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Potential Consumers' Perception of Treated Wastewater Reuse in Trinidad

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Abstract: *In many countries around the world, the reuse of treated wastewater has been adopted as a means of supplementing dwindling water resources and promoting water conservation. During the dry season of 2010, the Water and Sewerage Authority of Trinidad and Tobago provided treated wastewater from its Beetham Plant for industrial and agricultural purposes. The public's acceptance of reusing treated wastewater is a key element in its successful implementation as a water source. A survey of targeted sections of the population was carried out using unstructured interviews and questionnaires. It was found that the idea of non-potable use of treated wastewater for such purposes as firefighting and watering of public lawns was generally acceptable to the public. However, there was more apprehension about direct uses, particularly those involving human contact. The current perception is significantly influenced by the public's mistrust of the local water authorities to deliver safe and quality water; a general lack of knowledge of the treatment process; and perceived health risks associated with using treated wastewater. The ability to widely use treated wastewater in Trinidad in the future would depend on the relevant authorities mounting appropriate public awareness and education programmes.*

Keywords: *Wastewater reuse, public perception, Trinidad*

1. Introduction

In response to growing freshwater shortages, many water utilities around the world have implemented plans to augment their traditional water supplies (e.g. dams and groundwater) with new or alternative sources (e.g. recycled wastewater and desalinated sea water). An assessment of the status of wastewater management shows that in Caribbean region, particularly the Eastern Caribbean, municipal wastewater collection and treatment are underdeveloped and there is potential for its use to meet the demands of the tourism sector primarily in the form of irrigation water (Groves and Saldinger 2011; Peters, 2014). The use of treated wastewater to overcome water shortages has had success in many parts of the world (Miller and Buys, 2008). In the Caribbean, the four year GEF CReW Project with the overall goal of reducing negative environmental and human health impacts of untreated wastewater (Spencer 2013) is likely to lead to an increase in water reuse in the Caribbean, including Trinidad and Tobago. Notwithstanding the potential for wastewater reuse as possible means of achieving water security, gaining public acceptance is proving to be difficult (Longsworth, 2014).

For water augmentation projects to be successfully implemented, the support of the general public is required. Social acceptance is a key element to any reuse project, and can become the main barrier for a water reuse project (Jiménez 2012). Favourable Public perception of a project and so its feasibility can be facilitated by better communication between the sectors involved (Baggett et al., 2006).

It is critical, therefore, to understand public perception on the use of an alternative water source such as wastewater. Public perception can change through improve knowledge and awareness of issues related to wastewater treatment processes, particularly by promoting the high quality and safety of such treated wastewater. The media can play a major role in shaping perception. Yet, it was found that while media practitioners in Caribbean and Central America who participated in a sensitisation workshops on wastewater for journalists were prepared to improve their understanding of environmental and wastewater issues and felt they have a role in shaping or changing people's perception of wastewater, more than 50% of those surveyed could be classified as having low levels of knowledge on issues related to wastewater and the environment in general (Spencer 2014). In 2010, the water demand in Trinidad and Tobago was estimated at 224 million gallons per day (MGD) with a deficit of 38MGD (WASA 2013). The deficit can be satisfied by the 80 ML/d of wastewater collected and treated at Beetham Wastewater Treatment Plant (BWTP). Bahadoorsingh et al (2010) proposed a number of reuse options for the BWTP, ranging from urban to industrial

uses as well as options for indirect potable reuse and a multi-user option. During the drought of 2010, island-wide water shortages led to the experimentation with wastewater reuse. The Water and Sewerage Authority (WASA) provided treated wastewater from the BWTP for irrigation and industrial uses (Newsday, 2010).

In 2013, WASA signed a loan agreement for local wastewater management which included water recycling for industrial use (Boodram, 2013). The success potential for wider wastewater reuse in Trinidad, as in many other jurisdictions, can be limited by the level of public perception of recycled wastewater. In developing the potential reuse options for the BWTP, Bahadoorsingh et al. (2010) and Marx et al. (2011) highlighted that one of the main challenges in making use of the treated wastewater at the Beetham Plant is obtaining end user commitment. Consequently, during project design and implementation, appropriate consideration must be given to public attitudes towards wastewater reuse.

This paper explores the public's perception of reusing treated wastewater to better understand public acceptability of reused water. It is hoped that the results of this study can better inform decision makers in implementing future wastewater reuse projects and so increase water resource availability in Trinidad

2. Background

Worldwide, there is a growing shortage of fresh water, due to dwindling resources and increasing demands as a result of population and economic growth (Postel, 2000; Higgins et al, 2002; Hartley 2006). These shortages have motivated policy makers and water utilities to look for alternative fresh water sources like desalination and wastewater reuse. While treated wastewater is often superior to current potable water standards (Bixio et al., 2005; Wintgens, 2005), the notion of drinking wastewater is not a concept that gains full public support. In fact, Dolnicar and Schafer (2006) reported that the public often vehemently rejected wastewater reuse.

The benefits of wastewater reuse include reducing water pollution from wastewater disposal, reducing energy costs (Robinson, Robinson and Hawkins, 2005), and the provision of a reliable and constant water source (Toze, 2006). Moreover, it protects dwindling fresh water resources, prevents coastal pollution, expands river flow, provides savings in wastewater treatment and aids in replenishing groundwater resources (Angelakis and Bontoux 2001). Notwithstanding the benefits, there are many challenges in implementing wastewater reuse projects. In many cases, where wastewater reuse is being considered, municipalities are finding it difficult to gain public acceptance for the prospect. Robinson, Robinson and Hawkins (2005), Hartley (2006) and Po, Kaercher and Nancarrow (2003) all agree that public acceptance of wastewater reuse is integral to successful reuse projects and must be comprehensively addressed as it is the public who is served by and pays for this new technology.

There have been various studies on the public perception of wastewater reuse. Jeffrey (2002), Hurlimann and McKay (2003) and Robinson, Robinson and Hawkins (2005) assessed the relationship between socio-demographic factors and public perception of wastewater and concluded that regardless of the factors, respondents were generally willing to accept the reuse of water for non-potable uses but were strongly against its use with direct contact to humans. Hartley (2006) also reported that people generally supported the concept of using reclaimed water, with stronger support for using it for non-potable purposes. However, support waned as the possibility of human contact increased. In Australia, Dolnicar and Hurlimann (2010) reported that 92% of respondents would use recycled water for non-potable use like garden watering, but only 36% of drinking. Po, Kaercher and Nancarrow (2003) stated that the disgust emotion and risk perception may explain the research results that show that public perceptions and acceptance are affected by the specific use of the recycled water.

Hartley (2006) highlighted a case study from the mid-1990's, in which a wastewater reuse project was shut down due to the perception that the poorer neighbourhoods would be drinking the treated wastewater which was sourced from rich neighbourhoods. Po, Kaercher and Nancarrow (2003) stated that these perceived social justice issues would influence people's tendency to accept or not accept wastewater reuse projects. For example, Kaercher et al (2003) reported that there was a perception amongst communities that wastewater reuse projects should begin with larger consumers of water (e.g. industrial users) before domestic householders, as they believed that the amount of water that could be saved would be greater by targeting industrial users. Determining public perception by demographics is not straight forward. Savage (1993) found that the relationship between demographic factors and the dread of a hazard is the perceived personal exposure to the hazard. Later, Miller and Buys (2008) studied the difference in knowledge and acceptance of water recycling between genders and found that overall men and women's attitudes and perceptions of recycled water did not differ significantly. However, Hurlimann (2007) found that concerns increased as use became more personal, with women expressing greater concerns than men about the use of recycled water for clothes washing, vegetable growing and showering. Accept change above

The 'yuck' or disgust factor has been documented to influence a wide range of decisions including evaluative or intuitive judgments (Kelly and Morar, 2014).There is consensus among participants in wastewater reuse studies that there were psychological barriers to using treated wastewater. The yuck-factor is almost magical in nature, essentially the same type of thinking that

underlines voodoo practices (Monks, 2014). The barrier stems from the thought of using water that originated from unclean sources. Po, Kaercher and Nancarrow (2003) citing Rozin and Fallon (1987) explained this phenomenon through the "law of contagion" which suggests that a neutral object may become perceived as disgusting through association with another object. Schmidt (2008) explained that some concepts or objects like faeces are universally repugnant and are 'core disgust elicitors'. Miller and Buys (2008) noted that the 'yuck' factor has spurred heavy public opposition to several water recycling projects, resulting in their cancellation or delay. Public concerns about real or perceived risks hamper the use of reclaimed water (Robinson, Robinson and Hawkins, 2005). Risk perceptions are almost always related to public health issues from using the recycled water. Dolnicar and Hurlimann (2010) stated that perceived health risk is the dominant factor preventing people from accepting the use of recycled water. Participants in a study by Jeffrey (2002) claimed that they had no problem with using recycled water so long as it did not compromise public health. Po, Kaercher and Nancarrow (2003) proposed that based on the outrage factors adapted from general literature on risk by Frewer, Howard and Shephard (1998), people may perceive treated wastewater as unsafe and harmful to public health with unknown long term implications, leading to irreversible decisions on its use. In places where water shortages are experienced there is greater acceptance of wastewater reuse (Dishman, Sherrard and Rebhun, 1989). In Israel, with its water shortage problems, wastewater reuse is readily acceptable, and in the USA wastewater reuse for non-potable or indirect potable is widely accepted in drought-ridden communities (Hartley, 2005). In Singapore, Po, Kaercher and Nancarrow (2003) reported that the implementation of the NEWater project materialised after Singapore's water supply was threatened due to potential shortages associated with disputes with Malaysia over imported water. In Greece, Anastasiadis et al. (2014) reported that the public had a positive attitude towards wastewater reuse in agriculture.

Public attitudes on the environment may influence the willingness to accept treated wastewater reuse (Po, Kaercher and Nancarrow (2003). Jeffrey (2002) found that people who practiced water conservation in their homes were more tolerant of reusing greywater for non-potable purposes. Moreover, there is greater awareness of the need for the conservation of natural water resources through treated wastewater where dual systems exist (Hurlimann and McKay 2003; Marks et al, 2002).

Public acceptance of wastewater reuse can also be determined by the degree of public trust in the treatment processes and in the competencies of water utilities (Po, Kaercher and Nancarrow, 2003). Ormerod and Scott (2012) found that the public's acceptance of potable reuse was heavily dependent on the trust in the water and wastewater authorities, regulators, consultants, academics and elected local officials. Hartley (2006) reported that many scientific and engineering professionals agree that non-potable reuse is acceptable and necessary. However, there is non-uniform acceptance with respect to potable use. Such lack of consensus can introduce public doubt and lead to greater opposition to the use of treated wastewater. Consequently, mistrust in public agencies and officials creates challenges for wastewater reuse professionals (Hartley, 2006). There is greater trust, where organisations have a long history of good safety records and the objectives are not monetarily or politically driven (Nancarrow et al., 2003).

Marks et al. (2002) found that the majority of participants in his study expected to pay less for recycled water since they considered it to be of lower quality. Further, lower prices were seen as a necessary incentive to improve the willingness to use treated wastewater. For example, customers' expected lower prices for vegetables grown with treated wastewater (Nancarrow et al., 2003).

It was found, from numerous studies, that the public is more accepting of treated wastewater reuse for non-potable uses but becomes increasingly concerned and less accepting of wastewater reuse that involves direct human contact. The main factors shaping the public's perception of treated wastewater reuse were found to be, but not limited to, the 'yuck' factor; real or perceived risks; the awareness of water shortage problems; trust in the authorities; the costs; attitudes towards the general environment; and social justice issues (Po et al. 2014). While there is increasing support and acceptance of wastewater reuse for non-potable purposes, the support is progressively decreased for intended uses of the water as the degree and likelihood of close personal contact is increased. Lower levels of support were consistently reported for consumptive uses such as drinking and cooking. Moreover, widespread "in principle" acceptance does not automatically translate into the acceptance of real projects (ACTSE 2013).

In the Caribbean, for example in Jamaica, wastewater reuse is practiced in industries, some hotels and institutions (Caribbean Regional Fund for Wastewater Management 2015). However, given the high scarcity of water for irrigation in the Caribbean, wastewater reuse for farmers is getting support at the policy levels. A planned demonstration project to influence public perception to be undertaken by the United Nations Environmental Programme (UNEP) will be implemented in collaboration with the Food and Agriculture Organisation (FAO) and the Pan American Health Organisation (PAHO), to demonstrate how wastewater can be treated and reused to become a feasible option in combating the region's water scarcity (Longsworth, 2014).

In brief, public acceptance of reuse projects is vital to the overall future of wastewater reuse and the

consequences of poor public perception could jeopardise future wastewater reuse projects (Asano and Levine, 1996). The implementation of domestic wastewater reuse projects requires the consideration of all relevant factors and risks including public health, environmental, economic, scientific, energy and public perception (Peters 2014). Negative public perception can be modified by explaining to people the process of producing recycled water (Dolnicar, Hurlimann and Nghiem, 2010). In the Caribbean, the CRew GEF project can improve the situation by establishing innovative mechanisms for cost-effective and sustainable financing of wastewater management in the region; facilitating policy discussions and strengthening legislative frameworks; and facilitating regional dialogue and knowledge exchange on wastewater (The Gleaner, 2014). In conclusion, therefore, the willingness to reuse treated wastewater is based on subjective perception or expectations rather than on objective truth (Pannell et al. 2005), a cultural shift in relation to water management and social learning processes are key requirements to achieve a successful transition to wastewater reuse.

3. Methodology

The fieldwork for this study was carried out during February and March in 2014 using questionnaires and conducting personal interviews. A co-author and four assistants administered the interviews and questionnaire at the participant's residence or workplace. The questionnaire and interviews explored the relationship between the participants' perception of using and willingness to use treated wastewater. In November, 2013, a pilot study was carried out to test and finalise the questions to be used in the study.

For the study, a total of 195 questionnaire were administered to four (4) categories - general public (from North, South, East, West and Central Trinidad); farmers (from Central Trinidad), and professionals. For the general public, the areas were selected to give a more diverse sample and to highlight varying socio-economic backgrounds and water shortage issues. In the case of the professionals (that is technical and managerial persons who were likely to make decisions on the use of treated water in their organisations), twenty questionnaires were distributed to each group. Accept changes

Professionals were selected from 3 organisations—the Petroleum Company of Trinidad and Tobago Limited (Petrotrin), an industrial user; the Environmental Management Authority (EMA),a regulator; and the National Agricultural Marketing and Development Corporation (NAMDEVCO),a distributor of agricultural products.

The questionnaires were supported by personal interviews with 30 householders and 10 farmers who did not complete any of the 195 questionnaires. Farmers were accessed for the questionnaires and interviews over a two-day period at the Ministry of Food Production Central Division

The questionnaire included items related to socio-demographic indicators such as gender, age, education and income, and explored factors related to costs and incentives, environmental consciousness, knowledge and awareness of wastewater treatment processes, trust in local authorities and water utility, the yuck factor, perceived risk and water availability. To determine participants' perception of water reuse for different purposes, participants were asked to say whether they agreed, disagreed or were unsure. To determine participants' trust in the ability of water providers to deliver a safe supply, participants used a five point Likert scale (1= full trust; and 5= No trust). To determine participants' attitudes to the use of treated wastewater, , environmental and water conservation practices, costs and potential incentives questions were posed requiring a response of 'Never', 'Rarely', 'Sometimes' or 'Often'. Additional questions were asked to rate the participants' trust in the local water authorities. In the case of farmers, the questionnaire sought information on crop types, water availability, willingness to use treated wastewater for irrigation and used a four point scale ('Often', 'Sometimes', 'Rarely' and 'Never').

The interviews were designed to identify the interviewee's perception of wastewater reuse and understand the psychological and/or technical reasoning behind this perception, if any. Additional questions were used to rank the acceptance of wastewater reuse for various purposes. In all cases, participants were assured of the confidentiality of their responses before commencement of the interview and the completion of the questionnaire. Participants were given the option to have their responses excluded in the study even after providing their responses. IBM SPSS V.16 Student version was utilised to analyse the results of questionnaires. Descriptive statistics and frequency analyses were used to assess perceptions.

4. Results and discussions

4.1. Preferred use of treated wastewater

In terms of the specific use of treated wastewater, it was found that for both the general public (n = 111) and the professional group (n = 84), there was a greater willingness to accept non-potable uses of treated wastewater for purposes such as firefighting, watering of public lawns, agricultural irrigation and groundwater recharge. As the proposed uses involved more direct contact with humans, the acceptance declined as shown in Figure 1. Almost total average acceptance ninety-seven percent (97%) was for firefighting which was perceived as providing least contact with people. In the case where wastewater reuse was considered acceptable for household purposes, the greatest preference (sixty-nine percent) was for laundry use while the smallest

preference (sixteen percent) was for consumption uses. Further, there was a slightly higher willingness to accept the use of wastewater, among the professional groups at Petrotrin, the EMA and the NAMDEVCO than the general public, particularly for firefighting and the irrigation of public parks. This may be explained by greater understanding of the treatment processes amongst these groups.

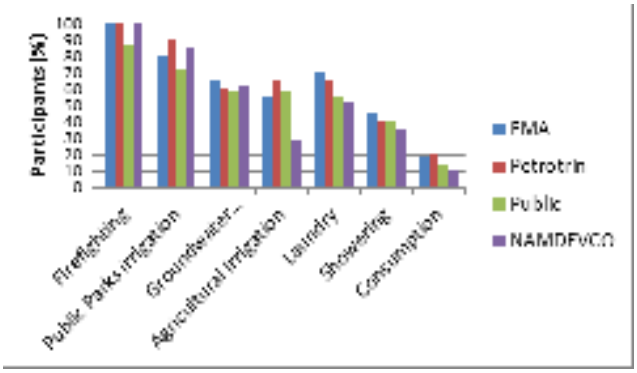

Figure 1. Willingness to use treated wastewater for different purposes

Amongst the 10 farmers, ninety percent (90%) were willing to use treated wastewater for irrigation of their crops in times of water shortage. However, five farmers (i.e., 50%) were willing to use treated wastewater for irrigation all the time. Seven farmers stated that if they were to use treated wastewater for irrigation of crops, they would select the types of crops that would be at low risk to be contaminated by treated wastewater. It was found that these farmers were enthusiastic about the reuse of treated water for irrigation. These farmers credit this high willingness to accept treated wastewater to good knowledge and understanding of the treatment processes allowing them to have greater confidence in the safety of the treated wastewater.

4.2. Socio-demographic Factors

Although women (n = 125, see Table 1) were less inclined than men (n = 70) to use treated wastewater for non-potable household use, the Chi-square test on the responses (significance level, $\alpha = 0.05$; p-values = 0.125 to 0.806 (see Table 2) found that there was no significant difference between the genders and acceptance of various uses of treated wastewater. Similarly, there were no significant statistical differences (significance level, $\alpha = 0.05$; p-values = 0.08 to 0.84 see Table 2) between the different age groups and their willingness to use treated wastewater for firefighting, irrigation, groundwater recharge, laundry and bathing. However, this was not the case for potable use (significance level, $\alpha = 0.05$; p-values = 0.03). The age of participants influenced the willingness to consider treated wastewater for potable use with the greatest willingness among the older (50 year plus) group. The 18 to 25 years group showed least willingness to consider the potable use of treated wastewater.

Table 1: Socio-demographic makeup of respondent

Socio-demographic Factor		Frequency
Gender	Male	70
	Female	125
Age Group	18-24	29
	25-34	76
	35-49	55
	50-64	24
	65+	11
Education	Did not complete high school	13
	Graduated from high school	52
	Did not complete university	19
	Graduated from university	84
	Completed Masters' Degree or higher	27

Table 2: Pearson chi-square tests for gender and educational influence on willingness to reuse treated wastewater

	Gender			Education		
Uses	**Value**	**df**	**p-value**	**Value**	**df**	**p-value**
Firefighting	2.351	1	.125	2.898	4	0.575
Public Lawns	0.155	1	0.694	1.404	4	0.844
Agri. Irrigation	1.401	1	.237	2.169	4	0.703
Groundwater Recharge	3.097	2	0.213	5.493	8	0.704
Laundry	0.60	1	0.806	3.678	4	0.451
Showering	0.579	1	0.447	8.269	4	0.082
Consumption	1.825	1	0.177	10.324	4	0.035

Four educational categories were used in the survey-did not complete high school, graduated from high school, and university graduate. It was found that among the participants of the four educational categories, the university graduates appeared to be more willing to use treated wastewater for non-potable uses (see Figure 2).

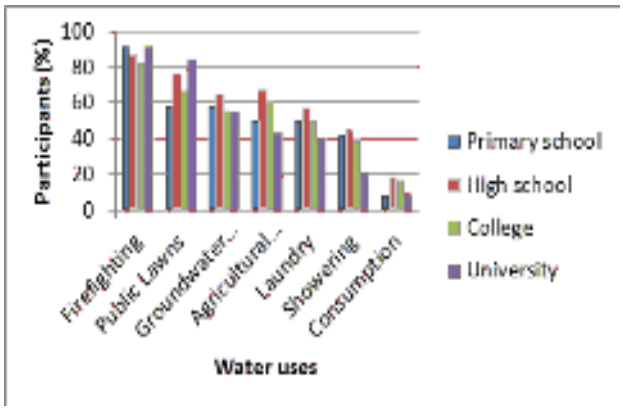

Figure 2. Education influence on acceptable uses of treated wastewater

However, there was a major drop in acceptance as the use of treated wastewater was focused on indirect or direct potable use and domestic purpose. Those participants who indicated that they had completed high school were more willing to use treated wastewater for potable use and other domestic purposes. Overall, there were no statistical differences among the educational categories in their willingness to accept treated wastewater since the p-values for the Chi square test (at $\alpha = 0.05$) ranged between 0.101 and 0.955.

Like age, income affected the willingness to accept treated wastewater for potable uses in the same ranking of uses (see Figure 3). Based on the Chi-square test results, it was found that there was a significant statistical association between income and the acceptance of treated wastewater for irrigation of public parks and for potable uses and at the 5% level, the p-values were 0.047 and 0.026, respectively (see Table 3). Participants in the low income (less than $5000 monthly) and high income (more than $20,000 monthly) categories were twice as willing, when compared with the middle income earners, to consider treated wastewater for domestic purposes.

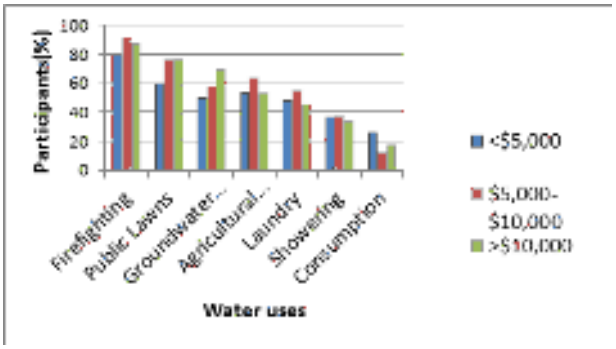

Figure 3. Influence of income on the acceptable use of treated wastewater

Table 3: Pearson chi-square tests for the influence of water shortage experiences on willingness to reuse treated wastewater

Uses	Value	df	p-value
Firefighting	6.683	3	0.083
Public Lawns	7.876	3	0.049
Agri. Irrigation	0.859	3	0.835
Groundwater Recharge	4.956	6	0.592
Laundry	0.352	3	0.950
Showering	1.643	3	0.65
Consumption	9.285	3	0.026

The order of acceptance of water reuse for the different purposes did not change for different socio-demographic groupings. The order of acceptance for non-household purposes was firefighting, irrigation of public lawns, groundwater recharge and agricultural irrigation. For household purposes, the order of preference for use was laundry then showering and finally consumption.

4.3. Impact of Water Shortage on Acceptability of Wastewater Reuse

For the general public in this study, eight percent (8%) and forty-one percent (41%) experienced water shortages never or rarely, respectively. Sixteen percent (16%) of participants frequently experienced water shortage and thirty-five percent (35%) sometimes experienced water shortage. Where participants experienced water shortages, all were prepared to use treated wastewater for firefighting, industrial purposes or for irrigating public lawns but expressed concerns for use in agricultural irrigation, domestic uses and for potable use. The correlation of water shortages to participants disposition for the acceptance of wastewater reuse to the different non-potable uses of treated wastewater is generally the same for all groups of participants (see Figure 4) with no statistical significance as shown by the Chi-square test (at significance level, $\alpha = 0.05$; $p = 0.35$ to 0.95, see Table 4).

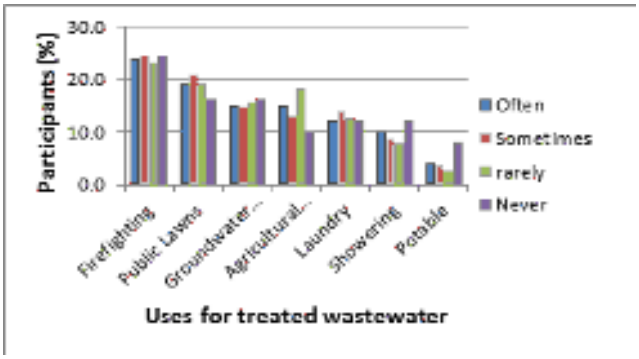

Figure 4. Willingness to reuse treated wastewater and frequency of water shortage

Table 4: Pearson chi-square tests for the influence of the trust in the authorities and willingness to reuse treated wastewater

Uses	Value	df	p-value
Firefighting	1.632	3	0.652
Public Lawns	3.284	3	0.350
Agri. Irrigation	12.182	3	0.007
Groundwater Recharge	1.559	6	0.955
Laundry	1.766	3	0.622
Showering	0.663	3	0.882
Irrigation of fruits and vegetables for direct consumption uses	3.242	3	0.356

Those participants who never experienced water shortages were more open to using treated wastewater for personal uses such as showering and potable purposes. Participants who rarely experienced water shortages showed the highest willingness to use treated wastewater for agricultural purposes where the product is not consumed directly, for example, ground provision

production, than for where it may be consumed directly without washing, such as lettuce or cucumbers. In the case of the farmers, sixty-five percent (65%) experienced some water shortage during the year with sixty percent (60%) of these experiences taking place during the dry season. Sixty percent (60%) of the farmers who experienced water shortages were willing to use treated wastewater for irrigation with greater willingness among those who were affected by dry season shortages (see Figure 5). The availability and use of treated wastewater in these circumstances was seen as providing opportunity for greater production and profits. However, farmers were generally unwilling to consider the use of treated wastewater as a replacement for their current water supplies. Where farmers did not experience water shortages, it was found that this was due to the availability of supplies from self-owned rainwater harvesting systems and nearby rivers. Only twenty-eight percent (28%) of these farmers were willing to consider the use of treated wastewater.

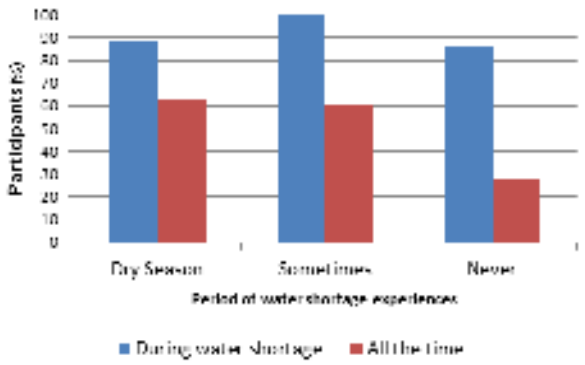

Figure 5. Time of irrigation application by farmers

4.4. Perceived Risks

As shown earlier, there is low level of support for treated wastewater to be used for potable purposes. Both farmers and the general public expressed serious concerns of possible risks that may be associated with using treated wastewater on farms within close proximity to human contact. Amongst the general public, seven percent (7%) believed that there were serious health risks associated with using treated wastewater for agricultural irrigation, showering and consumption. However, there was general willingness to use the treated wastewater for irrigation and non-potable domestic purposes if there was a guarantee given by some international agency that the water is safe. Participants' health concerns include skin diseases caused by inadequate treatment of wastewater, and the presence of chemicals and heavy metals like lead and other unnatural substances that may aggravate skin conditions. Some participants believed that there were long term health risks associated with using treated wastewater that could manifest itself into cancers in humans. Although over sixty percent (68%) of participants were aware of the possible negative impacts of indiscriminate disposal of toxic chemicals and other harmful substances in drains and ultimately into wastewater, only 8% were aware of the adequacy of current technologies in the treatment for such substances and as such there was a general concern about the possible existence of toxic chemicals in treated wastewater. Further, an associated concern is that initial mistakes that can be made with the introduction of wastewater reuse technology may adversely affect the population.

Perceived health risks impacts farmers' willingness to use treated wastewater for irrigation and which type of crops farmers would irrigate with this water. Thirty percent (30%) of farmers believed that there were serious health risks associated with using treated wastewater for agriculture. Twenty percent (20%) were unsure and fifty percent (50%) did not believe there were any health risks. Farmers were generally willing to use treated wastewater on crops where the water would not be in contact with any edible parts of the plant. Livestock farmers on the other hand, would only use treated wastewater for cleaning purposes and would not allow livestock to consume it for fear of the introduction of unknown diseases to the animals that can subsequently be transmitted to humans. The perceived risks induced unwillingness to use wastewater for financial reasons, as 45% of farmers believed that wastewater reuse would decrease customer confidence in their produce.

4.5. Trust in Water Authority

One of the factors considered by participants in their willingness to use treated wastewater was the lack of trust in the water authority to deliver safe and high quality treated wastewater. Ninety percent (90%) of participants were dissatisfied with the current water service, considering it substandard resulting in low levels of trust in WASA. Further, thirty-three percent (33%) of participants had little confidence in new state sponsored projects which are perceived as driven by political motives and lead to poor quality products.

Participants were asked to rate their trust in WASA to deliver treated wastewater for irrigation that was safe on a scale of 1 to 5, where 1 was full and complete trust and 5 was no trust. Figure 6 shows that participants had a low level of trust with about fifty percent (50%) having very little or no trust (represented by 4 and 5 as seen in Figure 6). Less than ten percent (10%) of the participants had full confidence in the ability of WASA to provide treated wastewater for reuse that was safe. The mistrust among participants is reduced when participants considered the scenario where the implementation of treated wastewater reuse is undertaken by WASA in partnership with an international organisation.

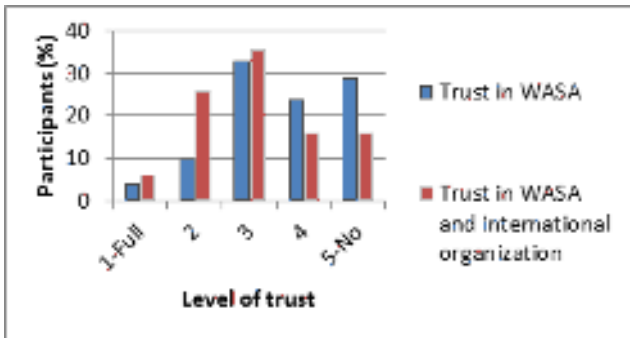

Figure 6. General public trust in water authority

On the other hand, farmers had a higher level of confidence in the local water authorities with forty percent (40%) having full and complete trust (see Figure 7). As in the case of the general public, farmers' level of trust would increase if WASA partnered with an international organisation to implement treated wastewater reuse. The farmers' greater trust appeared to be due to their lesser concern about water quality for their operation which is different from that of the general public's.

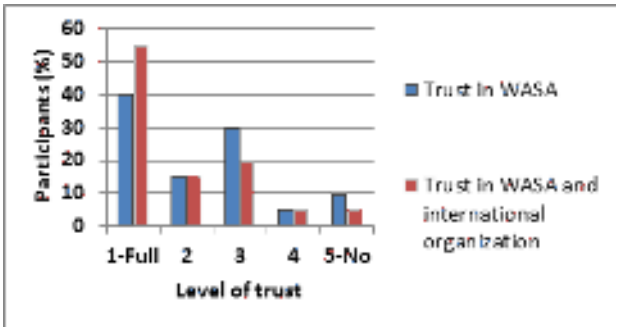

Figure 7. Farmers' level of trust in water authority

It was found that participants who were unwilling to use treated wastewater generally had low levels of trust in WASA, suggesting that trust may be an important factor in assessing willingness to use treated wastewater. This is supported by the Chi-square test (significance level, $\alpha = 0.05$; p-value < 0.001; see Table 5) which showed that there was a significant correlation between the public's trust in the water authorities and their acceptance of various uses of treated wastewater.

Generally, trust in the water authority was high for the farmers, with forty percent (40%) having full trust should WASA introduce a plan to distribute treated wastewater to farmers; and fifty-five percent (55%) having full trust if WASA, in conjunction with an international water authority, were to introduce a wastewater reuse plan for farmers. The farmers' challenges with the use of the treated wastewater had less to do with trust in the quality of the water to be provided but more to do with the inaccessibility of the potential points of delivery to some farms.

Table 5: Pearson chi-square tests for the influence of the trust in the authorities and willingness to reuse treated wastewater

Uses	Value	df	p-value
Firefighting	3.184	4	0.527
Public Lawns	18.827	4	0.001
Agri. Irrigation	31.554	4	0.000
Groundwater Recharge	18.141	8	0.20
Laundry	44.712	4	0.000
Showering	54.168	4	0.000
Consumption	34.685	4	0.000

4.6. Costs of Water

The willingness to accept treated wastewater was unaffected by the potential of lower water rates for eighty-two percent (82%) of the participants as there is general satisfaction with current water rates. In the particular case of farmers, however, the cost of the water was a concern and the indication is that water must be provided freely, as sources such as rainwater harvesting ponds and rivers are considered free. Moreover, forty-five (45%) of farmers were motivated to use treated wastewater due to the lower potential cost of irrigation water (see Figure 8). Lower costs of water and an improved availability could impact their financial operations.

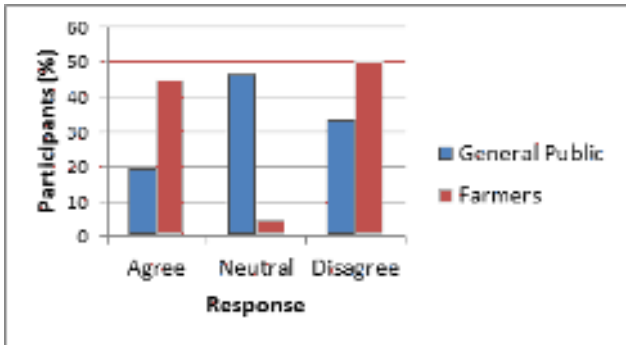

Figure 8. Costs as an incentive for accepting treated wastewater

4.7. Water Conservation and Environmentally Friendly Practices

Fifty three percent (53%) of participants practiced water conservation techniques and sixty-seven (67%) practiced other environmentally friendly activities or considered environmental issues in everyday decisions. However, sixty-eight (68%) of participants were unaware of the current water pollution rules. Previous studies (Po, Kaercher and Nancarrow, 2003; Jeffrey 2002) found that participants who practiced water conservation and participated in environmentally friendly activities were more open to using recycled water for various purposes.

While in this study, among the participants who did not practice water conservation and other environmentally friendly activities it appears that there is a greater willingness to use treated wastewater for laundry, showering and non-direct consumption (see Figure 9). The p-values which were greater than 0.35 for the Chi-square test (at α =0.05; see Table 6) showed that there was no significant correlation between respondents' environmental practices and their acceptance of various uses of treated wastewater. In the case where participants were dependent on rainwater harvesting as their main water supply, there was a high interest shown in treated wastewater reuse but they also shared the same health and quality concerns as the rest of the population.

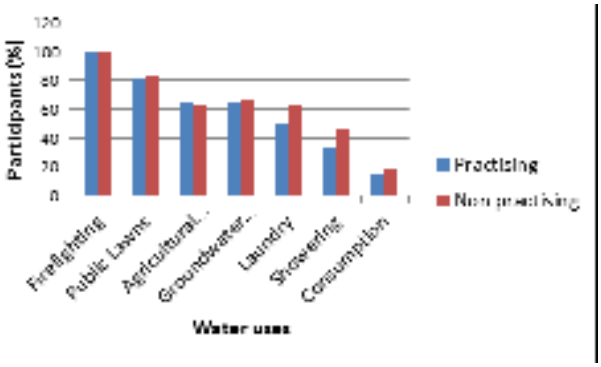

Figure 9. Willingness to reuse treated wastewater and environmental practices

Table 6. Pearson chi-square tests for the influence of the involvement in good environmental practices and the willingness to reuse treated wastewater

	Practice water conservation			Involved in good environmental practices		
Uses	**Value**	**df**	**p-value**	**Value**	**df**	**p-value**
Firefighting	0.804	2	0.669	0.455	2	0.797
Public Lawns	0.622	2	0.733	0.983	2	0.612
Agri. Irrigation	1.592	2	0.451	1.478	2	0.478
Groundwater Recharge	6.053	4	0.195	1.873	4	0.759
Laundry	1.532	2	0.465	1.899	2	0.387
Showering	2.110	2	0.348	0.802	2	0.670
Consumption	0.435	2	0.804	4.548	2	0.103

Faeces are a universal disgust substance and that disgust is deeply seated within our psychological make-up. The common "yuck-factor" reported elsewhere was not as evident in this study. Respondents were asked to select on a scale of 1 to 5 how they would feel if drinking purified wastewater where 1 and 5 represent disgusting and appealing respectively. Eighty percent (80%) of the general public showed no or little disgust to the idea of drinking treated wastewater. In this study, there was a general agreement that once the water was treated properly and was aesthetically equivalent to regular water there would be little concern.

The remainder consider treated wastewater as dirty water because of their perception of the current poor quality of water supply. Many of these participants use bottled water in preference to tap water. Twenty-one percent (21%) of participants agreed that their negative reaction to the use of treated wastewater would diminish if the water was provided in a developed country, particularly where the practice is already in use. This shows that there is greater trust in foreign water providers. The importance of the yuck-factor cannot be underestimated, as in many cases, wastewater projects have been abandoned due to public disgust of the concept. This was most vividly shown in the Australian city of Toowoomba in 2006 when local activists, represented by the group "Citizens against drinking sewage", defeated plans to introduce reclaimed sources, citing health risks and emotive factors (Monks, 2014).

5. Conclusion and Recommendations

People have a natural revulsion to water that is perceived to be contaminated, and sometimes that feeling can translate into opposition to reusing treated wastewater. In Trinidad, the public is generally uneasy with direct reuse of wastewater and this will likely pose a substantial barrier to promoting wider use of treated wastewater. However, while the majority of the participants in this study indicated a willingness to accept the non-potable use under some circumstances and for purposes such as firefighting and watering of public lawns, but there appears to be no support for the reuse of wastewater for drinking water.

Socio-demographic factors, water shortage issues, participation in environmentally friendly activities and cost of treated wastewater did not appear to be shaping the public's perception of using or willingness to use treated wastewater in Trinidad. For example, although there is a slightly greater portion of the technical and professional persons are more inclined to accept wastewater reuse, there were no significant differences among groups surveyed.

This study revealed that the current perception of the use of treated wastewater in Trinidad is mainly shaped by the public's mistrust of the local water authorities to deliver safe and high quality water; a general lack of knowledge of the treatment process; and perceived health risks associated with using treated wastewater.

While farmers have similar concerns about the use of treated wastewater for irrigation, they are willing to use treated wastewater for irrigation particularly during the dry season, but are concerned about the possible negative impact on the marketing of their products. As Trinidad and Tobago prepares to develop a viable treated wastewater reuse subsector, it is recommended that efforts to improve the public's trust and acceptance be strengthened through improvement of the current services and by public awareness programmes. Moreover, implementation programmes should be informed by the level of willingness to accept treated wastewater for different uses.

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