

Chapter 2

Urban Wastewater Reuse—A Common Reality

Exponential growth of population, rapid industrialisation and urbanisation, higher cultivation intensities, and poor water management practices over the past century has made freshwater availability a limiting factor in agricultural development (Ray and Gul 1999; Dupont 2003). In addition, the options for increasing supply have become expensive and often environmentally damaging (Frederick 2001). The United Nations World Water Development Report-2 (UNESCO 2006) clearly states that:

the insufficiency of water is primarily driven by an inefficient supply of services rather than by water shortages. Lack of basic services is often due to mismanagement, corruption, lack of appropriate institutions, bureaucratic inertia and a shortage of new investments in building human capacity, as well as physical infrastructure (p. 45).

The report further states that water crisis rest on how we as individuals, and as part of collective society, govern water resources and their benefits. Therefore, what is needed is managing the available freshwater resources effectively and use them based on fitness-for-purpose criteria. Also, our actions to counter water scarcity challenges should be sustainable, without depleting the natural resources or harming the environment. For these reasons, water managers and policy makers around the world are forced to continually look for alternatives to supplement limited and depleting freshwater resources. In such situations, ‘source substitution’ appears to be the solution as it allows higher quality water to be reserved for domestic supply and poor quality water may satisfy less critical uses (Hespanhol 1997). Consequently, urban wastewater (treated) is considered as a reliable alternative water source, and wastewater management is assuming prominence in the water management agenda of many countries (Asano 2001; Hespanhol 1997; Cullen 2004).

2.1 Source Substitution—Response to Freshwater Scarcity Challenge

Wastewater (re)use, particularly for non-potable purposes is an age-old practice (see Table 2.1), and was mainly uncontrolled. Such practices went unreported because the norm then was that wastewater should be treated before use (Ensink et al. 2002). The earliest documented experiment of wastewater use is the large-scale cropland application of municipal wastewater in Western Europe and North America during the early 1900s, when flush toilets and sewer systems were being introduced into these cities (Asano and Levine 1996; Asano 2001; van der Hoek 2004). Since then, there has been an increase in the extent of wastewater usage and applications, and in recent times severe water shortages have pushed the idea of wastewater reclamation and reuse to the forefront of water management discussions.

2.2 Urban Wastewater—Reuse Options and Applications

Urban wastewater reuse may be planned or unplanned; and planned reuse can be direct or indirect. Unplanned reuse is mostly confined to non-potable uses, even though we can find some cases of unplanned potable reuse. Figure 2.1 illustrates the typology of wastewater usage and applications with examples.

As already stated, planned reuse can be direct or indirect. Planned direct reuse can be for potable¹ or non-potable purposes. Planned direct potable reuse is the deliberate use of treated wastewater for some beneficial purpose such as drinking. It is the use of reclaimed water² straight from a wastewater treatment plant through a pipe-to-pipe system that connects the reclaimed water line directly to an established potable water supply system without intervening discharge to a natural water body. However, cases of planned direct potable reuse (treated wastewater directly reused for drinking water) are very rare, because of the perception of increased potential risk to public health and because of negative public perception. In general, even though the technology is well proven, direct potable reuse has occurred only when there is no other option, as in the case of Windhoek, Namibia, which is currently the only place where direct potable reuse takes place on a municipal scale.

Planned direct non-potable reuse is the use of treated wastewater where control exists over the conveyance of the wastewater from the point of discharge from a treatment plant to a controlled area where it is used for irrigation. Many countries in

¹An augment of drinking water supplies by highly treated reclaimed water. This includes direct and indirect potable water reuse.

²Treated effluent suitable for an intended water reuse application and is synonymous with 'reused water'.

Table 2.1 Examples of water reuse experiments around the world

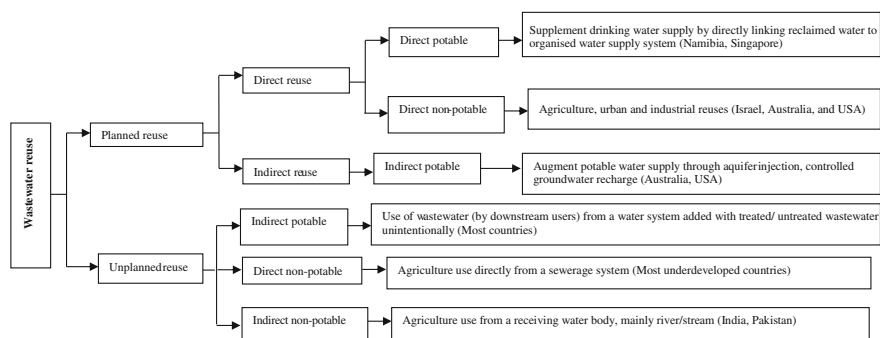
Year	Location	Purpose/usage	Year	Location	Purpose/usage
1912–1985	Golden Gate Park, San Francisco, California, USA	Water lawns and supplying ornamental lakes	1977	Dan region project, Tel-Aviv, Israel	Groundwater recharge and unrestricted crop irrigation
1926	Grand Canyon National Park, Arizona, USA	Toilet flushing, lawn sprinkling, cooling water, and boiler feed water	1984	Tokyo Metropolitan Government, Japan	Toilet flushing
1929	City of Pomona, California, USA	Irrigation of lawns and gardens	1985	City of El Paso, Texas, USA	Groundwater recharge by direct injection into aquifers, and power plant cooling
1942	City of Baltimore, Maryland, USA	Metals cooling and steel processing at the Bethlehem Steel company	1987	Monterey regional water pollution control agency, California, USA	Monterey wastewater reclamation study for agriculture—irrigation of food crops
1960	City of Colorado Springs, Colorado, USA	Landscape irrigation for golf courses, parks, and freeways	1989	Shoalhaven heads, Australia	Irrigation of gardens and toilet flushing in private residential dwellings
1961	Irvine Ranch Water District, California, USA	Irrigation, industrial and domestic uses, toilet flushing	1989	Consorci de la Costa Brava, Girona, Spain	Golf course irrigation
1962	La Soukra, Tunisia	Irrigation with reclaimed water for citrus plants, reduce saltwater intrusion into groundwater	1999	Northern Adelaide Plains, South Australia	Class ‘A’ water used to irrigate horticulture crops
1968	City of Windhoek, Namibia	Advanced direct wastewater reclamation system to augment potable water supplies		Willunga Basin, Adelaide, South Australia	Class ‘B’ waster used to irrigate premium quality grapes
1969	City of Wagga Wagga, Australia	Landscape irrigation of sporting fields, lawns, and cemeteries		Mawson Lakes reclaimed water scheme	A dual water reticulation system, recycled wastewater used for toilet flushing, and garden watering

(continued)

Table 2.1 (continued)

Year	Location	Purpose/usage	Year	Location	Purpose/usage
1970	Sappi Pulp and Paper Group, Enstra, South Africa	Industrial use for pulp and paper processes	2000	Rouse Hill recycled water scheme	A dual water supply system, with the recycled wastewater used for toilet flushing, car washing and garden watering
1976	Orange County Water District, California, USA	Groundwater recharge by direct injection into the aquifers	2003	Singapore	The 'NEWater' project provides safe, reliable source of high quality drinking water (sewer water purified to drinking water standards) for Singapore's 4.3 million residents

Source Compiled from Asano (2001), USEPA (2004), Anderson (2003), Salgot and Tapias (2004), van der Hoek (2004) and NEWater (2002)



Source: Compiled from Anderson (2003); Salgot and Tapias (2004) and van der Hoek (2004)

Fig. 2.1 Typology of wastewater usage for all purposes

the Middle East and countries like Australia, the United States of America, and Israel have developed large-scale irrigation schemes delivering reclaimed water for agriculture use, using reclaimed water after it has passed through water bodies like storages or wetlands following treatment, or taken from a river, lake, or aquifer that has received sewage or sewage effluent.³

Further, planned reuse can also be indirect potable reuse, by way of replenishment of ground water by the controlled addition of reclaimed water to the ground water basin through methods such as aquifer injection. Generally, planned indirect potable reuse is not thought to pose any health risk since it relies on natural treatment in surface water and aquifers, and the reclaimed water is diluted with ‘ordinary’ river or ground water before extraction, thus ensuring good drinking water quality (WHO 2006). Nevertheless, this is still a new approach and is restricted mostly to the developed countries.

Unplanned reuse, on the other hand is largely for non-potable purposes that can be direct or indirect. Unplanned direct non-potable reuse is the supply of wastewater directly to the land from a sewerage system or other purpose-built wastewater conveyance system. Such situations are found in most of the under developed nations facing water scarcity (Westcot 1997). Unplanned indirect reuse for non-potable purposes is common in developing countries like India and Pakistan, where irrigation water is drawn from rivers or other natural water bodies that receive wastewater flows, treated or not. However, unplanned potable reuse (common worldwide) is also practiced, largely unintentionally, when treated or untreated wastewater is added to a water supply system (reservoirs or rivers or streams) that is subsequently used by downstream communities as a water source for potable use, usually with additional treatment.

³Water that flows out of treatment plants.

2.3 Urban Wastewater Reuse Experiences

(Re)use of urban wastewater has increased in many places mainly because of increasing demand by the agriculture sector. The best way of using treated wastewater is in agriculture (Pescod 1992), and doing so can definitely relieve a great deal of pressure on fresh water resources. Replacement of freshwater by treated or untreated wastewater is seen as an important conservation strategy contributing to agricultural production. Further, the communities depending on wastewater reuse for their livelihoods, particularly in the developing world, can derive substantial benefits from using nutrient-rich wastewater.

Although wastewater reuse occupies a prominent place in water management policies today, there is no common regulation(s) of wastewater reuse across the world. This is mainly due to different economic and social conditions, and country or state-specific policies towards using wastewater. In developing countries like India, because of increasing water scarcity, lack of money for treatment and a clear willingness by farmers to use untreated wastewater, the practice of using untreated wastewater for irrigation is still being practiced (Ensink et al. 2002). Besides, the technology necessary to produce effluent of a required quality is often unavailable or not maintained, and the regulatory agencies can seldom enforce standards. Nevertheless, some developing countries including India have their own standards adapted from the leading standards set by the FAO or WHO (Achilleos et al. 2005). In developed nations, on the other hand, public health regulations and water pollution control requirements for treatment protect the agricultural workers and the consumers of crops irrigated with treated wastewater. So, wastewater reuse in developing countries is largely unplanned and uncontrolled whereas in developed countries it is controlled and planned (Parkinson and Tayler 2003). In other words, urban wastewater reuse in agriculture is ‘formal’ in developed countries implying that there is some form of fixed irrigation infrastructure, designed and possibly operated by the government or a donor agency, and used by more than one farm household, and in developing countries like India it is ‘informal’ which means irrigation is practiced by individuals or groups of farmers, without an irrigation infrastructure planned, constructed or operated by a government or donor agency (Cornish et al. 1999; van der Hoek 2004; IWMI 2007). Hence, use of wastewater for irrigation differs across the world and below are few examples from across the world. These experiences include planned, unplanned, potable, and non-potable applications.

2.3.1 *Windhoek, Namibia*

The history of wastewater reuse in Namibia dates back to 1968, when the City Council of Windhoek was forced to implement direct reclamation of wastewater for potable use as the city was approaching the limit of its conventional drinking water

sources (World Bank 2003). The first water reclamation plant—The Old Goreangab Water Reclamation Plant (OGWRP)—after successful operation for more than 30 years was nearing the end of its viable life in the late 1990s. Therefore, the New Goreangab Water Reclamation Plant (NGWRP) was built in 2002 through a 20-year operation and maintenance (O&M) contract between the City of Windhoek and the Windhoek Goreangab Operating Company Ltd. (WINGOC), which is a consortium of three international water treatment contractors (Lahnsteiner and Lempert 2007). As a result, the city's total water supply is now met by three main sources—(i) surface water, (ii) ground water, and (iii) reclaimed water from both the water reclamation plants.

Initially only 3–8% of reclaimed water was blended with premium water from other sources (bore holes and treated surface water). After several process improvements the portion of reclaimed water was raised gradually until it constituted up to 18% of the total potable water for the city (Lahnsteiner and Lempert 2007). While there is opposition to use recycled water for potable purposes in many parts of the world (Hurlimann and McKay 2006), the people of Windhoek derive pride from the fact that they are the only people in the world with potable reuse. The potable reuse project in Namibia is successful because of the specific attitudes of the users, derived from a growing scarcity of water and a different set of cultural values (McKay 2007a) and a set of water institutional reforms in Namibia, based on proper process design and quality management and on effective public awareness programs (Lahnsteiner and Lempert 2007; Heyns 2005).

2.3.2 *Singapore*

Singapore like Namibia has achieved a remarkable progress in water resource management as a result of efforts to create a comprehensive management system for the environment, the urban catchment and wastewater. The Four National Taps Strategy has resulted in diversification of Singapore's water sources (World Bank 2006) which includes water from local catchments, imported water (from Malaysia), the NEWater (drinking-quality water produced by treating secondary effluent), and desalinated water. The strategy is a success due to ongoing government support, institutional integration, integrated land use planning, effective enforcement of legislation, public education, and application of advanced technology.

The water institutions in Singapore provide favourable conditions for Integrated Water Resources Management (IWRM). The administrative barriers facing the process of adopting the IWRM approach that exist in many other countries are largely wiped away in Singapore and it has a comprehensive environmental legislation and strict implementation of water resource related regulations.

2.3.3 *United States of America*

In the United States, urban wastewater management strategies can be categorised as centralised or decentralised. However, from the end of the nineteenth century to the present day, centralised management has remained the preferred urban wastewater management method (Burian et al. 2000). Reclaimed water use in the United States is well established and ranges from pasture irrigation using partially treated reclaimed water to augmenting potable water supplies with highly treated reclaimed water. However, there are no federal regulations governing wastewater reuse, and the regulations and guidelines are developed at the State level (Crook and Surampalli 2005); and therefore, they vary across states. The first regulation of wastewater reuse for irrigation was developed in 1918 (Asano and Levine 1996) and is comprehensive with regard to public health.

2.3.4 *Europe*

When compared to other regions of the world, Europe has plentiful water resources. However, droughts experienced in the early 90s and in 2003 changed the situation in Europe, resulting in growing water stress, both in terms of quantity and quality (Hochstrat et al. 2005; Bixio et al. 2006). To counter water scarcity challenges the European Union and its member states have enacted the Water Framework Directive (WFD⁴) which highlights an integrated approach to water resources management. Further, the WFD favours municipal wastewater reclamation and reuse to augment water supply and decrease the impact of human activities on the environment (Bixio et al. 2006).

Water reuse is a growing field and many projects have been proceeding throughout Europe in the last fifteen years (Angelakis et al. 2003). Wastewater reuse in Europe is mainly for agriculture, industry, urban, recreational and environmental uses. As compared to the early 1990s, when wastewater reuse in Europe was limited and incidental, at present there are more than 200 fully operational water reuse projects, with many others in an advanced planning phase (Hochstrat et al. 2005). Nevertheless, there are no regulations for wastewater reuse at a European level and the only reference made by the European Union on the matter of wastewater is in the Urban Wastewater Treatment Directive (UWWTD). The UWWTD spells out the implementation of decentralised treatment so as to reduce pollution from households, apply strict sanctions on municipal wastewater treatment plants, and reduce the diffuse pollution from agriculture (Bixio et al. 2006; Achilleos et al. 2005).

⁴EU Council Directive for community action in water policy-2000/60/EC of October 23, 2000.

2.3.5 Israel

Due to a combination of severe water shortage, threat of pollution to its water resources and a concentrated urban population with high levels of water consumption and wastewater production, Israel has devoted more effort to wastewater reuse than any other country. Israel's national policy aims to gradually increase the fraction of reclaimed wastewater used instead of fresh water for agricultural use (Brenner et al. 2000). This is reflected by the fact that Israel occupies second place in overall wastewater reuse after California and has the highest percentage of wastewater reused for agricultural irrigation in the world (Achilleos et al. 2005). It is estimated that by the year 2020, 50% of agricultural water consumption will be provided by treated wastewater (Brenner et al. 2000). Understandably, the large-scale wastewater reuse schemes in Israel are mainly for agricultural irrigation. Though modern treatment technology can produce reclaimed water meeting drinking water quality, because of public acceptance considerations the focus in Israel is directed towards maximising saving or replacing freshwater for consumptive uses other than drinking. The Ministry of the Environment determines recommendations for effluent quality standards for various purposes.

The Country specific experiences highlight the potential of this valuable resource and it establishes that different countries have developed different approaches for wastewater reuse to protect public health and the environment. Developed countries have established conventionally low-risk guidelines based on a high technology/high-cost approach, while in developing countries the strategy is to adopt a low technology/low-cost approach based on WHO recommendations (Achilleos et al. 2005). Yet, the objective behind all the guidelines is to achieve better health protection by implementing stringent water quality limits and by defining other appropriate practices, depending on the type of reuse (USEPA 2004).

2.4 Challenges for Wastewater Management

Water resource management in the past was largely shaped by an engineering approach (Pahl-Wostl 2002). However, given the transformation the water sector is undergoing at all levels, water resource management in general is encountering new challenges that call for fresh strategies and institutional arrangements. Likewise, when we think of wastewater management, we find various obstacles. Despite all the potential that (treated) wastewater offers for augmenting freshwater supplies, implementing sustainable wastewater reuse schemes encounters many impediments.

Experiments of wastewater reuse projects around the world suggests that human health, economic prosperity, property rights, and a general responsibility to the natural environment are the important components of accomplishing effective wastewater solutions (Jones 2005). Furthermore, the multidimensional character of

this resource—time, space, multidiscipline, and stakeholders—make it important to consider a large number of parameters in the decision making processes. These include: ‘sustainability issues, legislation and health issues, techniques and technology, political and institutional issues, socio-economic impacts, and historical and cultural issues’ (Thomas and Durham 2003, p. 24). According to Livingston et al. (2004, p. 581), ‘successful implementation of new approaches to wastewater management is a multi-faceted challenge requiring input beyond mere technical’. Societal and institutional adaptation is therefore critical to ensuring long-term sustainability of reuse schemes (Asano 2001; Po et al. 2004, 2005; Mills 2000, Kasower 1998, Ritchie et al. 1998, all cited in Haddad 2002; Livingston et al. 2004).

2.4.1 Institutional Challenges

Wastewater collection, treatment and effluent use normally encompass a wide range of interests at different levels of administration. So the scope and success of any reuse scheme will depend to a large extent on the institutional organization (Pescod 1992). In any natural resource management regime, coordination complexity results in problems, due to varying roles and responsibilities and overlapping concerns among the public agencies managing the resources (MacDonald and Dyack 2004; McKay 2007b). Previous studies related to wastewater use (Asano 2001; Po et al. 2004, 2005) have identified similar conflicting agendas among water agencies: addressing water rights issues; dealing with opponents to recycling or reuse; modifying existing regulations; and acquiring funding, are the institutional challenges facing successful development of this dependable resource. Therefore, appropriate institutions with adequate resources are required for development of sustainable wastewater reuse schemes. More about institutions is presented in Chapter Four.

2.4.2 Public Perceptions and Acceptance

For successful implementation of reuse schemes, public acceptance is a very important (Asano 2001; Po et al. 2004; Marks 2004; Marks et al. 2006; McKay and Hurlimann 2003). Generally, the tendency of people to be motivated by a set of long-term goals, but to act in the short term towards those things that they control, is what affects wastewater reuse projects (Jones 2005). Therefore, understanding public perceptions and community acceptance of water reuse is very important. Failure to gain public acceptance has led to vocal opposition and, at times, has resulted in schemes being stalled. According to Robinson et al. (2005), public concerns about real or perceived risks are weighted against the use of reclaimed water.

There are very few studies that have tried to investigate the factors influencing public perceptions of water reuse and their influence on individuals' decision-making processes. It is only in the recent past that public perceptions and acceptance of water reuse have been considered important for successful implementation of reuse schemes. While reviewing the existing international and Australian literature on water reuse, Po et al. (2004) have identified the following factors to influence community's acceptance of a reuse scheme: disgust or 'yuck' factor, the perception of risks associated with using recycled water, the specific uses and cost of recycled water, the sources of water to be recycled, issues of choice, trust and knowledge, attitudes toward the environment, and socio-demographic factors. If wastewater resources are to become an integral component of water and waste management policies, the acceptance of reclaimed water must be comprehensively tackled; this is more critical if the application is for potable uses. However, this challenge can be systematically addressed through effective educational, policy, and management strategies, as in case of the Windhoek Water Reclamation Project, Namibia or the NEWater in Singapore.

Wastewater reuse history is marked with failure of reuse schemes mainly because of lack of community involvement (Po et al. 2004, 2005; Hurlimann and McKay 2006). According to Jones (2005), 'working with a community that does not have wastewater as a highest priority requires building participation through a combination of discussions about community outcomes, and more detailed action steps of technology identification, design work, and management'. Since it is the public who will be served by and pay for them, the policies on wastewater use and management must include the human dimension (Robinson et al. 2005). For a reuse scheme to be sustainable, community involvement and/or participation are very important. Asano (2001) suggests that water reuse project(s) should be built upon three principles:

- providing reliable treatment of wastewater to meet strict water quality requirements,
- protecting public health, and
- gaining public acceptance.

2.4.3 Market Imbalance

The best application for the use of wastewater after treatment is in agriculture (Pescod 1992) and use of this water for agriculture purposes can relieve a great deal of pressure on fresh water resources. This implies that the largest market for reclaimed water is in the agriculture sector. In addition, use of wastewater, mainly for non-potable purposes is also increasing. Although there is market for this valuable resource, it is imbalanced, as is explained by Abu Madi et al. (2003, p. 115):

the market for reclaimed water is unbalanced and it is due to a growth on the supply side of the market, revealed by increasing number of wastewater treatment plants and stagnancy on the demand side revealed by the substantial proportions of the resource being discharged without proper utilization.

The reason for this imbalance is once again the institutional challenges facing implementation of reuse schemes and lack of community involvement in the implementation of those schemes. Success or failure of reclaimed water schemes largely depend on institutional factors, such as federal and/or state financial support, devolution of sufficient authority to local authorities, and development of innovative resource management institutions (Mills 2000; Kasower 1998; Ritchie et al. 1998, all cited in Haddad 2002).

2.4.4 Financial Feasibility and Technicality

In addition to the above-mentioned impediments, financial feasibility is also important while implementing water reuse projects. Financing a reuse scheme is a challenge because acquiring funds to develop a water reuse scheme is an onerous task. Users' willingness to pay for the resource in question (wastewater in this case) to a large extent also influences the implementation of reuse schemes. According to Tsarakis and Georgantzis (2003, p. 112), 'more often than is usually believed, individually rational behaviour is compatible with socially desirable outcomes'. Therefore, public perceptions and acceptance of wastewater, community participation and willingness to pay are all interlinked.

Willingness to pay for reclaimed water is also influenced by the tariff structure adopted in a particular scheme. The general tendency observed in case of water reuse schemes is that users might not be willing to pay more for this resource because it is considered as waste, so why pay for it? Therefore, the tariff structure should be such that the community being served should perceive it to be appropriate, as well as taking into account the long term viability of the service provider.

Sound technicality is another factor to be considered while implementing reuse projects. This is important because the effluent should be treated to a quality acceptable to the end user and matched to particular application. In the present context reclaimed water used for agricultural irrigation must be of very high quality to meet the process needs of the agriculture industry and to minimize the potential impacts on human health by inadvertent exposures. Therefore, the acceptability of reclaimed water for different uses is dependent on the specific application and is highly variable. In developing countries like India, treatment facilities are either not available or not implemented on the grounds of cost. In such situations, farmers using wastewater should be encouraged to adopt safer approaches. This can be achieved through participatory approaches such as farmer's field schools and public health education.

References

- Abu Madi M, Braadbaart O, Al-Sa'ed R, Alaerts G (2003) Willingness of farmers to pay for reclaimed wastewater in Jordan and Tunisia. *Water Sci Technol: Water Supply* 3(4):115–122
- Achilleos A, Kythreotou N, Fatta D (2005) Development of tools and guidelines for the promotion of the sustainable urban wastewater treatment and reuse in the agricultural production in the Mediterranean Countries. Task 5: Technical guidelines on wastewater utilisation, European Commission, June 2005
- Anderson J (2003) The environmental benefits of water recycling and reuse. *Water science and technology: water supply*, 3(4):1–10
- Angelakis AN, Bontoux N, Lazarova V (2003) Challenges and prospective of water recycling and reuse in European countries. *Water Sci Technol: Water Supply* 3(4):59–68
- Asano T (2001) Water from (waste) water—the dependable water resource. Paper presented at the 11th Stockholm Water Symposium, Stockholm, Sweden, 12–18 Aug 2001
- Asano T, Levine AD (1996) Wastewater reclamation and reuse: past, present, and future. *Water Sci Technol* 33(10–11):1–14
- Bixio D, Thoeys C, De Koning J, Joksimovic D, Savic D, Wintgens T, Melin T (2006) Wastewater reuse in Europe. *Desalination* 187:89–101
- Brenner A, Shandalov S, Messalem R, Yakirevich A, Oron G, Rebhun M (2000) Wastewater reclamation for agricultural reuse in Israel: trends and experimental results. *Water Air Soil Pollut* 123:167–182
- Burian SJ, Nix SJ, Pitt RE, Rocky Durrans S (2000) Urban wastewater management in the United States: past, present, and future. *J Urban Technol* 7(3):33–62
- Cornish GA, Mensah E, Ghesquière P (1999) Water quality and peri-urban irrigation. An assessment of surface water quality for irrigation and its implications for human health in the Peri-urban zone of Kumasi, Ghana. (Report OD/TN 95). HR Wallingford Ltd., Wallingford, UK
- Cullen P (2004) Water challenges for south Australia in the 21st century. Adelaide thinker in residence, Department of the premier and cabinet, p 11
- Crook J, Surampalli RY (2005) Water reuse in the United States. *Water Sci Technol Water Supply* 5(3–4):1–7
- Dupont A (2003) Will there be water wars? *Development Bulletin*, 63 Nov 2003:16–20
- Ensink JHJ, van der Hoek W, Matsuno Y, Munir S, Aslam RM (2002) Use of untreated wastewater in peri-urban agriculture in Pakistan: risks and opportunities, (Research Report-67). International Water Management Institute, Colombo, Sri Lanka
- Frederick KD (2001) Water marketing: obstacles and opportunities. *Forum for Appl Res Public Pol* 16(1):54–62
- Haddad BM (2002) Monterey county water recycling project: institutional study. *J Water Res Planning and Manage* 128(4):280–287
- Hespanhol I (1997) Wastewater as a resource. In: Helmer R and Hespanhol I (Eds) *Water pollution control: a guide to use of water quality management principles*, published by E and F. Spon on behalf of WHO/UNEP
- Heyns P (2005) Water institutional reforms in Namibia. *Water Policy* 7:89–106
- Hochstrat R, Wintgens T, Mellin T, Jeffrey P (2005) Wastewater reclamation and reuse in Europe: a model-based potential estimation. *Water Sci Technol: Water Supply* 5(1):67–75
- Hurlimann A, McKay JM (2006) What attributes of recycled water make it fit for residential purposes? The Mawson Lakes experience. *Desalination* 187:167–177
- International Water Management Institute (2007) IWRM challenges in developing countries: lessons from India and elsewhere. *Water Policy Briefing* (24), Jan 2007
- Jones K (2005) Engaging community members in wastewater discussions. *EcoEng Newsletter* (11), Oct 2005
- Lahnsteiner J, Lempert G (2007) Water management in Windhoek, Namibia. *Water Sci Technol* 55(1–2):441–448

- Livingston D, Stenekes N, Colebatch HK, Ashbolt NJ, Waite TD (2004) Water recycling and decentralised management: the policy and organisational challenges for innovative approaches. In: Daniell T (ed) *Proceedings of the International Conference on Water Sensitive Urban Design: Cities as Catchments*, Adelaide, 21–25 Nov 2004:581–592
- MacDonald DH, Dyack B (2004) Exploring the institutional impediments to conservation and water reuse—National issues. CSIRO Land and Water Client Report
- Marks JS (2004) Advancing community acceptance of reclaimed water. *Water* 31(5):46–51
- Marks JS, Martin B, Zadoroznyj M (2006) Acceptance of water recycling in Australia: national baseline data. *Water* 33(2):151–157
- McKay JM (2007a) Policy changes in South Australia: elements of the social contract resulting in high urban and agricultural use of recycled water. South Australia Policy Online. Retrieved June 13 2007 from <http://www.sapo.org.au/opin/>
- McKay JM (2007b) Water governance regimes in Australia: implementing the National water initiative. *Water* 34(1):150–156
- McKay JM, Hurlimann A (2003) Attitudes to reclaimed water for domestic use: part 1. *Water* 30(5):45–49
- NEWater (2002) NEWater sustainable water supply. Retrieved May 10 2007, from <http://www.pub.gov.sg/NEWater>
- Pahl-Wostl C (2002) Participative and stakeholder-based policy design, evaluation and modelling processes. *Integr Assess* 3(1):3–14
- Parkinson J, Tayler K (2003) Decentralised wastewater management in peri-urban areas in low-income countries. *Environ Urbanisation* 15(1):75–89
- Pescod MB (1992) Wastewater treatment and use in agriculture. *Irrigation and Drainage* (Paper No. 47). FAO, p 118
- Po M, Juliane K, Nancarrow BE (2004) Literature review of factors influencing public perceptions of water reuse. Australian Water Conservation and Reuse Research Program, CSIRO
- Po M, Nancarrow BE, Leviston Z, Porter NB, Syme GJ, Karecher JD (2005) Predicting community behaviour in relation to wastewater reuse: what drives decisions to accept or reject? Water for healthy country national research flagship. CSIRO Land and Water, Perth
- Ray I, Gul S (1999) More from less policy options and farmer choice under water scarcity. *Irrigation and Drainage System*, 13:361–383
- Robinson KG, Robinson CH, Hawkins SA (2005) Assessment of public perception regarding wastewater reuse. *Water Sci Technol: Water Supply* 5(1):59–65
- Salgot M, Tapias JC (2004) Non-conventional water resources in coastal areas: a review on the use of reclaimed water. *Geologica Acta*, 2(2):121–133
- Thomas J, Durham B (2003) Integrated water resource management: looking at the whole picture. *Desalination* 156:21–28
- Tsagarakis KP, Georgantzis N (2003) The role of information on farmers' willingness to use recycled water for irrigation. *Water Sci Technol: Water Supply* 3(4):105–113
- United States Environmental Protection Agency (2004) Guidelines for water reuse. United States E.P.A. for International Development, Washington, DC
- van der Hoek W (2004) A framework for a Global assessment of the extent of wastewater irrigation: the need for a common wastewater typology. In: Scott C, Faruqi NI, Raschid L (eds) *Wastewater use in irrigated agriculture—confronting the livelihoods and environmental realities*. CABI/IWMI/IDRC
- World Bank (2003) Wastewater reuse. Water Resources and Environment Technical Note F.3. The World Bank, Washington, DC
- World Bank (2006) Dealing with water scarcity in Singapore: institutions, strategies, and enforcement. China, Addressing Water Scarcity. (Background paper No. 4). World Bank Analytical and Advisory Assistance Program. Washington, DC

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