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Key dimensions of public acceptance for managed aquifer recharge of urban stormwater

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ABSTRACT

The present study qualitatively explored psychological and policy-related factors underpinning community acceptance of treated urban stormwater for domestic uses, as well as community views regarding managed aquifer recharge for stormwater treatment and delivery. Participants ($N = 36$) took part in 2-h community workshops and focus groups, where they discussed existing knowledge and perceptions of stormwater and managed aquifer recharge. Results showed a high general acceptance for managed aquifer recharge using stormwater. Nine key social dimensions were found to be indicators of acceptance for stormwater: 1. Fair distribution of treated stormwater, 2. Trust in managed aquifer recharge technology and scientific information, 3. Environmental impact of managed aquifer recharge, 4. Cost of treating and distributing stormwater, 5. Wastage of stormwater if not utilised, 6. Issues relating to future water security, 7. Water quality, 8. Education, and 9. Perceived effectiveness of the stormwater scheme. These important dimensions and drivers of acceptance emerged within the data, highlighting what is important to an urban community with respect to acceptance of managed aquifer recharge of stormwater for potable and non-potable uses. A proposed model of social acceptance is presented, incorporating the policy-related characteristics, psychological factors and communication factors which emerged during the qualitative analysis as predictors of social acceptance for the managed aquifer recharge of stormwater. This model helps to conceptualise how the public perceives the use of stormwater in the home, and how public opinion of stormwater sits relative to other forms of alternative water, such as recycled water and rainwater. It is seems that public acceptance for stormwater is higher than for other types of alternative water, which is a significant finding in this research area. Future research can further explore the predictive nature of the hypothesised relationships between perceptions and intentions to use stormwater and water use behaviours.

1. Introduction

The reuse of urban stormwater in both emerging and developed nations is increasing, as water-stressed regions look to utilise alternative water sources to cope with the negative effects of climate change and rapid population growth (Bates et al., 2008). The prospect of future water shortages in denser urban areas are of most concern, where supply is often struggling to match demand. Urban stormwater, is a relatively untapped resource particularly in water-stressed regions such as Australia and parts of the USA and Africa (United Nations Environment Programme, 2000). Utilising treated stormwater could help cities meet future water supply demands as part of sustainable urban water management (SUWM) programs, where the emphasis is on water efficiency and demand management, environmental protection, fit-for-purpose end use, wastewater recycling, decentralised infrastructure, and inclusion of diverse local water sources (Brown et al., 2009; Marlow et al., 2013; Sharma et al., 2012).

An on-going challenge for many governments worldwide has been maintaining water capacity in existing reservoirs and providing storage for supplementary water supplies (McArdle et al., 2011). A "natural" way to increase storage for additional water supplies is to store water underground, in aquifers. *Aquifers* are underground layers of water-bearing permeable rock (or other geographical strata such as sand and silt); they are capable of

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storing and transmitting groundwater and are replenished naturally through infiltration from streams or rain soaking through rock and soil into the aquifer below (Dillon et al., 2009). An advantage of storing water underground is a reduction in water loss through evaporation and a reduction in transportation costs (i.e. water can be recharged at one geographical location and recovered at another location, depending on how big the aquifer is). *Managed aquifer recharge* is the recharge of water to aquifers for the purpose of subsequent recovery or environmental benefit and this can be done through mechanisms such as injection wells and infiltration basins. In urban areas, managed aquifer recharge (MAR) can provide effective storage for all types of treated water, such as recycled water, desalinated water, stormwater and even mains water (National Water Commission, 2012). With appropriate pre-treatment before recharge, and in some instances post-treatment upon recovery of the water, the stored water can be used for non-potable (e.g. irrigation, industrial water, toilet flushing) and potable (e.g. drinking water) applications (Dillon et al., 2009).

In combination, stormwater use through MAR is a favoured notion for addressing both water supply and water storage issues among some water experts. This method may be less expensive than alternative water options (e.g. desalination), uses passive low energy processes, is robust enough to operate at varying scales, and has the capacity to produce high quality water (Dillon et al., 2009). However, although MAR using stormwater has clear water provision benefits, it is a novel technology and is relatively unfamiliar to the general public. Therefore, the potential use of urban stormwater runoff via MAR for domestic (potable and non-potable) applications may raise social and economic issues relating to community acceptance (e.g. Wu et al., 2012). This study investigates dominant socioeconomic issues as they emerge through an exploratory analysis of public perceptions and acceptance of MAR and stormwater use for domestic purposes.

Limited social science research has been conducted on public attitudes towards MAR or stormwater reuse. Research by Leviston et al. (2006) examined public intentions to support an indirect potable reuse MAR scheme using recycled *wastewater*. Results showed that while 60% of people said they would drink the water provided by the MAR scheme, a large proportion of people were unsure about using the water. Participants qualified their reservations by stating that they required more information about MAR from sources they trusted, such as scientists from Universities and national government research organisations. Trust and risk were highly negatively correlated in the study, and perceptions of risks accounted for 69% of the variance in intended behaviour, indicating that a trustworthy source of information was critical to intended acceptance. Other psychological constructs, namely subjective norms and emotions, were also found to have a moderate contribution towards the prediction of intended behaviour relative to the recycled wastewater MAR scheme. Subsequent research by Wu and colleagues (Keremane et al., 2011; Wu et al., 2013, 2012) found that most people responded positively to the notion of using *stormwater* through MAR, particularly for non-potable applications where contact with the water was minimal. This finding supports past research conducted on the acceptance of recycled wastewater and tank water, where people are most willing to use alternative sources of water for non-potable, minimal contact applications (e.g., Hurlimann and Dolnicar, 2010; Mankad and Tucker, 2013; Marks et al., 2008). Wu and colleagues also found that trust, perceived health risks, emotions and environmental concerns were all associated with attitudes towards using stormwater, but not intentions to use it.

Beyond Wu and colleagues' work, there has been little examination of the social context surrounding stormwater reuse, either as a non-potable or potable water source. While this previous research is useful in highlighting which factors could predict a proportion of variance in stormwater acceptance, a limitation that exists in the stormwater literature is the assumption that stormwater acceptance is influenced by the same factors that predict acceptance of other alternative water sources, such as desalination and recycled water. That is, researchers have not explored psychosocial factors that may be unique to the stormwater context; rather, they seem to have extrapolated "common" water acceptance factors specific to recycled wastewater and mapped them into the stormwater context for examination. However, unlike other alternative water sources, stormwater has been shown to elicit different emotions to those elicited by, for example, recycled wastewater in which revulsion or the "yuck factor" predominates and rainwater, where emotions surrounding water "purity" dominate (Mankad and Tucker, 2013; Nancarrow et al., 2008). Therefore, while some socio-psychological factors of acceptance may indeed be shared across the various non-traditional water sources, the acceptance of stormwater should be approached as a unique context when conducting social–psychological research and relevant factors should be determined based on foundational qualitative research.

Previous MAR research (e.g. Leviston et al., 2006) has also suggested the need to identify other important factors likely to influence community support of a novel water source, which have been overlooked in stormwater research to date. In particular, factors impacting perceptions of health and system risk as well as other types of risk potentially associated with MAR (e.g. environmental risk) should be explored in further detail. Doing so will help to establish levels of risk acceptability in the community with respect to MAR, and highlight sociocultural values important to public acceptance of MAR beyond the influence of trust and risk perceptions. This is especially the case in areas where stormwater is already being used for some applications.

1.1. Present study

Utilisation of stormwater with MAR has potential for reducing or delaying the need to build expensive water storage or desalination infrastructure, and improving water security prospects for water-stressed nations in the face of variable climatic conditions. Therefore, understanding what drives acceptance of this technology is a valuable tool for planning, communicating, and implementing future stormwater initiatives. The present study addresses gaps in knowledge of public perceptions of stormwater and its acceptability, acceptance of the MAR process, as well as addressing recommendations of past research. This study explores important perceptual factors that influence acceptance and choice of MAR of stormwater in a communication-rich environment, where risk perceptions, technological uncertainty, and other factors associated with decision-making could be discussed among participants and experts. The purpose of this study is twofold: to explore and understand the psychosocial factors underlying community acceptance of treated urban stormwater for domestic uses; and to examine community views regarding the use of MAR as a stormwater treatment and delivery scheme. The research investigated community opinions by conducting two workshops, each comprising two interactive public focus groups to collect exploratory qualitative data.

A social psychological approach to understanding stormwater consumption is relatively new in the field of water research. As a consequence, there is no empirical baseline from which to launch future psychological research on public attitudes and engagement with stormwater specifically. Therefore, a preliminary model is presented as a summary of this social research, which incorporates the qualitative findings. The model groups key factors likely to be important in future research targeting key social–psychological