by Troy Vassos

Water Reclamation & Reuse

Understanding the promise – and the potential

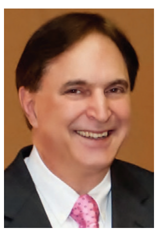
The Vancouver Convention Centre (VCC) West building has its own on-site state-of-the-art wastewater treatment system to cleanse and purify black and grey water for reuse in the facility for non-potable purposes. *Photo: Bobak Ha'Eri*

The world's supply of fresh water is finite and the availability of this precious resource to satisfy urban needs is threatened by pollution and climate change, resulting in higher temperatures, changes in precipitation, rising sea levels, and increases in the severity and frequency of severe weather events. Increasing use of limited water supplies to meet agricultural, industrial, and municipal demands is creating competitive pressure around limited fresh water resources and a growing need to manage water resources in a sustainable manner.

Water Supply Concerns Worldwide

Supply limitations and the deterioration of surface and groundwater supplies of water are serious concerns in many parts of the world. About half of European countries are estimated to be under water stress, where the total water withdrawal is a significant portion of a country's total renewable freshwater resources. Despite declining per capita potable water demands (due to water conservation efforts and building codes incorporating higher efficiency water fixtures and appliances), in 2008 at least 36 U.S. states – in particular California, Arizona, and New Mexico – were having to address severe and chronic water shortages. Based on water availability surveys taken in 2005 and 2007, Environment Canada rates the threat to water availability in British Columbia (with the exception of the Okanagan Valley), along with the North, Quebec, and the Atlantic Provinces as low; however it concludes that the southern part of the Prairie Region and the urbanized southwest part of Ontario have a high threat of severe water stress.

Population growth, contamination of surface water and groundwater, and frequent droughts caused by climate change are key exacerbating factors. The World Health Organization predicts that by 2030, 60 percent of the people on the planet will live in a city, increasing to 70 percent by 2050. At the same time, the overall population increases by 50 percent – to almost 11 billion people. The increase in urban population will severely stress the already depleted fresh water supplies and will, in turn, impact food supplies for cites as 70 percent of the existing water supply is used for irrigation to produce food.



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Planned IPR has been implemented for over 40 years in North America, where reclaimed wastewater is used to replenish depleted groundwater or surface water sources to augment drinking water supplies.

As communities look for ways of making more efficient use of existing potable water supplies, there is growing interest in putting highly-treated wastewater to beneficial use, making reclaimed wastewater an important water resource, rather than a liability, and a means of reducing anthropogenic impacts. A recent survey study of European, Israeli, and Australian medium- and large-scale water reclamation utilities identified over 3,300 international water reclamation projects (mostly in Japan and the U.S.), concluding that technological risks no longer represent a major concern for the development of water reclamation projects. Instead, issues such as the financing, failure management, and social acceptance have become the key critical issues for further implantation.

Changes in climatic conditions and historic weather patterns have caused droughts in many locations around the world; but, from an urban perspective, this has perhaps happened most notably in Australia, and in particular in Queensland, which has been experiencing unusually severe droughts since 1991. These droughts have dramatically changed the way that Australia manages its water resources, and municipalities in many states have now adopted wastewater reclamation and reuse practices to meet their water needs. This has been extended in Western Australia, with the emergence of utility companies that mine municipal sewers for water and recycle the water for residential and commercial building applications.

Implementing Water Reclamation Measures

Water reclamation and reuse involves treating wastewater for beneficial non-potable applications, including agricultural and landscape irrigation, toilet and urinal flushing, replenishing ground water (ground water recharge), cooling water, fire suppression, and a wide range of industrial applications. Unplanned indirect potable reuse (IPR) commonly occurs along freshwater rivers and lakes systems where upstream municipal treated wastewater discharges contribute to downstream municipal potable water intakes. Water flowing through the Colorado River and Mississippi River, for example, has been extracted, used, treated, and piped back into the river to be extracted as part of a public water supply many times over between the headwaters and the mouth of the rivers. Planned IPR has been implemented for over 40 years in North America, where reclaimed wastewater is used to replenish depleted groundwater or surface water sources for the intentional purpose of augmenting drinking water supplies. An example of a well-documented planned IPR project is the Water Factory 21 Direct Injection Project, located in Orange County, California, which has been injecting highly treated wastewater into a groundwater aquifer since 1975 to prevent salt water intrusion. Examples of cities practicing significant IPR using surface fresh water supplies includes Singapore, Las Vegas (NV, USA) and San Diego (CA, USA), where reclaimed municipal wastewater is treated using a multi-barrier process to a potable water standard, and is then blended with the raw water supply and treated again for drinking water use. Despite an inherent public reluctance to consider direct potable reuse, this has been successfully practiced in Windhoek, Namibia, since 1968, currently producing over 21,000 m^3/d of wastewater for drinking water use.

There has been a long history of wastewater reclamation for non-potable reuse in the U.S. and Canada, with growing public and industry interest regarding the use of reclaimed water for appropriate domestic, commercial, or industrial non-potable water applications. In the U.S., California has been a leader in developing standards for treating wastewater to generate a reuse product that is safe for a wide range of non-potable uses, and these standards have been adopted by many other states, with support and guidance from the Environmental Protection Agency through its publication *Guidelines for Water Reuse* (EPA/625/R-04/108, 2004). Canadian jurisdictions have also been adopting or considering legislation to facilitate water reuse, with British Columbia being the first province to establish a comprehensive wastewater reclamation regulation (1999), which was recently revised as the *Environmental Management Act - Municipal Sewage Regulation* (2012).

The Canadian federal government has also recognized the importance of using reclaimed wastewater for non-potable reuse applications to conserve potable water supplies. In 2010, Health Canada published the *Canadian Guidelines for Domestic Reclaimed Water for Use in Toilet and Urinal Flushing*, a document prepared with the financial support of the Canada Mortgage and Housing Corporation and a committee comprised of provincial health representatives from across Canada, for the purpose of reducing domestic potable water consumption. Established to ensure that the operation of water reclamation systems are protective of public health, the document provides guidelines for domestic reclaimed water quality for use by regulatory authorities, public health professionals, engineering consultants, and others with a technical understanding of the subject area.

The implementation of wastewater reclamation and reuse requires plumbing codes and performance standards to assist municipalities in permitting and regulating these systems. In Canada, the plumbing requirements for non-potable water systems are addressed by the Canadian Standards Association (CSA) Standard B128.1-06/

B128.2-06, *Design and installation of non-potable water systems / Maintenance and field testing of non-potable water systems* (CSA, 2006) as well as B128.3, *Performance of non-potable water treatment systems* (CSA, 2010), which establishes performance verification and testing criteria for onsite (in-building) wastewater reclamation package treatment technologies. Similar U.S. standards include the National Sanitation Foundation Standard 350 *Onsite Residential and Commercial Water Reuse Treatment Systems* and the draft International Association of Plumbing and Mechanical Officials Z1207 Standard, *Small Scale Residential Greywater Recycling Systems*.

The University of British Columbia Centre for Interactive Research in Sustainability (CIRS) building in Vancouver (completed in 2011), uses a "Solar Aquatics System" – designed to mimic the purification processes of naturally occurring water systems in close proximity to human inhabitation, such as streams and wetlands. *Photo: Don Erhardt, courtesy of University of British Columbia.*

Benefits to Municipalities

The economic rationale for municipalities to consider water reclamation opportunities, by-laws and plumbing codes is significant. Flushing with reclaimed wastewater can reduce water demands within the home by about 30 percent, equivalent to approximately 126 m^3 per year per household, and resulting in a savings of about $200 per year per household. Beyond the bulk value of the water saved, however, the benefits are numerous, including:

- a more balanced, practical approach to water management, providing consistent, reliable water supply as communities face climate change challenges;
- reduced demands on water supply, treatment, and distribution infrastructure;
- reduced demands on wastewater collection, transport, and treatment infrastructure;
- reduced discharge of treated wastewater into receiving environments and reduced water pollution;
- protecting and preserving environmental resources by providing more water and increased environmental benefits to many watersheds, rivers, and streams for fish habitat and salmon recovery;
- overall ability to provide water and wastewater services to a greater population density than would otherwise be possible without water reuse, using existing water and wastewater infrastructure; and
- eliminating, downsizing, or postponing the need for capital projects for upgrading water and wastewater infrastructure capacity.

Building-Scale, Decentralized Systems

Although most of the urban water reuse applications to date have involved large-scale centralized treatment facilities serving entire municipalities, there is a growing trend towards constructing building-scale decentralized systems, where the wastewater generated within a residential or commercial building is treated and reused to satisfy the non-potable water needs of that structure. While centralized systems are perceived to offer economies of scale, once the pumping and pipeline costs of transferring reuse water back into the community is taken into consideration, decentralized systems can be a more cost effective alternative – plus, they can adapt more readily to improvements in technology than centralized facilities.

There is a trend in major cities, including Tokyo and Beijing, to establish regulations requiring buildings that exceed a specific total floor area to install a wastewater reuse system. Water reuse guidelines established for Tokyo in 1984 requires large-scale buildings, with a floor area of more than 30,000 m^2, or buildings that use a daily total volume of 100 m^2 of water for non-drinking water purposes ("miscellaneous-use"), to use recycled water. Similarly, Beijing established a requirement for wastewater reuse in buildings in 1987, with the issuance of their *Regulation of Building Decentralized Wastewater Reclamation Systems*, which states that all hotels and residence areas with floor areas exceeding 20,000 m^2 and all other buildings with floor areas exceeding 30,000 m^2, must include in-building wastewater reclamation and reuse facilities. In both cities, the in-building reclaimed wastewater is commonly used to generate reuse water for toilet flushing and landscape irrigation, but is also used for building cooling, car washing, and fire protection.

Recent examples of buildings with internal wastewater reclamation and non-potable water reuse systems in North America include: the Missouri Department of Conservation Discovery Center (Kansas City, MO); Dockside Green (Victoria, BC); the Vancouver Convention Centre (VCC) West building (Vancouver, BC); and the recently completed (2011) University of British Columbia Centre for Interactive Research in Sustainability (CIRS) building (Vancouver, BC). All four buildings reclaim wastewater for non-potable reuse applications including toilet flushing, and satisfying irrigation demands. Toilet flushing and irrigation are typically responsible for 80 percent or more of a commercial building's water demands. The CIRS building also incorporates sewer mining, in order to generate sufficient reuse water to meet the building's irrigation demands during the summer, a period with fewest building occupants.

The architectural and development communities are also embracing the reclamation of wastewater to improve the sustainability of buildings. The Leadership in Energy and Environmental Design (LEED) rating system for the design, construction, operation, and maintenance of green buildings awards up to 10 points for water reduction design elements for new and existing buildings, including up to four points for innovative wastewater technologies and landscaping with no potable water use. Similarly, the Living Building Challenge calls for the design and construction of buildings with net zero water over a minimum 12 months of continuous occupancy. Both the VCC and the CIRS buildings have been awarded LEED Platinum certification due, in part, to receiving full points for their water conservation and reclamation practices.

The VCC and CIRS buildings' water reclamation facilities offer an interesting comparison, the former using a state-of-the-art activated-sludge membrane bioreactor process incorporating hollow-fiber ultrafiltration membranes, and the latter consisting of a conventional activated-sludge process that uses a secondary clarified for bacteria retention, but which also has floating plants over the bioreactors and polishes the treated effluent through a constructed wetlands.

The VCC treatment plant operates very much behind the scenes and, aside from signage in the building advising that reclaimed water is used to flush the toilets and urinals, most visitors to the building are relatively unaware of the water reclamation process. On the other hand, the CIRS system is very much evident to visitors entering the building, appearing to be a large in-building greenhouse located right in front of the main entrance. While the plants functionally do very little to treat the wastewater, they do serve as a highly visible reminder to the occupants and visitors that what is flushed down sinks and urinals will directly affect the plants in the treatment process, inherently making the occupants of the building part of the overall treatment process – helping to prevent contaminants from being released to the environment through source control.

Conclusion

Following the example of Beijing and Tokyo, there is no question that it will eventually become common practice for cities to adopt building codes and regulations requiring new and retrofitted buildings to incorporate measures including dual-plumbing and in-building wastewater reclamation and reuse to satisfy non-potable water demands within the buildings. Similar to the shift from municipal-operated central heating systems to the predominant use of in-building heating, ventilation, and air conditioning systems, wastewater reclamation systems will eventually become common place, certainly within larger buildings and developments. The benefits to municipalities are significant, as in-building systems reduce demands on municipal water supplies, and enable existing water and wastewater infrastructure to serve larger population densities without the need for expensive upgrades. This shift towards buildings becoming more self-sufficient in meeting water needs will require a paradigm-shift in municipal infrastructure planning – a shift that is probably best considered and implemented sooner rather than later in response to overwhelming development pressure. MW

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