Assessing perceptions and willingness to use urine in agriculture: a case study from rural areas of eThekwini municipality, South Africa

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ABSTRACT

In recent years there has been a growing body of knowledge exploring the benefits of using sanitation-derived nutrients. Such studies aim to uncover strategies that facilitate nutrient recovery from urine and faecal sludge for agricultural use. This paper presents the findings of a study which assessed the willingness to handle and use urine in agriculture among people living in rural areas of eThekwini Municipality, South Africa. Results show that less than 5% of participants are using urine as a fertiliser. This could be attributed to limited awareness of the value of urine in agriculture since only 9.7% are aware that urine contains essential nutrients that can support plant growth. Furthermore, health concerns, smell and the opinions of others are identified as barriers to the handling of urine. The study therefore recommends that participatory field trials and promotional activities are conducted to improve users' awareness and acceptance. The outcome of this research is of importance to help inform low- and middle-income countries' governments as they address urban and environmental challenges such as access to adequate sanitation, poverty and food security.

KEYWORDS South Africa, urine diversion toilets, urine re-use, user perceptions

1 INTRODUCTION

Fast-paced population growth and increasing water stress conditions are critical factors affecting the provision of waterborne sanitation facilities and sewerage connections in developing countries (Moe & Rheingans 2006). Acknowledging these challenges, a growing number of researchers and practitioners have been investigating the feasibility of dry sanitation options to address the sanitation backlog in challenging topographical and infrastructural conditions (Drangert et al. 2002). The concept of ecological or dry sanitation (sometimes called EcoSan) broadly encompasses technologies which aim to make use of waste (urine and faeces) as a resource. Sanitation technologies such as the urine diversion dehydration toilet (UDDT), which allows for the separation of urine from faeces at the source is one such example. A review of past EcoSan projects in developing countries (Jackson 2005) argues that the primary reasons for introducing such systems are to minimise the environmental and health risks related to inadequate and poor sanitation. Increasingly, however, applied research on dry sanitation has been linked to the idea of nutrient recovery through the re-use of urine and faeces in agriculture (Lienert et al. 2003). Human urine contains nitrogen (N), phosphorus (P) and potassium (K), in a ratio of 11:1:2, which can be used as a fertiliser. Urine application, after appropriate storage, has been reported to be a safe alternative to the application of mineral fertilisers in plant production (World Health Organization [WHO] 2006; Richert et al. 2010a, b).

The use of urine in agriculture is particularly urgent in view of the increase in the demand for and use of phosphorus in fertiliser production, which is estimated to grow at a yearly rate of 3%, boosted by the economic growth of developing countries (Drangert 1998). Furthermore, the depletion of phosphate rock supply (Cordell & White 2006), combined with recent price increases of fertilisers by 350% have further exacerbated global food prices, impacting negatively on food security, particularly in developing countries (Cordell & White 2006). Establishing a sustainable phosphorus supply is fundamental for long-term food security for a booming world's population, yet nutrient recovery from human waste remains largely unutilised due to the common perception of human urine and faeces as something that should be disposed of.

While it has been scientifically proven that urine and faeces can be safely used in agriculture (Schönning 2001; Phasha 2005; WHO 2006), users' acceptance of such practices has been an increasing concern for policy makers and practitioners in the sanitation sector (Richert et al. 2010a). A recent meta-analysis of user perceptions of the practice of applying human urine in agriculture (Roma et al. 2013) identified common hurdles in the acceptance of such practice. Poor awareness of the fertilising value of urine represents one obstacle in the uptake of such practice. In a study in Nigeria, Sridhar et al. (2005) found that just 7.7% of respondents were in favour of using urine as a fertiliser for vegetable production. Interestingly, after demonstrating the value and potential of urine in agriculture, the research identified a sharp increase in acceptance, with 80% of the respondents showing willingness to use urine in agriculture. Similarly, concerns for the presence of pathogens in urine and health risks from using it have represented an important hurdle in reusing urine in agriculture (Roma et al. 2013). Studies from Ghana and Nigeria (Cofie et al.) reported that quality assurance for the produce grown using urine is important in increasing acceptance. In the eThekwini municipality of KwaZulu-Natal (South Africa), the eThekwini Water and Sanitation Unit (EWS) has installed 75,000 UDDTs in rural areas to address the sanitation backlog and a cholera outbreak in 2000 (Sustainable Sanitation Alliance 2011). The municipality has provided households with training on how to use and maintain UDDTs, and more recently has been exploring the potential for reusing urine in agriculture, thus transforming UDDTs into 'productive' sanitation technologies, which allows for nutrient recovery from human waste. The implementation of dry sanitation requires a critical understanding of users' awareness of human waste and how they relate to the process of applying and reusing it in agriculture (Roma et al. 2013). In South Africa, very few studies have explored the impact of social and cultural factors on the acceptability of urine-based fertiliser (Duncker et al. 2007; Water Research Commission 2007). Thus, our research provides an important contribution to the body of knowledge exploring the dynamics relating to the management of human waste, providing recommendations for appropriate interventions.

2 METHODS

This study was undertaken in nine rural and peri-urban areas of eThekwini Municipality. Table 1 illustrates the distribution of participants across the different locations. The site selection was conducted in collaboration with local authorities (ward councillors) and EWS according to the following criteria: (a) households had a UDDT; (b) ward councillors agreed to the research; (c) areas were safe for conducting the study. Furthermore, none of the selected areas had received education on reusing urine. This was extremely important to minimise bias in the respondents' answers.

Table 1 Project area name

	Number of people surveyed	Percentage of sample
Crowder	28	5.9
Ehlanzeni	40	8.5
Umnini Informal	39	8.2
Cliffdale	101	21.4
eSthumba	48	10.1
Livapho	52	11.0
Mnamatha	35	7.4
Luganda	71	15.0
Salem	22	4.7
Ntshongweni	37	7.8
Total	473	100

Data were collected using mobile phones and the supporting software platform, 'Mobenzi Researcher' (see http://www.mobenzi.com/researcher/). The Mobenzi platform facilitates the translation of a questionnaire into a Java application which can be downloaded on mobile phones used by fieldworkers when administering the survey. Upon completion of the survey, the data were automatically sent to a web console, which allowed the researcher to monitor and analyse data in real time. Upon completion of the study, all the data were exported to Microsoft Excel spreadsheets. Coding and analysis of the data was performed using Statistical Package for the Social Sciences (SPSS) version 19.0. Descriptive statistics were used to describe some general characteristics of respondents as well as some of the variables explored by the research. An independent $\chi 2$ test was used to determine the relationship between the willingness to use urine-based fertilisers and the demographic characteristics of respondents. Variables with p-value <0.05 were considered statistically significant.

3 RESULTS

We surveyed 473 respondents, of which more than half (66.6% n=314) were females and 33.4% (n=158) were males (See Table 2). IsiZulu is the main language of nearly all participants (99.6% n=471). Only 5.5% (n=26) participants completed university. About a third (31.9% n=150) completed high school while 19.8% (n=93) did not complete primary school education.

Table 2 Demography of participants

	Number of responses	Percentage of responses
Sex		
Male	158	33.4
Female	315	66.6
Main language		
Zulu	471	99.6
Xhosa	1	0.2
Don't know	1	0.2
Level of education		
Did not finish primary school	93	19.8
Completed primary school	189	40.2
Completed high school	150	31.9
Completed university education	26	5.5
Do not know/do not remember	11	2.3
Age		
28 years and below	123	26
29–38 years	115	24.3
39–55 years	118	24.9
51+	117	24.7

Table 3 Gardening

		Percentage of responses	**Number of responses**
Have a garden	Yes/sometimes	46.9	222
	No/never	52.2	247
	Do not know/do not remember	0.8	4
Purpose of gardening	For eating/using for ourselves	95.1	215
	For selling	0.4	1
	Both	2.7	6
	Don't know	1.8	4
Produce from garden enough to feed family	Yes	61.5	139
	No	35	79
	More than enough	0.9	2
	Don't know	2.7	6
Garden location	By the house	94.2	213
	in a communal place	4	9
	Don't know	1.8	4

Less than half of the respondents (46.9% n=222) own a garden while 52.2% (n=247) do not or have never owned a garden. Nearly all respondents who own gardens (95.1% n=215) reported that the cultivated produce is for family consumption, while less than 1% (0.4% n=1) sell their garden produce (See Table 3). More than half (61.5% n=139) of respondents who own gardens reported that their agricultural produce is enough for the family while 35% (n=79) reported that not enough for subsistence is produced. The gardens of the majority of respondents (94.2% n=213) are located in close proximity to their households. Only 4% (n=9) of respondents' gardens are located in a communal place.

Half of those who own a garden sometimes use fertiliser (52.2%

n=118), whilst the remaining 44.7% (n=101) have never used fertiliser. There are different types of fertilisers being used by respondents (Table 4). The content of toilet pits/vaults is used least often (1.7% n=1) while 76.9.9% (n=90) use animal dung. Chemical fertilisers (12.2% n = 15) are also used by participants. Of those respondents who use fertiliser, close to half (44.1% n=52) get it from their neighbours. Another 13.6% (n=16) buy fertilisers from shops in the city.

Table 4 Fertiliser usage in vegetable garden

		Percentage of responses	Number of responses
Use fertiliser for garden	Yes/sometimes	118	222
	No/never	101	
	Do not know/do not remember	7	
Type of fertiliser	Store bought (pellets)	15	12.8
	Compost	9	7.7
	Animal dung	90	76.9
	Content of toilet pits/vault	2	1.7
	Don't know	1	0.9
Where fertilisers are obtained	Local shop	5	3.4
	From a shop in the city	16	13.6
	From our neighbours	52	44.1
	Given free from government	6	5.1
	From our animals	40	33.9

Exploring respondents' willingness to own a garden is important to understand the potential for promoting gardening practices in the study areas (Table 5). Over a third of those who currently do not own a garden (79% n=195) expressed willingness to have one. Conversely, 20% (n=49) reported that they will not/will never own a garden. Table 5 shows that nearly all male respondents (81.4%) want to own a garden while 116 (77.3%) of the 315 female respondents would like to own a garden. This result shows that among the study participants, willingness to own a vegetable garden is slightly higher in male participants compared to female participants though it is unclear who would be responsible for the act of gardening. Respondents aged 28 years and below constitute the highest percentage (82% n=50) of those who would like to own a garden. This is followed by respondents in the 29–38 age group, 79.2% (n=57) of whom indicated willingness to own a garden. These results show that willingness to own a vegetable garden is higher among respondents in the lower age brackets.

Table 5 Willingness to own vegetable garden

	Yes/sometimes Number of responses (percentage)	No/never Number of responses (percentage)	Do not know Number of responses (percentage)
Sex			
Male	79 (81.4)	16 (16.5)	2 (2.1)
Female	116 (77.3)	33 (22.0)	1 (0..7)
Total	195 (79.0)	49 (19.8)	3 (1.2)
Age			
28 and below	50 (82.0)	11 (18.0)	0
29-38	57 (79.2)	14 (19.4)	1 (1.4)
39-50	46 (78.0)	13 (22.0)	0
51 +	42 (76.4)	11 (20.0)	2 (3.6)

Understanding the current practices, use and willingness to handle urine are important precedents for the successful adoption of urine as a fertiliser. Such understanding would also uncover the constraints to handling and using urine for agricultural purposes. For this purpose, respondents were asked to choose from a list of options of what they think are the effects of urine on flora and fauna (see Figure 1). Results show that close to half of respondents (41.6% n=197) think that urine kills plants. Only 9.7% (n = 46) think that urine helps plants to grow. Similarly, 4% (n = 19) of respondents hold that urine pollutes the soil, whilst 14.8% (n=70) said that urine kills insects in the garden. All these demonstrate that knowledge about the value and usefulness of urine in the study area is quite limited. Given that only 9.7% of participants think that urine could help plants grow, acceptance of urine-based fertiliser in the study area is expected to be very low. This is exacerbated by the fact that 41.6% think that urine kills plants.

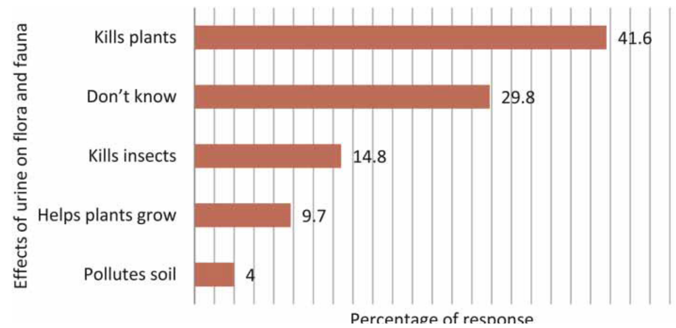

Figure 1 Effect of urine on garden.

Participants were also asked to indicate the various ways that they have used urine in the past. Figure 2 shows that, despite fears about urine in agriculture, the usage of urine among study participants is surprisingly high. More than a quarter of respondents (27.1% n=128) have used urine for antiseptic/medicinal purpose. As illustrated in Figure 2, 5.5% (n=26) have used urine for magical or ritual purposes while 1% (n=1) have used it for washing or cleaning. Only 3.6% (n=18) have used urine-based fertiliser in their garden. This limited usage could have implications for the introduction of interventions or programmes aimed at encouraging urine usage.

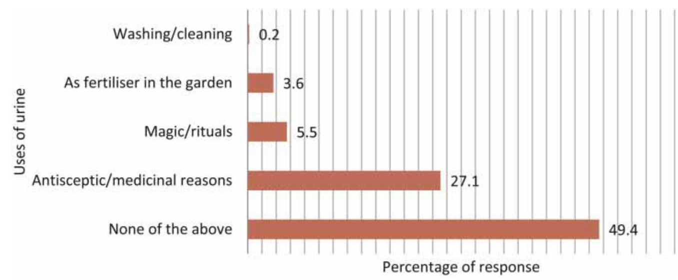

Figure 2 Uses of urine.

Agricultural purpose

An exploration of respondents' perceptions about the use of urine-based fertiliser for agriculture is important for the Municipality to understand the potential for developing activities involving the collection, processing and distribution of urine-based fertiliser for agriculture. To this end, respondents were asked whether they would use fertiliser based on the urine of their family members or urine obtained from other people (See Table 6). More than half of respondents (53.3% n= 252) reported they would use fertiliser from urine of family members. Conversely, only 20.5% (n= 97) would use urine-based fertiliser from urine of their neighbours. There is no difference between male (53.8%) and female (53%) respondents in terms of their willingness to use urine-based fertiliser from the urine of their family members; only a fifth of respondents stated that they would be willing to

Table 6 Willingness to use urine-based fertiliser from urine of family members and urine of other people

	Yes Number of responses (percentage)	No Number of responses (percentage)	Total Number of responses	χ2	Yes Number of responses (percentage)	No Number of responses (percentage)	Total Number of responses	χ2
Total responses	252 (53.3)	221 (48.8)	473	-	97 (20.5)	376 (79.5)	473	-
Sex								
Male	85 (53.5)	73 (46.2)	158	0.76	33 (20.9)	125 (79.1)	158	0.23
Female	167 (53.0)	148 (47.0)	315		64 (20.3)	251 (79.7)	315	
Age								
28 and below	70 (56.9)	53 (43.1)	123	0.55	25 (20.3)	98 (79.6)	123	0.79
29-38	67 (58.3)	48 (41.8)	115		21 (18.3)	94 (81.7)	115	
39-50	60 (50.8)	58 (49.2)	118		23 (19.5)	95 (80.5)	118	
51+	55 (47.0)	62 (53.0)	117		28 (23.9)	89 (76.0)	1171	
Level of education								
Did not finish primary school	47 (50.5)	46 (49.5)	93	0.51	17 (18.3)	76 (81.7)	93	0.61
Completed primary school	98 (51.9)	91 (48.1)	189		39 (20.6)	150 (79.4)	189	
Completed high school	87 (58.0)	63 (42.0)	150		35 (23.3)	115 (76.7)	150	
Completed university education	12 (46.1)	14 (53.9)	26		5 (19.2)	21 (80.8)	26	

use urine-based fertiliser from urine of others.

A χ2 test of independence shows that the level of education is not statistically related in a significant way to willingness to use urine-based fertiliser from either the urine of family members (p-value=0.63) or urine of others (p-value=0.53). Furthermore, a χ2 test of independence shows that the relationship between gender and willingness to use urine-based fertiliser from family members is not statistically significant (p-value=0.76). Similarly, the relationship between gender and the willingness to use urine-based fertiliser from urine of other people is not statistically significant (p-value=0.23).

A cross tabulation between age and the willingness to use urine-based fertiliser from urine of family members shows an inverse relationship between the two variables. These results shows that younger respondents are more willing to use urine-based fertiliser from the urine of family members but less willing to use urine-based fertiliser from the urine of neighbours. However, the relationship between age and the willingness to use urine-based fertiliser from the urine of either family members (p-value =0.55) or the urine of others (p-value =0.79) was not statistically significant.

A further question asked the study participants to give the reason why they would not use urine-based fertilisers made from the urine of either family members or other people. Table 7 shows that health hazards has the highest response in terms of the reason why respondents would not use urine-based fertiliser from the urine of either family members (42.1% n= 93) or urine of others (48.1% n= 181). This is followed by smell which is the reason why 34.4% (n= 76) respondents would not use urine-based fertiliser from the urine of family members and 34% (n= 128) would not use fertiliser from others' urine. Only one respondent would not use urine-based fertiliser from the urine of family members while seven respondents would not use urine-based fertiliser from urine of neighbours due to magical reasons. Apart from religious reasons, other reasons for being unwilling to use urine-based fertiliser are higher for urine-based fertiliser from urine of neighbours. This shows that respondents are more willing to use urine-based fertiliser from urine of family members compared to that from urine of neighbours.

We hypothesised that perceptions of family members and neighbours could impact respondents' willingness to use urine-based fertilisers. Respondents were therefore asked to respond to the question 'would your family approve if you used urine-based fertiliser for agriculture?' In addition, respondents were asked if their neighbours would approve if they used urine-based fertiliser for agriculture. As illustrated in Figure 3, there is no significant percentage difference in the level of agreement between male and female. Neighbours' approval had the highest level of disagreement for both male (40.5% n=64) and female (52.9% n=166) respondents. The highest level of expected approval comes from family members (30% n=49 and 34.1% n=107 respectively) for both male and female respondents. These show that approval of the use of urine-based fertiliser is higher at the family level compared with neighbours.

Table 7 Why wouldn't use fertiliser from urine of family members or others.

	Family members		Neighbours	
	Number of response	Percentage of response	Number of response	Percentage of response
The smell	76	34.4	128	34.0
Health hazard	93	42.1	181	48.1
Magical powers	1	0.5	7	1.9
Religious reasons	15	6.8	14	3.7
Others' opinion	22	10.0	27	7.2
Don't know	14	6.3	19	5.1

Given the potential for employment in the collection of urine, respondents were asked to indicate their willingness to take a job that would require handling urine. More than half of respondents (63.2% n= 299) are willing to take jobs that involve working with urine (Table 8). When compared with the distribution of the gender of respondents in the sample, nearly the same percentages of male (63.3%) and female (63.2%) respondents are willing to take up a job that requires working with urine. The result of the χ2 test for independence shows that the relationship between gender and willingness to take a job that would require the handling of urine is not statistically significant (p-value=0.95).

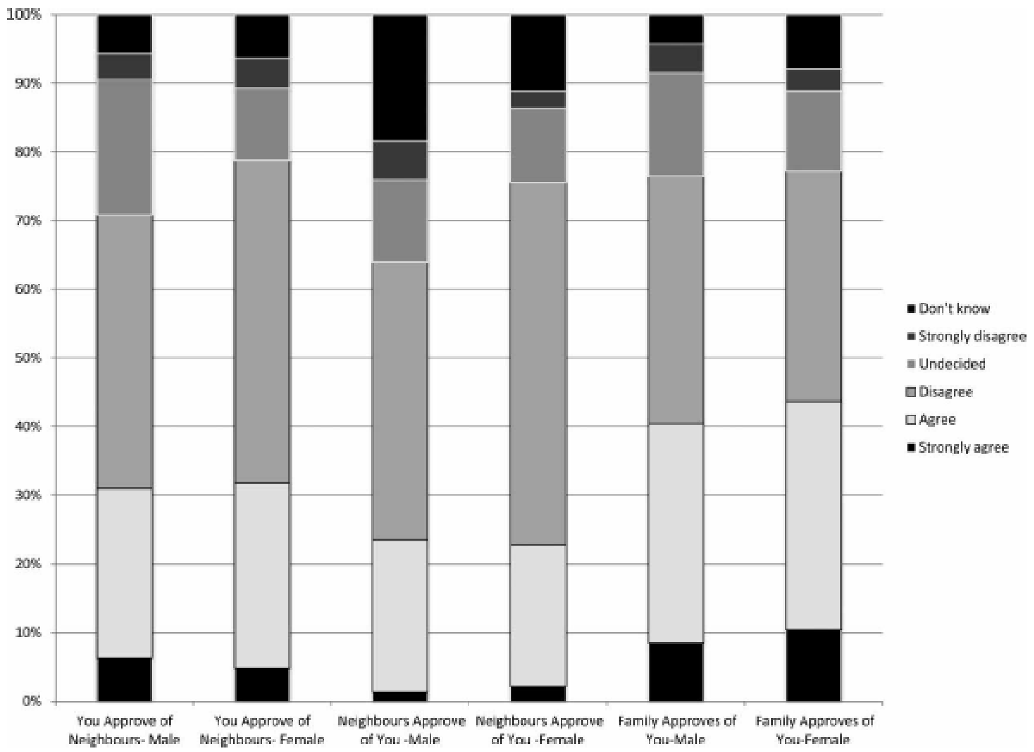

Figure 3 Expected level of approval of the use of urine-based fertiliser.

A cross tabulation between age and willingness to have a job in volving handling of urine shows an inverse relationship between the two variables. Respondents aged 28 years and below have the highest willingness (73.2% n=90) to take a job that would require the handling of urine while those above 50 years are the least willing (56.4% n=66). The relationship between age and willingness to take a job that would require the handling of urine was not statistically significant (p-value=0.60). This relationship could be attributed to the rising level of unemployment with the active age group having the highest unemployment. As a result of the high unemployment rate, unemployed youths might become more willing to overcome their perceptions in order to get a job. The percentage of those who would take up jobs that require working with urine was highest (73.2%) for those who did not finish high school while those who have completed university education had the lowest percentage (56.5%).

4 DISCUSSION

This study has explored UDDT users' perceptions of using urine in agricultural activities. The results of this study demonstrate that gardening is a common activity in the study area with nearly half (46.9%) of participants reporting to own a garden for food and/or flowers. In addition, more than half (79%) of those who do not own a garden would like to have one. Despite the proven value of urine in agriculture, our study shows that only 3.6% of the participants currently use urine as an alternative fertiliser in their gardens and less than 1% (0.4% n=1) of respondents sell the produce of their gardens. The limited usage of urine as an alternative fertiliser could be attributed to the lack of knowledge that urine could act as a sustainable and effective replacement to conventional ones. This lack of knowledge is evident given that only 9.7% of respondents are aware that urine helps plants to grow. While current usage of urine is low among respondents, more than half (53.3% n=252) are willing to use urine-based fertiliser from the urine of their family members. Conversely, only 20.5% (n=97) would use urine-based fertiliser from the urine of others. These results are consistent with previous studies of users' perceptions of urine from Ghana and Nigeria (Cofie et al. 2010), where low awareness of the possibility of using urine in agriculture constituted hindrance to such practice.

The most recent literature has shown that participatory trials to sensitise all stakeholders involved (from users to consumers), coupled with promotion and education activities, are fundamental to establish use of urine in agriculture (Sridhar et al. 2005; Kassa et al. 2010). Such activities may also be crucial to address the cultural, religious and health concerns that inhibit the re-use of urine (Cho 2012). In line with previous research reporting concerns for health hazards associated with urine (Beler Baykal et al. 2011), 42.1% of our study's participants showed concern about the health implications of using urine in agriculture. In this respect, perceptions play an important role in the acceptance of such practice. Similarly, 34.4% are concerned about the smell of urine, corroborating previous results from Kenya (Mariwah & Drangert 2011), associating urine smell with a feeling of disgust and the presence of pathogens. These constraints call for the development of sound sanitation technologies and hygiene practices to minimise health risks of urine collection and handling (Richert et al. 210b; Roma et al. 2013), coupled with education on the appropriate use and maintenance of existing UDDTs. Furthermore, technical interventions, such as the development of appropriate guidelines and standard measures on health effects related to the re-use of urine based on rigorous evidence should be developed and implemented by local authorities.

An additional hurdle to the re-use of urine relates to the social stigma linked to using dry sanitation and urine-based fertiliser. Our study showed that concern about the opinion of others may impact on users' willingness to apply urine in agriculture. For instance, less than half of respondents (43.1% n= 204) reported

Table 8 Willingness to handle urine by age

	Yes Number of responses (percentage)	No Number of responses (percentage)	Total Number of responses	χ2 (p-value)
Sex				
Male	100 (63.3)	58 (36.7)	158	0.95
Female	199 (63.2)	116 (36.8)	315	
Age				
28 and below	90 (73.2)	33 (26.9)	123	0.60
29-38	72 (62.6)	43 (37.4)	115	
39-50	71 (60.2)	47 (39.8)	118	
51+	66 (56.4)	51 (43.6)	117	
Level of education				
Did not finish primary school	90 (73.2)	33 (26.8)	123	0.71
Completed primary school	72 (62.6)	43 (37.4)	115	
Completed high school	71 (60.2)	47 (39.8)	118	
Completed university education	66 (56.5)	51 (43.6)	117	

that their family members would approve of them collecting urine for agricultural purposes. Additionally, only 23.8% (n= 109) of respondents reported that their neighbours would approve of them collecting urine for agricultural purpose. Community sensitisation aimed at stimulating discussions and demonstrating the value of urine as a fertiliser could help in improving the current level of expected approval.

The reported willingness to have a job involving urine handling provides a good opportunity for eThekwini Municipality to develop business models tailored towards the collection, processing and distribution of urine for agricultural purposes. This could be increased by addressing some of the reasons identified as constraints to the handling of urine. Whilst some of these challenges can be tackled through technological innovations other challenges such as religious and cultural considerations should be addressed through education and promotional activities. The importance of this is underpinned by the fact that perception plays an invaluable role in how people relate to and adapt to change (Duncker et al. 2007). This can also be instrumental in dealing with obstacles such as the expected low level of societal approval of the use of urine-based fertiliser.

5 CONCLUSIONS

Our research provided an overview of current perceptions of UDDT users in eThekwini Municipality on the re-use of urine for agricultural purposes, highlighting some of the hurdles encountered. Managing the re-use of urine as a resource requires a radical shift in perceptions and practices, which involves all stakeholders in the value chain, from local authorities to end users and consumers. Yet this study provides only an overview of existing perceptions on the re-use of urine. Further research is recommended to assess the impact of suggested interventions (i.e. participatory field demonstrations, training and promotion activities) to increase users' awareness of the value of urine-based fertiliser and acceptance of the practice.

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