Investigating psychological factors of behavioural intention of urban residents in South Australia to use treated stormwater for non-potable purposes

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ABSTRACT

This paper reports on the intentions of urban residents in two South Australian Local Government Areas (LGAs) (council areas) to use stormwater treated through a managed aquifer recharge process for various potential non-potable uses. Data were collected through an online survey of the residents in these LGAs. The key finding is that, in common with recycled sewage water, the intention to use treated stormwater was lower for uses having closer contact with people. A hypothesized model consisting of possible factors influencing the intention to use treated stormwater was developed based on the contemporary literature relating to usage of treated sewage water. Greater trust in the local water authority was shown to be associated directly and closely with a lower perceived health risk. A positive attitude by respondents to the use of treated stormwater (as an aspect of a sustainable future) was found to be more likely to result in an intention to use the treated stormwater for non-potable purposes. Respondents' perceived health risk, emotions and environmental concerns all had significant associations with their attitudes to using stormwater but were not associated with their intention to use it.

Key words | managed aquifer recharge, perceived health risk, public acceptance, recycled stormwater, trust in water authority

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INTRODUCTION

In Australia there is a growing interest in achieving sustainability in the use of water resources. Within the urban context this includes, among others, recycling treated sewage water and using treated stormwater, which are both under investigation and in operational use (NWC 2009; AWRCE 2010).

Stormwater harvesting and reuse is a relatively new concept in Australia, particularly when compared to the reuse of treated sewage and harvesting roof water (DEC NSW 2006). The harvesting of stormwater received policy impetus in the early years of this century through the National Water Initiative (COAG 2004), and this has resulted in strategic policy responses from all Australian state governments. For example, the South Australian *Local Government Stormwater Management Amendments Act 2007* makes explicit the provision, regulation and capability for the capture of stormwater (Ward & Dillon 2011); the *Queensland Urban Drainage Manual 2007* (Department of Natural Resources and Water 2007) and the *Urban Stormwater Quality Planning Guidelines 2010* highlight the importance of improved urban stormwater quality and quantity management (Department of Environment and Resource Management 2010); and the *ASR for Melbourne Metropolitan Water Supply 2008* proposes to solve the water shortage of the city through Managed Aquifer Recharge (MAR), through discharging stormwater flows into the aquifers below Melbourne for storage and future use as a non-potable water supply (Bonacci Water 2008). By 2008, five states and territories in Australia had operational MAR projects, and investigations into further MAR projects were underway in two states (National Water Commission 2009).

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One driver of urban MAR implementation in Australia is the securing and enhancement of water supplies to substitute for all, or some, uses of existing mains water supplies (Dillon *et al.* 2009).

Stormwater is, in most cases, an abundant resource in Australian urban areas. The mean annual stormwater discharge across Australian cities is between 85 and 145% of mains water use (Dillon *et al.* 2009). However, domestic use stormwater requires treatment and storage before use. MAR systems provide a solution to this issue, by storing excess treated stormwater flows from urban catchments during wet periods for subsequent extraction for reuse during dry periods (Dillon *et al.* 2009).

The availability of stormwater to make useful contributions to urban water supplies is therefore not a constraint. Furthermore, advances in treatment processes have broadened the range of potential uses of the resource. However, the primary limitation to stormwater use, particularly for household purposes, and in common with recycled sewage water, is community acceptance (Dillon *et al.* 2009; Keremane *et al.* 2011; Wu *et al.* 2011).

Even though water reuse is widely promoted and largely supported by the Australian community as an option for responsible water resource management, community responses are frequently unfavourable when it comes to actually using the recycled water (Po *et al.* 2005), often demonstrating a distinct personal reluctance to use it. Little is known about how people make their decisions to accept or reject different water recycling schemes for a range of different uses depending on the degree of direct human contact with the water (Po *et al.* 2005). This is particularly true for stormwater reuse schemes since using stormwater for household purposes is very new to the Australian community. Accordingly, this paper is based on our recent work which investigated the intention of Australian urban communities to use treated stormwater for potential non-potable uses. These include uses which involve close personal contact (personal washing, washing clothes, washing dogs, and watering fruit, vegetables and flowers), and uses having less or no personal contact (flushing toilets, watering lawns, parks and gardens, and washing cars). Hence, for the purposes of the following discussion, there is a continuum of 'closeness'.

The study was conducted in three LGAs, two in South Australia and one in Queensland. Whilst Keremane *et al.* (2011) provide a general overview of the survey for all three LGAs, this paper focuses only on the two South Australian LGAs because both have implemented stormwater harvesting and reuse projects through the MAR process, while the MAR programme in the Queensland LGA has been put on hold.

The aims of this research were: to explore residents' attitudes and intentions to use stormwater treated through the MAR process for several non-potable purposes (see above); to identify key psychological factors related to their attitudes and intentions to use stormwater; and to determine the extent to which variance in the attitudes and behavioural intentions could be explained by factors identified in the parallel literature. Accordingly, a hypothesized model consisting of possible factors influencing intentions to use the treated stormwater was developed for this study, informed by the contemporary literature related to the usage of treated sewage water.

A model with the power to predict intended behaviour – rather than simply providing a description of attitudes and perceptions – could be used by planners and utilities to identify which factors are most likely to influence intended behaviour in individual communities. Results from this research could then act as a useful tool for decision-making agencies to identify key factors in their communities that are likely to influence their support and their decisions in relation to using stormwater for non-potable purposes. As well, the study can guide policymakers should they decide to moderate or allow non-potable uses of treated stormwater.

Development of the model

As mentioned previously, since stormwater harvesting and usage is a relatively new form of water reuse, compared to the reuse of effluent from sewage treatment plants, there is a dearth of research into the community's attitudes and intentions in relation to using treated stormwater for household purposes. Therefore, in developing the model for this study (Figure 1), we have reviewed previous works related to the use of sewage water recycling schemes; for example, the work of Bruvold (1979), Po *et al.* (2005), Leviston *et al.* (2006), Nancarrow *et al.* (2007), Hurlimann *et al.* (2008), Hurlimann & Dolnicar (2009) and Dolnicar & Schäfer (2009). Whilst a detailed review of the literature is beyond

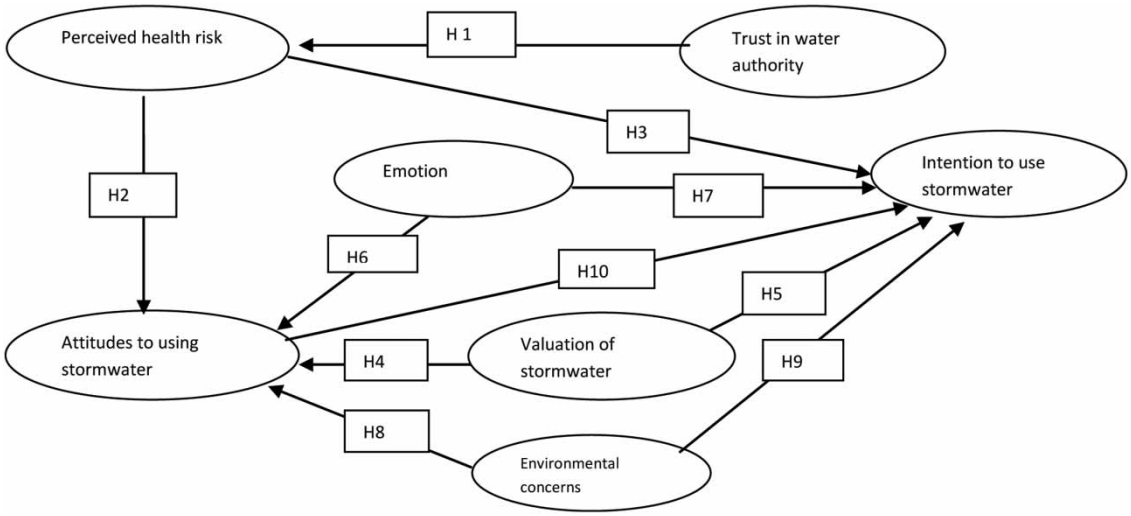

Figure 1 | Hypothesized intended behaviour model for using stormwater for non-potable purposes.

the scope of this paper, a brief review is provided to establish the inclusion of possible factors influencing intentions to use treated stormwater.

Research on community attitudes and intentions toward using recycled sewage water, relative to the degree of human contact with the water, began in the 1970s. In the USA, Burvold (1979) assessed the intentions of the Californian community to use recycled sewage water and found that the closer the use of the water was to human contact, the less preferred it became. This finding has been confirmed by many recent studies in Australia, for example: Po *et al.* (2005), Leviston *et al.* (2006), Nancarrow *et al.* (2007), Hurlimann *et al.* (2008), Hurlimann & Dolnicar (2009) and Dolnicar & Schäfer (2009).

In addition, all these studies (Po *et al.* 2005; Leviston *et al.* 2006; Hurlimann *et al.* 2008; Hurlimann & Dolnicar 2009) identified factors that may have significant associations with people's acceptance and behaviours in relation to water recycling use schemes. Among the previous studies, the three Australian studies conducted by Po *et al.* (2005), Leviston *et al.* (2006) and Hurlimann *et al.* (2008) are most relevant to our research because they attempted to predict the behavioural intentions of residents (except Hurlimann *et al.* 2008), and they also examined the relationships between the potential influencing factors and the intentions. The study by Nancarrow *et al.* (2007) also attempted to predict behavioural intentions of using recycled water, but only for potable reuses.

Environmental concerns were found to be great contributors in Po *et al.*'s (2005) behavioural intention model for their study conducted in Melbourne. The authors found that the more people felt an obligation to protect the environment, the more positive were their attitudes to the intended behaviour (buying vegetables grown with recycled wastewater).

Trust in the water authority has often surfaced as an issue in relation to the community's attitudes to using recycled water (Hurlimann *et al.* 2008). Understanding the role of trust in the water authority, in relation to the community's attitudes to recycled water, may help to increase its acceptance and use by the community (Hurlimann *et al.* 2008). Po *et al.* (2005) and Leviston *et al.* (2006) included 'trust in water authority' in their behavioural intention model as an important variable and found that trust did not have a significant direct effect on intended behaviour, but did have a significant direct effect on perceived health risk.

While emotions are often considered to be irrational, they are generally difficult to cope with and are frequently found to be the major reason for the failure of past schemes to gain public acceptance. Po *et al.* (2005) conducted the first quantitative study to test the role of emotions (e.g. 'feeling yuck') in people's behavioural decisions in relation to using recycled water. The researchers found that the relationship between the emotional factor and people's

attitudes was significant, and that its influence on intentions was mediated by attitudes. Leviston *et al.* (2006), in the following year, tested the emotional factor again and reported significant association between emotions and people's behavioural intentions as well.

Perceived health risk was another key factor with respect to recycled water schemes in studies in this area (Po *et al.* 2005; Leviston *et al.* 2006; Hurlimann *et al.* 2008). However, perceived health risk was found to be less important in influencing behavioural intentions. Risk was quite strongly influenced by trust in all of the afore-mentioned studies. Apart from research by Hurlimann *et al.* (2008), where trust had a significant influence on community attitudes, other studies showed trust as having only a weak influence on attitudes (Po *et al.* 2005) and/or an insignificant effect on intended behaviours (Po *et al.* 2005; Leviston *et al.* 2006). This finding was interesting given that it is assumed that health risks are important issues in people's behavioural decisions.

Accordingly, based on the review of previous studies, a hypothesized intended behaviour model described in Figure 1 was developed for this study.

Correspondingly, the following hypotheses are of research interest:

H1. The more trust in the water authority, the less health risk the respondent perceives in relation to the treated stormwater through the MAR process for _____ use.

H2. The more health risk the respondent perceives of MAR water, the less he/she would like to use the water for _____ use.

H3. The more health risk the respondent perceives of MAR water, the less he/she intends to use the water for _____ use.

H4. The more the respondent values MAR water, the more he/she would like to use the water for _____ use.

H5. The more the respondent values MAR water, the more he/she intends to use the water for _____ use.

H6. The worse the respondent feels about using MAR water, the less he/she would like to use the water for _____ use.

H7. The worse the respondent feels about using MAR water, the less he/she intends to use the water for _____ use.

H8. The more the respondent feels that using MAR water is good for the environment, the more he/she would like to use the water for _____ use.

H9. The more the respondent feels that using MAR water is good for the environment, the more he/she intends to use the water for _____ use.

H10. The more the respondent would like to use MAR water, the more he/she intends to use the water for _____ use.

As seven potential uses, including personal washing, washing dogs, flushing toilets, washing clothes, watering fruit, vegetables and flowers, watering lawns, parks and gardens, and washing cars, are involved in our study, we accordingly conducted seven latent variable modelling tests (see Table 4 in later section of this paper). The variables used in the study and contributing measurement items are detailed in Table 1.

Data collection

Data were collected through an online survey using email addresses bought from a permission-based and research-only internet panel (this method has been employed and examined by Dolnicar & Grün (2009)). The survey was sent to 4,000 randomly selected e-mail addresses (2,000 in each South Australian LGA), and incentives (a chance of winning one of 10 supermarket vouchers, each valued at $50) were provided to encourage responses. The final number of valid responses received was 207, comprising 103 from the Salisbury LGA and 104 from the Charles Sturt LGA. We acknowledge that the response rate (5.2%) is low and thus the results are likely to be biased. We note this as one of the limitations of this study. Another issue is the potential sample-selection bias, which is an obvious limitation of using online surveys because the people taking the survey may not be representative of the population in general (Damurski 2011). For example, compared to 2006 Census statistics, our study has more people aged 25–54 years, more people not working, and more females. It is worth mentioning at this point that focus group discussion(s) will be conducted as part of the next stage of the project to further explore respondents' thoughts on a number of specific items in the questionnaire to supplement the results of this study.

Table 1 | Variables used in the study and contributing measurement items

Variables	Items
Stormwater values	(1) Stormwater is not 'new' water but a part of the overall surface water balance that needs to be accounted for. (2) Stormwater reuse is essential to help manage future water shortage. (3) Stormwater is a valuable resource that should be reused.
Environment concerns	(1) Given an appropriate quality is guaranteed, it would be good for managing water shortages if we use the stormwater treated through MAR process for_____. (2) Given an appropriate quality is guaranteed, it would be good for environment if we use the stormwater treated through MAR process for_____. (3) Given an appropriate quality is guaranteed, it would be good for next generations if we use the stormwater treated through MAR process for_____.
Trust in water authority	(1) I trust the information about the safety of stormwater treated through MAR process given to me by water authorities. (2) I trust water authorities to ensure the stormwater treated through MAR process to which I have access is healthy and safe.
Emotion	(1) I feel 'yuck' when I think of using the stormwater treated through MAR process for_____. (2) It is frustrating if I have to use the stormwater treated through MAR process for_____.
Perceived health risk	(1) Any treated water through MAR process must meet the Australian Water Quality Guideline. Given the quality is guaranteed, I believe that there is no health risk to me from using stormwater treated through MAR process for _____. (2) Given the quality is guaranteed, it will not lead to health problems in the community to use stormwater treated through MAR process for_____.
Attitudes to using stormwater	(1) Given an appropriate quality is guaranteed, I would like to use the stormwater treated through MAR process for_____. (2) I feel no problems to use the treated stormwater through MAR process for _____.
Intention to use stormwater	(1) Given an appropriate quality is guaranteed, I would put the stormwater treated through MAR process in my water pipes for_____. (2) Given an appropriate quality is guaranteed, I would use the stormwater treated through MAR for_____.

Note: For a detailed description of the variables, please refer to Leviston *et al.* (2006).

Descriptive results

The majority of respondents (around 77%) stated an intention to use stormwater treated through the MAR process as fit-for-purpose water supplies; around 3% of respondents indicated that they would not use stormwater, while 20% felt unsure.

Over 80% of respondents agreed that 'stormwater is a valuable resource and its reuse is essential to help manage future water shortages'. Respondents generally agreed that using stormwater is good for managing water shortages, the environment and for the good of the next generation. More respondents (45%) indicated that they would trust the water authorities to ensure that stormwater to which they have access is healthy and safe, than those (18%) who indicated lack of trust in the water authorities.

Respondents' emotions concerning the use of stormwater treated through the MAR process were also closely related to the proximity of use to human contact. Respondents did not feel good about using stormwater for personal washing and washing of clothes, while they cared emotionally the least about using stormwater for flushing toilets and washing cars. Generally, respondents considered that using stormwater was not risky to themselves or the community. They perceived significantly less risk if stormwater was used for flushing toilets, watering lawns, parks and gardens, and washing cars rather than for other uses. Options which have close human contact such as personal washing, washing dogs, and washing clothes were less preferred; options without close human contact such as flushing toilets, watering lawns, parks and gardens, and washing cars were more preferred.

Partial least square tests

Partial least square test (commonly referred as PLS test) was used to explore the associations between the influencing factors and the respondents' intentions to use stormwater for non-potable purposes. We therefore established seven models targeting the seven intended behaviours based on our hypothesized intended behaviour model (Figure 1), and the seven models were run independently to test the seven intended behaviours respectively. PLS Graph Version 3.00 (Chin 2001) was used to conduct the tests.

Prior to running the PLS tests, we ensured that the composite reliabilities for the indicators in this study ranged from 0.888 to 0.977, well over the recommended acceptable level of 0.7 (see Table 2). Convergent and discriminant validity are assessed by finding whether the square root of the average variance extracted (AVE) by a construct from its indicators was at least 0.5 (i.e. AVE $\geq$ 0.5) (Sanchez-Franco 2006). The indicators used in the study satisfied the conditions of convergent and discriminant validity (see Table 3).

The PLS structural model and hypotheses were then assessed by examining path coefficients (β) (like standardized beta weights in a regression analysis) and their significance levels. Table 4 shows the hypotheses and their path coefficients. It is noted in this study that there is a limitation of absence of model level fit by PLS, but that these indicators are usually subject to variability/questionable reliability based on sample size and degrees of freedom (McQuitty 2004).

The hypotheses that have significant path coefficients were accepted while the others having insignificant path coefficients were rejected:

Hypothesis 1 was accepted. Trust in water authority was found to have direct and close association with respondents' perceived health risk regarding usage of stormwater for all potential uses.

Hypothesis 2 was accepted. Perceived health risk regarding use of stormwater was found to have a direct association with the respondents' attitudes to usage of stormwater for all potential uses.

Table 2 | Composite reliabilities of constructs in models A–G

	Model A	Model B	Model C	Model D	Model E	Model F	Model G
Stormwater values	0.91	0.90	0.91	0.91	0.91	0.91	0.91
Environmental concerns	0.97	0.97	0.96	0.97	0.96	0.97	0.96
Trust in water authorities	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Emotion	0.96	0.95	0.92	0.95	0.94	0.91	0.90
Perceived health risk	0.92	0.92	0.91	0.90	0.92	0.89	0.90
Attitudes to using treated stormwater	0.96	0.94	0.93	0.93	0.95	0.93	0.93
Intention to use treated stormwater	0.97	0.97	0.96	0.97	0.96	0.96	0.96

Table 3 | Average variance extracted (AVE) of constructs in models A–G

	Model A	Model B	Model C	Model D	Model E	Model F	Model G
Stormwater values	0.77	0.76	0.76	0.77	0.77	0.77	0.77
Environmental concerns	0.91	0.92	0.89	0.92	0.90	0.91	0.89
Trust in water authorities	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Emotion	0.91	0.90	0.86	0.90	0.89	0.83	0.82
Perceived health risk	0.86	0.85	0.83	0.82	0.84	0.80	0.82
Attitudes to using treated stormwater	0.95	0.89	0.87	0.87	0.91	0.87	0.87
Intention to use treated stormwater	0.95	0.95	0.93	0.94	0.92	0.92	0.93

Table 4 | Hypotheses and corresponding significant path coefficients

	Model A Personal washing	Model B Washing dogs	Model C Flushing toilets	Model D Washing clothes	Model E Watering fruit, vegetables and flowers	Model F Watering lawns, parks and gardens	Model G Washing cars
H1: The more trust in water authority, the less health risk the respondent perceives of the treated stormwater through MAR process for:	0.400[a]	0.422[a]	0.375[a]	0.443[a]	0.339[a]	0.351[a]	0.339[a]
H2: The more health risk the respondent perceives of MAR water, the less he/she would like to use the water for:	0.504[a]	0.353[a]	0.304[a]	0.352[a]	0.439[a]	0.243[b]	0.306[b]
H3: The more health risk the respondent perceives of MAR water, the less he/she intends to use the water for:					0.208[a]		
H4: The more the respondent values MAR water, the more he/she would like to use the water for:							
H5: The more the respondent values MAR water, the more he/she intends to use the water for:							
H6: The worse the respondent feels about using MAR water, the less he/she would like to use the water for:	0.187[a]	0.194[a]		0.242[a]	0.116[a]	0.124[b]	0.127[a]
H7: The worse the respondent feels about using MAR water, the less he/she intends to use the water for:							
H8: The more the respondent feels using MAR water is good to environment, the more he/she would like to use the water for:	0.342[a]	0.451[a]	0.594[a]	0.442[a]	0.450[a]	0.599[a]	0.552[a]
H9: The more the respondent feels using MAR water is good to environment, the more he/she intends to use the water for:							0.275[a]
H10: The more the respondent would like to use MAR water, the more he/she intends to use the water for:	0.774[a]	0.683[a]	0.602[a]	0.714[a]	0.685[a]	0.759[a]	0.573[a]

Note: [a]$p < 0.001$.
[b]$p < 0.01$ (based on $t(499)$, two-tailed test), $t(0.001;499) = 3.310124157$; $t(0.01;499) = 2.585711627$; $t(0.05;499) = 1.964726835$ (Sanchez-Franco 2006).
Only significant coefficients are presented.

Hypothesis 3 was rejected for all uses except for watering fruit, vegetables and flowers. Perceived health risk had little association with respondents' intention to use stormwater.

Hypotheses 4 and 5 were rejected. Stormwater values had no association with either respondents' attitude or their intention to use treated stormwater through the MAR process for whatever optional uses.

Hypothesis 6 was accepted for all uses except for flushing toilets. Emotion was found to have direct association with respondents' attitude to using stormwater for all uses except flushing the toilet.

Hypothesis 7 was rejected. Emotion was found to have no association with respondents' intention to use stormwater for whatever uses.

Hypothesis 8 was accepted. Environmental concerns were found to have a direct association with respondents' attitude to using stormwater for all uses.

Hypothesis 9 was rejected for all uses except washing cars. Environmental concerns had little association with respondents' intention to use stormwater for all uses.

Hypothesis 10 was accepted. Attitudes to using stormwater were found to have a direct and close association with the intention to use stormwater for all potential uses.

DISCUSSION AND CONCLUSION

Research into public acceptance of recycled water helps inform policy makers not only about the areas of application for which people would be most comfortable using recycled water, but also about strategies to increase public acceptance of alternative water schemes (Dolnicar & Grün 2009). The present study illuminates a number of specific issues related to the community's acceptance, preference and intention to use stormwater treated through the MAR process for various non-potable uses. What follows is a reflection on the issues highlighted by this empirical analysis.

First and foremost, this study found that the urban community in South Australia considers stormwater to be a valuable resource and, in general, supports using stormwater as a future water supply alternative. It was also found that there was a reasonably high degree of trust in the water authorities to ensure that the stormwater treated through the MAR process is healthy and safe. The community generally considers that using stormwater treated through the MAR process does not lead to health risks. There is a great degree of support and intention to use stormwater for non-potable uses, which reflects the fact that the Australian community supports the idea of total water cycle management that encourages water capture, treatment and reuse within all parts of the water cycle and its sub-cycles.

Secondly, the preference of the South Australian community for using treated stormwater for non-potable uses is inversely related to the proximity of the use to human contact. The uses which have close human contact such as personal washing, washing dogs and washing clothes are the least preferred options.

These findings are consistent with the majority of previous acceptance studies and hence are not surprising. Previous research indicated that communities support and promote the concept of water reuse, but often reject the scheme when their behavioural support is required. Until now, sponsors of recycling schemes worldwide have been instituting public acceptance programmes with little understanding of what will govern people's actual behaviour. This research has developed a predictive behavioural model which has been tested in two LGAs and provided an understanding of how people make their decisions about using stormwater treated through the MAR process for non-potable uses. Given the scarcity of such studies, this research makes contributions to the work of identifying variables in people's behavioural decision making and the relative contribution of the variables to the decision.

Past international experience and the results of this research support the need to promote the trust of communities in authorities early in the planning phases of new or re-engineered schemes. The more the community trusts the authorities, the less health risk they perceive the water has. In common with recycled sewage water, other factors such as media representation, personal experience and existing attitudes also influence community perception and affect the implementation of reuse policies (Ching 2010). However, our model did not include these factors as they were fairly rare, mainly because of the fact that stormwater reuse is a relatively new concept to the community compared to other alternative options such as treated sewage and rainwater tanks.

It is already known that emotions (i.e. the 'yuck factor') play a large part in people accepting or rejecting water reuse schemes, but the role of emotion is probably still inadequately understood. In the present study, the model showed that emotions directly affected respondents' attitudes to using the stormwater but had no association with their intentions to use the stormwater. The study has contributed to elaborating the role of emotion; however, the relationship is likely to be even more complex and further research is warranted. Another surprising finding is that perceived health risk had significant association with attitudes to using stormwater but did not have associations with their intentions to use the water. Similarly, environmental concerns were found to have a significant association with the respondents' attitudes to using the stormwater but not with their

intentions to use the water. However, the attitude, as a variable, was found to have a close and direct association (0.57–0.77) with intention. Hence, the factors 'emotion', 'perceived health risk' and 'environmental concerns' associate with intention indirectly, being mediated by 'attitudes'.

Of considerable interest was the finding that people's perceived value of stormwater did not emerge in the latent variable modelling as a factor associated with people's intentions to use the stormwater for whatever potential uses. This is perhaps not surprising, because the value of using stormwater cannot be doubted given the growing interest in sustainable perspectives; however, it does not necessarily lead to an intention to use it. This finding has shown that embedding such factors into further research on behavioural models may be unnecessary.

It is expected that the contribution to the model of the different variables would differ for other recycling schemes. It would therefore be interesting to test this on a very different case study. This research has provided a promising start and the findings of this study may be a tool that will allow planners and water utilities to predict a community's potential behaviour in relation to their proposed reuse schemes and to understand more about their local communities.

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