts or by encouraging and enabling water recycling and harvesting. Using greywater for flushing is a positive practice that should be encouraged among householders, as it reduces overall water demand as well as the trips necessary for them to fetch water for the household. Rainwater harvesting also provides the household with a backup supply which can be used in times of extreme drought or water cuts.

ANNEXURE N: Port St John's Case Study

Introduction

In 2009 the WRC commissioned a study investigating the feasibility of adapting the pour flush technology to South Africa. A prototype was developed which could be flushed with as little as one litre of water (with toilet paper as cleansing material; if newspaper is used then a second flush is needed) and the first units were installed in the field in September 2010. A further 20 units were installed in 2011 and have been in use since. A low flush adaptation was then developed and successfully tested in schools near Durban. User responses were very positive and blockages were rare. This successful R&D exercise demonstrated that contrary to the general preconception, pour flush actually could work in Africa, and work well.

Following the initial work, further installations were carried out, bringing the total number of demonstration pour flush toilets to above 1000, 300 of which were built in 2015 or before. In addition to the demonstration pour flush toilets, the technology has seen additional growth elsewhere through the promotion efforts of organisations like the WRC, Envirosan, and Cemforce. The total number of household pour flush toilets installed in South Africa as of 2018 was 16 466, with a majority in the Eastern Cape, followed by KwaZulu-Natal.

The WRC has been conducting ongoing monitoring of pour flush toilets throughout 2018 and 2019, in order to gain understanding on the acceptance and outcomes of installation of pour flush toilets in rural and peri-urban areas. This brief report presents an overview of findings from pour flush toilets in the Port St. John's area in Eastern Cape.

Case Study: Port St John's, Eastern Cape

In 2016, 240 single pit pour flush toilets (Eaziflush) were constructed in Port St John's in the Eastern Cape as part of an OR Tambo DM sanitation project. These single pit toilets have off-set single pits. Ninety-one percent (40/44) of householders interviewed said that their pour flush toilet was in use. This is a positive outcome, especially given that the primary water sources in the area are communal taps and rainwater (for houses located too far from communal taps).

Figure N167: Typical pour flush toilet in Port St John's

Figure N168: Single leach pit in Port St John’s

Condition of PF toilets

During the assessments, 95% (42/44) of the toilets had no odour, while 2% had some odour. This demonstrates the effectiveness of the water seal to prevent odours from entering the toilet structure, even after a long period of use. Twenty-three percent of the toilets assessed were clean, while 59% were a bit dirty and 18% were very dirty.

User feedback

Users were asked to report what they like or dislike about pour flush toilets, and the results from these questions are presented in Figure D72 and Figure D73. The most common aspects that users like about pour flush toilets include that they have fewer odours (73%) and that they are safer for small kids (66%). Typically, respondents answer this question relative to the status quo option, which is in Port St John's is typically using their home built pit toilet. This explains the large emphasis placed on lack of odour and on increased safety of pour flush toilets, as they do not put small children over a pit of sludge and there is no risk of children falling through the seat. Thirty-one percent of respondents said that there is nothing they dislike about pour flush toilets.

The most common negative criticism of pour flush toilets was that refilling the bucket for flushing is too difficult (61%). This was similar to the outcomes in other areas included in the study and highlights people's dislike of the inconvenience of carrying water to the toilet, as opposed to having a water source inside or directly next to the toilet. This response is echoed by the relatively large percentage (57%) that said they would consider changing their toilet to a low flush toilet by adding a cistern. Prior to these interviews, only 7 participants knew that this was a possibility with their pour flush toilet. However, converting to low flush toilets is not feasible in this area, because the majority of households use communal taps or rainwater as their primary water sources. Thus, a direct water connection to household toilets is unlikely. A potential upgrade that could improve people's experience with the toilets in this area includes installation of a larger storage tank adjacent to or connected to the toilet structure, which could hold larger volumes of water and then be used for filling jugs for flushing the toilet. This would simply mean that the large bucket needs to be refilled less frequently to meet flushing needs.

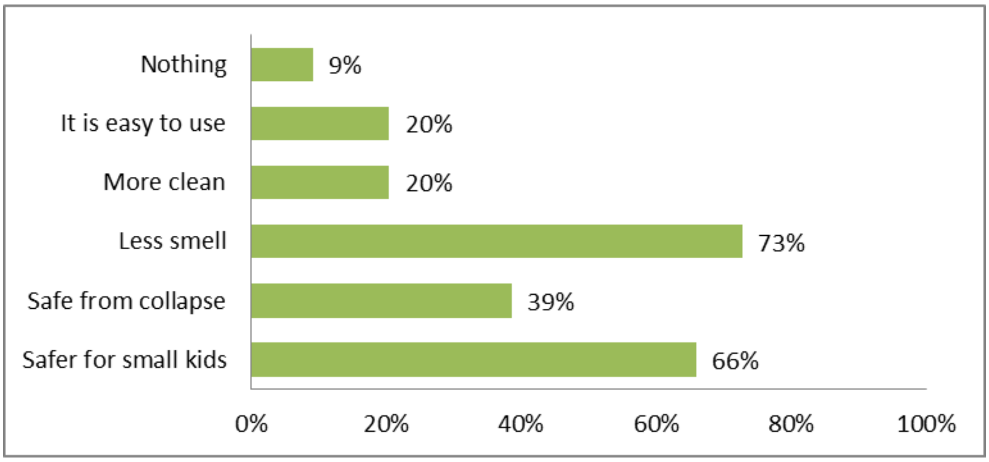


Figure N169: What do users like about pour flush toilets?

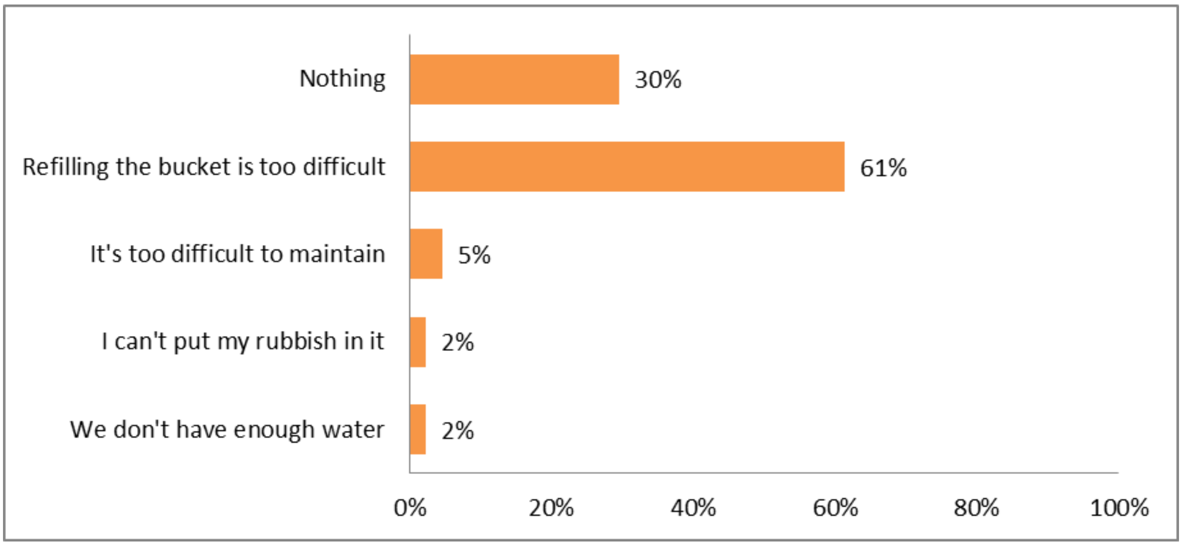


Figure N170: What do users dislike about pour flush toilets?

Users generally said that they would recommend pour flush toilets (32/40) to those who do not have them. The reasons people would recommend pour flush are similar to the aspects people like about pour flush toilets (Figure D72), including that it looks nice (57%), it is safe to use (52%), and that it is better than a VIP toilet (36%). The most common reason some people would not recommend the toilet is that refilling the bucket is too difficult (6) and that the toilet cannot be used when there is no water (3).

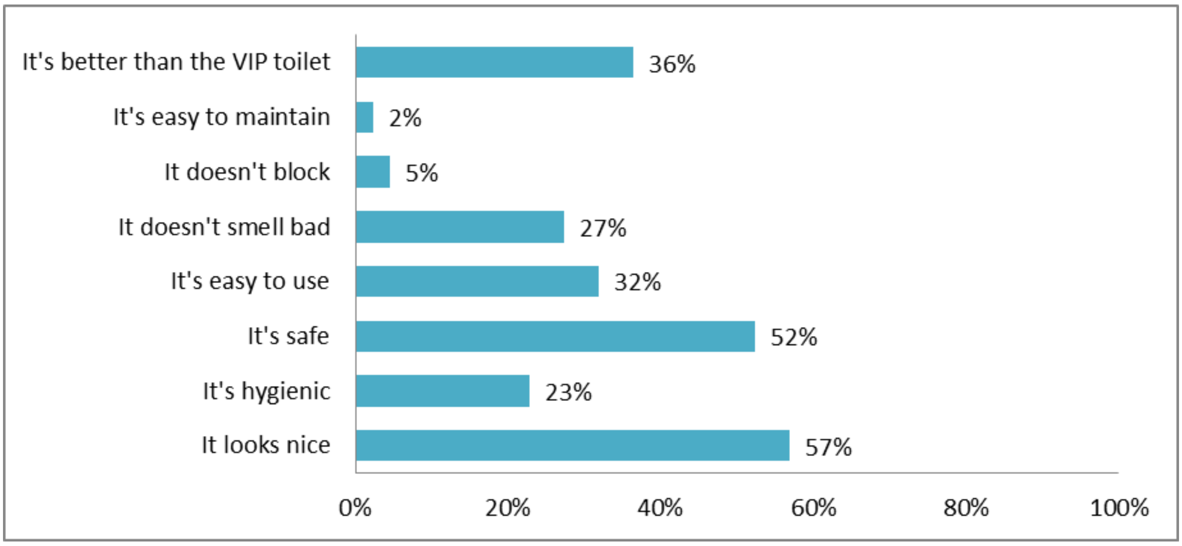


Figure N171: Why would users recommend pour flush toilets?

Maintenance considerations

Water usage

Users were asked to report how much water is required to flush urine and faeces down the pour flush toilet. In general, flushing urine requires 1 to 2 litres (77%), including 1 user who reported that they do not use the toilet for urinating. In contrast, only 11% of users reported using 2 litres or less to flush faeces, which is not consistent with the requirements of the technology, as testing in a controlled setting. Most commonly, householders use 5 litres to flush faeces (59%), but a small percentage use 10 litres or more (11%). This is likely due to the practice of each user taking a full bucket of water with them to the toilet and then pouring the entire contents in, rather than using a smaller jug provided during installation to flush the contents. This is further evidenced by results from the visual inspections, in which 61% of toilets had a water bucket in the toilet and only 36% had a smaller jug available for flushing.

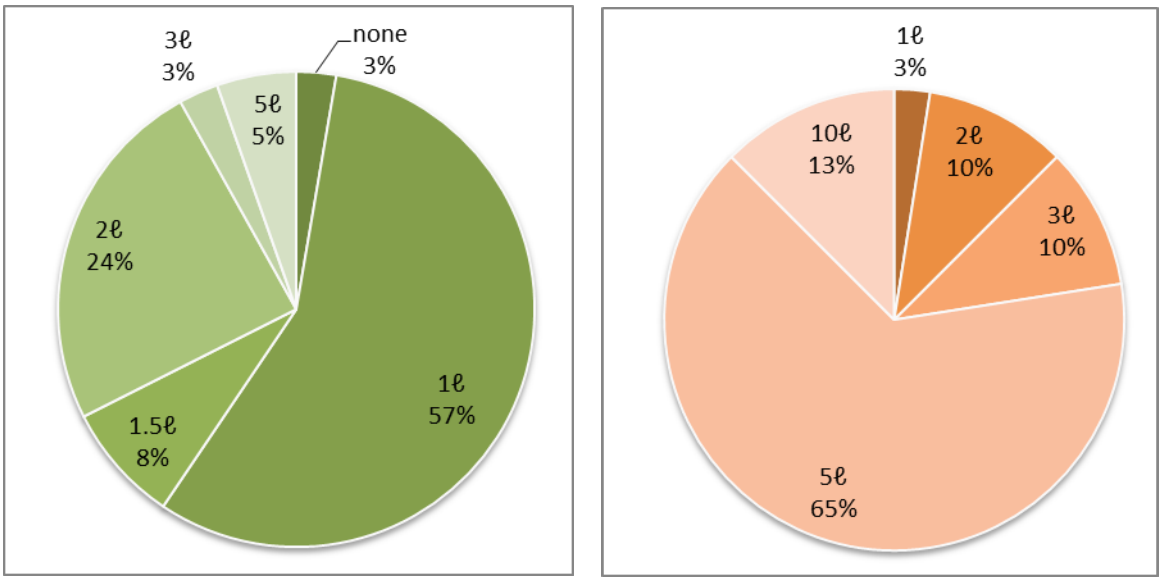


Figure N172: How much water do users use to flush urine (left) and faeces (right)?

It is important to consider resilience to water shortages in communities before implementing pour flush toilets. In Port St John's, 64% of users said that there are times that they go without water. The frequency of not having water varied from less than once a month (32%) to most days in the week (32%), and one household even said they don't have water on a daily basis. When there is no water to flush, a large majority (12/28) said that they use their old pit toilet. Others use greywater (7/28) or rainwater (5/28) to flush, which demonstrates a level of resilience to water shortages at the household level. Overall, 57% of respondents said they use greywater for flushing their toilet, with 8 households saying they do this all the time. This is a fantastic method for reducing water consumption as well as the number of times families must fetch water from the nearby sources.

Occurrence of blockages and leakages

Overall, only 1 household has ever experienced a blockage of their pour flush toilet, and they indicated that this is due to random people often using their pour flush toilet. Furthermore, no households have ever experienced a leakage of their pour flush toilet, which is a positive outcome of using pour flush toilets instead of low flush or full flush toilets. While providing a cistern water connection may enhance convenience, it is bound to lead to constant leakages unless a leak-free cistern is used, which is more expensive.

Sludge accumulation and pit emptying

During inspections of 16 pits, none of the pits were over 50 percent full. Pits with the following characteristics were excluded from the analysis of sludge accumulation rates in Port St John's: pits that have a layer of water covering the sludge layer; pits with missing or incomplete data; pits with accumulation rates less than 10 ℓ/c.a or greater than 105 ℓ/c.a. Thus, 7 valid measurements have been included, which have a median sludge accumulation rate of 29.7 ℓ/c.a, which slightly exceeds the overall median of 27.8 ℓ/c.a across all sites in the study.

Pit emptying can be planned using a median accumulation rate determined across all study areas (27.8 ℓ/c.a), the median of number of people per household (5), and the total pit volume available. In the case of Port St John's, the single pit provided has a volume of approximately 1.5 m^3. This suggests that pour flush toilets built in Port St John's towards the end of 2016 will require emptying in approximately 2027, 11 years after installation. Conservatively, it would be wise to plan for emptying to take place approximately 8 years after installation to accommodate larger household sizes and avoid overflowing pits and unhappy residents.

Conclusions

Overall, householders in Port St John's reported positive experiences with pour flush toilets and resilience despite less than ideal water sources in the area. The relatively high usage of pour flush toilets (40/44) is evidence that the technology is accepted, which is not surprising given that the most common alternative is a home-built pit toilet. Despite householders' interest in having cisterns with water connections installed, this should be done sparingly, given that only one of the households has a household water connection in their yard. Further, with water shortages common, it is wise to keep water wastage to a minimum, and incorporation of a cistern with water connection will lead to leakages. To reduce the maintenance burden, the municipality could consider constructing additional pits with associated pipework when the first pits fill up. This will extend the life of the leach pits and greatly reduce the frequency that the toilets require emptying. It is unclear whether the municipality has plans to continue implementing pour flush toilets, but this is an encouraging case, as the initiative came from the municipality independent of a pilot project.