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Comparing actual de facto wastewater reuse and its public acceptability: A three city case study

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ABSTRACT

Increases in water treatment technology have made water recycling a viable engineering solution to water supply limitations. In spite of this, such water recycling schemes have often been halted by lack of public acceptance. Previous studies have captured the public's attitudes regarding planned reuse schemes, but here we focus on unplanned reuse (i.e. de facto reuse), present in many cities across the U.S. We performed a survey in three metropolitan areas, Atlanta, GA (N = 421), Philadelphia, PA (N = 490), and Phoenix, AZ (N = 418), to assess basic perceptions of treated wastewater occurrence and its acceptance in the public water supply. These perceptions were then coupled by estimates of the actual extent of occurrence in the corresponding cities. The key results are that (1) de facto reuse occurs at rates across the three cities higher than what is perceived; (2) roughly 25% of respondents perceive de facto reuse to occur in their home tap water; and (3) respondents who perceived de facto reuse to occur at their tap were ten times more likely to have a high level of acceptance for de facto reuse in their home tap.

1. Introduction

Globally, many countries struggle to cope with water resources that are increasingly limited in both quantity and quality (Dolnicar & Schafer, 2009). Water utilities that manage potable water and wastewater treatment have begun to incorporate planned water reuse strategies as part of sustainable water resource management (Anderson, 1996; Angelakis & Bontoux, 2001; Bixio et al., 2006; Miller, 2006). Wastewater reuse involves the treatment of municipal wastewater for a number of beneficial uses, including replenishing freshwater resources (Asano, Burton, Leverenz, Tsuchihashi, & Tchobanoglous, 2007). A variety of wastewater treatment technologies are available to achieve recycled water of a quality that is often superior to existing potable water standards (Asano et al., 2007; Bixio et al., 2005). Despite this technical evaluation, the idea of drinking treated wastewater does not have wide public support (Po, Kaercher, & Nancarrow, 2003). Several factors hinder recycled water uptake, and new approaches are needed if water reuse is to be a partial solution to water supply sustainability (Weber, 2006). Public perception and acceptance are recognized as two of the main hindrances for the successful implementation of water reuse projects (Hurlimann & Dolnicar, 2010; Marks, 2006).

A growing number of studies indicate that public knowledge of and experience with wastewater reuse plays a crucial role in its acceptance (Dolnicar, Hurlimann, & Grun, 2011; Hartley, 2006). In one early study, for instance, Baumann and Kasperson (1974) suggested that a successful strategy should associate the water reuse program with pleasant activities the public enjoys and approves—for instance, to "put the reclaimed water in an attractive setting and invite the public to look at it, sniff it, picnic around it, fish in it, and swim in it" (Baumann & Kasperson, 1974). This notion was corroborated in another early study, which found that people's opposition to recycled water dropped significantly after they swam in such water, implying that tying recycled water to a pleasant encounter can increase acceptance. (Bruvold & Ward, 1970) As these early studies indicate, and several later studies support, people who have had positive experiences with, or knowledge about, recycled wastewater are more likely to approve its use (Hurlimann, 2007; Jeffrey & Jefferson, 2003; Tsagarakis & Georgantzs, 2003). Further, higher education—sometimes considered a proxy measure for knowledge—was also associated in several studies with higher approval of wastewater reuse (Dolnicar & Schafer, 2009;

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Flack & Greenberg, 1987; Robinson, Robinson, & Hawkins, 2005). Other studies note perceived risk, trust in water authority, perception of fairness and financial benefit, information regarding the treatment process, emotional and affective response to wastewater reuse as aspects of public acceptance (Callaghan, Moloney, & Blair, 2012; Dolnicar, Hurlimann, & Nghiem, 2010; Hurlimann, Hemphill, McKay, & Geursen, 2008a). In most cases, however, this approval was restricted to non-potable wastewater uses or those with low or no public health risk (Dolnicar & Schafer, 2009; Hurlimann, Hemphill, McKay, & Geursen, 2008b; Jeffrey & Jefferson, 2003; Tsagarakis & Georgantzs, 2003).

Affective and emotional response to planned wastewater reuse is often referred to as the 'yuck factor'. The 'yuck factor' is a term coined by Arthur Caplan to describe the influence of instinctive responses against new technologies (Schmidt, 2008). Publications dating back to the 1970s refer to psychological disgust as a barrier to water reuse (Baumann, 1983; Hanke & Athanasiou, 1970). The visceral nature of this reaction makes it hard for the water reuse community to overcome. The reaction of disgust is likely to be linked to the association of reclaimed water with sewage and wastewater, given that urine, excrement, dirt, and mud are all widely recognized to evoke disgust cross-culturally (Curtis, 2011; Curtis & Biran, 2001). Emotions of disgust are defined as the emotional discomfort generated from close contact with certain stimuli (Angyal, 1941). The law of contagion is one possible reason as to why the levels of disgust attributed to excrement and urine are attached to water reuse no matter what level of treatment is completed to the final product (Nesse & Williams, 1995; Rozin, Haidt, McCauley, Dunlop, & Ashmore, 1999). This law suggests that neutral objects can acquire disgusting properties from another object just by means of brief contact. In the field of water governance, the 'yuck' factor has been an intractable problem in the implementation of water-reuse policies (Po et al., 2003). To counter the 'yuck' factor, some water projects avoid referring to water reuse as treated wastewater (Rock, Solop, & Gerrity, 2012). Yet research indicates that promoting the knowledge of wastewater reuse, rather than hiding it, may in some cases increase public acceptability (Baumann & Kasperson, 1974; Bruvold & Ward, 1970).

Building on these findings, water utilities spent over a decade attempting to persuade the public to accept wastewater reuse, primarily through social marketing or public education; these approaches, however, are now generally recognized as ineffective (Po et al., 2003). Therefore, there is a need for research that utilizes public knowledge of reuse to create pathways toward acceptance for recycled wastewater, without solely relying on current social marketing or public education approaches. To address this, our research enters this debate from a novel starting point: many Americans are already consuming recycled wastewater as part of their municipal water supply.

De facto reuse is defined as the unplanned or incidental presence of treated wastewater in a water supply source (National Research Council, 2012). In the United States, de facto potable reuse of wastewater in domestic and public water supply is widespread and increasing. Indeed, treated wastewater can represent a significant portion of the total flow in many receiving waters across the U.S. Previous research in 25 sites across the U.S. found that the water supply was comprised of 2% to 16% treated wastewater discharged upstream of water supplies (Rice, Wutich, & Westerhoff, 2013). This percentage fluctuates seasonally and is higher under low river flow and/or drought conditions due to lower dilution potential. Noteworthy examples include the Platte River downstream from the City of Denver; the Schuylkill River in Philadelphia, PA; the Quinnipiac River in Connecticut; the Santa Ana River in southern California; the Ohio River near Cincinnati, Ohio; and the Occoquan Watershed southwest of Washington, DC (Asano et al., 2007; Mitch, Krasner, Westerhoff, & Dotson, 2009; Mitch & Sedlak, 2004; Morehouse, Carter, & Sprouse, 2000; Spahr & Blakely, 1985).

This study builds on prior research showing that public acceptance of wastewater reuse depends on people's knowledge of and experience with recycled water (Dolnicar et al., 2011). Unlike prior studies—which explored opinions regarding wastewater reuse that was planned, consensual, and often restricted to non-consumptive uses—we are focused on wastewater reuse that is de facto, unplanned, and already occurring in domestic water supplies in the U.S. In this paper, we examine the following key questions for residents of three major U.S. cities: (1) How much de facto wastewater reuse, as a percentage of total water supply, do people find to be acceptable?; (2) How does the public's knowledge of de facto reuse compare with the modeled amount of treated wastewater actually present in their city's water supply?; and (3) Are people more likely to be accepting toward wastewater reuse in their domestic water supply when they are aware that de facto reuse is already occurring? This is a particularly controversial issue, as public acceptance of wastewater reuse in the U.S. has long been thought to depend upon the isolation of wastewater from human contact, i.e., for purposes other than consumptive and hygienic uses (Hartley, 2006).

2. Materials and methods

2.1. Overall approach

An interdisciplinary approach was used to answer the questions set forth in this article, integrating environmental engineering analysis and social science survey methods. The method consisted of four steps: (1) conduct a social survey to measure certain attitudes regarding de facto wastewater reuse; (2) estimate the actual extent of de facto wastewater reuse in the selected cities; (3) analyze the data to determine the traits of respondents associated with higher acceptance values; and (4) perform a spatial analysis to compare the actual and perceived values. Results from the social survey (aggregated by zip code) were added into a geographic information system (ArcGIS) model to represent the actual and perceived values of de facto wastewater reuse across three cities in the U.S.

2.2. Social study design

A social survey was launched within an online survey (Evans & Mathur, 2005) platform across three cities that were provided samplings by Survey Sampling International (SSI, headquartered in Shelton, CT). SSI's "open-door" sourcing obtains its sample from panels, social media, online communities, and affiliate partners. Data integrity is ensured through timestamps to flag "speeders," and quality control questions to identify inattention. Data is then authenticated through several steps, including digital fingerprinting and matches against third party databases. Their approach to data integrity and authentication has earned them an "outstanding" Grand Mean Auditor rating (performed by Sample Source Auditors located in East Islip, NY).

SSI collected data from 400 survey respondents per metropolitan statistical area for the cities of Atlanta, Philadelphia, and Phoenix. These cities were selected to represent different climate zones and water resource availabilities, as these factors are expected to affect the extent of de facto reuse present. Atlanta is in the humid subtropical climate zone, with rainfall evenly distributed throughout the year. From 2007–2008, the city underwent water shortages as Lake Lanier Reservoir shrank to historic lows; rapid population increase from 1990 to 2007 (6.5–9.5 million people) was the main cause. Due to this prior water shortage, this area has one of the only indirect potable reuse systems installed in the

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