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Recycled water reuse: what factors affect public acceptance?

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Summary

Globally, water resources are under immense and increasing pressure. This, coupled with the threat of climate change, has increased global interest in water reuse. However, global water reuse remains limited because of public opposition. This paper thus examines public perceptions and attitudes to water reuse across the world. It finds that results from studies of water reuse acceptance have tended to be context specific, although claims can be made about the universal relevance of some predictors, underscoring the need for individual water reuse schemes to carefully consider their local context. Disgust remains a constant in the public psyche, while public trust in delivery agents as well as how water reuse is communicated vis-à-vis perceptions about the quality and safety of recycled water are also critical. The latter particularly highlights public concerns about the indeterminate health risks associated with water reuse.

Introduction

Global water resources are under immense and increasing pressure because of human population increase and dwindling water supplies. This, coupled with the looming threat of climate change, has ramped up global interest in the potential of water reuse (van Rensburg 2016). The need for sustainable water sources has never been more urgent (Leong 2016). If the current global water management configuration remains unaltered, the world may face a 40% water deficit by 2030 (WWAP 2015). Thus, recycled water reuse presents an important and necessary alternative; however, only a miniscule proportion of treated wastewater is put to use (Leong 2016, van Rensburg 2016).

Recycled water can be defined as wastewater treated or processed to a certain standard suitable for reuse (Ong 2016). Technologically speaking, it is no huge feat to turn wastewater into a usable resource (Miller 2012). Significant recent improvements in wastewater reuse technology suggest that in the future highly treated wastewater may become an important element of sustainable solutions to water insecurity (Ormerod & Scott 2013, Wester et al. 2015). However, the viability of non-traditional sources of water for addressing water insecurity and as a sustainable water management solution is predicated on its acceptability by culturally diverse communities across the globe. Across the world, potable water reuse schemes remain contentious in communities and objects of intense research and public relations campaigning (Ormerod 2016). Documented cases of successful potable reuse schemes are few, and most of these have occurred in the USA, with a few others located in the UK, Australia, Belgium, Singapore, South Africa and Namibia. The success of these schemes, however, has not translated into widespread acceptance due to continuing public resistance (Kemp et al. 2012, Ormerod & Scott 2013, Wester et al. 2015).

Critically, public responses to recycled water are still not properly understood by researchers (Ormerod & Scott 2013). According to Hurlimann and Dolnicar (2016), existing knowledge gaps hamper a thorough understanding of the specific conditions under which the public is receptive to alternative sources of water and the ways in which public acceptance can be influenced across locations. The predictors of water reuse acceptance are quite complex as well as intimately interconnected. This presents considerable conceptual and methodological challenges to researchers when attempting to isolate and hierarchically scale these predictors. This review therefore does not focus on individual predictors and their histories, but rather considers their interconnections and how these might aid public engagement interventions vis-à-vis the mechanics of water reuse communication. As far as this paper is concerned, no known study has assumed this approach to intentionally focus attention on examining the intersection with information communication. This paper therefore has two objectives: (1) to provide an integrative synthesis of the existing research on recycled water reuse acceptance; and (2) to examine the

applicability of water reuse research outcomes to water reuse practice, especially as it pertains to public information communication.

Review method

To isolate the pertinent literature, the study separately used the following keywords: water reuse, recycled water, disgust, public acceptance, public attitudes, risk perceptions, risk preferences and recycled water predictors. The literature search was conducted in Google Scholar, Web of Science, AgEcon and EconLit databases. Additionally, the reference sections of key authors were scrutinized for relevant articles. The articles that were chosen (including case studies) were mostly those that focused on identifying and explaining predictors and success factors and that especially highlighted knowledge gaps and irregularities. The study intentionally restricted itself to analyses focusing on centrally delivered recycled water and primarily considered more recent studies focusing on recycled water for both potable and non-potable uses. A prior reading of the literature identified important predictors and factors that became the focus of the review: disgust, risk perceptions, trust in the authorities and institutions responsible for the delivery of water recycling schemes and knowledge communication.

Disgust, trust and risk perceptions

The available literature discusses many important factors for public acceptance of recycled water. Of significance, negative emotional reactions – otherwise often referred to as disgust – have been given considerable attention (Po et al. 2004). Disgust describes the visceral psychological reaction of dread or revulsion associated with recycled wastewater (Smith et al. 2018). An important problematic for researchers concerns how disgust is constituted, as well as the extent to which disgust can be considered an important and independent predictor of public acceptance. Wester et al. (2015) stated that the real nature of these emotional reactions is not properly understood – see the same authors for an exemplar problematization of the constitutive nature of the emotion of disgust and the possible implications that this might have for public communication. Wester et al. (2016) asserted that people's decision-making about water reuse is a function of emotion, cognition and the interaction between emotion and cognition.

Nancarrow et al. (2008) presented an often-cited study regarding the role played by emotions in predicting willingness to accept recycled water. Up until this research, few pertinent studies since the genesis of public attitudes studies in the 1970s had attempted to systematically decompose the impact of disgust on people's behavioural intentions. The research explored factors responsible for the observed disjuncture between public support of the concept of water reuse as a means of responsible water resources management and public reactions to the actual use of recycled water. The study found emotion, subjective norms (the effect of the views and opinions held by people), fairness and health risk to have had significant relationships with intended behaviour. Health risk was found to be the only risk component to have a direct influence on intended behaviour. Trust had no direct effect but mediated the relationship between health risk and intended behaviour (also see Ross et al. 2014). These results replicate those of prior studies; for example, Leviston et al. (2006) identified concerns about risk to human health to have had the most influence on respondent intentions towards water reuse.

Wester et al. (2015) investigated factors that underlie the negative emotions thought to be responsible for public opposition: specifically, what aspects of pathogen disgust sensitivity predict discomfort at the idea of using recycled water for the purpose of drinking. Gender (being female), having less education and having a heightened sense of pathogen disgust were all significantly and independently associated with feelings of discomfort (also see Rozin et al. 2015). In view of their findings, Wester et al. (2015) submitted that the broad conceptualization of negative reactions to recycled water can be focused on disgust, particularly pathogen disgust. In other words, public concern over pathogens can be seen as the principal driver of the emotional reactions towards water reuse. Wester et al. (2015) supposed that this determines acceptance of water reuse along with other higher-order cognitive factors such as trust. Nancarrow et al. (2008, 2009) acknowledged the role played by negative emotional reactions, and the finding that women had a heightened sense of pathogen disgust is consistent with the general literature, which shows that men are generally more accepting of recycled water reuse (see Tsagarakis et al. 2007, Nancarrow et al. 2008, Dolnicar & Schafer 2009, Savchenko et al. 2019a). More broadly, however, studies that have attempted to analyse the effect of demographics on acceptance have yielded inconsistent results (see Dolnicar et al. 2011, Mankad & Tapsuwan 2011, Price et al. 2012, Smith et al. 2015, Savchenko et al. 2018).

Ong (2016) explored the question of quality in reused water for potable use vis-à-vis the presence of pathogens and chemical contaminants and related implications for public health and acceptance; he reviewed existing high-specification technologies used to treat domestic wastewater for indirect potable reuse. Ong (2016) noted that technologies still possess shortcomings with regards to the treatment of some biological and chemical molecules and compounds of emerging concern (also see Saurí & Arahuetes 2019). This raises doubts about the desirability of treated wastewater in the face of scientific imprecision and uncertainty vis-à-vis quality and safety assurance, especially in the absence of universally acceptable guidelines and standards that address water quality and health. Tortajada and Ong (2016) suggest that in different parts of the world the main constraint on the implementation of water reuse schemes appears to have been a lack of full public support due to perceived health hazards and environmental impacts. This suggests that the public has concerns about the ability of recycled water-provisioning authorities to ensure water quality and safety (see Dolnicar et al. 2014). van Rensburg (2016) examined barriers to direct potable reuse through a case study review of the Windhoek recycled water reuse scheme, specifically the technical and nontechnical barriers to direct potable reuse: whether the technology is adequate (appropriate and safe) and its proper management vis-à-vis the effective management of health risks. van Rensburg (2016) argued that the Windhoek direct potable reuse scheme has been successful in part because it has satisfied technological requirements to an extremely high specification; safety and health risk concerns have been adequately addressed. The extant research shows that amplified health risk perceptions correlate with lower acceptance of water reuse (Hurlimann 2006, Nancarrow et al. 2008, 2009, Dolnicar & Hurlimann 2010). This would suggest that water reuse planners should give careful attention to addressing public fears about health risks.

The existing research also shows that the public is traditionally less willing to accept recycled water for close-contact applications (see Kemp et al. 2012). Again, this can be linked to public fears about contagion (contamination) and the presence of pathogens. Hurlimann and Dolnicar (2016) compared public acceptance of recycled water, desalinated water and rainwater across Australia,

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Belgium, Canada, Israel, Japan, Jordan, Mexico, Norway and Los Angeles (CA, USA). Investigating willingness to use and perceptions of alternative sources, they found that water source preference varied between water use purposes and perceptions held of various water sources varied across locations. If anything, the variation in the perceptions of users from diverse locations suggests that policies need to be cognizant of location-specific drivers.

Consistent with prior studies, recycled water was the least preferred water source for close-contact applications. In order of preference, respondents indicated that they intended to use desalinated water, rainwater and, finally, recycled water (Hurlimann & Dolnicar 2016). The preference for rainwater over purified and scientifically tested recycled water for close-contact applications likely signifies revulsion and public health concerns. Smith et al. (2018), citing prior studies (Bruvold 1985, Callaghan et al. 2012), noted that support for water reuse tends to decline at the idea of using recycled water within homes and declines further at the idea of using it for applications involving personal skin contact or the possibility of ingestion, such as bathing and drinking. Dolnicar et al. (2011: 941) had found that study participants' perceptions in terms of public health were more positive for desalinated than recycled water: 38% perceived recycled water as 'disgusting', but only 25% perceived desalinated water as such.

Some studies have explored aversion to recycled water by investigating consumers' willingness to pay (WTP) for agricultural products. Savchenko et al. (2018) determined that consumers had lower WTP for produce irrigated with recycled water versus conventional water or an unknown irrigation water source. Similarly, Ellis et al. (2021) found that among Israeli consumers demand for agricultural produce declined significantly when irrigated with recycled water versus conventional or an unspecified source of water. This result is particularly interesting given Israel's over 36-year history of alternative water use. Li et al. (2018) found that disclosing that conventional and recycled water was used to irrigate grapes induced a reduction in WTP for wines relative to no information being provided. Consumers preferred ignorance; even positive information about the benefits of recycled water failed to increase WTP. The drivers behind these reactions were indeterminate.

Disgust as more than simple revulsion

Following in the footsteps of earlier critics of the singular focus on disgust as a limiting analytical construct (see Russell & Lux 2009), some scholars have sought to explain aversion to recycled effluent by examining social and cultural processes. For instance, Ormerod and Scott (2013) investigated the relationship between trust in the professional institutions responsible for municipal water development and public willingness to drink recycled water in Tucson (AZ, USA). The study situated public perception in its social context as opposed to studies that have emphasized disgust and have tended to privilege the views of experts over those of the 'lay' public. The emphasis on psychological explanations has led experts to routinely attribute lack of public acceptance to emotional or irrational aversions; psychological explanations geared towards public acceptance methodologically reinforce hierarchical technocratic decision-making, which might explain why water reuse schemes routinely fail (Ormerod & Scott 2013). Potable reuse may be conceptualized as a politicized issue, where expressed concerns reflect social–cultural values that are more complicated than simple revulsion (Ormerod & Scott 2013). The suggestion is that conventional assessment of risk in probabilistic terms is counterintuitive because the public's assessment of risk is informed by a range of intervening subjective factors that operate to influence people's perceptions despite the technological elimination of risk and associated expert assurances. This makes it imperative to consider processes at the expert–public interface, especially at a time when the wider professional water provisioning and scientific community is largely supportive of recycled water reuse (Saurí & Arahuetes 2019).

Ormerod and Scott (2013) suggest that public opinion is mediated by levels of trust in experts who have influence on system design as well as the experts who supply interpretations (communications to the public). The research makes a notable contribution in highlighting the social basis of public perceptions: how these are shaped by social processes involved in water development, including people's experiences and democratization of decision-making processes. It presents potable reuse schemes as both prescriptive and, to a lesser degree, negotiated systems. In this regard, Stenekes et al. (2006) argued that institutional change is required to build opportunities for constructive public engagement. Similarly, Tortajada and Nambiar (2019) cited institutional arrangements, regulation and public engagement as obstacles to the expansion of water reuse operations for potable purposes. Thus, in view of the existence of a bifurcation between expert and public perceptions of water reuse, meaningful dialogic public engagement is critical because it recognizes the proposition that a combination of technical and non-technical issues integrate to influence public trust (see Ormerod 2016). The multiplicity of challenges and complexities involved means that decision-making about water reuse should be driven by both science and emotion (Morgan & Grant-Smith 2015). Leong (2016) suggests that allowing for dialogue between expert and public opinion produces rational clarity. Evidence indicates that technocratically driven water reuse schemes that treat the public as subjects rather than agents are likely to flounder; studies have ascribed the failure of water reuse schemes such as Toowoomba and San Diego to a 'decide, announce, defend approach' (Kosovac et al. 2017).

However, Ormerod and Scott (2013) placed limited emphasis on contextual factors such as the desert climate of Arizona. Goodwin et al. (2018b) state that public acceptance of water reuse schemes, especially schemes aimed at augmenting drinking water supplies, is shaped by specific contextual factors. In this regard, the cases of Namibia and Singapore are illustrative (see Dolnicar et al. 2011, Kemp et al. 2012, Ching 2015). The Namibia case is particularly interesting in that the technology for water purification at the time when the project was introduced in 1968 was far less advanced than it is today (see van Rensburg 2016). Enabling factors included a harsh arid climate, restrictive conditions to indirect potable reuse due to the absence of rivers and the economics of recycled water supply versus conventional water supply.

According to Smith et al. (2018), the regions of the world where water reuse is more commonplace tend to be those that regularly experience water scarcity; however, Hurlimann and Dolnicar (2016) found that Norwegians were most willing to use recycled water for high-contact purposes despite being the least water stressed of the nine study locations that they investigated. Additionally, water shortages and harsh conditions are found in East Valley (CA, USA), where the plan for implementing a US $55 million recycled drinking water (RDW) scheme was rejected (see Leong 2016). Similarly, the Toowoomba water reuse scheme was not supported by the public even in the face of a severe drought (see Hurlimann & Dolnicar 2010). A more recent analysis of water reuse for potable purposes in Singapore, Orange County

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(CA, USA) and Queensland (Australia) suggests that droughts and water scarcity have been instrumental in changing the perceptions and attitudes of policy-makers and communities to be more willing to consider recycled water for potable use (see Tortajada & Nambiar 2019). Given these contrasting outcomes, what then are the specific conditions under which the public might support water reuse?

Ross et al. (2014) investigated the role of trust in predicting risk perceptions and acceptance and the factors that help to promote trust. The research tested a social–psychological model of the relationship between trust, risk perceptions and acceptance of a proposed potable reuse project among residents of Toowoomba in South East Queensland (Australia). In the context of a severe drought, the water reuse scheme was strongly opposed by the community action group Citizens Against Drinking Sewage and subsequently rejected by the public in a referendum. The research found that the more community members perceived the water authority to have used fair procedures, the more they perceived a shared social identity with the water authority. In turn, the more community members perceived a shared social identity with the water authority, the more credible they were perceived to be and the more people trusted them. An important contribution regards the identification of fair procedures and the building of a shared identity between the community and the water authority in the implementation of water reuse projects as critical generators of trust (also see Radcliffe 2006). The existing literature shows that higher levels of trust correlate with low perceptions of risk, which in turn increase public acceptance levels (Hurlimann 2006, Nancarrow et al. 2008, 2009). Saurí and Arahuetes (2019) have suggested that public trust should extend beyond trust in the authorities to include the many stakeholders intervening in the process, such as academics and politicians; processes intended at building public trust should be a lot broader than has conventionally been practiced. Kosovac et al. (2017) recommended the implementation of trust-building activities between water practitioners and the public.

Leong (2016) investigated the role of emotions in technical decision-making in the context of RDW implementation, with reference to two schemes – one that was successful (Windhoek, Namibia) and one that failed (East Valley, CA, USA). The analysis conceived of emotions as being part of a larger narrative. Emotions were compared between the two cases, both in terms of content and intensity. Disgust was found to be present in both cases. However, the emotions of fear, disgust and hostility were woven into vastly different narratives about RDW between the two cases – leading to different policy responses from the authorities. Narratives in the case of Windhoek were relatively low in emotional intensity, with interlinked themes such as governance (health risk and technology), trust and sustainability, whereas East Valley showed narratives that were charged with anger, social injustice and disgust. Leong (2016) noted that although both cases shared the principal cognitive idea that there was an urgent need for water (East Valley due to a serious increase in demand and Windhoek due to its dry climate), the emotional differences between the two cases resulted in two different narratives about RDW. A notable contribution is the attempt to empirically test and demonstrate how emotions can be a part of the social ecology of institutional change (i.e., how they can impact on policy processes) and how 'policy entrepreneurs' can play on or manipulate the emotional quality of policies in the implementation of RDW schemes. In other words, how policies are framed or communicated can influence emotions that open or close policy windows or opportunities.

Communicating recycled water reuse to the public

Wester et al. (2016) have highlighted the role that negative emotional reactions play in shaping both societal-level discourse on water recycling and individual decision-making. They cite clear examples of incidents in which parties opposed to recycled water reuse have highlighted aversive elements in their framing of public messages. In this regard, research has focused on understanding the ways in which information communication can aid or confound the implementation of water reuse schemes – specifically, how the nature of messaging (source, content, timing, complexity, etc.) affects public attitudes and perceptions towards recycled water. Various aspects of water reuse processes have been considered, inter alia the production process (Dolnicar et al. 2010), the recycling process and water safety (Fielding & Roiko 2014), the safety of non-potable recycled water (Goodwin et al. 2018b) and the risks and benefits of water reuse (Price et al. 2015). It remains somewhat unclear, however, what the focus and manner of public messaging should be.

In general, the available research literature demonstrates that information communication is positively associated with public willingness to use recycled water (Alhumoud & Madzikanda 2009, Dolnicar et al. 2010, Fielding & Roiko 2014). However, the specifics of studies on the subject point to nuances and variations in the mechanics of public communication and related responses. Dolnicar and Schafer (2009) investigated whether providing the public with information (specifically visual information) about how recycled and desalinated water are produced increases public acceptance. The likelihood of acceptance increases significantly if the public is furnished with information about the production process; providing visually appealing and easily digestible information about water treatment processes may improve public acceptance (Dolnicar & Schafer 2009). Water quality concerns (risk considerations) appeared to overwhelm other factors, including economic and environmental considerations, in the public's decision to accept or reject water from alternative sources (Dolnicar & Schafer 2009).

However, Kemp et al. (2012) showed that simple information campaigns may not necessarily work in the face of negative oppositional narratives. They experimentally investigated the effectiveness of public communications in building resistance towards recycled water scare campaigns by employing Inoculation Theory, which proposes that the public can be 'vaccinated' against negative narratives or counter-narratives (see Compton et al. 2016). The results did not support the efficacy of Inoculation Theory in the specific case of water, as anticipatory information campaigns did not lead to inoculation against scare campaigns. Members of the public were influenced by the information presented to them, negative or otherwise. However, a powerful recency effect was identified – meaning that timing of public communications is critical (also see Dolnicar & Hurlimann 2010).

The fate of recycled water reuse schemes in San Diego (CA, USA) and Toowoomba (Australia) are instructive in this case. In the case of the City of San Diego, authorities had been planning to use highly treated recycled water for indirect potable use. However, the project got mired in politics, which redirected the discourse/public messaging about recycled water. Negative phrases such as 'toilet to tap' were introduced to persuade the public. Suffice it to say that the reframing from 'repurified' to 'toilet to tap' caused sufficient damage and the project was halted (see Po et al. 2004). Price et al. (2015) suggested that more and repeated exposure to specific types of information about recycled water

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may produce substantial shifts in public attitudes (also see Kemp et al. 2012). This is the strategy that has been employed by Singapore's NEWater scheme. For instance, continuous messaging about technological improvements has served to maximize public confidence that the scheme remains current on ensuring water quality and safety (Tortajada & Nambiar 2019). In this regard, Smith et al. (2018) cautioned against the simple provision of information to the public and argued for more comprehensive thinking around public engagement approaches. An approach that involves a wide range of activities, appeals to both rational and emotional/experiential processes and is undertaken/supported by a wide range of actors is ultimately what may underpin a broader social shift towards legitimizing water reuse (Smith et al. 2018).

Price et al. (2015) experimentally investigated whether the complexity and sidedness of messages influenced attitudes towards a proposed recycled water scheme for potable use in South East Queensland (Australia). The study also examined whether individuals' initial attitudes influenced their responses to information. In this case, by comparing the attitudes of South East Queensland residents to those from various other locations around Australia, they assessed how messages about the relative risks and benefits of potable recycled water influence public support. Consistent with prior studies, support for recycled water increased after the provision of information. The increase in support was greater when the information presented was complex rather than simple, although those supportive of recycled water were positively influenced by both simple and complex messages. The study found little evidence, contrary to prior analyses, for the efficacy of two-sided messages (messages that present advantages and refute criticisms versus messages that only present advantages), but it found some evidence that authorities who provide two-sided messages may be trusted more. Contrary to prior research, one-sided more than two-sided messaging induced greater support for recycled water in people who were neutral or ambivalent about recycled water. The effectiveness of information was dependent on the initial attitudes of the target audience (also see Fielding & Roiko 2014). Price et al. (2015) thus suggested that communication should understand people's motivation to process information and be tailored to match attitudes and the stage of recycled water schemes. For instance, communicating about the low risks of recycled water is likely going to be more persuasive when water reuse schemes are developed and close to implementation. These results underscore the importance of the timing of communications as well as the need for communications designers to desist from treating the public as a homogeneous and undifferentiated entity, which again emphasizes the need for more nuanced and sensitive communications designs.

Consistent with prior studies, Price et al. (2015) determined that messaging about the low risks of potable recycled water is more critical than messaging about its benefits; study participants who perceived risks to be low had a heightened sense of perceived benefits. However, Price et al. (2015) noted that although the research demonstrates the efficacy of providing detailed information about the low risks of recycled water, the effects of the information on risk perception and support were small across both studies – see Price et al. (2015) for specifics on the possible mediating factors for this relationship, as well as prior studies that made a similar determination. This review has already pointed out how associations and attitudes to water reuse are mediated by multiple factors. There is thus a question regarding the extent to which processes such as negative information campaigns, such as occurred in Toowoomba (Citizens Against Drinking Sewage), may amplify risk perceptions and affect public responses to the identified effective messaging practices, as explained by Kemp et al. (2012). Ellis et al. (2021) found that exposing consumers to information about the risks and benefits (two-sided messages) of recycled wastewater increased consumers' WTP for produce irrigated with desalinated water. The aversion to recycled irrigation water is likely due to disgust because of its source and/or concerns about potential health risks (Ellis et al. 2021). Savchenko et al. (2019a) identified disgust and safety concerns as the key issues that influence consumers to accept or reject foods produced with recycled water. Savchenko et al. (2018) found that providing consumers with information about the risks of recycled water reduced WTP, while disclosing benefits alone did not alter consumer preferences versus proving balanced information about environmental benefits and potential health risks. Savchenko et al. (2019b) found that messaging about benefits, risks or both benefits and risks had no statistically significant effects on consumers' likelihood of purchasing processed or fresh foods grown with recycled water. These contrasting outcomes illustrate the complexities involved.

Ching (2015) examined public perceptions and norm formation in RDW using the case of Singapore, where a key finding was that technology can change current paradigms, largely through the reframing of the discourse surrounding disgust. In Singapore's NEWater policy, the discourse shifted attention away from the source (wastewater or sewage) by focusing on technology (the treatment process). The proposition is that focus needs to be on highlighting the role of technology and reason (not pitching science against disgust) and the creation of a rich institutional narrative that recognizes the many reasons behind the acceptance of recycled water. Reference has also been made to the success of recycled water reuse schemes in the USA where superior technology has ensured public safety, with community confidence being central to public acceptance (also see Mainali et al. 2011).

Lee and Tan (2016) reviewed Singapore's experience in planning, developing and expanding the supply of NEWater (water from treated sewage) to isolate the factors behind its successful implementation and sustained track record of good water quality. Strong political will, good governance and effective public engagement (education) as well as the availability of high-specification technology in the scheme's design and operation, including dual-membrane filtration and ultraviolet disinfection, complemented by a strict operating philosophy and comprehensive water quality management programme, played a critical role in the success of the NEWater scheme for indirect potable use and direct non-potable use. Other success factors included: (1) a long history of interest in and efforts at water security sustainability that provided contextual momentum – water reuse has always been an integral part of Singapore's overall water security strategy since at least its 1972 Water Master Plan; (2) the success of recycled water reuse in the USA, where it had been practiced for more than 20 years by the time NEWater was developed in 2002 – this was critical to winning public confidence because it showed that recycled water reuse had historical precedent (also see Tortajada & Nambiar 2019); and (3) the technology was locally tested and there was rigorous assessment of water safety (some 20 000 test results over a period of 2 years). Lee and Tan (2016) noted that the comprehensive data on water quality and health effects gave technical experts, political leaders and members of the public confidence in the safety and reliability of NEWater.

Importantly, NEWater implemented an effective public and consumer engagement programme. An extensive public communications and education plan was implemented with a consistent

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message that had three key components: recycled water reuse is not new; the multiple-barrier treatment process is safe and reliable and indirect potable use provides a further environmental buffer; and NEWater is a sustainable source of water for Singapore. The project framed recycled water as NEWater to emphasize its ultra-clean state and sewage treatment plants as water reclamation plants. The scheme also engaged a wide range of stakeholders in the dissemination of information, including the media, politicians and grassroots leaders – a clearly comprehensive process – as has been advocated by Smith et al. (2018). A visitor centre was also opened to demystify the treatment process and the public were allowed to try the bottled NEWater to address organoleptic concerns such as taste (also see Tortajada & Nambiar 2019). Ellis et al. (2019) have stated that a critical part of increasing public acceptance of recycled water will be to allow the public to experience drinking it.

How recycled water is framed can influence user responses. For instance, Menegaki et al. (2009) experimentally compared the effects of descriptive terms on consumers' and farmers' willingness to use and pay for artificially cleaned water or its derivative agricultural products. In their experiment, they framed treated effluent either as 'recycled water' or 'treated wastewater.' Of the two experimental groups that they used, the group that was administered survey instruments that described treated effluent as 'recycled water' showed a higher willingness to use it. Unwilling respondents in both samples often cited emotions of disgust followed by distrust in the delivery authorities and worries of contamination as critical to their decision to reject, which again places personal disgust and health risk at the core of water reuse acceptance decisions.

What should be the focus of public communications?

This review largely highlights that getting the public mind out of the sewer and assuaging public fears about health risks should be major targets of communication interventions (see Miller 2012). Disgust is identified as an important predictor of public acceptance. To reiterate, disgust derives from thoughts of contamination connected with the common association of water reuse with 'toilet to tap' framing. According to Wester et al. (2016), although the disgust felt in response to this association is real and important, it is also mutable. Ching (2015) stated that the instinctive rejection of recycled water can be overcome. Critically, the emotion of disgust does not appear to derive purely from aversion but appears to be woven into broader concerns about health risks (see MacDonald et al. 2016). Within the context of water reuse, disgust is associated with pathogen avoidance (Wester et al. 2016). This has important implications for water reuse implementation messaging.

According to Wester et al. (2016), the prominence of disgust as an important factor for water reuse attitudes suggests that an affective (pertaining to emotions and not cognition) appeal may be more effective at increasing people's willingness to accept water reuse. An experimental investigation of the impact of affective framing of recycled water information on a sample of Australians found that participants exposed to positive affective framing had more positive feelings towards recycled water than those exposed to negative affective framing (Greenaway & Fielding 2020). The positive affective framing group also had lower risk perceptions and higher acceptance levels. Fielding and Roiko (2014) contended that the critical significance of perceptions of health risks to water reuse acceptance makes it imperative to communicate information that specifically targets such perceptions.

Miller (2012) noted in his review of a recycled water facility in Orange County (CA, USA) that churns out 70 million gallons of ultra-pure water per day to meet the needs of 600 000 residents that the water is not piped to people's kitchen sinks; rather, it is pumped into the ground (aquifers) and distributed for indirect potable reuse for psychological and not engineering or technological reasons. He describes the public as being too squeamish about drinking recycled wastewater straight from the tap. The feeling of revulsion or disgust is innate and intuitive and does not necessarily submit to scientific logic (Miller 2012). Thus, whatever science says, winning people over necessarily involves the delicate work of overcoming deep-seated psychological barriers and cultural taboos surrounding human waste. Miller (2012) quotes a respondent as having opined that: 'For most of us, risk perception is not the output of a scientific, mathematical calculation, but of a gut feeling'. This gut reaction (precognitive) may predetermine, to some extent, an individual's acceptance of recycled water, which in turn impacts how the individual processes and interprets information related to a water reuse scheme and the overseeing institutions (Smith et al. 2018).

Rozin et al. (1989) theorized the emotion of disgust according to the law of contagion, which supposes that there is a potentially permanent exchange of properties when two objects come into contact with each other. Thus, in the mind of some people, water that has come into contact with human waste remains contaminated. This mental association induces what might be considered irrational behaviour in people, causing them to reject what is otherwise pure, scientifically treated water. The mental association produces 'evidence insensitivity' (see Rozin et al. 2015). Scientific assurance of the quality and safety of recycled water does not remove the sense of contamination due to 'spiritual contagion', meaning that mere advances in water purification technology will not automatically guarantee public acceptance (Rozin et al. 2015). Although technology can eradicate every microcosm of dirt and urine from sewage water, it cannot wipe out the mental association (Ching 2015). Saurí and Arahuetes (2019) stated that disgust and sensitivity to pollution are two key reasons why water reuse schemes are rejected irrespective of how sophisticated and comprehensive treatment systems may be. A pertinent question then becomes how to get the cognitive sewage out after the actual sewage is gone (Miller 2012). Presently, the only way that this has been possible is through indirect potable reuse. This is because environmental buffers make water recycling less visible and seemingly natural, which diminishes the likelihood of public rejection (Ormerod 2016). The simulation of natural recycling processes appears disruptive to contagion, removing stigma (Rozin et al. 2015), or in contexts where extreme local conditions have coalesced to override natural and cultural aversion to direct potable reuse, such as in Namibia and Singapore.

It is worth emphasizing that no water is absolutely pure or new. Whether naturally recycled or otherwise, such water will have come into contact with contaminants. Unplanned indirect potable reuse is a case in point, where treated effluent is discharged into rivers or streams that serve as sources of water for downstream communities (Ormerod & Scott 2013). It therefore makes sense to suggest that the quality and safety of the water – where the technology component has been satisfied – should be a more important consideration than the type of the water source (Ong 2016).

Tortajada and Nambiar (2019) stated that human health concerns represent credible concerns for policy-makers, regulators, the public and the media. Since these concerns have been

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addressed properly when producing potable reused water, this message has to be communicated clearly. Technology is not necessarily the issue; the issue is how technology is communicated. Goodwin et al. (2018b) established that public communications framed in terms of compliance with water quality requirements had positive impacts on public attitudes as opposed to messages framed around the ability of water treatment technologies to remove contaminants.

The research literature also indicates that people who are familiar with unplanned potable reuse (unintentional reuse/de facto reuse in their water supply) are more accepting of planned potable reuse (Rice et al. 2016). This supports the proposition that reframing water reuse in terms of the urban water cycle in which all water is essentially recycled has great potential to help make water reuse schemes more acceptable (see Rozin et al. 2015, Ong 2016, van Rensburg 2016). Smith et al. (2018) suggested that rather than awareness of the need for reuse as a solution to water supply issues, awareness of reuse as an existing normal part of the water resource context may be an important driver of acceptance (also see Savchenko et al. 2019a). Inversely, Wester et al. (2015) found some evidence showing that participants who were unfamiliar with water reuse had greater feelings of discomfort at the idea of using recycled water. Goodwin et al. (2018a) looked at the impact of the news media's framing of a proposed indirect potable reuse scheme for London (UK) on people's perceptions. They found people's prior knowledge of the water cycle to have been one of the factors that influenced perceptions. Study participants were unaffected by 'toilet to tap' framing; some described the source of the water as unimportant, especially those who expressed the view that all water is recycled. One could say that familiarity produces acceptance (see Dolnicar et al. 2011). MacDonald et al. (2016) suggested that users' prior experience with a product may facilitate consumer acceptance, which makes initial attitudes and experiences all the more critical.

Conclusions

This paper has highlighted some of the complexities involved in explicating the specific ways in which the predictors of public acceptance operate, especially their interaction and the implications that this might have for public engagement. Wester et al. (2016) have stated that there is uncertainty as to which factors are most critical to water recycling decisions, which is a hierarchical scaling dilemma, a situation that is further compounded by the geographical variability of water reuse schemes. Therefore, an important question becomes how to derive a useful integrated explanatory model and workable non-prescriptive public communications framework that can be applied in disparate contexts. Binz et al. (2016) have suggested a framework for technological legitimation that proposes how successful practices can be transferrable to new contexts that pose entirely new challenges.

This paper has also highlighted health risk considerations as an important determinant of people's acceptance of water reuse. It remains one of the key risk factors that pose a threat to the future viability of water reuse schemes (Wester et al. 2016). Since it is now clear that technology can 'address' health risks, it remains an issue of communicating this to the public. This review has shown that effective public engagement and education present viable pathways; however, it also remains an open question as to the mechanics of effective public engagement. No known public communications framework exists. Related studies have in the interest of parsimony investigated specific elements and under varied conditions. It is still unclear what techniques are likely to yield positive public outcomes across contexts. Thus, policy-makers and water reuse practitioners should consider pre-testing or pilot studies for specific water reuse schemes in order to gauge the mood of the public and to discover contextual factors that might influence public perceptions. What can be gleaned is that inoculation does not work; the timing of communications is crucial; and affective messaging is possibly the way to go, due to the prominence of disgust as a predictor of acceptance and the possible impact of affective messaging on health risk perceptions (Wester et al. 2016, Greenaway & Fielding 2020).

It might be instructive for water reuse researchers to assess whether public trust in water reuse schemes has increased or declined with the passing of time. Indications are that it has increased, but what are the underlying reasons for this, and can these provide useful entry points for the reshaping of values, practices and norms? One would assume that at a time when technology is pervasive and there is a wider emphasis on environmental issues such as climate change, public attitudes might be more positive. However, as people become more aware of scientific limitations, questions about pollutants of emerging concern abound (see Saurí & Arahuetes 2019) and the public is increasingly exposed to information on institutional failures, it is possible that public confidence might actually erode. This makes it the more imperative to advance our current understanding of water reuse communication vis-à-vis the expert–public interface. Bell and Aitken (2008) have called for research that investigates the tension between the technical and the social, especially research that attempts to break the strict distinction between the two views towards a relational approach. This is especially important given the current wider acceptance of water reuse by technocrats and increasing societal engagement with environmental issues. In this regard, focus should also be on how current forms of social narrative might affect disgust and health risk considerations and thus responses to water reuse (see Smith et al. 2018). Some insights regarding public engagement include:

- Initial attitudes held by people and personal experiences may have important implications for messaging; messages must be tailored to specific groups. Identifying the groups with the potential to influence outcomes is critical.
- Messaging detailed information about the low risks of potable water reuse is possibly more critical than messaging about its benefits; this can also enhance perceived water reuse benefits. Water safety communications framed in terms of compliance with water quality requirements have positive impacts.
- Reframing is critical, pertaining to the source of the water, the production process and the final product. Messaging should use terms that are attractive to the public and avoid terms routinely used by experts.
- Repeated and sustained public messaging of specific types of information about water reuse can lead to a shift in public attitudes.
- People's familiarity with the water cycle improves perceptions. Water reuse schemes need to be framed in terms of the urban water cycle in which all water is essentially recycled.
- Public familiarity with technology and the end product (demystification of the process and product) improves attitudes.

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References

Alhumoud JM, Madzikanda D (2009) Public perceptions on water reuse options: the case of Sulaibiya wastewater treatment plant in Kuwait. *International Business & Economics Research Journal* 9: 141–158.

Binz C, Harris-Lovett S, Kiparsky M, Sedlak DL, Truffer B (2016) The thorny road to technology legitimation – institutional work for potable water reuse in California. *Technological Forecasting and Social Change* 103: 249–263.

Bruvold WH (1985) Obtaining public support for reuse water. *Journal – American Water Works Association* 77: 72–77.

Callaghan P, Moloney G, Blair D (2012) Contagion in the representational field of water recycling: informing new environment practice through social representation theory. *Journal of Community & Applied Social Psychology* 22: 20–37.

Ching L (2015) A quantitative investigation of narratives: recycled drinking water. *Water Policy* 17: 831–847.

Compton J, Jackson B, Dimmock JA (2016) Persuading others to avoid persuasion: inoculation theory and resistant health attitudes. *Frontiers in Psychology* 7: 122.

Dolnicar S, Hurlimann A (2010) Water alternatives – who and what influences public acceptance? *Journal of Public Affairs* 11: 49–59.

Dolnicar S, Hurlimann A, Grün B (2011) What affects public acceptance of recycled and desalinated water? *Water Research* 45: 933–943.

Dolnicar S, Hurlimann A, Grün B (2014) Branding water. *Water Research* 57, 325–338.

Dolnicar S, Hurlimann A, Nghiem LD (2010) The effect of information on public acceptance – the case of water from alternative sources. *Journal of Environmental Management* 91: 1288–1293.

Dolnicar S, Schafer A (2009) Desalinated versus recycled water: public perceptions and profiles of the accepters. *Journal of Environmental Management* 90: 888–900.

Ellis SF, Kecinski M, Messer KD, Lipchin C (2021) Consumer perceptions after long-term use of alternative irrigation water: a field experiment in Israel. *Applied Economic Perspectives and Policy* doi: 10.1002/aepp.13162 (epub ahead of print).

Ellis SF, Savchenko OM, Messer KD (2019) What's in a name? Branding reclaimed water, *Environmental Research* 172: 384–393.

Fielding KS, Roiko AN (2014) Providing information promotes greater public support for potable recycled water. *Water Research* 61: 86–96.

Goodwin D, Raffin M, Jeffrey P, Smith HM (2018a) Evaluating media framing and public reactions in the context of a water reuse proposal, *International Journal of Water Resources Development* 34: 848–868,

Goodwin D, Raffin M, Jeffrey P, Smith HM (2018b) Informing public attitudes to non-potable water reuse – the impact of message framing. *Water Research* 145: 125–135.

Greenaway T, Fielding KS (2020) Positive affective framing of information reduces risk perceptions and increases acceptance of recycled water. *Environmental Communication* 14: 391–402.

Hurlimann A (2006) Melbourne office worker attitudes to recycled water use. *Water: Journal of the Australian Water Association* 33: 58–65.

Hurlimann A, Dolnicar S (2010) When public opposition defeats alternative water projects: the case of Toowoomba Australia. *Water Research* 44: 287–297.

Hurlimann A, Dolnicar S (2016) Public acceptance and perceptions of alternative water sources: a comparative study in nine locations. *International Journal of Water Resources Development* 32: 650–673.

Kemp B, Randle M, Hurlimann A, Dolnicar A (2012) Community acceptance of recycled water: can we inoculate the public against scare campaigns? *Journal of Public Affairs* 12: 337–346.

Kosovac A, Hurlimann A, Davidson B (2017) Water experts' perception of risk for new and unfamiliar water projects. *Water* 9: 976.

Lee H, Tan TP (2016) Singapore's experience with reclaimed water: NEWater. *International Journal of Water Resources Development* 32: 611–621.

Leong C (2016) The role of emotions in drinking recycled water. *Water* 8: 548.

Leviston Z, Nancarrow BE, Tucker DI, Porter NB (2006) *Predicting Community Behaviour: Indirect Potable Reuse of Wastewater through Managed Aquifer Recharge. Science Report 29/2006*. Clayton, Australia: CSIRO Land and Water.

Li T, McCluskey JJ, Messer KD (2018) Ignorance is bliss? Experimental evidence on wine produced from grapes irrigated with recycled water. *Ecological Economics* 153: 100–110.

MacDonald DH, Rose JM, Lease HJ, Cox DN (2016) Recycled wastewater and product choice: does it make a difference if and when you taste it? *Food Quality and Preference* 48: 283–292.

Mainali B, Ngo HH, Guo WS, Pham TTN, Wang XC, Johnston A (2011) SWOT analysis to assist identification of the critical factors for the successful implementation of water reuse schemes. *Desalination and Water Treatment* 32: 297–306.

Mankad A, Tapsuwan S (2011) Review of socio-economic drivers of community acceptance and adoption of decentralised water systems. *Journal of Environmental Management* 92: 380–391.

Menegaki AN, Mellon RC, Vrentzou A, Koumakis G, Tsagarakis KP (2009) What's in a name: framing treated wastewater as recycled water increases willingness to use and willingness to pay. *Journal of Economic Psychology* 30: 285–292.

Miller G (2012) Getting minds out of the sewer. *Science* 337: 679–680.

Morgan EA, Grant-Smith DCC (2015) Tales of science and defiance: the case for co-learning and collaboration in bridging the science/emotion divide in water recycling debates. *Journal of Environmental Planning and Management* 58: 1770–1788.

Nancarrow BE, Leviston Z, Po M, Porter NB, Tucker DI (2008) What drives communities' decisions and behaviours in the reuse of wastewater. *Water Science and Technology* 57: 485–491.

Nancarrow BE, Leviston Z, Tucker DI (2009) Measuring the predictors of communities' behavioural decisions for potable reuse of wastewater. *Water Science and Technology* 60: 3199–3209.

Ong CN (2016) Water reuse, emerging contaminants and public health: state-of-the-art analysis. *International Journal of Water Resources Development* 32: 514–525.

Ormerod KJ (2016) Illuminating elimination: public perception and the production of potable water reuse. *WIREs Water* 3: 537–547.

Ormerod KJ, Scott CA (2013) Drinking wastewater: public trust in potable reuse. *Science, Technology, & Human Values* 38: 351–373.

Po M, Kaercher JD, Nancarrow BE (2004) Literature Review of Factors Influencing Public Perceptions of Water Reuse. Clayton, Australia: CSIRO Land and Water, Australian Water Conservation and Reuse Research Program.

Price J, Fielding KS, Gardner J, Leviston Z, Green M (2015) Developing effective messages about potable recycled water: the importance of message structure and content. *Water Resources Research* 51: 2174–2187.

Price J, Fielding K, Leviston Z (2012) Supporters and opponents of potable recycled water: culture and cognition in the Toowoomba Referendum. *Society and Natural Resources* 25: 980–995.

Radcliffe JC (2006) Future directions for water recycling in Australia. *Desalination* 187: 77–87.

Rice J, Wutich A, White DD, Westerhoff P (2016) Comparing actual de facto wastewater reuse and its public acceptability: a three city case study. *Sustainable Cities and Society* 27: 467–474.

Ross VL, Fielding KS, Louis WR (2014) Social trust, risk perceptions and public acceptance of recycled water: testing a social–psychological model. *Journal of Environmental Management* 137: 61–68.

Rozin P, Haddad B, Nemeroff C, Slovic P, Baron J (2015) Psychological aspects of the rejection of recycled water: contamination, purification and disgust. *Judgment and Decision Making* 10: 50–63.

Rozin P, Nemeroff C, Wane M, Sherrod A (1989) Operation of the sympathetic magical law of contagion in interpersonal attitudes among Americans. *Bulletin of the Psychonomic Society* 27: 367–370.

Russell S, Lux C (2009) Getting over yuck: moving from psychological to cultural and sociotechnical analyses of responses to water recycling. *Water Policy* 11: 21e35.

https://doi.org/10.1017/S037689292100031X Published online by Cambridge University Press

Saurí D, Arahuetes A (2019) Water reuse: a review of recent international contributions and an agenda for future research. *Documents d'Anàlisi Geogràfica* 65: 399–417.

Savchenko OM, Kecinski M, Li T, Messer KD (2019a) Reclaimed water and food production: cautionary tales from consumer research, *Environmental Research* 170: 320–331.

Savchenko OM, Li T, Kecinski M, Messer KD (2019b) Does food processing mitigate consumers' concerns about crops grown with recycled water? *Food Policy* 88: 101748.

Savchenko O, Kecinski M, Li T, Messer KD, Xu H (2018) Fresh foods irrigated with recycled water: a framed field experiment on consumer response. *Food Policy* 80: 103–112.

Smith HM, Brouwer S, Jeffrey P, Frijns J (2018) Public responses to water reuse – understanding the evidence, *Journal of Environmental Management* 207: 43–50.

Smith HM, Rutter P, Jeffrey P (2015) Public perceptions of recycled water: a survey of visitors to the London 2012 Olympic Park. *Journal of Water Reuse and Desalination* 5: 189–195.

Stenekes N, Colebatch HK, Waite TD, Ashbolt NJ (2006) Risk and governance in water recycling: public acceptance revisited. *Science, Technology, & Human Values* 31: 107–134.

Tortajada C, Nambiar S (2019) Communications on technological innovations: potable water reuse. *Water* 11: 251.

Tortajada C, Ong CN (2016) Reused water policies for potable use. *International Journal of Water Resources Development* 32: 500–502.

Tsagarakis KP, Mellon RC, Stamataki E, Kounalaki F (2007) Identification of recycled water with an empirically derived symbol increases its probability of use. *Environmental Science & Technology* 41: 6901–6908.

Wester J, Timpano KR, Çek D, Broad K (2016) The psychology of recycled water: factors predicting disgust and willingness to use. *Water Resources Research* 52: 3212.

Wester J, Timpano KR, Çek D, Lieberman D, Fieldstone SC, Broad K (2015) Psychological and social factors associated with wastewater reuse emotional discomfort. *Journal of Environmental Psychology* 42: 16–23.

WWAP (2015) *The United Nations World Water Development Report 2015: Water for a Sustainable World*. Paris, France: UNESCO.

van Rensburg P (2016) Overcoming global water reuse barriers: the Windhoek experience. *International Journal of Water Resources Development* 32: 622–636.

https://doi.org/10.1017/S037689292100031X Published online by Cambridge University Press