Water Resources and Wastewater Reuse: Perceptions of Students at The Ohio State University Campus

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Abstract: As global population increases and more people achieve higher standards of living, the availability of freshwater across the world may be threatened in the coming decades. Reuse of wastewater is seen as one of the many solutions that can reduce the need for freshwater and lead to long-term sustainability. However, the concept of wastewater reuse does not elicit unconditional public support. Universities worldwide have taken the lead in creating water management programs for their local watersheds. Students at the main campus of The Ohio State University were surveyed for their opinions on water resources and wastewater reuse using an online questionnaire. Results indicate weak awareness of facts and practices regarding water usage and quality, but strong support for implementing a wastewater reuse program in the region. Level of contact with the treated wastewater and familiarity with the institution undertaking the wastewater reuse program have strong impacts on perceptions of the processed wastewater quality. This is important for institutions that serve public needs and depend on consumer trust to promote new and innovative environmental initiatives. Water management programs involving wastewater reuse could be an effective method to reduce the risks in scenarios which project potential water shortages in urban areas during the coming decades.

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INTRODUCTION

An increasing global population with higher standards of living may threaten the availability of freshwater across the world in the coming decades, a situation that could be intensified by fluctuations due to climate change. Although the concept of sustainable development was formally defined in 1987 in the Brundtland Report (United Nations 1987), its meaning and framework in the context of water resources has been a work-in-progress. The definition of sustainability in water resources has evolved over time, starting from the idea that all human demands be met by natural supplies. In the light of increasing population and the development of technology, it was expanded to include meeting the water demand from the natural supplies, not just in quantity but also in quality through adequate treatment processes (Hermanowicz 2008). At the minimum, the term sustainability in the context of water resources indicates "maintenance of natural water resources in adequate quantity and with suitable quality for human use and for aquatic ecosystems" (Roy and others 2010). Reuse of wastewater is seen as one of the many solutions that can reduce the demand for freshwater and lead to long-term sustainability.

The evolution of wastewater reclamation, recycling, and reuse has its roots in the early water and wastewater system of the Minoan civilization in ancient Greece (Angelakis and others 2005). Although wastewater reuse has been practiced in many countries for centuries, renewed interest in water reuse is surging (Asano and Levine 1996). Wastewater reclamation and recycling have been prominently used or are being considered in the arid and semi-arid parts of the world such as West Asia (Al-A'ama and Nakhla 1996), Mediterranean Europe (Angelakis and others 2005), parts of Africa (Bahri and Brissaud 1996), Australia (Eden 1996), and in China, where demand for clean water outstrips supply (Yang and Abbaspour 2007). In the U.S., wastewater reuse for non-potable or indirect potable purposes is being practiced in arid regions of Arizona, California, Colorado, and Texas, and in humid regions of Florida, Georgia, Puerto Rico, and the U.S. Virgin Islands (Hartley 2006).

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Public Perception

Understanding the behavior of local communities towards natural resources is integral to the creation of effective policies and their implementation. These policies are advocated at a national or regional level, but implemented at a local level. Increased local ownership, involvement, or participation can raise awareness about the resources, thereby, helping the programs that oversee these environmental resources and goods become more sustainable (Lipchin and others 2004). Perceptions about the environmental resources are often shaped by several influences (Sia Su and Cervantes 2008), some of which include historical or anecdotal information, visual imagery, and personal experiences. The technology required to treat wastewater and convert it to reusable water that surpasses drinking water standards is currently available (Bixio and others 2005). However, the notion of consuming treated wastewater is not a concept that elicits unconditional public support (Dolničar and Schäfer 2009). Irrespective of scientific and engineering-based considerations, public opposition has the potential to cause wastewater reuse projects to fail - before, during, or after their execution. Wastewater reuse programs may face public opposition resulting from a combination of prejudicial beliefs, fear, attitudes, lack of knowledge and general distrust of public utilities (Jeffrey and Temple 1999; Wegner-Gwidt 1991).

Public support for wastewater reuse increases when the level of contact with the reusable water decreases (Bruvold 1984; Jeffrey and Jefferson 2003), the primary source of wastewater becomes more personal (Jeffrey and Jefferson 2003), and the reuse implementation process is transparent to the general public (Hartling 2001). Insufficient dissemination of information to the public and poorly managed public information campaigns were responsible for non-completion of a number of large-scale wastewater reuse proposals in the U.S. during the 1990s (DeSena 1998; Hartling 2001). Gibson and Apostolidis (2001) state that the best way to involve the general public and gain its acceptance is through successful demonstration or pilot projects.

Universities as Role Models

As scientific challenges acquire social dimensions, institutions of higher learning play a unique role in advancing the cause of sustainable efforts. Not only do universities educate the citizenry with interdisciplinary knowledge, they are prestigious and influential institutions capable of impacting the environment as well as influencing local and global communities (Uhl and Anderson 2001). Universities worldwide have taken steps to reduce, reuse, and recycle wastewater (Staff Reporter 2004; USAID 2006). The reasons for undertaking these wastewater reuse initiatives include water shortage in arid climates, the need to sustain and protect the local watershed, and to set an example to the local community.

In the U.S., universities in arid, drought-prone, and water-impoverished regions were quick to adapt to the growing demands of water, while those in other areas followed later. In 1971, University of Hawaii initiated a pilot study to irrigate sugarcane and grasslands using treated wastewater (Lau and others 1972). The University of Florida has utilized its own wastewater treatment plant since 1948 (University of Florida 2010) and reclaims approximately three million gallons per day (Campbell and others 1998). Penn State University has been reusing its wastewater since 1963 using the `Living-Filter', an organic wastewater treatment system, after the long-term viability of clean ground and surface waters in the region was threatened (Bitler 1990). In 2009, the University of North Carolina constructed a water reclamation system on the university's campus in response to the severe drought that affected the region in 2002 (University of North Carolina 2009).

Given the importance of water conservation and reuse worldwide and the role of universities in promoting effective management strategies, the perceptions of university students on water resources and reuse is a critical piece of the public policy dialogue on this issue. University students are an important section of the society because of their ability to influence the nation's policies in the coming years, both as policy-makers, and as consumers and producers of affiliated goods and services.

METHODS

Students at the main campus of The Ohio State University were surveyed for their perceptions on the water resources and wastewater reuse through an online questionnaire.

Constitutive Definitions

Some of the terms, used throughout this literature, are defined the following way:

Perception: Affect for or against a psychological object (Thurstone 1931).

Wastewater: Any water that has been reduced in quality to be below acceptable minimum regional/national standards for potable use. It comprises liquid waste discharged by domestic and commercial properties, industry or agriculture, and can encompass a wide range of natural and manmade contaminants at varying concentrations.

Wastewater reuse: Using wastewater from one application (primary purpose) to another application (secondary purpose) (USEPA 1992). The deliberate use of wastewater must be in compliance with the applicable rules for the secondary purpose.

Contact: The act of physically touching an object - in this case, reused wastewater.

Survey Methodology

After approval of the survey methodology and the questionnaire from the Institutional Review Board, contact information for a random sample of the students (18 years or older) was obtained from the university's Office of Enrollment Services. Eight hundred and nineteen (N=819) students participated in the web survey, conducted over a period of two weeks (12-25 November 2009), through email. The survey questionnaire was hosted on a third party website, which also provided the raw data for analysis at the conclusion of the survey. Two reminders were sent to the participants - after five and 11 days from the date of the first e-mail. The entire questionnaire is available in Vedachalam (2011).

Questionnaire

Items on the questionnaire can be grouped into four sub-topics.

Water consumption and practices. Three factual lead-in questions were asked at the beginning of the questionnaire. Two questions were on water consumption in the U.S., and the third one was related to wastewater generated on the campus. The factual questions were included to test the participants' knowledge about water-related issues. Listed below are the lead-in questions.

1. Globally, the average domestic water consumption in urban areas per individual is 45 gallons per day. The same figure for an average American is ____ times this value.

   a. About the same b. 2 c. 3 d. 4 e. 5

2. In an average American home, where is the maximum amount of water consumed?

   a. Shower b. Toilet c. Faucet d. Washing Machine e. Leaks

3. The university's football stadium is an iconic structure on the campus. Which of the following options most accurately describes what happens to the wastewater that is generated in the stadium during a season game?

   a. The wastewater is treated within the stadium and drains into the river that flows through the campus.

   b. The wastewater is treated within the stadium and reused for watering plants around the stadium.

   c. No treatment is carried out within the stadium. The wastewater drains into the river that flows through the campus.

   d. No treatment is carried out within the stadium. The wastewater is sent to the city's treatment plant

These questions were followed by several opinion-based questions on water quality and management.

Campus and general water quality. The respondents were asked to rate the quality of drinking water provided in campus buildings and off-campus facilities, based on their overall perceptions of taste, appearance, and smell (on a five-point Likert scale ranging from 1=poor to 5=excellent). On the next item, the respondents were given a hypothetical scenario of an outbreak of water-borne illness in the region and were asked to indicate their level of disagreement or agreement on a five-point Likert scale on two statements: 1) utility companies will take extra steps to ensure high quality water in case of such an event; and 2) the university will take extra steps to ensure high quality water in case of such an event. The final question in this section was on the issue of surface water quality. The respondents were asked to select the primary source of river pollution in the U.S. from five options: 1) storm sewer outflows, 2) industrial discharge, 3) septic systems, 4) run-off from farmland, and 5) animal farms.

Wastewater reuse. The final section of the questionnaire was focused on opinions regarding reuse of treated wastewater. In a series of questions, participants were asked to indicate their level of agreement or disagreement (on a seven-point Likert scale ranging from 1=strongly disagree to 7=strongly agree) on statements related to reuse of wastewater, such as reusing treated wastewater: 1) is being environmentally responsible, 2) reduces amount of pollutants discharged to the environment, 3) will cause health concerns, 4) will bring personal economic benefits, and 5) will bring economic benefits to the participant's community. The participants' views on these statements are expected to provide an indication of their overall view on the general practice of wastewater reuse. The change from a five-point scale to a seven-point scale was made for this section of the questionnaire to align the results with other studies on wastewater reuse that utilize a seven-point scale.

In addition, the participants were asked to indicate their level of approval or disapproval (on a seven-point Likert scale ranging from 1=strongly disapprove to 7=strongly approve) if a program involving reuse of treated wastewater were to be implemented in Ohio for each of these activities: 1) industrial manufacturing, 2) firefighting, 3) washing cars in a commercial facility, 4) watering golf courses, 5) watering domestic lawns, 6) flushing toilets in the participants' residence, 7) flushing toilets in public restrooms, 8) use in domestic washing machines, 9) discharge into a river, and 10) growing food crops in a farm. Participants' level of approval for these reuse applications is expected to provide an indication of which applications, in particular, are preferred by them.

Demography. Participants were asked to provide demographic data, which included sex, age, academic level (undergraduate, graduate, professional), academic program, and hometown. This information was matched against the university registrar's office data to ascertain if the sample was representative of the population under study. Additional information on the respondents' housing status, amount of the water bill paid monthly, involvement with environmental organizations, and political affiliation was obtained to identify any underlying trends in the responses.

Analysis

The raw data was stored as a Microsoft Excel spreadsheet and the analysis was conducted on SPSS software. The statements on campus water quality were analyzed using chi-squared ($\chi2$) distribution tests. Paired sample t-tests and boxplots were used to analyze the results for the source of river pollution, and support for statements on wastewater reuse and applications involving wastewater reuse. Cronbach's alpha was used to determine the internal consistency of items measuring support for wastewater reuse applications. Additionally, factor analysis was performed to determine variations in the levels of support for different wastewater reuse applications.

RESULTS

Response Rate

A total of 819 responses were obtained from the survey; 218 were not considered for analysis due to lack of responses to a majority of the opinion questions. The remaining 601 responses were analyzed for the purpose of this study. Since the participants did not answer all the questions, the number of respondents for each particular question is indicated in parenthesis. The survey was emailed to a random list of 10,000 students; hence the overall response rate was approximately eight percent (N=819). The response rate is lower than the response rates achieved in other web-based surveys targeted at the student population, which range from 12.4 percent (Yanling 2006) to 36 percent (Boulianne and others 2010).

Demographic Breakdown

There were 258 male (43.07 percent) and 341 female (56.93 percent) respondents (N=599). Female participation was considerably higher in the survey than in the general student population (48.14 percent), which is consistent with observations from previous studies involving student surveys (Porter and Umbach 2006; Porter and Whitcomb 2005; Sax and others 2003). The demographic distribution of the respondents and that of the general population is shown in Table 1 and Fig.1. The survey responses show an under-sampling of students in the 18-22 age group and an over-sampling of students in all other age groups. Since most surveys of college students are conducted at four-year campuses where the range of student age is fairly narrow, the effect of age on survey responses has not been studied well. However, a study on students enrolled in community colleges in the Los Angeles Community College District, California recorded a higher response rate among older students compared to their younger peers (Sax and others 2008). The response rate of students from

Table 1

Demographic distribution of the sample and the population

Characteristic	Sample (%)	Population (%)*
Sex		
Male	43.07	51.86
Female	56.93	48.14
Age (years)		
18-22	50.58	60.8
23-27	30.55	23.32
28-32	9.52	8.33
33 and above	9.35	7.55
Academic Status		
Freshman	12.44	13.76
Sophomore	12.10	16.53
Junior	12.27	17.01
Senior	21.85	27.45
Graduate	34.62	19.19
Professional	6.72	6.06
Hometown		
Ohio	79.13	78.77
Other U.S. states	15.53	13.53
International	5.34	7.70
Size (n)	601	55,014

* Enrollment data from Fall Quarter 2009 used to determine population demographics.

the colleges of Engineering (17.8 percent); Food, Agricultural and Environmental Sciences (8.4 percent); Mathematics and Physical Sciences (6.0 percent); and Public Health (1.8 percent) was significantly higher ($\chi2=9.29$, $p < 0.05$) than their distribution in the university population (15.1 percent, 4.6 percent, 4.2 percent and 0.4 percent, respectively), indicating a possible connection between interest in the survey topic and academic major.

The distribution of students according to academic status (N=595) as undergraduate, graduate, and professional students shows that a larger proportion of graduate students (34.62 percent) responded to the survey as compared to their proportion in the general population (19.19 percent). This could be due to the fact that graduate students understand the implications of research initiatives such as this, and are more likely to participate in surveys than undergraduates. This would also explain the undersampling of the 18-22 age group, in which most of the undergraduate students are likely to fall. However, their distribution as per their hometown (see Table 1) and academic major (see Fig. 1) reflected the university-wide distribution.

Water Consumption and Practices

The questionnaire started with three questions concerning water consumption and practices. Nearly one-third (32.83 percent) of the respondents (N=600) gave the correct response that the average American consumes three times the global urban average. A little more than 20 percent of the respondents felt that each of the choices b, d and e represented the right answer to the question. Including the respondents who said that Americans consume twice or four times the global urban average (options b and d), three-fourths of the respondents gave an answer that was broadly representative of the fact.

Nearly half (47.75 percent) of the respondents (N=599) thought that showers consumed the maximum amount of indoor water, while only 24.21 percent gave the correct response as toilet. Though no wastewater is treated on campus, 19.87 percent of the respondents (N=599) thought that water treatment is carried out inside the stadium (options a and b). The correct response (option d) was provided by 61.77 percent of the respondents, while 18.36 percent of the respondents thought that untreated water is being discharged into the river that flows through campus. .

Campus and General Water Quality

Based on overall perceptions of taste, appearance and smell, the students were asked to rate the quality of drinking water provided in off-campus buildings (residences and commercial establishments) by utility companies and in on-campus buildings by the university. Fig. 2 shows that nearly half the respondents (N=589) rated the water quality in on- and off-campus buildings as average. A $\chi2$ test revealed significant difference between the distributions of the response to both the statements ($p < 0.001$). More students rated the quality of water in on-campus buildings as good or excellent (39.58 percent) as compared to that in off-campus buildings (29.47 percent), even though the university does not undertake any additional treatment of water before supplying it through the university buildings.

Students were also asked to indicate their level of agreement or disagreement (on a five-point Likert scale ranging from 1=strongly disagree to 5=strongly agree) on the willingness of utility companies and the university to take extra steps to ensure high quality water in case of a water-borne illness in the region. Fig. 3 shows that nearly three-fourths (73.67 percent) of the respondents agreed or strongly agreed with the statement about the

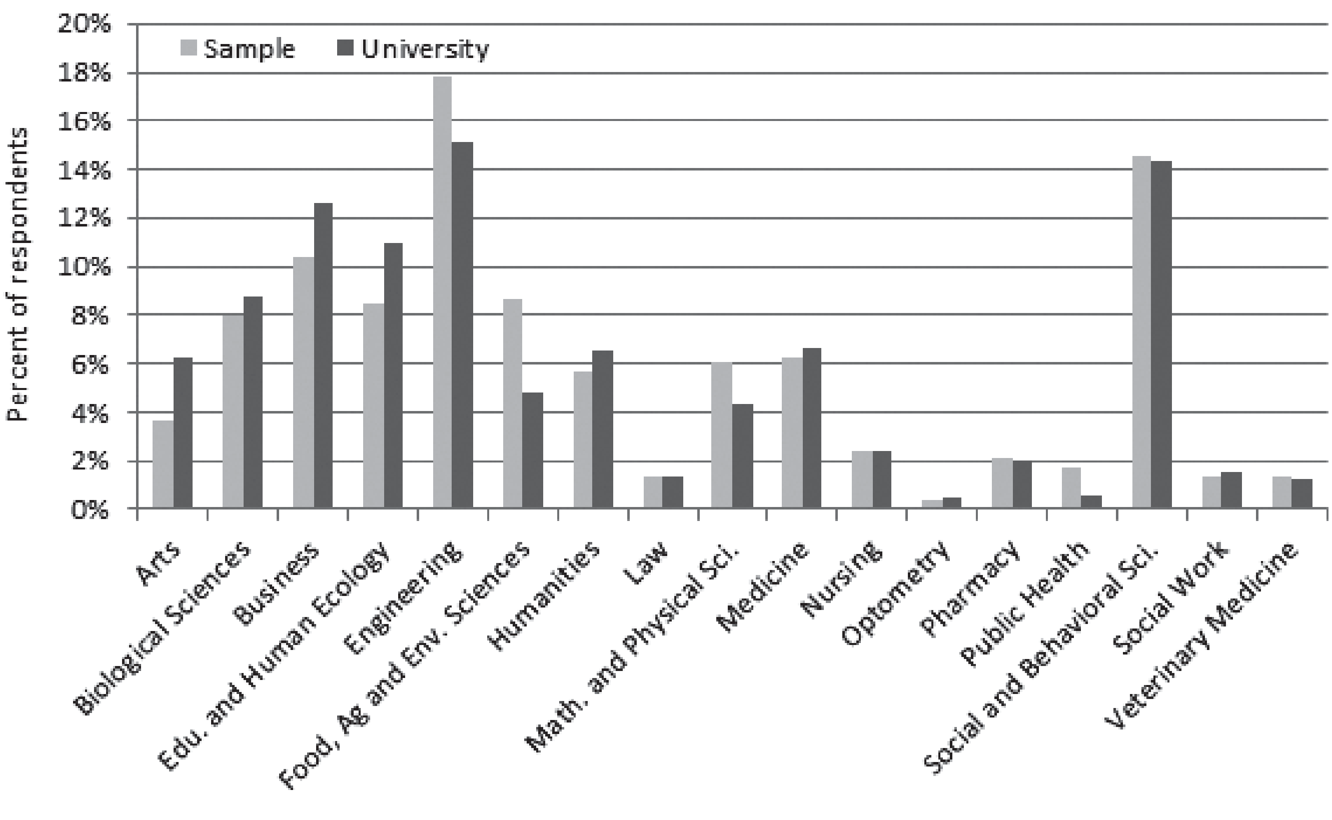

Figure 1. Distribution of respondents according to academic major

university, while only 40.64 percent did so regarding the utility companies. A $\chi2$ test revealed significant difference between the distributions of the response to both the statements ($p < 0.001$).

On the issue of pollution in U.S. rivers, the students were given several sources of pollution and were asked to indicate their level of agreement or disagreement (on a seven-point Likert scale ranging from 1=strongly disagree to 7=strongly agree) with the statement that a particular activity was the primary cause of river pollution. Fig. 4 shows a boxplot of the student responses on the five options. The ends of the whiskers extend to 1.5 times the height of the box, or if there is no value in that range, to the minimum and maximum values. If the data are distributed normally, approximately 95 percent or the data are expected to lie between the whiskers.

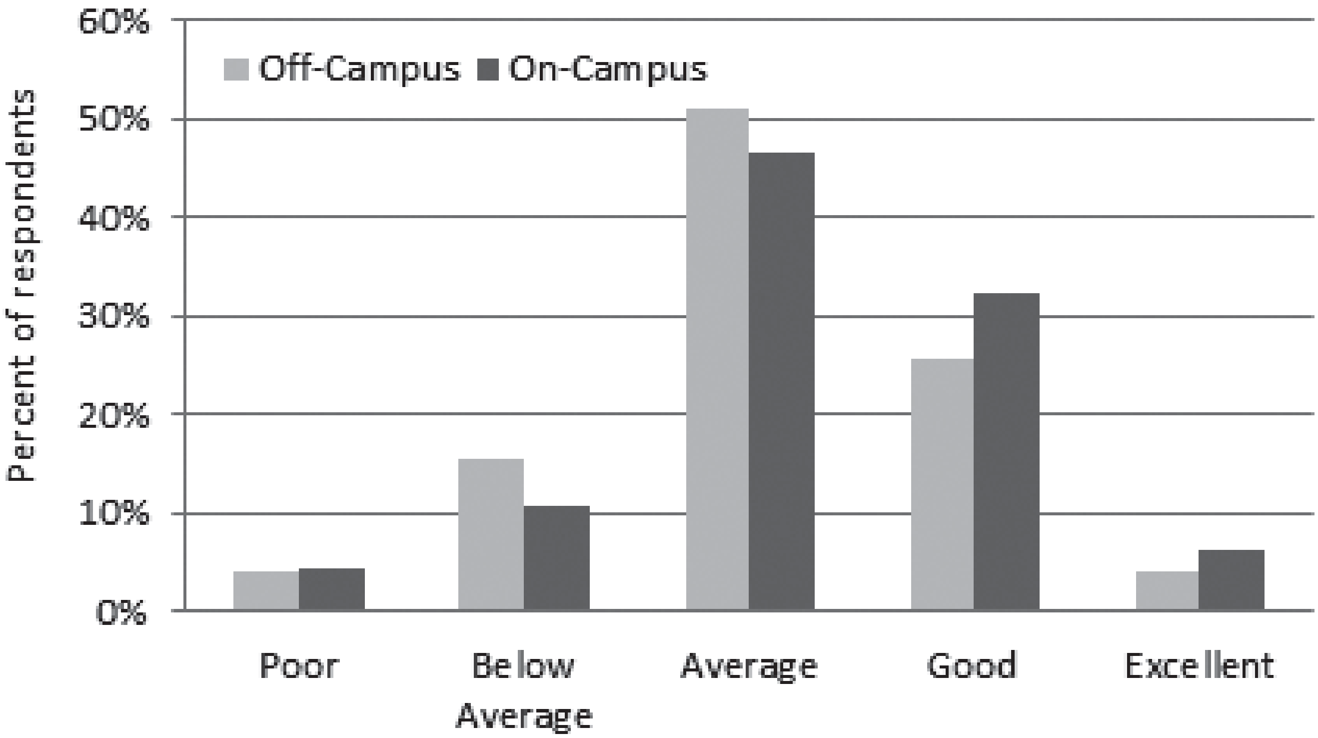

FIGURE 2. Student responses on (a) the quality of water available in off-campus (served by utility companies) and on-campus buildings (served by the university)

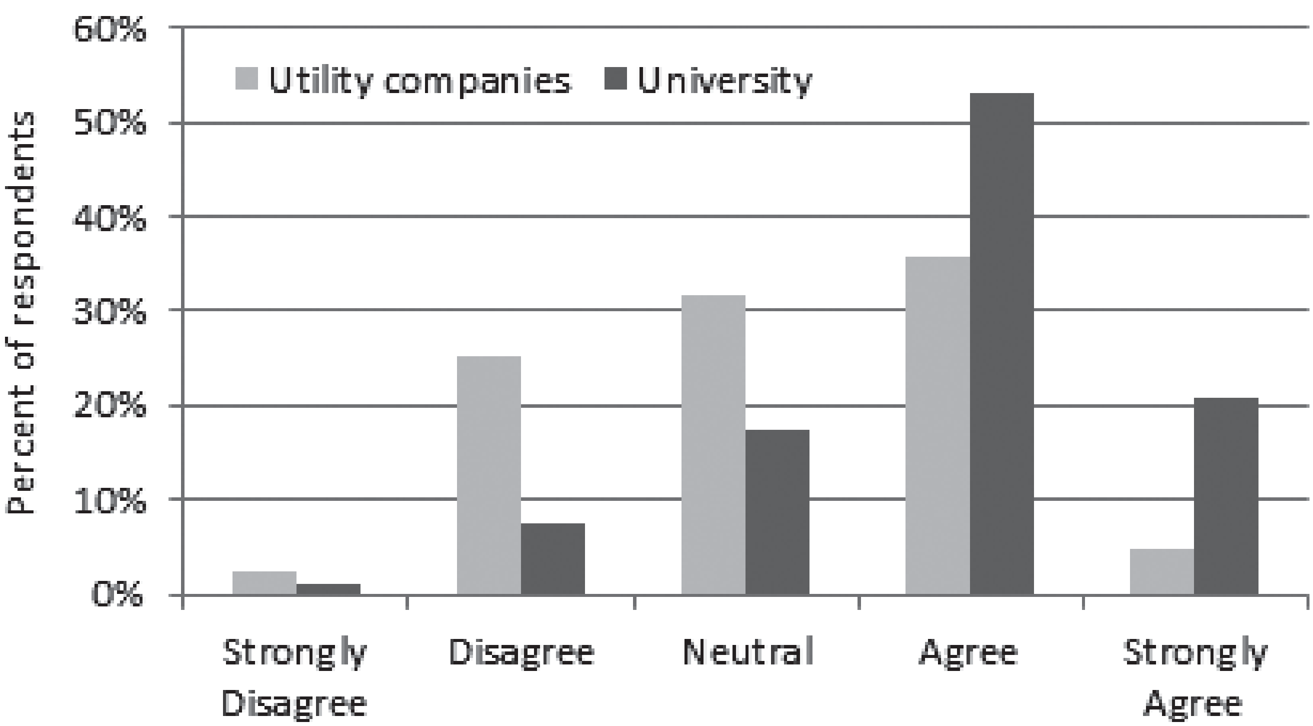

FIGURE 3. Student responses on statements indicating that utility companies/university will take steps to provide good quality drinking water in the case of an illness outbreak.

Industrial discharge (mean=5.90 and standard deviation=1.12) and fertilizer run-off from agricultural farms (mean=5.77 and S.D.=1.21) were considered to the primary cause of river pollution by the respondents. A t-test revealed no significant difference between the two options ($p > 0.0125$). Industrial animal farms (mean=5.59 and S.D.=1.31) were rated as the next most likely cause of river pollution. Of the five likely sources listed, storm sewer overflows (mean=5.26 and S.D.=1.29) and septic systems (mean=5.02 and S.D.=1.29) were considered the least likely cause of the river pollution. A t-test revealed significant difference between the two options ($p < 0.0125$).

Wastewater Reuse

The respondents were asked to indicate their level of agreement or disagreement (on a seven-point Likert scale) with five statements about wastewater reuse in general. Fig. 5 shows a boxplot of the student responses on the five statements about wastewater reuse, some of which were adapted from Dolničar & Schäfer (2009). Respondents strongly agreed that reuse of wastewater is an environmentally responsible activity (statement a; mean=6.04 and S.D.=1.02). There is also agreement on the statements that reuse of wastewater reduces the amount of pollutants discharged into the environment (statement b; mean=5.09 and S.D.=1.45), and that undertaking wastewater reuse will bring economic benefits - both personal (statement d; mean=4.81 and S.D.=1.24) and for their community (statement e; mean=5.11 and S.D.=1.24). The respondents were divided in their opinion about potential health concerns arising from wastewater reuse (statement c; mean=3.79 and S.D.=1.48).

The final opinion question on the questionnaire asked the students to indicate their level of approval or disapproval (on a seven-point Likert scale) for specific reuse applications, if a hypothetical program involving reuse of treated wastewater were to be implemented in Ohio. Some of these applications were adapted from Friedler and others (2006), and Dolničar & Schäfer (2009). Florida already uses reclaimed water for several activities listed on the questionnaire (Davis 2000).

Figure 6 shows a boxplot of the student support for ten hypothetical wastewater reuse applications. Based on the mean scores, flushing toilets in public restrooms (mean=6.18 and S.D.=1.09) and firefighting (mean=6.16 and S.D.=1.13) received the strongest support, followed by industrial manufacturing (mean=5.95

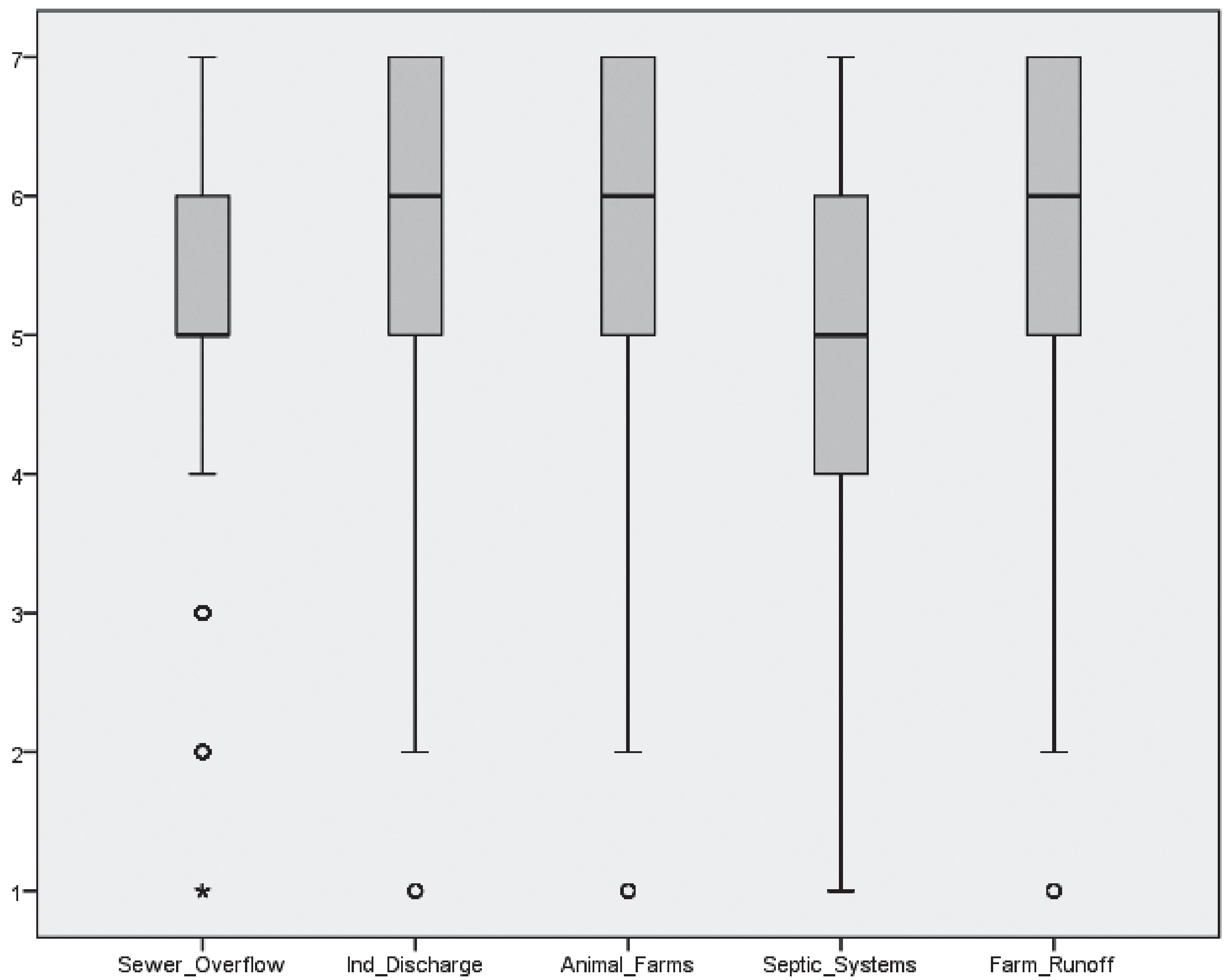

Figure 4. A boxplot of student responses on a scale of 1(strongly disagree) to 7 (strongly agree) about each of the activities being the primary source of pollution in rivers – a) sewer overflows, b) industrial discharge, c) animal farms, d) septic systems, and e) runoff from agricultural farms. The bottom and top of the box represent the 25th and 75th percentile and the band near the middle of the box is the 50th percentile (or the median). The circles and asterisk represent extreme values or outliers.

and S.D.=1.17), flushing toilets in residences (mean=5.94 and S.D.=1.27), and watering golf courses (mean=5.95 and S.D.=1.38), further followed by watering lawns (mean=5.84 and S.D.=1.35). Applications such as discharge into the river (mean=4.82 and S.D.=1.64)-a current practice-and usage in domestic washing machines (mean=4.57 and S.D.=1.75) received low level of support.

DISCUSSION

Only one-third of the respondents correctly indicated that the amount of water consumed by an average American is three times the global urban average. Knowledge of water consumed or wastewater generated is generally not well-known among the public. In a study conducted in Greece, Kantanoleon and others (2007) reported that only 22 percent of the respondents could reasonably estimate the amount of wastewater generated per person in their household. Similarly, Robinson and others (2005) reported that number to be only 20 percent in a study conducted in southeastern U.S. Selection of showers as the most water-consuming indoor activity by nearly 50 percent of the respondents could be a reflection of the focus by several environmental organizations on reducing the carbon and water footprint by reducing the time spent in showers. According to the American Water Works Association, toilets consume the maximum amount of indoor water in an average home, representing one-fourth the total consumption. Washing machines consume about one-fifth the total usage, followed by showers, faucets, and leaks (USEPA 2008). A little more than three-fifths of the respondents provided the correct response that the wastewater generated within the university's stadium is sent to the city's wastewater treatment plant. Although a small section of the respondents are still unaware of the status of the wastewater, knowledge about this issue is better than questions about general water quantity and household consumption. The authors believe that this may be attributed to an increased awareness of campus issues as compared to general water issues.

Using forecasted precipitation and demand, the Natural Resources Defense Council (Roy and others 2010) issued a county-by-county projection for the year 2050 on various parameters, including one called the Water Supply Sustainability Index. The index was derived under two scenarios – one considering effects of climate change, and one without any climate change impacts – and rated risk to the counties as extreme, high, moderate or low.

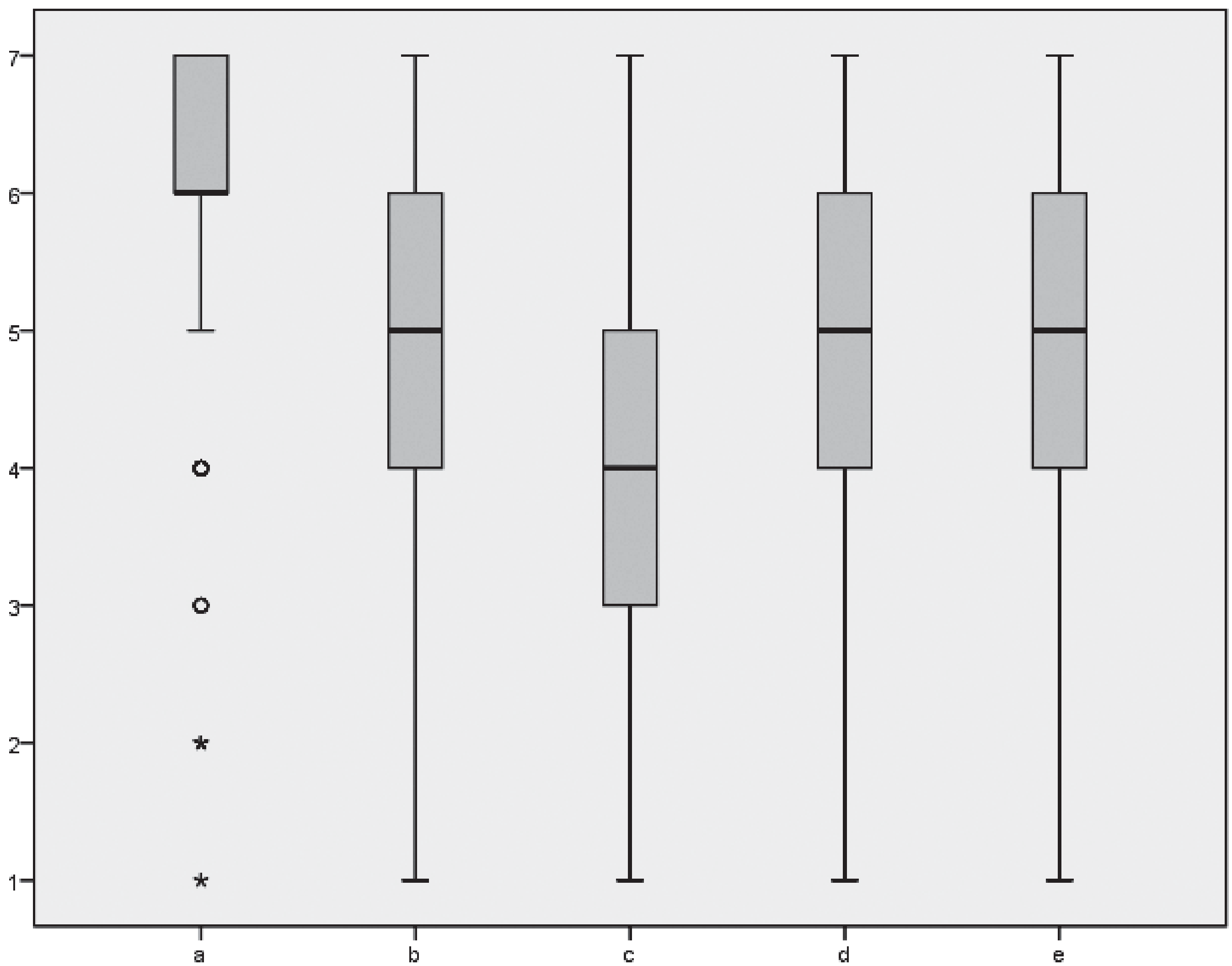

FIGURE 5. A boxplot of the student responses on a scale of 1 (strongly disagree) to 7 (strongly agree) about five statements on reuse – reusing treated wastewater a) is being environmentally responsible, b) reduces amount of pollutants discharged to the environment, c) will cause health concerns, d) will bring personal economic benefits, and e) will bring economic benefits to the participant's community. The bottom and top of the box represent the 25th and 75th percentile and the band near the middle of the box is the 50th percentile (or the median). The circles and asterisk represent extreme values or outliers.

When climate change was not considered, only one county in Ohio was rated at high risk – Franklin County, home to Columbus, the largest city in the state, while more than a dozen counties were rated at moderate risk. When the impact of climate change based on available models was considered, Franklin County was rated at extreme risk, while 14 counties, mostly around the three largest cities in the state – Columbus, Cleveland and Cincinnati; and along the Ohio River were rated at high risk. Although most of Ohio and the Midwestern region were considered to be at moderate risk, some of the urban counties may face water shortages, irrespective of the forecasted impacts of climate change.

Rating the quality of water in both on- and off-campus building as average either reflects the perceptive quality of drinking water or that students have a higher expectation of water quality, and neither of the waters meet that quality. It is also possible that the respondents did not have a strong opinion and therefore, selected the middle option to reflect their neutrality. When a hypothetical scenario of an outbreak of water-borne illness was provided in the questionnaire, students placed a higher level of trust on the university as compared to the local utility companies to ensure supply of high quality water. Utility companies' failure to maintain public trust (Kantanoleon and others 2007) has been compounded by incidents such as the Cryptosporidium outbreak in 1993 in Milwaukee, Wisconsin (Mac Kenzie and others 1994). Being a public educational institution, the university is likely to be perceived as more trustworthy than local utility companies. In a study on public trust in the siting of hazardous waste facilities in Arizona, Ibitayo (2002) reported that a greater proportion of the public lacked trust in the developer managing the hazardous waste facilities as compared to the state agency. The accountability of a public institution could be a reason for the higher level of trust placed on it by the stakeholders.

Agricultural run-off and industrial discharge have been long known to cause pollution in rivers (Logan 1993, Nedeau 2003, Singh and others 2005). However, strict monitoring by USEPA since the 1970s has reduced pollution from point sources such as industrial discharges. Non-point sources such as agriculture, animal farms, sewer overflows, and septic systems are now considered major sources of pollution. Though industrial animal farms have been in existence for over 60 years, their contribution towards pollution in local watersheds has been highlighted recently due to consolidation of farms (Marks 2001) and development of

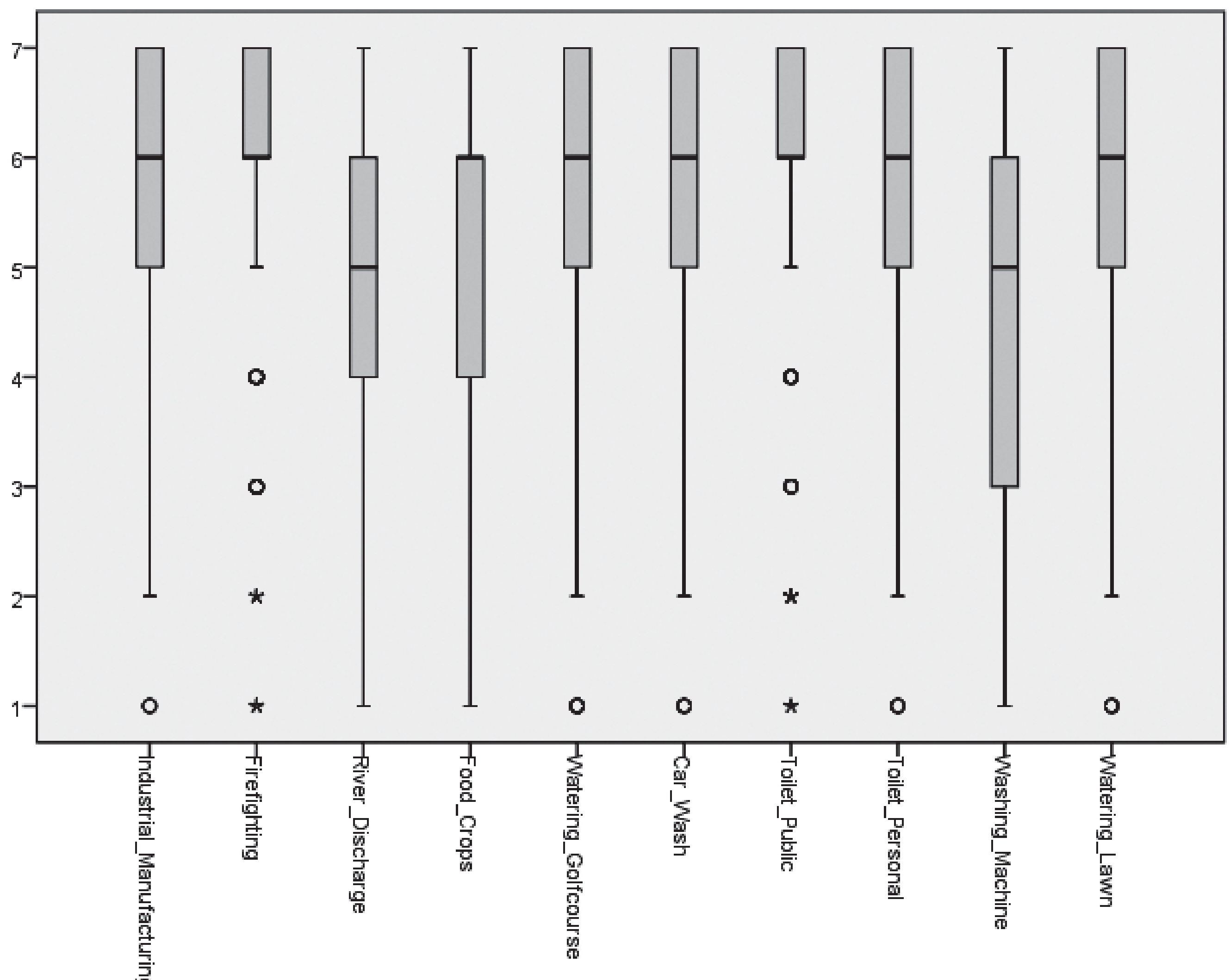

Figure 6. A boxplot of the students' support on a scale of 1 (strongly disapprove) to 7 (strongly approve) for ten hypothetical reuse applications – a) industrial manufacturing, b) fire fighting, c) washing cars in a commercial facility, d) watering golf courses, e) watering domestic lawns, f) flushing toilets in the participants' residence, g) flushing toilets in public restrooms, h) use in domestic washing machines, i) discharge into a river, and j) growing food crops in a farm. The bottom and top of the box represent the 25th and 75th percentile and the band near the middle of the box is the 50th percentile (or the median). The circles and asterisk represent extreme values or outliers.

newer techniques like the microbial source tracking using genetic markers for various animals such as cattle (Call and Plescia 2008) and pigs (Mieszkin and others 2009). In a study conducted to assess public support for the wet weather improvement program in Hamilton County, Ohio, the respondents were asked to indicate the most likely source of pollution in the Ohio River (Vedachalam and others 2010). The respondents rated industrial discharge as the most likely source (mean score=5.7 on a Likert scale of 1 to 7), followed by storm sewer overflows (mean=5.6) and industrial animal farms (mean=4.7). Septic systems were not offered as an option to the respondents. Though the responses provided by the students are in alignment with the views of the general population, they are not indicative of the factors causing pollution in water bodies.

When presented statements about wastewater reuse, the respondents agreed with the benefits of wastewater reuse, although they were divided in their opinion about potential health concerns arising from wastewater reuse. Some of these statements were adapted from Dolničar and Schäfer (2009), where the authors reported results as the number of respondents who agreed with certain statements related to treated wastewater (the authors used the term 'recycled water'). More than 85 percent respondents agreed with statements a and b, while 60 percent of the respondents agreed that consumption of treated wastewater could lead to health concerns (statement c).

The approval scores for wastewater reuse applications match those obtained by Friedler and others (2006) and Dolničar and Schäfer (2009). In the original study, Friedler and others (2006) collected the opinion of residents of Haifa, Israel on 22 applications, which were divided into three categories based on the level of contact as low, medium, or high. Similarly, the ten applications presented in this questionnaire were categorized in the following way:

Low contact: industrial manufacturing, firefighting, washing cars in a commercial facility, and flushing toilets in public restrooms.

Medium contact: watering golf courses, flushing toilets in own residence, and watering personal lawns.

High contact: growing foods crops on a farm, discharge into a river, and for use in domestic washing machines.

Friedler and others (2006) reported that reuse options such as firefighting, public park irrigation, domestic toilet flushing, private garden irrigation, and washing cars received high levels of support, while high contact applications such as discharge into recreational lakes and aquifer augmentation received low levels of support. Similarly, Dolničar and Schäfer (2009) reported that toilet flushing, watering gardens, firefighting, golf course irrigation and washing cars received high levels of support, while applications such drinking and cooking received low levels of support. Respondents' support for the ten reuse options was recorded to ultimately determine their broader perceptions towards the practice of wastewater reuse. This is determined by measuring the Cronbach's alpha, which is a measure of internal consistency of the responses. A high value of alpha (0.70 or higher) is often used as evidence that the individual items (statements or questions) on the questionnaire truly measure an underlying construct. In the case of wastewater reuse applications, the Cronbach's alpha for the ten applications was 0.839, suggesting that the items have internal consistency. Tests conducted to verify if factor analysis is appropriate for this data yielded favorable results. The Kaiser-Myer-Olkin (KMO) measure of sampling adequacy yielded a score of 0.836, and the Bartlett's test of sphericity yielded significant results (approx. $\chi2=2740.22$, $p < 0.001$). A KMO statistic close to 1 indicates that patterns of correlations are relatively compact and therefore, factor analysis should yield distinct and reliable factors. The Bartlett's test of sphericity tests the null hypothesis that the original correlation matrix is an identity matrix. Therefore, a significant result means that the original matrix is not an identity matrix and that there are certain relationships between the variables that can be studied further (Field 2005). Factor analysis indicated the presence of two components, one containing all the high contact applications and another containing all the medium- and low-contact applications. This analysis shows that support for wastewater reuse is dependent on the level of contact and confirms the observation reported by Bruvold (1984), Jeffrey and Jefferson (2003) and Friedler and others (2006) that support for wastewater reuse decreases as the severity of contact increases.

Conclusions

The survey results indicate that most students lack information about certain facts and practices regarding water usage or wastewater. The students have limited knowledge on issues related to water consumption and quality. The students have a perception that the university provides a higher quality of drinking water compared to utility companies, even though the university does not undertake any additional treatment. The students displayed more trust in the university over utility companies to provide high quality drinking water in the hypothetical event of a water-borne illness outbreak. The students incorrectly attributed the poor quality in rivers to discharge from industrial establishments. The students are overwhelmingly supportive of wastewater reuse efforts, but are somewhat concerned about health safety, one of the common concerns expressed by consumers when a reuse program is proposed (Friedler and others 2006; Hartley 2006). Support for any wastewater reuse application is inversely related to the level of contact with the reused water. Discharge of treated wastewater into river, a currently EPA approved practice received low support, indicating that some of the perceptions are not based on available scientific information.

The survey showed strong support from students towards a water management and wastewater reuse program, but also demonstrated a need to educate them on issues related to water quality and quantity. Azapagic and others (2005) reported a similar result where undergraduate engineering students recognized the importance of sustainable development, despite their low level of knowledge on that topic. Setting up pilot projects is a recommended method to gain public acceptance of wastewater reuse projects (Gibson and Apostolidis 2001). Given the higher level of trust in the university, the wastewater reuse program could be instituted on the university campus as part of an effort to increase awareness about the issue and also serve as an educational tool. The water supply projection for the year 2050 by Roy and others (2010) shows urban areas at high to extreme risk. Water management and wastewater reuse programs could be way to enhance water security in an uncertain future.

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