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Golf Course Superintendents' Attitudes and Perceptions Toward Using Reuse Water for Irrigation in the Southwestern United States

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SUMMARY. Golf course superintendents in the southwestern United States (Tucson, Ariz.; Phoenix, Ariz.; Las Vegas, Nev.; Orange County, Calif.) were surveyed to assess attitudes toward using reuse water for irrigation. Eighty-nine golf course

personnel returned the survey, with 28% indicating that they irrigate with municipal water, 36% with well water, and 27% with reuse water. The reason for switching to reuse water varied by state, with 40% of respondents switching in Arizona because of mandates, 47% switching in Nevada because of cost incentives, and 47% switching in California because it was considered a more reliable source of water. Less than 20% of the respondents rated the use of reuse water on golf courses and parks to have a negative impact on cost, the environment and health. However, respondents indicated that using reuse water does have a negative impact on the operations of the golf course, with pond maintenance and irrigation maintenance having the highest negative impact (~80%). Multiple regression analysis revealed that among those who indicated that using reuse water would have a negative impact on golf course management, a higher percentage were individuals who had a greater number of years of experience irrigating with reuse water ($P = 0.01$) and individuals who have taken classes on how to use reuse water ($P = 0.05$). Respondents who currently irrigate with reuse water indicated they had changed a wide range of landscape and turfgrass management practices as a result of using reuse water. Based on the results of this survey, it was concluded that golf course personnel in the southwestern U.S. do not oppose the transition to reuse water for irrigation. However, it was also clear they recognize using such water negatively impacts their golf courses' operations.

The population of the southwestern U.S. (Arizona, California, Nevada) increased by 18% from 1990 to 2000 [Nevada 66%, Arizona

40%, California 14% (U.S. Census Bureau, 2004)]. Such growth places increasing pressure on available water resources, which impacts directly and indirectly the quality of life of all residents residing in this geographical area. Golf courses in particular are being asked to conserve more water. Irrigating based on evapotranspiration feedback (Devitt et al., 1992), improving irrigation uniformities (Leskys et al., 1999), and reducing leaching fractions (Dean et al., 1996; Devitt et al., 1992; Leskys et al., 1999) will all help golf courses meet new conservation standards being set, such as 7.0 acre ft (8634.4 m³) per year in southern Nevada (Southern Nevada Water Authority, 2004). To reallocate fresh water for higher priority uses, many golf courses in the southwestern U.S. are also being asked to transition to reuse water (tertiary-treated sewage effluent). In some cases economic incentives are used while in other cases it is simply mandated. Although reuse water provides nutrients and under conditions of drought is often considered to be a more reliable source of water than municipal water, reuse water also contains elevated levels of unwanted soluble salts (U.S. Golf Association, 1994). Fortunately, golf courses typically have state-of-the-art irrigation systems and highly trained personnel to undertake this challenge.

In previous surveys that assessed the general public's attitudes toward reuse water options (Bruvold et al., 1969, 1981; Kasperson, 1977), a consistent pattern was observed between negative attitudes toward reuse water and the degree of human contact. Other surveys have documented support for wastewater being treated and reused rather than being discharged into the environment (Bruvold and Ongerth, 1974). Factors that can influence decisions to use reuse water include cost (Pagorski, 1974), public perceptions of water shortages, and whether adequate treatment technologies exist to provide safe reuse water (Bruvold, 1985). Bruvold in 1988 found that in communities faced with making decisions regarding their options for reuse water, degree of human contact was not the controlling factor. Instead, public opinion was found to favor reuse options that conserved water, enhanced the environment, protected health and held down treatment and distribution costs.

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Superintendents in the southwestern U.S. have expressed concerns over the long-term impact such water will have on their courses (various regional golf course superintendents, personal communications). Educational outreach programs through cooperative extension at universities in the southwestern U.S. (University of California, University of Arizona, and University of Nevada) have been initiated to address some of these concerns. Unfortunately, little quantifiable information has been gathered on attitudes and perceptions of end users using reuse water. Therefore, a survey was conducted of superintendents working in the southwestern U.S. to assess their attitudes and perceptions toward using reuse water for irrigation.

Materials and methods

A questionnaire was developed and delivered in 2002 to assess golf course superintendents' or assistant superintendents (one response per golf course) attitudes toward using reuse water for irrigation on golf courses in Arizona (Phoenix and Tucson), Nevada (Las Vegas Valley), and California (Orange County) ($n = 170$). Responses totaled 89, with 43 respondents from Arizona (56%), 32 from Nevada (64%), and 14 (33%) from California. The questionnaire was made up of four parts: Part 1 assessed the respondents' job and place of employment; Part 2 assessed the respondents' views on environmental issues; Part 3 assessed the respondents' knowledge, use, and views on using reuse water for irrigation; and Part 4 assessed the sociodemographic characteristics of the respondents.

Responses were analyzed as a composite sample and also by state and plotted as bar graphs. Where appropriate, linear or multiple linear regressions were performed on the data. A backward stepwise approach was used for the multiple regressions, with variables removed if nonsignificant at $P > 0.05$. When attitudes or perceptions were assessed, either the respondents were instructed to select one response from among several, or a ten-point response scale was used (where a rating of 1 = least or lowest; 10 = most or highest).

Results and discussion

DESCRIPTION OF RESPONDENTS. Forty-eight percent of the respondents

Table 1. Responses of golf course superintendents working in the southwestern U.S. to sociodemographic questions on a survey regarding their use of reuse water.

Location	Response (%)	Occupation	Response (%)	Time in industry	Response (%)	Age	
						Age group (years)	Response (%)
Arizona	48	Superintendent	81	<1	1	20–30	21
Nevada	36	Assistant superintendent	18	1–5	2	31–40	39
California	16	Horticulturist	1	6–10	21	41–50	28
				11–15	30	51–60	10
				16–20	22	>60	2
				>20	24		

Table 2. Responses of golf course superintendents working in the southwestern U.S. to sociodemographic questions on a survey regarding their use of reuse water.

Gender	Response (%)	Ethnicity		Education		Salary	
		Ethnic group	Response (%)	Highest degree	Response (%)	Salary group (\$1000)	Response (%)
Male	100	Caucasian	84	High school	12	15–30	3
Female	0	Hispanic	11	Trade school	3	31–60	49
		Native American	3	Some college	19	61–100	39
		Asian	1	2-year degree	26	>100	9
		Pacific Islander	1	4-year degree	35		
		African American	0	Advanced degree	5		

were from Arizona, 36% were from Nevada, and 16% were from California (Tables 1 and 2). All of the respondents were male, 84% were Caucasian, 81% were superintendents, 97% had worked in the golf course industry for more than 5 years, 66% possessed a 2-year degree or higher from a university, 67% were 31 to 50 years in age, and 48% had a yearly salary of \$61,000 or greater.

When respondents were asked where they obtain their professional information concerning golf course management, 10 of the 15 information sources were being used on a regular basis by at least 70% of the respondents (Fig. 1). Ninety-nine percent indicated that they rely on their professional organizations to provide this type of information on at least a regular basis (≥ 5 , where 5 = regularly). However, with the exception of newsletters, none of the other general mass media categories were selected as a source of information they would use on at least a regular basis by greater than 50%. Post-formal education classes (semi-

nars and conferences) ranked higher for providing information than university classes, which suggest that universities wishing to transfer technology should be coordinating with educational outreach programs in the community (such as extension-type programming to reach this clientele).

Respondents were also questioned as to their job satisfaction. Eighty-nine percent of the respondents indicated that they were satisfied or very satisfied with their current job. Ninety-five percent indicated they plan to continue to work in the golf course industry, while only 71% indicated they plan to continue to work in their current geographical location.

DESCRIPTION OF GOLF COURSE FACILITIES IN SURVEY. Seventy percent of the respondents worked on 18-hole golf courses, whereas 28% worked on golf courses with greater than 18 holes. As expected, the number of employees on these golf courses varied in a linear fashion with the number of holes at the golf course. The number of holes on each golf course accounted

for 46% of the variability in the number of employees [number of people employed = $2.72 + 0.47(\text{number of holes})$, adjusted $R^2 = 0.46$, $P = 0.001$]. Forty-nine percent of the golf courses had 11 to 25 employees, 28% had 26 to 50 employees, and 15% had over 50 employees. The number of years each facility had been in operation was quite variable, with 15% in operation less than 3 years, 23% in operation from 4 to 10 years, 23% in operation from 11 to 19 years, and 36% in operation 20 or more years. Seventy percent of the golf courses had annual operating budgets in the range of \$500,000 to \$2,000,000, with annual water budgets ranging from \$3,000 (well water, Arizona) to \$1,200,000 (municipal water, 54 holes, Nevada). Annual operating budgets varied according to the number of employees working at the golf course and the cost of water (but not the number of holes), with both variables accounting for 62% of the variability in the annual operating budget ($P = 0.001$).

The type of water used for irrigation included municipal water (28%), well water (36%), and reuse water (27%). Those golf courses that switched to reuse water did so either because switching to reuse water was mandated (33%), cost incentives were provided (26%), reuse water was a more reliable irrigation source (24%), or water conservation (15%). Interestingly, the main driving force varied by state (Fig. 2), with the largest number of responses in Arizona switching because it was mandated (40%), in Nevada because of cost incentives (47%), whereas in California because it was a more reliable source of water for irrigation (47%).

ENVIRONMENTAL ATTITUDES OF RESPONDENTS. Ninety-five percent of the respondents rated environmental issues significant to the southwestern U.S. as extremely important. Among the six individual environmental issues they were asked to rank, high to highest ratings (≥ 7 , where 7 = high) were given to: water conservation (96% of respondents), water pollution (90%), pesticide usage (85%), energy conservation (80%), air pollution (70%), and population growth (52%). Only 33% of the respondents had confidence that technology will be able to resolve these environmental problems (48% said maybe). Eighty percent of the survey respondents indicated that water issues were a priority in their community, and

Fig. 1. Respondents were given a list of sources of information they use on a regular basis for making management decisions. Only responses ≥ 5 (where 5 = regular use) were included. Responses are reported as a percentage of the total number of responses.

Fig. 2. Respondents were given a list of reasons why they switched to reuse water. Responses are reported as a percentage of the total number of responses and separated by the state where the respondent worked (Arizona, California, or Nevada).

95% indicated that they have made a conscious effort to conserve water. Only 31% believed that their communities had enough water to support growth (38% not sure). When asked how their community should balance

its water needs, 32% indicated it should use all possible means, 31% indicated emphasis should be placed on conserving water, 17% suggested controlling growth, while 14% indicated the pursuit of new water sources

ATTITUDES TOWARD REUSE WATER.

Although 36% of the respondents currently use reuse water for irrigation, 28% not currently using reuse water believe they will be using reuse water in the near future. When asked where treated sewage effluent was discharged or used in their community, less than 30% of the respondents, irrespective of their state, knew the correct answer. When asked what percentage of local municipal water is eventually discharged as treated sewage effluent, over two thirds of the respondents in each state indicated that they did not know. Although these two questions are not critical to managing reuse water on golf courses, such information reflects a general lack of knowledge concerning regional water balances and how reuse water and golf courses fit into this balance.

Respondents were asked to rate their level of acceptance toward using reuse water for different purposes (Fig. 3). As the degree of human contact with reuse water increased, responses rating the activity as unacceptable increased. Use of reuse water for dust control, golf courses, parks, home lawns and crops had fewer than 20% of the respondents rating these activities as unacceptable (rating of ≤ 4), with no statistical separation occurring based on the use of reuse or fresh water for irrigation. Reuse water used for drinking and food preparation was rated unacceptable by greater than 80% of the respondents. It was somewhat surprising that the use of reuse water for irrigating home gardens did not have a higher percentage of respondents rating it as unacceptable (22%). This may have been due to confusion whether home gardens meant edible plants or ornamentals. Respondents were then asked to rank the potential negative impact that using reuse water (cost, environment, health) might have on golf courses, parks, recharging groundwater, discharging into lakes and streams and using reuse water for drinking purposes (Fig. 4). Less than 20% of respondents (no statistical separation occurred based on whether the respondents used reuse or fresh water for irrigation) considered the potential impact of reuse water to be negative on golf courses and parks. However, responses toward using reuse water for recharging groundwater, discharging into surface water, and for drinking purposes revealed a significantly lower

Fig. 3. Respondents were asked to rank the unacceptability of different potential uses for reuse water. Only responses ≤ 4 (where 4 = a slightly unacceptable use) were included. Responses are reported as a percentage of the total number of responses.

Fig. 4. Respondents were asked to rank their perception of negative impacts resulting from the use of reuse water on golf courses, parks, for groundwater recharge, discharge into lakes and streams, and supplementing drinking water. Respondents were asked to further rank perceived impacts based upon economic cost, impact on the environment and impact on health. Only responses ≤ 4 (where 4 = a slightly negative impact) were included. Responses are reported as a percentage of the total number of responses.

level of acceptance (~20% to 80% of respondents giving low ratings). Although health issues were ranked low, when asked who was a trusted source of information regarding the safety of using reuse water (Fig. 5), university scientists were selected first, followed closely by turfgrass professional organizations. However, statistical separation ($P < 0.05$) did occur between these two groups (scientists and professional organizations) based upon whether respondents used reuse or fresh water for irrigation. A higher percentage of those using reuse water rated university scientists as a more trusted source of information on the safety of using reuse water (50% vs. 22%) whereas a higher percentage of those using fresh water rated turfgrass professional organizations higher (34% vs. 15%). Surprisingly, public health organizations and sanitation districts did not rank as high. Politicians received no survey votes, yet they propose regulations and statutes mandating golf courses to transition to reuse water.

Forty-six percent of the respondents indicated that they had no prior experience with reuse water, and 28% indicated they had less than 5 years of experience. On a state basis, California had a lower percentage of respondents with less than 5 years of experience (64%) than Nevada (81%) and Arizona (82%). Only 44% of the respondents indicated that they have attended classes on the use of reuse water, whereas 89% of those taking classes thought they were better or somewhat better prepared to use reuse water for irrigation. When asked to rank the negative impacts that reuse water might have on golf course operations (Fig. 6), pond maintenance ranked highest followed by irrigation maintenance (no difference between users and nonusers). Possible negative impacts on golfers, rounds of golf and green fees were selected by less than 20% of the respondents. Separation of responses between reuse users vs. non-reuse users, using a 10% difference as the basis for separation, revealed three such categories: irrigation of shrubs and trees (10% difference, higher negative rating by users), public relations (15% difference, higher negative rating by users), and human health (17% difference, higher negative rating by nonusers). Differences in the response between users and non-users are most likely due

Fig. 5. Respondents were asked who they trusted for sources of information regarding the safety of using reuse water. Responses are reported as a percentage of the total number of responses.

Fig. 6. Respondents were asked to rate their perception of the negative impact of using reuse water on different golf courses operations. Only responses ≤ 4 (where 4 = a slightly negative impact) were included. Responses were separated based upon whether they currently use reuse water (reusers) or do not use reuse water (non-reusers). Responses are reported as a percentage of the total number of responses.

to the experience gained by those golf course personnel using reuse water. Multiple regression analysis revealed as experience with reuse water increased, there was an increased perception that golf course public relations would be impacted negatively ($P = 0.01$). This response decreased if the respondent took classes regarding reuse water ($P = 0.05$). However, in the case of irrigating shrubs and trees, separation occurred between superintendents and assistant superintendents ($P = 0.01$). A greater number of assistant superintendents believed that less damage would occur, when compared to superintendents, possibly indicating a difference in their education and level of experience. Multiple regression analysis revealed that those with more experience with reuse water ($P = 0.01$) and had taken classes on how to use reuse water ($P = 0.05$) perceived that using reuse water would have a greater negative impact on golf course management.

Respondents who indicated that they irrigate with reuse water were asked what landscape or turfgrass management practices they changed as a result of using reuse water (Fig. 7). Although the highest percentage of respondents indicated a change in irrigation scheduling (78%), the other categories (irrigation maintenance, soil amendments, fertilizers, drainage and soil preparation) were selected by at least 65% of the respondents. It appears that golf course personnel were more likely to change management practices that they perceived were more directly under their control. Pest control practices were changed by less than 20% of the respondents using reuse water, indicating pest problems were not perceived to substantially increase as a result of using reuse water. Based on these actual or perceived changes, they were asked the type of research that would most benefit them. All of the choices were perceived as important (turfgrass management 80%, water management 75%, fertilizers 70%, plant water use 65%, irrigation technology 65%, and desert landscapes 50%) (≥ 7 , 7 = high). When selection was separated based on reuse users vs. non-reuse users and a higher rating (≥ 8) was used as the cutoff, only turfgrass management met this criterion for reuse users but plant water use, irrigation technology, water management and turfgrass management met this criterion for non-reuse users. This suggests that

Fig. 7. Respondents were asked what changes in golf course operations would be needed when changing to reuse water. Only responses ≥ 7 (where 7 = high likelihood of change) were included. Responses are reported as a percentage of the total number of responses.

the perceived research needed to support experienced users of reuse water is more focused than that perceived needed by nonusers, which probably reflects their differences in education, experience and confidence.

In the final section of the survey we asked the respondents if they had school age children and if those children played at public parks. We then revisited the question of acceptance toward using reuse water for the irrigation of parks (≥ 7 , 7 = highly acceptable). We found less acceptance (73% vs. 53%) if the respondents had children who could come in closer contact with this water. Such a response suggests that respondents were more likely to support the use of reuse water for irrigation if the perceived impact was on someone else and not on a member of their own family.

The respondents' perceptions of reuse water's impact on human health, cost, conservation, and the environment were documented in this survey, however, not all of these factors proved to influence acceptance. Acceptance of using reuse water to recharge groundwater decreased as the perceived impacts on human health ($P < 0.01$) and the environment ($P < 0.05$)

increased, accounting for 54% of the variability. The acceptability of using reuse water for recreation and boating decreased as the perceived impact on human health became more negative ($r^2 = 0.39$, $P < 0.001$). Acceptance of irrigating parks with reuse water was linked to a positive impact on the environment ($r^2 = 0.30$, $P < 0.001$), whereas acceptance of using reuse water for drinking purposes decreased as the perceived impact on human health became more negative ($r^2 = 0.28$, $P < 0.001$). Finally, the acceptance of irrigating golf courses with reuse water ($r^2 = 0.25$) increased as perceptions of its negative impact on human health decreased ($P < 0.001$) and positive impact on water conservation increased ($P < 0.05$). The fact that using reuse water to irrigate golf courses had a very high acceptance rating, connected to a perceived positive impact on human health and water conservation, suggests that golf course personnel do not consider the human contact factor to be as much of an issue on golf courses, in clear contrast to the use of reuse water for other purposes (Fig. 3).

Based on the results of this survey we concluded that golf course personnel in the southwestern U.S.

do not oppose the transition to reuse water for irrigation. However, they recognize that using such water will negatively impact the operations on golf courses and that these impacts have associated costs. Recognizing that these negative impacts occur and having access to current information on Best Management Practices (BMPs) will help minimize the level of impact. Identifying impacts, however, requires more experience using reuse water by golf course personnel and better information transfer by universities and professional turfgrass organizations. Only 36% of the golf courses in this survey irrigate with reuse water, with 74% of the total respondents having either no prior experience or less than 5 years of experience irrigating with reuse water. Responses differed based on whether the respondent irrigated with reuse water or not and whether the respondent was a superintendent or an assistant superintendent. These differences will be especially critical for new courses transitioning to reuse water in which the superintendent lacks prior experience or education. Water agencies regulating reuse water should recognize the impact reuse water has on golf courses. When reuse water for golf course irrigation is implemented, golf courses need an appropriate lead time for education to occur; it must be recognized that water requirements will increase as a direct result of using this water (higher salt content); and it must be anticipated that unidentified costs will be associated with using reuse water, such as foliar damage to landscape plants, deterioration of water quality, increased pond maintenance, increased irrigation maintenance, soil drainage improvements, and potential damage to salt sensitive (bentgrass) greens. Hence, water purveyors must recognize that reuse water and fresh water do not have the same value to the end user, and that there are costs associated with the use of reuse water.

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