

THE WORLD OF WATER REUSE: Lessons from Abroad

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The world of water reuse is rich with variety, fast expanding, and full of valuable lessons for those who will travel to the far-flung corners of globe. This article presumes to whet your appetite for visiting other regions of the world where water recycling is happening in one form or another. Some of the lessons are dramatic, some are prosaic, others are tales of caution, but every one of them has a kernel of wisdom, or at least a quantum of knowledge that may be transferable. In this distillation, some generalizations are offered at the risk of loss of precision, in the cause of brevity and the hope of maintaining the reader's interest.

The learning process is of course reciprocal, as many countries emulate water recycling practices and regulations common in the more developed nations. The regulations in effect in various parts of the world—for control of water recycling activities—bear uncanny resemblances to one another.

Not all the lessons cited here are positive; some valuable lessons are learned from

unwholesome practices that should be avoided. This article is an attempt to systematize and to organize the lessons that each country or region offers to the others, without any intent to judge the quality of the lessons and/or their relative worth to the other countries. Nor is it intended to criticize or denigrate the practices common in one area in favor of another. Consider the four broad categories of lessons listed below, before a description of water recycling practices in selected individual countries:

- Gaining confidence in the universal safety of regulated water reuse
- Avoiding pitfalls of under-regulated wastewater use
- Expanding the envelope, going beyond the familiar and the "comfortable"
- Viewing the world as a laboratory for experimentation and varying the variables

AUSTRALIA

Australian water reuse is almost as diverse and as complex as in the United States. A wide range of water reuse practices can

be found in different parts of the country. Landscape irrigation is a major customer of recycled water. A vigorous debate over the merits and risks of potable reuse continues in some parts of Australia, especially in the states of Queensland and New South Wales. Public acceptance issues are critical to the success of proposed water reuse projects in Australia, and potable reuse is facing an uphill road.

On-site water recycling systems are in fairly common use in the arid areas of the country, successfully providing reclaimed water for irrigation of landscaping. One such system, referred to as "Water Mining" is a small scalping plant tapping major wastewater collection interceptors and treating water to tertiary level for unrestricted non-potable uses. Use of gray water for residential landscape irrigation is common in many parts of Australia and generally accepted. Most of the systems in use are simple conveyance mechanisms and do not provide treatment of the wastewater—exclusive of sanitary wastes.

BAHRAIN

Not as rich in oil resources as its neighboring states, Bahrain nonetheless maintains a relatively high standard of hygiene and wastewater management. The collection system serves nearly the entire population of Manama, the capital city, and the effluent is largely reused for agricultural and landscape (greenery) irrigation. Tertiary treatment is the standard level of recycled water quality. Monitoring and oversight of the reuse systems are generally lacking. Public acceptance for non-potable reuse is apparently high. The term "treated sewage effluent" (TSE) is widely used to describe the recycled water, with no evident adverse public reaction. A mix of WHO and "Title-22" style water reuse regulations are in effect.

EGYPT

The Nile River water has long been used untreated for agricultural and urban landscape irrigation in a dual distribution system, in many parts of Cairo and

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WaterReuse Association is a non-profit mutual benefit corporation. Its objectives shall be to promote water reclamation and recycling as a supplemental source of water; to work for the adoption of legislation and regulations that allow the safe use of recycled water; to facilitate the development of technology aimed at improving water recycling; to promote legislation that would increase funding available for water recycling projects; and to increase public awareness and understanding of related water problems and solutions.

WaterReuse Association distributes the WaterReuse Update to its members and other interested parties four times a year. Editorial comments can be sent to: WaterReuse Update, 915 L Street, Suite 1000, Sacramento, CA 95814, (916) 442-2746, (916) 442-0382 (fax).

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other Egyptian cities. This water is highly contaminated with human waste, because of the unhygienic sanitation practices common in the upstream reaches of this famous river. The result is common infections with various intestinal parasites, including the devastating Schistosomiasis. While this dual distribution of untreated nonpotable water is far from the typical planned water reuse concept, it portrays the potential for human harm from use of inadequately treated wastewater for "nonpotable" purposes. Inadequacy of controls on human exposure to the untreated water, potential for cross-connection, and the re-contamination of water in open conveyance channels are the main reason for the high rates of infection. Regulated water reuse practices in Egypt are being promoted by international funding agencies, primarily as a means of keeping effluent discharges out of the Nile River, and delivering a recycled water supply high in nutrients to the agricultural areas surrounding major metropolitan areas.

ISRAEL

Israel is an active innovator and pioneer in water recycling, currently reusing over 65 percent of its treated wastewater. The farming villages have experimented with the use of reclaimed wastewater at all treatment levels. Research conducted in Israel, under actual farming practice, proved early on that inadequately disinfected primary and secondary effluent sprayed on agricultural crops can produce infection and disease in persons living and working in adjacent villages. Practical solutions have been developed for

use of different quality waters under different conditions, and on-site controls.

A unique water reuse project in the outskirts of the City of Tel Aviv, is a soil aquifer treatment (SAT) scheme, which includes groundwater recharge. Sewage from the Greater Tel Aviv area (about 130 MCM/Y) is treated in an activated sludge process. The effluent is then recharged into a sandy aquifer for polishing and storage. Then, it is pumped and conveyed 100 km south to the Negev Desert where the effluent is used for agricultural irrigation. Named the Dan Regional Wastewater Reclamation Project, this is a long-running groundwater recharge scheme, infiltrating secondary reclaimed water into an aquifer dedicated to agricultural irrigation. Withdrawal wells surround the periphery of the aquifer recharged from spreading basins at its center. The quality of withdrawn water has proven the sustained ability of the geologic strata to remove pollutants and microorganisms effectively and continuously. This project is a true laboratory for testing the effectiveness of the natural filtration processes taking place in the geological formations, over a long period of time (nearly 30 years, at this writing).

JAPAN

Japan enjoys an average annual rainfall of 1,714 mm (67.5 in), yet, frequent droughts, rapid population growth, and concentrated population centers combine to produce frequent drought conditions. This should serve as a harbinger of what is to come in the populated desert regions of

the world. Most of the water reuse in Japan is urban, implemented on a relatively small scale such as in a single building or several buildings forming a block-wide water recycling system without the benefit of public sewerage systems. The most unique lesson from the Japanese water reuse practice is the effectiveness and feasibility of "on-site" treatment and reuse. Every building with greater than 30,000 m² (~300,000 ft²) of living or office space is required to provide its own self-contained water recycling system. This requirement includes commercial buildings and residential apartment complexes. Japanese regulators allow and encourage use of gray water in both residential and commercial buildings. Special sinks built atop the toilet reservoir provide for reuse of the hand-washing wastewater for toilet flushing.

JORDAN

Jordan has a fast-growing population in a semi-arid climate zone. Many Jordanian communities are using reclaimed water—with inadequate treatment levels—for irrigation of farms, close to human dwellings. As a result, public hygiene is poor and infant mortality rates are generally high. The extensive pond systems treating wastewater from the City of Amman are highly overloaded and produce a coffee-colored, high-nutrient effluent. The effluent runs about 30 kilometers (20 mi) in a channel before discharging in the river system and ending up at the King Talal Dam/Reservoir. This reservoir then flows into the famous Jordan River, and becomes the source of water for many downstream communities' irrigation and other needs. Some of this water ends up in the drinking water

supply of several Jordanian communities, after filtration and disinfection. Along the way, the effluent is used by farmers for direct irrigation of citrus crops, vegetables, and other crops. The high nutrient concentration causes severe problems for crops, such as citrus, which must be starved of nutrients after the onset of the fruiting stage.

KUWAIT

Kuwait is located on the Arabian Peninsula, along the coast of Persian Gulf, with extremely high annual temperatures and very low rainfall, despite its coastal situation. The government of Kuwait is highly interested in expanding "greenery" in the urban experience in Kuwait City. Brackish groundwater (TDS > 2,500 mg/L) has been used extensively for landscape irrigation, with a rather limited palette of salt-tolerant, drought-tolerant vegetation. Use of disinfected tertiary recycled water (called "treated sewage effluent" or TSE) became more prevalent in the 1970s. Today, there is an active plan to transport and utilize all of the recycled water from the City of Kuwait for greenery irrigation along the highways, and for agricultural irrigation (food crops) at a farming area 60 km (40 mi) to the Northeast of Kuwait City—near the Iraqi border. This ambitious project is currently under design. Kuwait exemplifies the possibility of highly protective water reuse practice under developmentally challenging conditions.

MEXICO

Mexican farmers commonly utilize raw, untreated wastewater for irrigation of a wide variety of crops, even though this practice flaunts the laws and regulations in effect.

There is a school of thought, among some Mexican academics, that use of raw sewage is sustainable and economical, because (1) it avoids costly treatment, (2) it preserves nutrients and organic matter in raw wastewater for use on the farm, and (3) it keeps excess nutrients from reaching the waterways. The low-organic content desert soils can benefit highly from the addition of organic matter in raw sewage—if only a high level of safety for the farm workers and public health protection for the consumers of the crops can also be ensured through effective barriers to pathogen transfer. Given an adequate level of public health protection, the Mexican model might be viewed as a highly sustainable resource utilization system, combining water recycling with nutrient and organic matter beneficial use.

Advocates of this practice maintain that farmer safety and consumer health can be protected with site controls and crop choice restrictions, enunciated in the existing Mexican regulations. Furthermore, they claim that high levels of wastewater treatment remove low-level ambient exposures that assure development and maintenance of strong immunity against disease in human communities. This point-of-view is strongly challenged by public health professionals in the more developed parts of the world, but it is worthy of consideration for those areas of the world where resource scarcities are so critical that public health protection against viruses is viewed as a luxury. Site controls and plant materials restrictions can play a large part in minimizing public exposure to pathogens.

MOROCCO

Morocco supplies fresh fruit and vegetables to the lucrative European market several weeks (or months) before the European farmers (at a higher latitude, hence delayed seasons) can supply the demand. This "early" niche is extremely important to the agricultural economy of the Northern African tier of countries. Availability of reclaimed water at the margins of major metropolitan areas of Morocco—cities such as Casablanca, and Rabat—is an essential ingredient in the production of the early market (*primeur*) vegetables and fruits. Levels of treatment are primary and, in some cases, secondary. To date, no adverse claims of superiority have been noted from competitors selling early vegetables irrigated with "snowmelt," although growers, as in other locations, are apprehensive.

NAMIBIA

Namibia has the distinction of being the only country in the world with a planned, direct, potable reuse system in the capital City of Windhoek, with over 30 years of actual experience. The treatment system uses membrane technology and there are plans to double its 5.5-mgd (21,000 m³/d) capacity in the near future. No adverse public health effects from the use of recycled water in the community water supply have been noted, based on epidemiological studies of comparable populations. Public acceptance has been complete and no controversies have erupted. One important lesson is that the public can get accustomed to what is status quo, especially if there are no adverse consequences over a prolonged period of time. Source control of contamination of the wastewater resource is a paramount concern of the

system managers. The City collects all harmful substances free of charge, so that local residents do not dispose such materials into the drain as a way of saving money. An extensive monitoring program is conducted. The concept of multiple barriers is fully incorporated into the treatment scheme.

PERÚ

Perú is a resource-poor developing nation with deplorable sanitation practices. Wastewater collection systems are inadequate, even in the major metropolitan areas of the capital city, Lima. The country suffers one of the highest rates of infant mortality in the world. Farms in the vicinity of the City of Lima use untreated wastewater, drawn from the river, and from sewer outfalls for irrigation of food crops, including vegetables normally consumed raw, such as lettuce and green onions. Several master planning studies have been conducted for amelioration of these conditions—funded by a variety of international agencies, including USAID, the United Nations, the Government of Japan, and the Israeli Government. Lack of resources has hampered implementation of appropriate water reuse schemes recommended in these studies, thus far. The current wastewater irrigation practices are stark testimony to the need for water reuse practices under strictly adherence to regulations.

SAUDI ARABIA

The rich petroleum reserves of Saudi Arabia are expected to last well beyond the 21st Century. Nonetheless, the Saudi infrastructure planners are keenly aware of the importance of extending the useful life of these

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resources as far into the future as possible. Desalinated seawater comprises the main source of municipal, industrial, and agricultural water supply for the Kingdom of Saudi Arabia, supplemented by a diminishing supply of ancient brackish groundwater in localized aquifers. The energy required for desalinization and transmission of seawater 460 km (300 mi) inland must come from the Kingdom's fossil fuel resources. A recent economic analysis for the capital City of Riyadh showed that significant monetary savings could be achieved with the use of recycled water for nonpotable applications—in contrast to building additional desalinization capacity to meet all future water demands.

Currently, recycled water is used in several Saudi cities on a limited basis, primarily for landscape irrigation, providing proof for feasibility of the concept and gathering public acceptance. Future plans call for fully planned communities with all the water cycle infrastructure put in place in advance of housing development so as to maximize the utilization of recycled water. These plans visualize satellite water reclamation plants at strategic locations, cited in such a way as to facilitate distribution of recycled water for irrigation of residential and public common landscaping. A recent declaration of religious acceptability of use of recycled water by the Council of Islamic Experts is expected to pave the way for public acceptance of widespread water reuse. Public attitudes toward water reuse are heavily informed by religious beliefs and the

opinions of trusted interpreters of Islam—i. e., the Council of Experts.

SPAIN

The Spanish Riviera, along the Mediterranean coastal strand, has become a favorite vacation region for many Europeans in recent years, resulting in development of many resort communities in regions with inadequate water supplies. This has led to an aggressive development of water reuse opportunities for irrigation of golf courses, parks and other landscaping in these communities. The water supply situation has become so severe that some communities have even resorted to seawater desalinization to augment the drinking water supplies. A comprehensive Spanish language guide to use of recycled water for golf course irrigation has been published and water recycling seminars and conferences have been held in Barcelona, Marbella, and Madrtid in recent years.

SYRIA

Farmers in the outskirts of Aleppo, Damascus and other major Syrian cities routinely tap raw sewage from the city sewers (with pumps lowered into the maintenance holes) to irrigate vegetables. These raw-eaten vegetables are then sold on the market for public consumption. Periodically (every few years) an outbreak of major communicable diseases, such as cholera, typhoid, hepatitis, etc., brings the full force of authority to eradicate the ill-advised farming operations with military bulldozers, until the epidemic subsides. Shortly thereafter, the practice of sewage farming resumes unchecked, until the onset

of the next full-fledged epidemic. Efforts at planning for high-quality water reuse practices have been unsuccessful in the past because of insufficient funding of wastewater treatment systems, due to traditionally low priority placed upon sanitary systems, and the dire need for expenditures in other public sectors.

TUNISIA

Tunisia is a relatively dry country with limited water resources. In contrast to most other North African countries, it has a well developed wastewater management system in nearly all of its urban areas, with the effluent usually discharged to the Mediterranean. In recent years, some reclaimed water has been utilized in specifically designated "irrigation perimeters", government-sponsored farming schemes in which highly subsidized water is allocated for production of crops needed for national consumption. A recent economic analysis found that investment for an extensive nationwide development of water reuse was not competitive with development of other water resources—even after accounting for the environmental benefits of removing effluent discharges from the sea. Nonetheless, a dozen local agricultural irrigation water reuse projects are operational and more are on the planning horizon. Most of the water recycling volume in Tunisia is in agricultural irrigation schemes, some of which involve switching from dryland farming to irrigated agriculture. The tourism industry is another customer of recycled water, with a number of landscape and golf course irrigation projects in newly developed tourist resorts.

UNITED ARAB EMIRATS (UAE)

Located at the Southern tip of the Arabian Peninsula, on the shores of Persian Gulf, the UAE consists of a series of autonomous City States, the most prominent of which are Dubai and Abu Dhabi. These oil-rich emirates enjoy a relatively high level of sanitation and clean water infrastructure. As a result, use of disinfected tertiary recycled water for irrigation of greenery (public landscape) is well developed and accepted. Consequently, arriving by air into the airport at one of these Emirates is like entering a sudden wet zone in the middle of the desert. At a recent seminar on water reuse, held in Abu Dhabi, the discussion was most animated around the issue of potable reuse. The technical community appears to be far more accepting of the concept of direct potable reuse than the public policy decision makers. Recognition of the high mineral quality of recycled water from the desalinated source water favors the greatest possible utilization of recycled water in this region.

UNITED KINGDOM

Water resources in the United Kingdom are abundant. Nonetheless, interest in water reuse is increasing, primarily because of its environmental benefits. In recent years, several reports about the use of recycled water in fisheries, irrigation of pasture and other farming practices have appeared in the literature.

UNITED STATES

Water reuse practices in the United States vary from state to state, depending on regulations in place, and the drivers that influence the extent of use of recycled water. A

1992 compendium by the United States Environmental Protection Agency remains the most definitive guide to water reuse regulations and practices in this country, even though some of the regulations have been in a state of constant flux. California and Florida are the most active states judging by the volume of water reused. Other states with significant water reuse projects are Texas, Arizona, Nevada, New Mexico, and North Carolina. Two major indirect potable reuse projects in Florida (Tampa) and California (San Diego) were recently proposed and nearly implemented—only to be rejected at the last moment by political decision makers, largely due to adverse public controversy, and the availability of alternative water resources.

The California proposed regulations (commonly referred to as

Title 22) are arguably the world's most well-developed and the most protective of the public health against the remotest chance of microbiological and chemical exposure. Groundwater recharge regulations are still in draft form and are expected to be incorporated into these regulations when the latter are finalized.

Professional associations involved in water reuse activities are the American Water Works Association, Water Environment Federation, and the WaterReuse Association. WaterReuse is expanding its activities internationally, in support of increased global water reuse. Research in many cutting-edge areas of water reuse is underway, funded by governmental agencies and supported by professional associations.

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DID YOU KNOW?

Twenty percent (20%) of the water demand within the Irvine Ranch Water District (IRWD) is met with recycled water. If all of the urban areas in California were as effective as IRWD, the recycled water production in California would exceed the average yield of the State Water Project.



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