2007

Desalination and recycling: Australians raise health, environment and cost concerns

Sara Dolnicar
University of Wollongong, s.dolnicar@uq.edu.au

A. Schafer
University of Edinburgh, UK

Publication Details
This article was originally published as Dolnicar, S & Schafer, AI, Desalination and recycling: Australians raise health, environment and cost concerns, International Desalination & Water Reuse Quarterly, 16 (4), 2007, 10-16.

Desalination and recycling: Australians raise health, environment and cost concerns

Abstract

Desalination and recycling are hot topics in Australia, with considerable public opposition to both technologies in a country that is desperately short of water. The authors have done new research which show that, while the results are "very clear", the lack of knowledge among the population makes their choices less than informed.

Keywords

Public acceptance, recycled water, desalinated water, marketing

Disciplines

Business | Social and Behavioral Sciences

Publication Details

This article was originally published as Dolnicar, S & Schafer, AI, Desalination and recycling: Australians raise health, environment and cost concerns, International Desalination & Water Reuse Quarterly, 16 (4), 2007, 10-16.

DESALINATION AND RECYCLING
Australians raise health, environment and cost concerns

Sara Dolnicar, University of Wollongong, Australia, and **Andrea I Schäfer**, University of Edinburgh, United Kingdom.

Editor's note

Desalination and recycling are hot topics in Australia, with considerable public opposition to both technologies in a country that is desperately short of water. The authors have done new research which show that, while the results are "very clear", the lack of knowledge among the population makes their choices less than informed.

Water resources are limited in both quantity and quality. The global water-cycle is a closed system with water molecules being continuously taken in and excreted by living organisms [1]. Against this continuum of natural recycling, an interesting debate is taking place regarding the acceptance and suitability of human-assisted water recycling.

Water recycling is the treatment of municipal wastewater for the replenishment of available freshwater resources and consumption. Water recycling hence closes the water-cycle on a more local level with the possibility of closing water-cycles for individual households, buildings, factories, towns or regions.

The motivation for this activity is mostly the realization that human water consumption has increased beyond sustainable levels, resulting in extended periods of 'drought', depletion of environmental flows in natural water systems and the decrease in healthy levels in drinking water reservoirs, including groundwater systems.

While wastewater treatment is available to achieve recycled water qualities often superior to current potable water standards [2,3], the notion of drinking wastewater is not a concept that benefits from unconditional public support. In fact, the public often vehemently reject water recycling activities and several public consultation studies have been carried out to explore reasons for this resistance and how to gain community support. As a result recycled water is available in countries with severe water restrictions, but clients for this recycled water often cannot be found.

Blame for this can be apportioned to:

- lack of infrastructure to supply such recycled water;
- a highly subsidized and very cheap potable water resource; and possibly
- a lacking community awareness of the limitations of such freshwater resources, in particular in urban areas.

This requires new problem-solving approaches to water supply [4].

In a different approach to circumvent the difficulties with recycled water acceptance, some countries are considering desalinating seawater to make up the shortfall in drinking water and avoid public acceptance problems. In other countries desalination is well established, and reuse is considered as an alternative.

The growth in the production of desalinated water worldwide is near exponential [5]. Such growth can be explained with reduced costs of desalination technology, although the cost of desalinated water remains higher than what the public is normally charged [5].

This raises a number of key issues with regards to energy consumption, water quality and environmental impacts. Of interest in this project is to:

- evaluate the perception of recycled versus desalinated water;
- evaluate the comparative acceptance of the community of recycled versus desalinated water;

- determine which water the population surveyed would be willing to consider for a range of applications; and
- assess which are currently the major concerns about adopting these alternative water sources.

The study is conducted in the Australian context.

Energy consumption and cost

Energy is a prime driver when decisions about water and wastewater treatment technology are to be made, since energy is a large fraction of the cost of water provision. Water transport as well as treatment require energy, and, in general, the more advanced the treatment, the more energy is required.

Other cost factors are pretreatment, chemical addition, cleaning, maintenance and capital. Both water recycling and seawater desalination for potable purposes use an almost identical technology, namely reverse osmosis.

However, given the nature of the water to be treated, energy requirements are different, as the amount of total dissolved solids (TDS), a measure of salinity, to be removed from seawater is significantly higher. The TDS concentration of municipal wastewater can be expected between 0.1-1 g/L, while seawater TDS is generally above 35 g/L, hence 35-350 times higher. As the name implies, reverse osmosis operates by overcoming the osmotic pressure of a water by an applied pressure. Hence, the higher the TDS, the higher the required energy to supply the necessary pressure.

According to Dawoud [5], 50% of the cost of desalinated water is the energy component, while Hinkebein and Price [6] give a figure of 44% also for seawater. Côté et al. [7] estimate energy costs to be 33% of the total lifecycle cost for desalination and a four times higher feed pressure and higher feed flow compared with reuse.

Comparing desalination with water recycling, both capital costs as well as operation & maintenance costs were double for the desalination plant, with the overall cost for desalination being 2.21 times higher than reuse [7]. However, according to Dawoud the demand for water is greater than that for energy [5], which may be one reason for the frequent neglect of energy considerations.

Adham et al. [8] have developed a model that allows the estimation of order-of-magnitude desalination costing for three water sources, namely brackish groundwater, surface water and recycled water (TDS assumed as 1 g/L for all). Power costs are linear with plant capacity and represent about 25% of the operational cost where cost for brackish water desalination is about 50% of water recycling.

Unfortunately no seawater data is available. Adham et al. [8] noted that power costs are the most important and volatile component of such systems. In a very comprehensive cost comparison, Dreizin [9] describes water recycling and brackish water desalination with a very similar cost. The cost of desalinated water is presented as to be within this range and the energy cost being 25% of the total cost, and 65% of the operational cost.

Energy is seen as the determining factor in the economics of different source waters, with the specific energy consumption for surface, brackish or wastewater being 0.4-1.0 kWh/m^3, versus that of seawater being 3-3.4 kWh/m^3. This illustrates the extreme vulnerability of desalination to energy costs.

Water quality issues

Water quality is a concern in water recycling, as the primary source is municipal wastewater, while seawater is seen as a more pristine source. Wastewater carries what humans excrete and discharge to the drain from various sources such as the kitchen, laundry or miscellaneous dumps of household or garden toxins or pharmaceuticals.

As summarized well by Toze (10), of primary concern are microorganisms, including bacteria, viruses, protozoa and helminthes, that are excreted from ill persons and are the carriers of infectious disease. Such organisms are retained with several ‘barriers’ in water recycling, although the risk of treatment failure exists. This risk is relatively small due to the general implementation of multiple barriers which requires the combination of multiple simultaneous failures.

A second concern is the presence of trace organic compounds such as pharmaceuticals or ‘endocrine disrupting chemicals’ (10). Such compounds do, according to current knowledge, not generally pose an immediate health risk but are a chronic risk where long-term exposure may cause fertility, behaviour, cancer, and other problems of which the real source is more difficult to identify. Other exposure routes for such compounds are food, beverages, contact with chemicals (such as pesticides) or discrete exposure due to accidents, leisure or workplace.

The production of hazardous chemicals is a further concern in treatment, where often specific chemicals are added (such as coagulants and antiscalants) or by-products formed in disinfection or oxidation processes. While the removal of the majority of such chemicals is possible, the technical effort is extensive and possibly unnecessary. Guidelines as well as risk assessment based on possible health effects are being discussed globally at present with regards to specific water applications. It is such water quality and possible failure concerns that limit the acceptability of recycled water for potable purposes, although many drinking water or groundwater supplies are not free of such contaminants.

It should be noted that the technology used for water recycling and desalination on which this study is based is identical (reverse osmosis) which can treat both seawater and wastewater to a quality higher than required for most water applications, especially when considering that about 70% of water is used for irrigation in Australia (11).

Environmental issues recycled vs desalinated water Variation of environmental flows and wastewater discharge with associated impacts on habitats and biodiversity are the obvious consequences of unsustainable water consumption.

This affects natural water bodies such as rivers, lakes, groundwater bodies and wetlands.

Water recycling not only provides clean water, it also requires the clean-up of wastewater which often is discharged to the environment without adequate treatment which causes a range of environmental problems (5,12-15) and may also contaminate drinking water (16).

The environmental impacts with regards to water recycling and desalination can be summarized in the following categories:

Energy consumption and related greenhouse gas emissions as well as air pollution due to desalination are high. Energy requirements, in particular for seawater desalination, need to be reduced. Meerganz von Medeazza [17] suggests a reduction of environmental impacts by a target energy consumption for water production (including transport) at 3 kWh/m^3. Environmental impacts depend on the energy source, and are in most cases associated with significant airborne emissions [17,18]. The desalination approach is in danger of shifting the problem from water to energy. Raluy [19] suggest the coupling of desalination with renewable energies as the environmental impact of desalination plants is dominated by energy.

Waste production and discharge/treatment (such as cleaning effluents and brines/concentrates) affect both the economics as well as the environmental impact of desalination. The concentrate produced in reverse osmosis is a substantial portion of the treated water and contains a concentrated amount of the salt and other contaminants retained by the process. The high salt concentration of brines in seawater desalination can destroy large areas of ocean floor due to the high density of such wastes [17,20]. The effects of brine discharge are further worsened by chemicals added as antifouling agents, coagulants, disinfectants, pH adjustments and specific compounds such as heavy metals that were concentrated [17]. Those compounds are released with to date unknown impacts.

Land usage, noise, visual impact as well as disturbance of recreation areas are other environmental impacts on a more local scale. While broader environmental issues include groundwater intrusion, soil salinity, deteriorated catchments, as well as the spread of invasive species [11]. Lake and Bond [11] predict that if business continues as usual restoration and conservation efforts "will struggle to keep pace with the degradation generated by past legacies, and by continued pressure from resource development".

Review of prior research.

While the issue of public acceptance of desalinated water has not received much attention in the past, prior work into public acceptance of recycled water has taken a number of directions. The majority of work has investigated the willingness of people to adopt recycled water [21-29], finding that the use of recycled water for food preparation and drinking was opposed most, with more than half of respondents (on average across all studies) expressing that they would not want recycled water to be used for this purposes, whereas public uses with lower human contact such as firefighting and irrigation of public spaces demonstrated high public acceptance levels.

A second direction of prior work is the investigation of concerns and perceived advantaged of using recycled water. Bruvold [30] identified negative environmental consequences and economic and health concerns. Dishman et al. [31], in the context of direct potable use, found public health concerns to be central to low acceptance levels. In Australia, Higgins et al. [32] found "public health and the environmental effect of microbiological agents" together with chemicals such as endocrine disrupters a prime concern, while Marks et al. [33] identified quality and cost as the two main concerns among users.

Hamilton [34] proposed that opposition to potable reuse schemes was due to suspicion towards politicians and organizations involved in the projects. While this appears to be of minor importance at first glance, it is in fact central to the development of any measures aiming at increase in public acceptance to be aware of which sources are trusted and which are not.

Not many studies have investigated the perceived advantages of using recycled water. Marks et al.[33] identified three perceived benefits among users at an Australian site: cost savings, positive effect on the environment and the nutritional value of reclaimed water.

Finally a number of studies have aimed at identifying market segments of adopters or recycled water [24-26,35-40]. The one personal characteristic found consistently over a number of studies to be related to acceptance levels of recycled water was education, followed by age and knowledge about reuse, income and gender.

The most comprehensive study of the acceptance of recycled and alternative water uses so far has been published by Marks et al. [41]. In this study the preference for non-potable uses has been confirmed, and, for the first time, other alternative water sources have been included as a comparison with recycled water. While not all uses were evaluated for all water options, respondents demonstrated a high willingness to use grey water and stormwater for garden irrigation and toilet flushing and 52% stated that they were willing without hesitation to use desalinated seawater for all water uses.

Data and methodology

The questions relevant to this research were included in a survey about environmentally friendly behaviour conducted in Australia using a permission-based internet panel. Respondents were randomly selected from a panel maintained to contain respondents representative of the Australian population and received an invitation to complete a 30-minute questionnaire online. The invitation to participate was withdrawn when 1000 respondents had completed the survey.

The questionnaire contained the following questions which allow comparisons between the public perception and acceptance of recycled and desalinated water:

(1) a perceptions / knowledge question in which respondents were asked to state whether or not a number of statements were true for recycled and desalinated water;
(2) a likelihood-of-use question in which respondents were asked to state on a five-point scale how likely they were to use recycled / desalinated water for a list of purposes;
(3) a question in which respondents were asked to rank water uses separately for recycled and desalinated water indicating in which order they would adopt the above listed purposes; and
(4) an open-ended question asking respondents to state their primary concerns with using each of the two water sources.

While the study contains new elements which have not been investigated in the past (knowledge / perceptions about water types in comparison to each other, ranking of uses etc.) some of the limitations of traditional public acceptance studies (see [40,42,43]) also apply to our study: the question about the likelihood of adoption is hypothetical given that most of the respondents have had no prior experience with either recycled or desalinated water, while appearance and smell could not be included in the written online fieldwork as evaluation criteria for their likelihood of use. This study does not assume that the perceptions identified are stable and can be generalized beyond Australia[44].

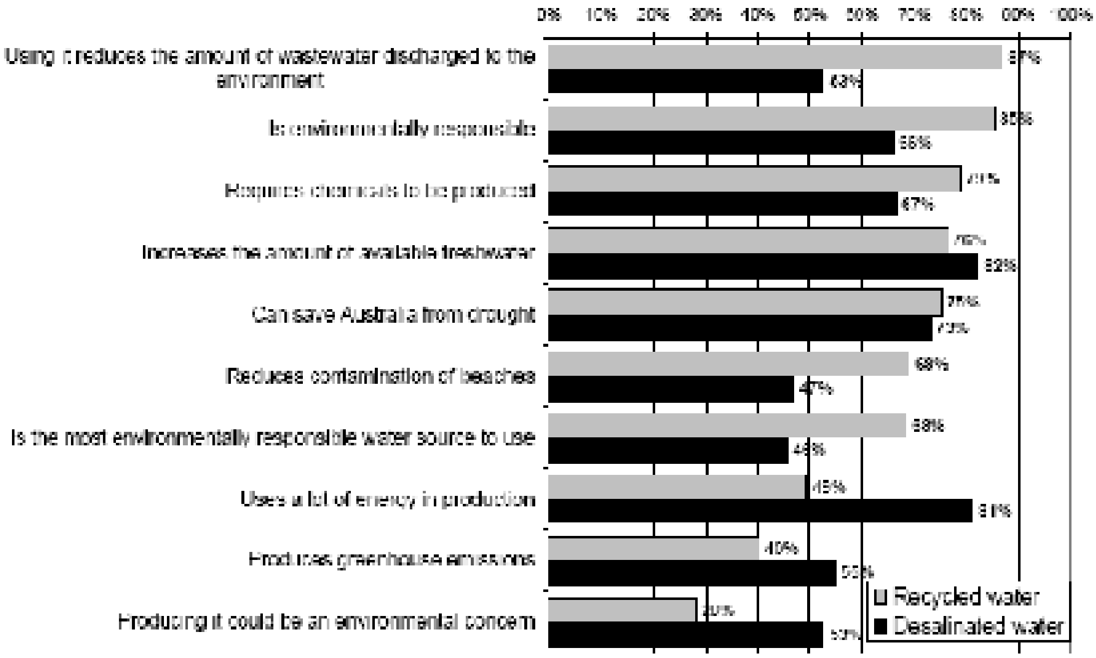
Results and discussion

The open-ended question in which respondents were asked to state their main concerns with recycled and desalinated water led to very clear results. The three main concerns raised by the respondents were health concerns, environmental concerns and cost. Recycled water is perceived as more risky from a health perspective (55% of respondents listed health-related concerns in the open-ended question), desalinated water is primarily perceived as bad for the environment (12%, only 23% mention health-related concerns), but is also viewed as the more expensive alternative with 11% mentioning a cost-related concern. This confirms the earlier findings by Bruvold [30], Dishman et al. [31], Higgins et al. [32] and Marks et al. [33].

However, results derived from the open-ended question do not permit direct comparisons between recycled and desalinated water to be drawn, as respondents were free to express whatever they wanted. We therefore use the set of questions in which respondents were asked to evaluate their perceptions / knowledge about recycled and desalinated water.

The comparison of items related to environmental issues is provided in Figure 1 (sorted in descending order for recycled water).

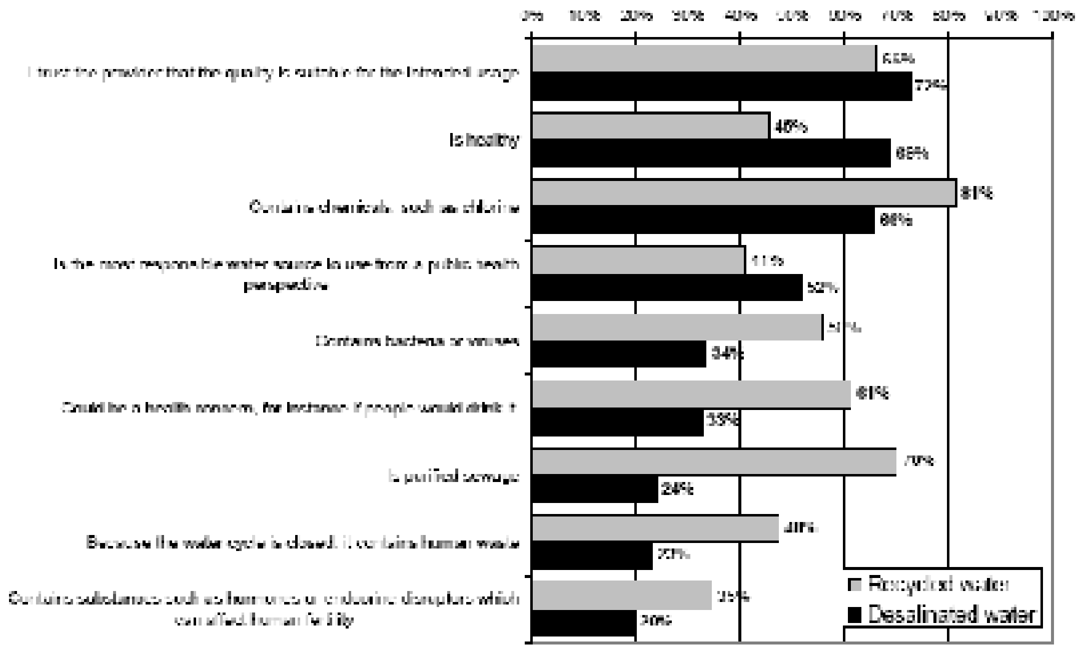
Figure 1: Comparative perceptions / knowledge about environmental issues



As can be seen, the responses to the open-ended questions are mirrored well: recycled water is seen as more environmentally friendly and respondents appear to be well aware of the fact that desalination produces higher levels of greenhouse emissions and requires more energy. Surprisingly, 46% of respondents state that desalinated water is environmentally responsible. Both water options are seen as equally well suited to save Australia from a drought and both are able to increase the amount of available freshwater.

Figure 2 provides the answers to the health-related items.

Figure 2: Comparative perceptions / knowledge about health issues

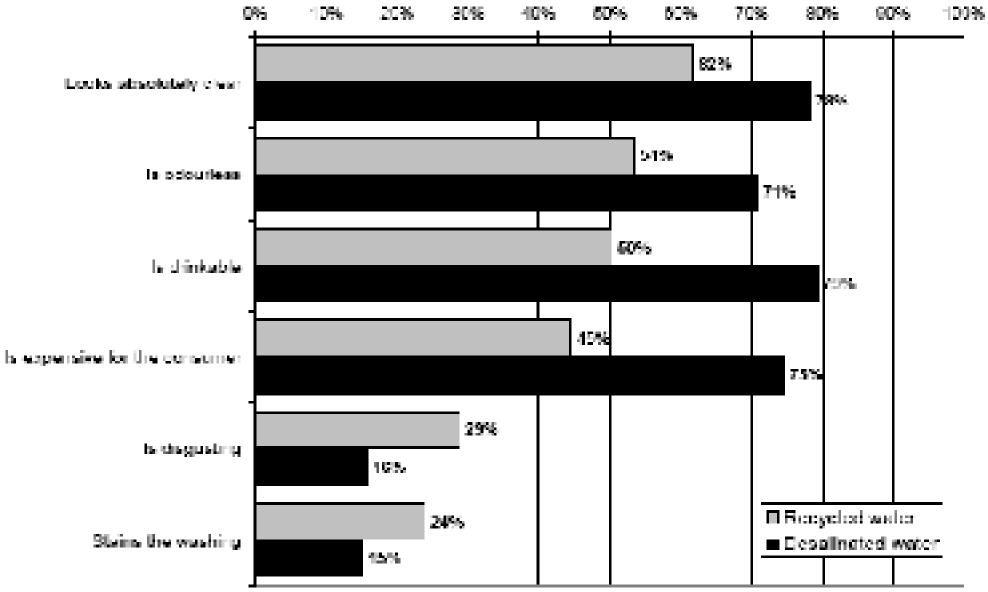


Some 69% of respondents believe that desalinated water is healthy, as opposed to only 46% who state that recycled water is healthy. With respect to all the health-related questions, respondents feel that desalinated water is the safer choice. Interestingly, the level of trust towards providers of both recycled and desalinated water is very similar and high with more than two-thirds expressing their confidence in the water providers.

Despite these clear results, the lack of knowledge in the population is illustrated by the knowledge questions in Figures 1 and 2. For instance, 24% of respondents believe that desalinated water is purified sewage and 20% believe that endocrine disruptors can be found in desalinated water, which is both incorrect.

A number of other, less knowledge-oriented questions were included in the questionnaire, the responses to which are provided in Figure 3.

Figure 3: Comparative perceptions of general nature



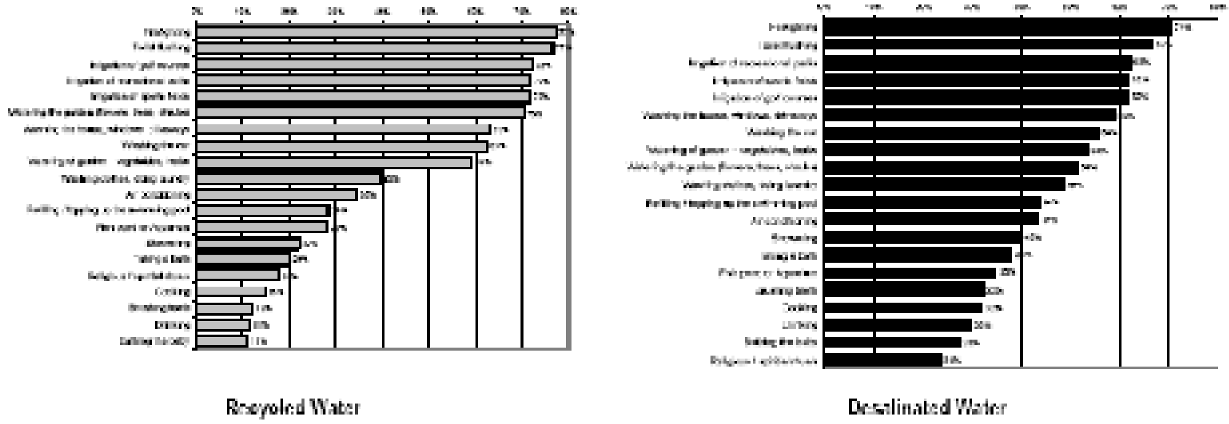
From these results it becomes evident that the reservations of the population towards recycled water are higher than those towards desalinated water. While 79% of respondents perceive desalinated water as drinkable, only half of the respondents classify recycled water as such. Although 61% have health concerns if drinking recycled water, only 33% have those concerns for desalinated water.

Even with respect to clarify and odourless respondents perceive desalinated water to be outperforming recycled water. Recycled water further is seen to contain more chemicals such as disinfectants as well as microorganisms. The one disadvantage that is acknowledged, however, is the higher cost associated with desalinated water.

These results lead to the hypothesis that acceptance levels of recycled water will be lower than acceptance levels of desalinated water. In order to assess whether or not this is the case, the questions about the likelihood of use are analysed.

Figure 4 contains the percent of respondents who indicate a high likelihood of use for each of the listed water usages.

Figure 4: Comparative likelihood of use



As can be seen desalinated water is not generally more likely to be used than recycled water. For those purposes that are close to the body, desalinated water is “very likely” to be used by a larger proportion of the population. For uses which are not close to the body (such as watering the garden) recycled water is “very likely” to be used by a larger proportion of Australians.
A step in likelihood can be observed for recycled water from garden watering to clothes washing, while the decrease in likelihood is more steady for desalinated water. It is possible that the (about 10%) lower likelihood of using desalinated water for “low body contact” applications reflects the knowledge of some respondents that such high quality water is not required for those applications. In the “high body contact” spectrum, this result turns and desalinated water is used about 10-20% more likely than recycled water. Those results indicate that markets for different waters vary.
While this finding is very interesting and can be compared directly to prior work in which acceptance levels or the likelihood of use were studied, the question format of the likelihood question does not put respondents into a situation of trade-off. In principle, they can state not to be likely to use recycled and desalinated water for any of the listed uses.
The above findings are therefore validated by studying the ranking question in which respondents had to indicate in which order they would adopt recycled and desalinated water for different uses, respectively. This question format does put respondents in the situation of having to compare water uses and state the order of adoption of recycled and desalinated water.
While the absolute order shows the typical pattern of close to body uses being adopted last, the above pattern is mirrored in the ranking task: items such as watering the garden, irrigation of parks, and toilet flushing were adopted earlier in the case of recycled water; uses such as refilling the swimming pool, cooking and drinking were adopted earlier in the case of desalinated water.

Conclusions

The Australian population clearly discriminates between recycled and desalinated water.
Although the responses given to the knowledge questions indicates gaps in the general level of knowledge in the population, respondents clearly understand that recycled water is the more environmentally friendly option, whereas desalinated water is perceived as less risky from a public health point of view. The responses to general items such as “is disgusting” indicate that Australians currently have fewer reservations about desalinated water than recycled water. This fact is supported by the question about the likelihood of adoption of both kinds of water where the levels of adaptation for close to body uses are higher for desalinated water.
Interestingly, however, the results indicate that it is not possible to state that either desalinated water or recycled water is generally perceived as preferable by Australians. It appears that Australians discriminate by the nature of the water use, where the likelihood of adoption for “close

to body" uses is comparatively high for desalinated water, as opposed to irrigation and cleaning the car or the house, for which recycled water is ranked higher in the adoption sequence.
While these findings are derived from the aggregate of all respondents, future work should investigate whether personal characteristics, such as the education level, prior experience with recycled or desalinated water, prior experience with drought etc. impact on the knowledge, perception and likelihood of use. Further, other water resources such as stormwater, yellow water (urine) and greywater need to be considered.

Acknowledgements
This project was supported by the Australian Research Council under Discovery Grant DP0557769 and the International Science Linkages programme established under the Australian Government's innovation statement Backing Australia's Ability. It is funded by the Commonwealth Department of Education Science and Training for the project OzAquarec: Integrated Concepts for Reuse of Upgraded Wastewater in Australia (CG030025).

References

1. Suzuki, D. *The sacred balance*; Allen & Unwin, 1997.
2. Bixio, D.; De Heyder, B.; Joksimovic, D.; Chikurel, H.; Aharoni, A.; Miska, V.; Muston, M.; Schäfer, A.; Thoeye, C. Municipal wastewater reclamation: where do we stand? An overview of treatment technology and management practice; *Water Science & Technology: Water Supply* 2005, 5, 77-85.
3. Wintgens, T.; Melin, T.; Schäfer, A. I.; Khan, S.; Muston, M.; Bixio, D.; Thoeye, C. The role of membrane processes in municipal wastewater reclamation and reuse; *Desalination* 2005, 178, 1-11.
4. Weber, W. J. J. Distributed optimal technology networks: an integrated concept for water reuse; *Desalination* 2006, 188, 163–168.
5. Dawoud, M. A. The role of desalination in augmentation of water supply in GCC countries; *Desalination* 2005, 186, 187-198.
6. Hinkebein, T. E.; Price, M. K. Progress with the desalination and water purification technologies US roadmap; *Desalination* 2005, 182, 19-28.
7. Côté, P.; Siverns, S.; Monti, S. Comparison of membrane-based solutions for water reclamation and desalination; *Desalination* 2005, 182, 251-257.
8. Adham, S.; Kumar, M.; Pearce, W. H. Model developed for brackish and reclaimed water; *Desalination & Water Reuse* 2005, 15, 3, 38-46.
9. Dreizin, Y. Ashkelon seawater desalination project - off-taker's self costs, supplied water costs, total costs and benefits; *Desalination* 2006, 190, 104-116.
10. Toze, S. Water reuse and health risks - real vs. perceived; *Desalination* 2006, 187, 41-51.
11. Lake, P. S.; Bond, N. R. Australian futures: freshwater ecosystems and human water usage; *Futures* 2006, in press.
12. Beder, S. *Toxic Fish and Sewer Surfing*; Allen & Unwin: Sydney, 1989.
13. Braga, O.; Smythe, G. A.; Schafer, A. I.; Feitz, A. J. Steroid estrogens in ocean sediments; *Chemosphere* 2005, 61, 827–833.
14. Sumpter, J. P. Endocrine disrupters in the aquatic environment: an overview; *Acta Hydrochimica Hydrobiologica* 2005, 33, 9-16.
15. Ternes, T. A.; Stumpf, M.; Mueller, J.; Haberer, K.; Wilken, R.-D.; Servos, M. Behavior and occurrence of estrogens in municipal sewage treatment plants - I. Investigations in Germany, Canada and Brazil; *The Science of the Total Environment* 1999, 225, 81-90.
16. Heberer, T. Tracking persistent pharmaceutical residues from municipal sewage to drinking water; *Journal of Hydrology* 2002, 266, 175-189.

17. Meerganz von Medeazza, G. L. “Direct” and socially-induced environmental impacts of desalination; *Desalination* 2005, 185, 57-70.
18. Alameddine, I.; El-Fadel, M. Stack emissions from desalination plants: a parametric sensitivity analysis for exposure assessment; *Desalination* 2005, 177, 15-29.
19. Raluy, G.; Serra, L.; Uche, J. Life cycle assessment of MSF, MED and RO desalination technologies; *Energy* 2006, in press.
20. Einav, R.; Harussi, K.; Perry, D. The footprint of the desalination processes on the environment; *Desalination* 2002, 152, 141-154.
21. Bruvold, W. H.; Ward, P. C. Public attitudes toward uses of reclaimed wastewater; *Water & Sewage Works* 1970, 120-122.
22. Bruvold, W. H. “Public attitudes towards reuse of reclaimed water,” University of California, Water Resource Centre, 1972.
23. Stone, R.; Kahle, R. Wastewater Reclamation. In Socio Economics, Technology and Public Acceptance; Office of Water Resource Research, US Department of the Interior: Washington, DC, 1974.
24. Sims, J. H.; Baumann, D. Renovated waste water: The question of public acceptance; *Water Resources Research* 1974, 10, 659-665.
25. Kasperson, R. E.; Baumann, B.; Dwarkin, D.; McCauley, D.; Reynolds, J.; Sims, J. “Community adoption water reuse system in the United States,” Office of Water Resources Research, US Dept. Interior, 1974.
26. Olson, B. H.; Henning, J. A.; Marshack, R. A.; Rigby, M. G. In Water Reuse Symposium: Denver, Colorado, 1979; pp 1219-1231.
27. Bruvold, W. H.; Olson, B. H.; Rigby, M. Public policy for the use of reclaimed water; *Environmental Management* 1981, 5, 95-107.
28. Milliken, J. G.; Lohman, L. C. Analysis of baseline survey: Public attitudes about Denver water anf wastewater reuse; *Journal of American Waterworks Association* 1985, 77, 72.
29. Po, M.; Kaercher, J. D.; Nancarrow, B. E. Literature review of factors influencing public perceptions of water reuse. In CSIRO *Land and Water*, 2004.
30. Bruvold, W. H. Public opinion on water reuse options; *Journal WPCF* 1988, 60, 45-49.
31. Dishman, C. M.; Sherrard, J. H.; Rebhun, M. Gaining public support for direct potable water reuse; *Journal of Professional Issues in Engineering* 1989, 115, 154-161.
32. Higgins, J.; Warnken, J.; Sherman, P. P.; Teasdale, P. R. Surveys if users and providers of recycled water: quality concerns and directions for applied research; *Water Research* 2002, 36, 5045-5056.
33. Marks, J.; Cromar, N.; Fallowfield, H.; Oemcke, D.; Zadoroznyj, M. In IWA World Water Congress: Melbourne, 2002.
34. Hamilton, G. R. In Recycled Water Seminar: Newcastle, 1994; pp 100-107.
35. Hanke, S. H.; Athanasiou, R. B. In Western resources conference: Boulder, Colorado, 1970; pp 113124.
36. Johnson, J. F. In University of Chicago, Department of Geography Research Paper No.135, 1979.
37. Gallup, G. J. Water quality and public opinion; *Journal of American Waterworks Association* 1973, 65, 513.

38. Carley, R. L. Wastewater reuse and public opinion; Journal of American Waterworks Association 1985, 77, 72.
39. Hurliman, A.; McKay, J. In OzWater 2003: Perth, Western Australia, 2003.
40. Alhumoud, J. M.; Behbehani, H. S.; Abdullah, T. H. Wastewater reuse practices in Kuwait; Environmentalist 2003, 23, 117.
41. Marks, J. S.; Martin, B.; Zadoroznyj, M. Acceptance of Water Recycling in Australia: National Baseline Data; Community Consultation 2006, 151-157.
42. Baumann, D. D. Social acceptance of water reuse; Applied Geography 1983, 3, 79-84.
43. Comrie, D.; Evans, S.; Gale, R.; Kitney, P. In OzWater 2003: Perth, WA, 2003.
44. Russell, S. "Community responses and consultation," University of Wollongong, 2004.