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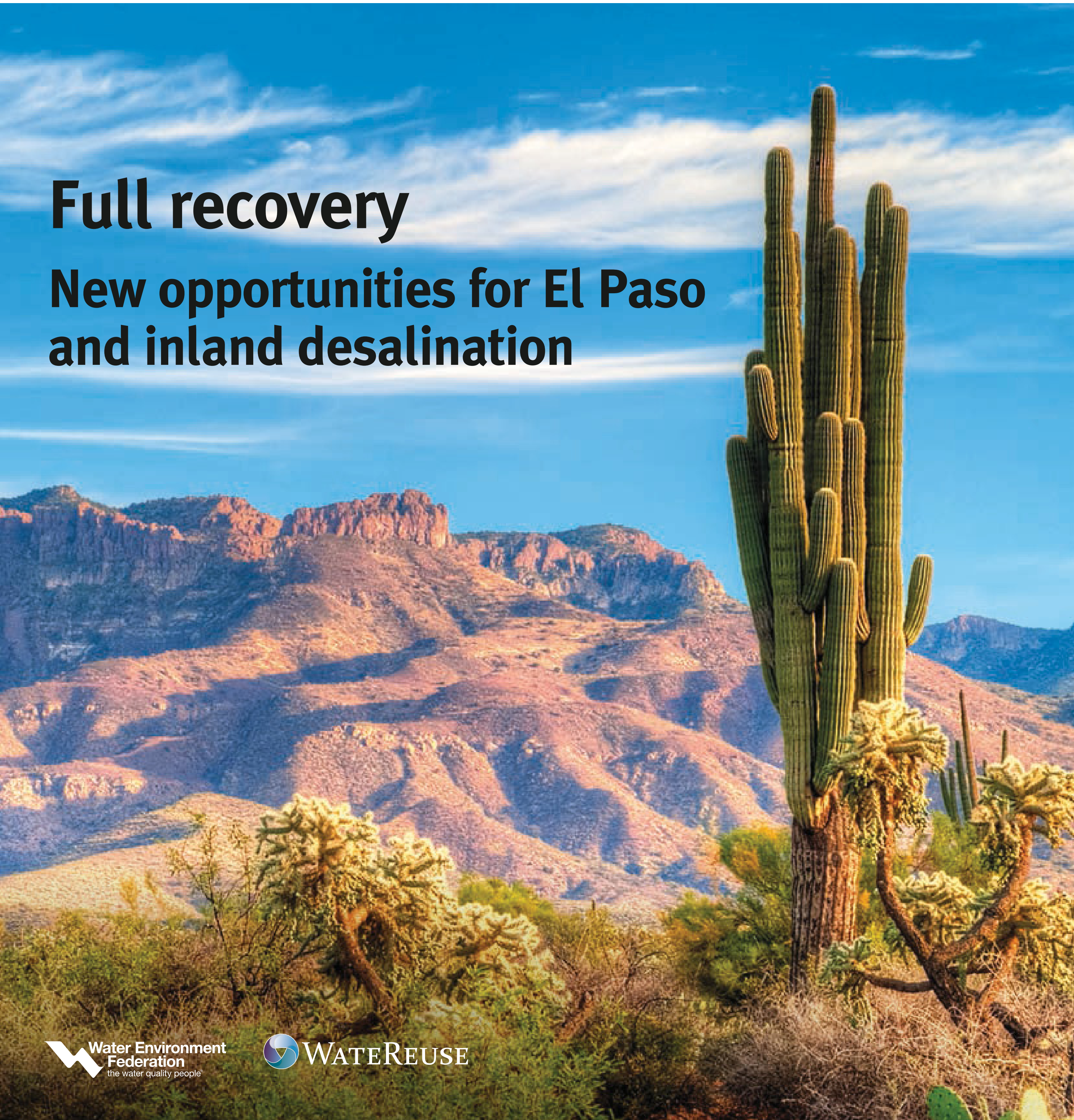
Autumn 2017



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Hydraulic fracturing surge drives water demand

Bluefield Research forecasts that since a rebound in hydraulic fracturing last year, spending by energy companies on US water management solutions is projected to increase 47 percent by the end of 2017.

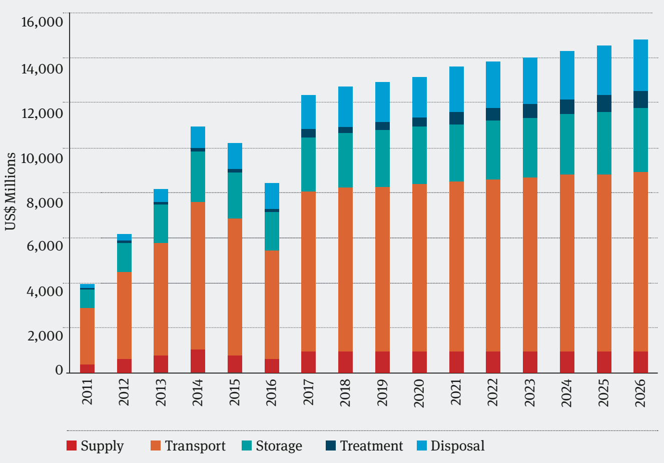
"Oil prices are up 62 percent from last year, and the impact on water demand is following in step. This turnaround, from the industry's collapse, has thrust upstream oil and gas into a new phase, one in which water services are even more critical at US$50 per barrel of oil," says Bluefield President Reese Tisdale.

Over the last 6 months, the stabilization of oil prices close to $50 per barrel (bbl) and improved techniques have created a surge in water demand. According to Bluefield's analysis of sector demand, spending, and competitive strategies, energy companies will spend more than $136 billion from 2017 to 2026 on water management -- including water supply, transport, storage, treatment and disposal.

Other findings include:

- Demand for water solutions is rising exponentially because of increased water volume per frack and an almost 30-percent reduction in time to complete a well. In some basins, well completions require as much as 12 million gallons of water per frack – triple the water volumes needed 5 years ago.
- From 2017 to 2026, more than 20 billion barrels of water will be required to serve the US hydraulic fracturing market at today's rig count. Cost of water transport, rather than availability, has become the primary concern for most energy companies.

More details on the sector are available in Bluefield Research's new market insight, *Water for U.S. Hydraulic Fracturing Market: Competitive Strategies, Solutions, and Outlook, 2017-2026*.



Source: Bluefield Research

Milestones

Robert Whitley, one of the founding directors for the WateReuse Association and WateReuse Foundation, has been elected to the Academy of Distinguished Alumni in the Department of Civil and Environmental Engineering at the University of California, Berkeley. Established in 2011, the Academy recognizes alumni who are outstanding and recognized engineers with special expertise in civil and environmental engineering disciplines and leaders with distinction in management.

As a practicing engineer for more than 50 years, Whitley has become one of California's leading experts on recycled water. He has been a principal at West Yost Associates since it acquired Whitley Burchert and Associates earlier this year. He was senior vice president and chairman of the Board for Whitley Burchett for 32 years.

Whitley earned his bachelors in science in civil engineering from UC Berkeley in 1964 and his masters in science in civil and environmental engineering from UC Berkeley in 1965. He has continued to provide service to the university by enhancing engineering alumni, students, and faculty relationships through periodic on-campus activities.

West Yost Associates is a consulting civil and environmental engineering firm based in Walnut Creek, California, United States.

Anue Water Technologies announced on July 24, 2017, that **Tonya Chandler** is joining the company as vice president of sales and marketing in its headquarters in Oceanside, California, USA. Anue manufactures high-efficiency ozone and oxygen generation systems for the elimination of odor, corrosion, and FOG (film, oil, grease) in municipal and industrial wastewater.

Chandler recently served as national sales manager for Veolia Water Technologies – Food and Beverage. She has earned numerous certifications and awards, including Water Systems General Operator (OTM/NN), ASTM Environment Site Assessment, Hygenic Design & Sanitation in Food Plants (MWFPA), Microsoft SQL Server Reporting, and has received Veolia's Pinnacle Award for Sales Excellence.

IDE to build Taiwan SWRO facility

Formosa Petrochemical Corporation (FPCC) commissioned IDE Technologies, based in Israel, to build a seawater reverse osmosis (SWRO) desalination plant, which will be located at the Mai-Liao Power Corporation in Yunlin County, Taiwan. With a capacity of 105,000 cubic meters per day, the facility will produce high-quality water for industrial applications.

IDE says that the facility will optimize energy and chemicals consumption, while also being cost-effective. The government recently reduced water rights for Formosa from natural sources to support agriculture, requiring the company to seek an independent water supply. The facility will use IDE's boron removal system to meet Formosa's requirement for low boron concentration. The system is the world's first to reach the extremely low and challenging boron concentration level requirement of less than 0.01 parts per million. IDE will design the Formosa desalination facility, supply and install equipment, commission the plant, and supervise operation and maintenance for two years.

Treated graywater better for irrigation in arid regions

Reusing graywater in dry areas may require treatment for more efficient irrigation in arid, sandy soils, according to a new study published in *Chemosphere* by researchers at the Ben-Gurion University of the Negev (BGU) Zuckerberg Institute for Water Research.

Graywater includes any wastewater generated in households or office buildings except from the toilet. It has been proven safe for agriculture irrigation. "Most of the scientific research and legislation efforts have focused on graywater's health risks, while less attention has been given to its environmental outcomes, including its effect on soil properties," says Professor Amit Gross, head of the Department of Environmental Hydrology and Microbiology in the Zuckerberg Institute.

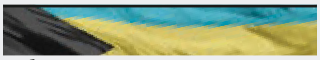
Professor Gross and his team found that graywater does not infiltrate through the soil as easily as freshwater and is slower to reach plant roots. It can also cause water runoff leading to erosion. He explains, “This condition, called ‘graywater-induced hydrophobicity,’ is likely temporary and disappears quickly following rainwater or freshwater irrigation events. However, it is a more significant concern in arid lands with negligible rainfall as compared with wetter regions.”

According to the researchers, treating the graywater using biofiltration to degrade the hydrophobic organic compounds will eliminate the problem.

In the study, the researchers examined how graywater induces soil hydrophobicity, as well as its degree and persistence. They created three graywater models using raw, treated, and highly treated graywater to irrigate fine-grained sand compared to a freshwater control. The result was that only the raw graywater irrigated soil showed hydrophobicity, which could be mitigated with both moderately and highly treated solutions.

“Onsite reuse of graywater for irrigation is perceived as a low risk and economical way of reducing freshwater use and, as such, it is gaining in popularity in both developing and developed countries,” says Gross. “As many government authorities are establishing new guidelines, the results of this study reinforce the recommendations to treat graywater before reusing for irrigation, particularly in arid regions.”

Field Notes



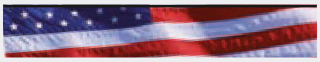
Bahamas

A new desalination plant will provide approximately 2.7 million liters per day of water to the Caribbean island of Eleuthera, located about 80 kilometers east of Nassau. GE Water & Process Technologies is building a seawater reverse osmosis (RO) desalination plant for the Water and Sewerage Corporation Bahamas. Under the terms of the 15-year outsourcing service agreement, GE will build, own, and operate the new facility, scheduled to begin commercial operation in the first quarter of 2018. This facility, located in North Eleuthera, is GE’s fourth seawater desalination plant on the island.

Netherlands

Hatenboer-Water will supply two Tethys reverse osmosis (RO) water treatment units for diving support barges scheduled to be deployed along the Gabon coast. The company designs and constructs freshwater modules for compact applications.

The RO units will be installed aboard two diving support barges currently under construction in the Holland Shipyards’ site in Hardinxveld-Glessendam, the Netherlands. Each unit will provide up to 6 cubic meters of drinking water per day. Holland Shipyard previously ordered Hatenboer-Water RO units for their Tridens project and Caspian Sea accommodation barges, which are scheduled for deployment in August and September.



USA

The Southwest Regional Water Reclamation Facility project in Citrus County, Florida, is now officially underway following the official groundbreaking ceremony attended by the Florida Department of Environmental Protection, Citrus County Board of Commissioners, Southwest Florida Water Management District, and local officials. The project is funded through a US$12.4-million loan through the state’s Clean Water State Revolving Fund and a $4-million legislative appropriation grant.

The new facility will provide advanced wastewater treatment to reduce nitrogen loading to the Chassahowitzka Springs and River, and it will have double the treatment capacity of the former Sugarmill Woods plant. The newly expanded and upgraded facility will provide future service to more than 5,000 homes currently on septic tanks and will replace an existing sprayfield with a rapid infiltration basin system. Additionally, the new facility will produce high-quality reclaimed water for irrigation of public access areas, which will further reduce nitrogen loading and reduce the need for groundwater withdrawals.

Significant increase in water reuse ahead, says new WateReuse executive director

WateReuse Association names **Patricia Sinicropi** as new executive director to advance the organization’s 2017-2021 Action Agenda. In an interview with *World Water: Water Reuse & Desalination (WR&D)*, Sinicropi discusses future water reuse trends in the United States and the organization’s plans to address sector challenges.

The greatest challenges to increasing water recycling are policy and public perception, says Patricia Sinicropi, the new executive director of WateReuse Association as of September 5. Faced with increasing demands and finite water resources, municipalities and industries realize the importance of tapping wastewater as a major source of water, but they must still educate the public on the benefits of water reuse.

Sinicropi has nearly two decades of experience as a policy expert and advocate on water-related issues in Washington, DC, USA. Prior to joining WateReuse, she served as the senior legislative director for the National Association of Clean Water Agencies, legislative counsel to the Water Environment Federation, and as deputy director at the President’s Council on Sustainable Development during the Clinton Administration.

Water Reuse & Desalination (WR&D) ____ Water reuse has come a long way since the first water recycling facility was built in the US state of California in the 1930s. What do you think is the future of water reuse in the United States?

Patricia Sinicropi ____ I think we will see a significant increase in water reuse in the coming years. According to the US Environmental Protection Agency (EPA), the US produces about 121 billion liters of wastewater every day, but we only recycle approximately 7.5 to 11.4 billion liters, or about 7 to 8 percent of the total produced. When you consider the big picture of supply and demand, wastewater is a major source of water that remains largely untapped.

WR&D ____ Why do you think water reuse is going to increase so much?

Sinicropi ____ The answer is simple: supply and demand. Water is used in every aspect of our lives, from cooling power plants that generate our electricity to growing food that feeds our families to manufacturing everything from clothes to cars. The US population is expected to grow to 450 million by the end of this century. As the US population and economy grows, the demand for freshwater will increase. At the same time, we only have a finite supply of freshwater resources, which will come under increased pressure not only from population and economic growth but also from climate change. So we are going to have to look toward recycling our water resources to ensure we have adequate supplies of potable and non-potable supplies of fresh water to meet future demand needs.

WR&D ____ The drought in California created a lot of momentum for water reuse. How do you think the end of the drought emergency will impact your efforts to increase water recycling?

Sinicropi ____ We really need to think about water reuse in the context of comprehensive water management so we can be prepared for whatever type of hydrological phenomenon we

> WateReuse is truly unique in that we are the only national trade association dedicated solely to advancing laws, regulations, funding, and public acceptance for water recycling.
>
> Patricia Sinicropi
> Executive Director, WateReuse Association

will face, not just as a response to periodic drought. By integrating water reuse into long-term water supply planning, communities can avert a more costly and disruptive water crisis. Even communities that are not threatened by water shortages can benefit from incorporating recycled water into their water portfolio as Hampton Roads, Virginia, is demonstrating through a water reuse project designed to address sea level rise and subsidence.

WR&D What do you see as the greatest challenges to increasing water reuse?

Sinicropi Research and innovation have tackled many of the technological and engineering obstacles to water reuse, but policy and public perception need to catch up to the science.

First, water policy needs to be a national priority. As a nation, we need to recognize that water infrastructure is as important as transportation infrastructure to our economy. Investing in municipal and industrial water, wastewater, and water reuse facilities, like we invest in roads and bridges, will provide a solid foundation for economic growth and job creation.

Second, we need to continue to educate the public about the safety of recycled water. The fact is that all water is recycled. We have the same water now that we had at the beginning of time. The primary difference is that now we have the technology to clean it faster and better than ever before, even better than nature.

WR&D What are the challenges with public acceptance, and how is WateReuse addressing them?

Sinicropi The biggest challenge is that most people do not think about where their water comes from beyond turning on the tap. If we understand the water cycle, we know that all water has been used repeatedly since the beginning of time. Proven and science-based technology just helps us speed up the process.

We've learned from experience that the public relies on health professionals to provide assurances of water quality. That's why WateReuse is building a coalition with the medical community to bring greater awareness and understanding to the safety of water reuse.

WR&D How important is research to the future of water reuse?

Sinicropi The peer-reviewed, applied research produced by the Water Environment & Reuse Foundation (formerly the WateReuse Research Foundation) is essential to public health and environmental protection. The science drives both innovation and informed policy. As a result, new and better technologies come to market quicker, and regulatory frameworks are based on empirical evidence.

WR&D How can the US federal government help communities develop a safe, reliable supply of water?

Sinicropi The overwhelming majority of our members believe that state and local communities are primarily responsible for cleaning and delivering water to consumers. However, federal funding provides a financial incentive for increased public and private investment in much-needed water infrastructure. Many states and local communities leverage federal funding to accelerate implementation of new, complex, or large water projects. Tax-exempt municipal bonds and programs like Title XVI, WIFIA (Water Infrastructure Finance and Innovation Act), and the Drinking Water and Clean Water State Revolving Funds are vital financial tools for water reuse projects.

WR&D Industry is also a large consumer of municipal drinking water. What can the federal government do to encourage businesses to recycle water?

Sinicropi Although recycled water is a viable alternative for many industrial processes, the cost of retrofitting existing facilities to use recycled water is prohibitively expensive. That's why we support a tax credit that creates an incentive for companies to retrofit facilities to accept municipal recycled water or to clean and recycle water onsite. Providing a narrowly focused, dollar-for-dollar reduction in federal income taxes for investments in water reuse infrastructure and technology will reduce the cost of these improvement projects, making them financially feasible. A tax credit for retrofitting existing industrial facilities to reuse water will also encourage companies to invest their money in capital projects that provide a benefit to the public and taxpayers.

WR&D WateReuse has an ambitious 5-year agenda – the 2017-2021 Action Agenda – to increase funding for water reuse infrastructure, improve the regulatory climate for water reuse, and further build public support for water reuse. How will you implement this action agenda?

Sinicropi We are going to work hard to educate lawmakers and policymakers about the benefits of water reuse to our environment, economy, and standard of living.

WR&D How does WateReuse facilitate knowledge sharing and education within the water industry?

Sinicropi Our Annual WateReuse Symposium is the preeminent conference dedicated to water reuse and provides an excellent opportunity to gain insight into best practices and to learn about the latest innovations. We also host specialty conferences, workshops, and convenient webinars to keep our membership and the water community at large informed.

WR&D Does WateReuse have new initiatives to help engage your members?

Sinicropi WateReuse recently launched a new member-only, online community called WateReuse Connect. The online platform allows members to ask questions, offer expert advice, and share experiences, strategies, and success stories with other water professionals, 24 hours a day, 7 days a week.

WR&D What makes WateReuse different from other national organizations that advocate for water issues?

Sinicropi WateReuse is truly unique in that we are the only national trade association dedicated solely to advancing laws, regulations, funding, and public acceptance for water recycling. That singular focus makes us more effective in everything that we do, from federal advocacy to knowledge sharing to networking.

WR&D What kind of impact do you think WateReuse can have on national water policy and funding?

Sinicropi WateReuse is a powerful and influential voice for our members in the nation's capital. We represent more than 200 utilities serving communities with nearly 60 million people, or one-fifth of the nation's population. Our members include national leaders who are achieving water resiliency through policy, projects, innovation, education, and knowledge sharing. With a focused message in the nation's capital, we can hopefully accomplish many important policy goals.

WateReuse names new executive director

The WateReuse Association has named Patricia Sinicropi as its new executive director. Sinicropi, who previously served as the senior legislative director for the National Association of Clean Water Agencies (NACWA), has extensive experience in federal advocacy with both Congress and federal agencies. She brings a wealth of knowledge and skills in advancing the legislative, regulatory, and funding priorities of wastewater utilities and related businesses.

Sinicropi replaces Melissa L. Meeker, who is now the chief executive officer of the Water Environment & Reuse Foundation (WE&RF), a research and education organization, based in Alexandria, Virginia, USA, that collaborates closely with WateReuse.

Southern California hosts international water reuse conference

More than 640 water reuse practitioners and researchers from around the world gathered in Long Beach, California, USA, on July 23-27 for the 11th IWA International Conference on Water Reclamation and Reuse. The International Water Association's conference on water reuse, jointly hosted by the Water Environment & Reuse Foundation, WateReuse California, and the National Water Research Institute, served as a unique opportunity for leaders around the world to share knowledge on a range of topics addressing water reuse research, policy, technology, and public engagement.

Hosted in North America for the first time, the conference featured renowned plenary speakers including:

- Takashi Asano, PhD, Professor Emeritus at the University of California, Davis, USA
- Jeff Kightlinger, General Manager for the Metropolitan Water District of Southern California, USA
- Jörg E. Drewes, Dr.-Ing., Chair Professor of Urban Water Systems Engineering at the Technical University of Munich (Germany).

WateReuse Board of Directors appoint water leaders

The WateReuse Association announces the appointment of five new US water industry leaders to the Board of Directors to help lead the organization in advancing laws, regulations, funding, and public acceptance for water recycling.

- With his extensive experience in government affairs, Jon Freedman, Vice President of Global Partnerships & Government Affairs for General Electric's global water business unit, will increase the influence and impact of the association's federal advocacy effort.
- As chief executive officer (CEO) of one of the preeminent engineering firms specializing in water, B. Narayanan of Carollo Engineers brings a wealth of business acumen, experience, and expertise to the organization.
- Named a 2017 Northern Virginian of the Year, Karan Pallansch is CEO of Alexandria Renew Enterprises in Virginia, one of the most advanced resource recovery public utilities in the United States.
- Paul Steinbrecher is Director of Permitting and Regulatory Conformance for JEA, the largest community-owned utility company in Florida.
- Norma Camacho, Interim CEO of the Santa Clara Valley Water District in California, will serve the remainder of the term for Jim Fiedler, who recently retired from his position at the water agency.

More than 30 talented, highly regarded water industry leaders were nominated to the Board of Directors, resulting in a large pool of qualified candidates and a very competitive selection process.

"WateReuse had an overwhelming response to the call for nominations," says WateReuse President Guy Carpenter of Carollo Engineers. "We were very intentional about selecting and appointing new directors who represent the diversity and geography of water reuse across the United States, and who have the ability to help us implement the five-year legislative action agenda we created last year."

Annual WateReuse Symposium coming to Phoenix

WateReuse will host the 32nd Annual WateReuse Symposium, September 10-13, 2017, in Phoenix, Arizona, USA, at the Renaissance Downtown Hotel. The Annual WateReuse Symposium is the preeminent conference on water reuse and the only annual conference that is dedicated solely to advancing the policy, technology, innovation, and public acceptance of water reuse.

This year's Symposium will feature more than 100 presentations, panel discussions, and workshops – as well as a Reuse Bootcamp. Networking opportunities include an exhibition, awards luncheon, dinner, and an optional baseball game. In the latest twist on using beer as an outreach tool, brewers from across Arizona will brew beer with purified water and compete for prizes at the Pure Water Brew Challenge.

WateReuse members advocate for reuse in US Senate

In testimony before the United States (US) Senate on August 2, 2017, four WateReuse Association members highlighted water reuse as a key strategy in developing reliable local water supplies. The US Senate Committee on Energy & Natural Resources, Subcommittee on Water and Power, convened the hearing to examine increasing water security and drought preparedness through infrastructure, management, and innovation.

"WateReuse members are leading the nation in advancing water reuse," said WateReuse President Guy Carpenter of Carollo Engineers. "Because of their commitment to science-based policy, communities across the nation are providing a safe, reliable, locally controlled water supply by recycling water."

Hosted by Subcommittee Chairman Senator Jeff Flake (R- Arizona) and Ranking Member Angus King (I-Maine), the hearing's witness panel included state and local officials, business leaders, and an academic.

"Oftentimes discussions on water policy at the federal level are dictated by costs. However, it's important that Congress also consider the barriers that local communities face as they plan and pursue new water projects," Senator Flake said in his opening remarks.

Tom Buschatzke, director of the Arizona Department of Water Resources, explained that his state has a philosophy regarding drought preparedness and water management that includes continuously developing and improving laws, policy, and infrastructure. The Palo Verde Nuclear Generating Station in the US state of Arizona's Phoenix metropolitan area is an example. The facility uses treated municipal wastewater to produce up to 4,200 megawatts of power for approximately 4 million people in four states.

"Arizona was reusing substantial volumes of reclaimed water long before reuse became a common practice," Buschatzke said in his testimony.

Offering a utility perspective, Shirlee Zane, board chairwoman for the Sonoma County Water Agency in the US state of California, added that her agency relies on a diverse portfolio of water sources to maintain a secure supply, including recycled water, groundwater, and surface water storage.

President and CEO of GE Power—Water & Process Technologies, Heiner Markhoff recommended that Congress develop policies that would promote more rapid adoption of water reuse solutions such as reducing regulatory and cost barriers, providing financial incentives, and requiring more water recycling. "One of the biggest opportunities the world has yet to capitalize on is the reuse of wastewater streams to alleviate the pressure of finding and creating new water resources," he said.

President and CEO of Poseidon Resources, Carlos A. Riva testified about the benefits of public-private partnerships. Poseidon Resources is a Boston-based private firm in the US state of Massachusetts that has partnered with communities to develop water reuse and desalination projects. Riva said that the time is right for Congress to encourage and remove barriers to the wider use of such partnerships.

Left-Right: Jeffrey Kightlinger, General Manager, Metropolitan Water District of Southern California; Diane d'Arras, Suez Water Europe and President of International Water Association; Takashi Asano, University of California-Davis; Jörg Drewes, Technical University of Munich; Peter Joo Hee Ng, PUB Singapore; Melissa Meeker, Water Environment & Reuse Foundation.

Growing demand for reuse fuels membrane market

Growth in the membrane market remains sporadic with fewer but high-value membrane-based water and wastewater treatment projects under development. **Deepthi K. Sugumar** of Frost & Sullivan reports on current trends affecting the demand for advanced membrane treatment in the municipal and industrial sectors.

Growing industrialization, combined with rapid increase in population and urbanization, has resulted in pressure on limited water resources. As a result, municipal and industrial segments are encouraged to move toward circular economy of water reuse by employing advanced technologies such as membranes. Membrane technology is continuing to advance, with benefits including energy efficiency and the ability to meet increasingly stringent water quality standards. Developing membrane technology can also lead to higher water reuse and recovery rates, which is important at a time when water recycling and reuse is of growing importance.

Nearly one-fifth of the global population dwells in water scarce areas, some of which are also experiencing high industrial activity and rapid population increase. Water reuse will play an imperative role as it offers greater resilience and water security. Water reuse also reduces the stress on groundwater and fresh water resources. Besides being a reliable water source, water reuse in industries can bring down the cost spent on water and decrease load on urban wastewater treatment plants.

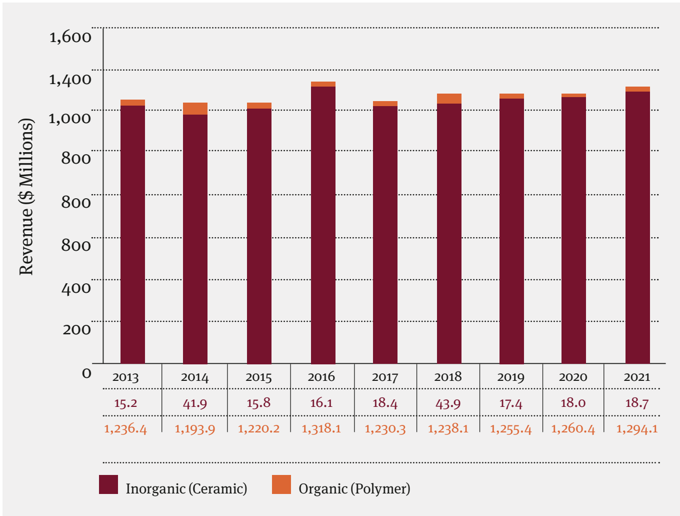
Many technologies exist in today's modern world for treating water and wastewater, and membrane technologies have been garnering interest because of their ability to produce high quality output. Countries including the United States, Japan, and many European countries have long used advanced membrane technology for treating water and wastewater both in the industrial and municipal segments.

Europe's water and wastewater treatment market is driven by legislation with stricter discharge limits and higher recycling rates. As far as water treatment is concerned, removal of impurities and bacteriological contamination is paramount. Focus on industrial wastewater lies in water reuse and recycling, especially in the Southern European and Mediterranean regions. Energy efficiency of membrane treatment systems has amassed greater attention recently, with many companies investing capaciously in research and development for energy efficient membrane treatment systems.

According to findings of Frost & Sullivan, central factors that influence revenue of membrane industry include energy efficiency, membrane replacement (due to significant installed base in the municipal and industrial segment), plant refurbishment and upgrades, stringent discharge regulations, and higher recycling rates. Due to stringent regulation in Europe, specialized membranes will always be on demand to treat wastewater for reuse and safe disposal of the treated effluent in water bodies of sensitive areas.

Frost & Sullivan estimates the total membrane systems market for water and wastewater treatment in Europe to be at an overall size of approximately US$1.33 billion as of 2016. The installed base of all countries in Europe, primarily in the municipal segment, indicates growth opportunities for replacement, refurbishment, and upgrades.

The growth rate in the municipal membrane market is sporadic and is attributed to fewer but high-value membrane-based water and wastewater treatment projects in a year. For example, the 90-million-liters-per-day (MLD) ceramic membranes of a municipal drinking water plant in southwest England are the first combined technology planned to be installed in the United Kingdom (UK), according to PWN Technologies of the Netherlands. The industrial sector will have fewer large-capacity, membrane-based plants; however, there is a constant need for highly efficient membrane treatment technologies to meet stringent discharge regulations, with a persistent demand for new installation as well as replacement.



Total membrane Systems Market: Revenue Forecast by Membrane Material, Europe, 2013-2021

Countries such as France, Germany, Netherlands, and the UK can be considered a prospective replacement market. Germany, especially, has a significant installed base of ultrafiltration membranes for treating potable water as well as backwash water. Italy will have more membrane-based decentralized systems primarily in small municipalities along the coastal regions, as it is preparing to comply with EU regulations. It is also predicted that core membrane investments are likely to shift from Western to Eastern Europe, attributable to changes in the investment climate in these regions.

Microfiltration and ultrafiltration membranes are prominent among the municipal water treatment segment, primarily for their suitability to remove key impurities, especially micro-organisms, when compared to other conventional filtration equipment. These membranes have always reported higher water reuse and recovery. Europe is a water surplus region, and the Mediterranean region is home to the membrane-based desalination market.

Recently, ceramic membranes have proven to be a particularly promising alternative technology for their low fouling tendency, longer life span, and scarcer operational difficulties. Most importantly, ceramic membranes

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Introducing the new

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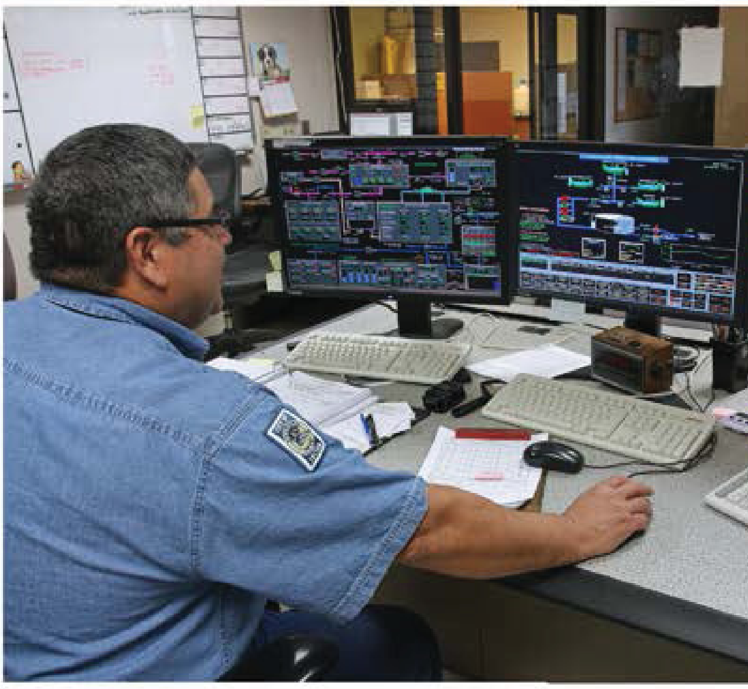

Today's high-tech water reuse programs require specialized skills to plan, manage, and operate.

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Latin American governments have taken positive steps to address water scarcity by implementing water recycling and reuse policies and projects. Authors **Jon Freedman**, **Jessi Tseng**, and **Marcus Vallero** of GE Water & Process Technologies and **Melissa Meeker** of the Water Environment & Reuse Foundation take a close look at Brazil's adoption of water reuse regulations and technologies by municipalities and industries. Additionally, the authors cover effective tools that can be used in many countries to further expand water recycling and reuse practices with the goal of increasing water supply.

Addressing water scarcity through recycling and reuse

Latin America has almost 31 percent of the world's freshwater resources – more freshwater per capita than any other region in the world – but still faces acute water scarcity challenges. The fundamental problem is simply that much of the population lives in places where water is scarce. For example, 73 percent of Brazil's freshwater is in the Amazon River Basin, but only 4 percent of Brazil's population lives in areas that account for 27 percent of its water.

In Mexico, more than 75 percent of the population lives in the central and northern regions, but 72 percent of the country's freshwater is in the south. And in Peru, 97.5 percent of surface water is in the Peruvian Amazon basin, yet only 30 percent of the population lives there.

According to the World Bank, 45 percent of the water in Latin America is lost before reaching the end consumer, with losses of up to 75 percent in some large cities. Moreover, only 20 percent of the region's wastewater is treated, and roughly 100 million Latin Americans lack access to sanitation.

Despite such challenges, many improvements are being made. The World Bank reports that the percentage of the population in the region with ready access to water for domestic purposes has been steadily increasing over the past two decades.

Water reuse should be considered equally important as a way to generate more water supply for the overall population.

For Latin America to reach its full water reuse potential, two key changes are necessary: increased awareness of proven technology alternatives at competitive prices, and policies that facilitate and regulate the use and reuse of water resources.

Brazil is the world's most water-rich country, with 13.7 percent of the world's freshwater resources. However, the mismatch between its freshwater resources and locations of high population density and water reuse, along with factors such as population growth and changing weather patterns, result in water stress for many areas of the country. São Paulo and Rio de Janeiro, the nation's two most populous cities, recently encountered unprecedented drought conditions.

Recognizing the importance of water security to the sustainable development of the country, the Brazilian government has recently bolstered investment in the water sector (including water reuse) through multi-billion dollar programs. These actions by Brazilian leadership come in the face of significant water supply and demand challenges: uneven distribution of water resources; rapid urbanization; growing demand for energy, agriculture, and other large water uses; dwindling groundwater supplies; deteriorating water quality; and lack of wastewater infrastructure.

Rio de Janeiro recently experienced unprecedented drought conditions. Photo by Brunomsbarreto, iStock

Water supply infrastructure is more developed than wastewater infrastructure in Brazil. Access to a drinking water supply is available for more than 82.5 percent of households, and drinking water quality standards are considered well developed, monitored, and enforced. Wastewater collection, however, is only available for 48.6 percent of households, with just 39 percent of total wastewater collected actually treated. As a result, some of the primary challenges – and therefore the largest opportunities – for investment in Brazil are connectivity, treatment, and the consequent reuse of sewage.

Investment in the country's infrastructure is allocated through the government's Growth Acceleration Program (PAC), which spent US$9.4 billion from 2007-2011. A remaining $4.9 billion has yet to be allocated. For the period of 2013-2018, market analysts forecast that the water and wastewater equipment market in Brazil will grow at a compound annual growth rate (CAGR) of 9.3 percent. For both water and wastewater, capital expenditure in Brazil is set to double from its 2013 baseline to $9.9 billion by 2018.

Moreover, the National Basic Sanitation Plan (PLANSAB), approved in 2013 by Brazil's National Cities Council, launched the goal of providing universal water supply and sanitation for the whole country. PLANSAB calls for $220 billion in water infrastructure investment over 20 years, or nearly four times more than called for in recent years, according to the private National Water and Sewerage Concessionaires Association (ABCON). The Plan outlines short-, medium, and long-term goals across 23 water supply and wastewater indicators to guide public and private investment in the water sector through 2033. Among these goals are targets for 99 percent of urban and rural households to be connected to the water distribution network (or supplied by a well or channelized spring), and at least 92 percent of households to be connected to a sewer network or septic tank. Importantly, PLANSAB encourages the "rationing and controlled reuse of water, and the use of treated sewage" in water programs.

Since 1992, planned water reuse has been used primarily for aquaculture, crop irrigation, and highway and pavement cleaning. Currently, overall reuse in Brazil is estimated to be less than 0.1 percent of water produced, according to the most recent figures cited in a 2015 *BNAmericas* report.

Despite this low estimate, water reuse in Brazil is becoming increasingly attractive, driven primarily by the financial benefits to industry. There are several industrial water reuse initiatives in São Paulo and Rio de Janeiro, one of the most notable being the Aquapolo Ambiental project, which reuses municipal wastewater for a petrochemical complex in São Paulo. The Aquapolo project was initiated to reduce potable water use in the city and is the largest industrial water reuse project in the Southern Hemisphere.

Depending on the need for conveyance and storage, the cost of reclaimed water is often lower than potable water and therefore attractive to industry. During the last 10 years, Petrobras, the state-run oil company, has been upgrading its downstream operations, including modernizing treatment systems and implementing water reuse projects in refineries. Petrobras estimates that its reuse activities resulted in more than 35 billion liters of water savings in 2015.

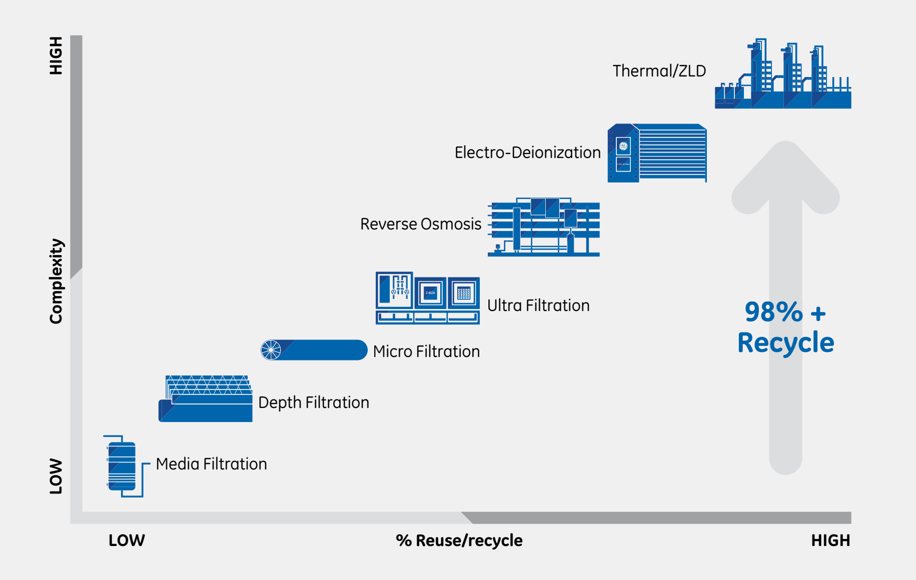
In the steel industry, ArcelorMittal Brasil reuses virtually all of the water used in industrial processes (taking into account six industrial units) with an average recirculation rate of 98 percent. Another example of water reuse is in the packaging sector for the production of glue, cleaning, irrigation, and cooling. For instance, five production units owned by Klabin, a paper producer, reuse 100 percent of factory effluents.

At the city level, São Paulo is leading the way, at close to 2 percent of water reuse. In July 2015, the government of São Paulo signed a financing contract for an innovative plug-and-play technology that will allow the increased production of reused water for industries and services. SABESP, the water utility of São Paulo, believes that water reuse in São Paulo could increase by a two-digit percentage in the medium term and that strong and clear government regulations are needed to encourage companies to invest in water reuse technologies.

Regulation

Primary responsibility for water and wastewater regulation in Brazil – and thereby water reuse – lies with the federal Ministry of Environment. The National Water Agency (ANA) is part of the Ministry of Environment and is responsible for implementing the National Water Resources Policy, established by law in 1997.

The country's first major water legislation to address water stress and pollution dates back to the 1934 Water Code. A 1997 update to this Code, the Federal Water Law, established political instruments and basic principles to help guide water resources management. Most notably, it states that water is a limited natural resource with an economic value, a principle that is the foundation of water conservation and



Reuse technology spectrum: GE water reuse technologies as a function of the percentage of reuse/recycle and the level of project complexity

water use fees. The Federal Water Law makes companies pay for wastewater discharges and withdrawals from water bodies. As a result, after the law was passed, the reuse of large volumes of water has become quite common within certain industries because water reuse lowers costs.

In 2007, the National Sanitation Law was passed to establish national guidelines for basic sanitation.

Starting in 1997, regulations for agricultural, municipal, and industrial water reuses have been established. The NBR 13.969/97 regulation identifies four categories for treated effluent reuse with four distinct recommended technologies to reach the required specifications. Resolution No. 54/2005 is the first specific legislation on non-potable water reuse in Brazil. It establishes procedures, guidelines, and criteria for direct non-potable water reuse for urban use, agriculture and forestry, environmental application, industry, and aquaculture.

The CONAMA Resolution No. 357/2005 classifies water bodies and indicates wastewater discharge standards. The resolution stipulates three classes of water; it categorizes water supplies that are suitable for human consumption after treatment. As a result, this regulation indicates that indirect potable reuse is permissible.

At the state level, in Rio Grande do Sul, the state Ordinance No. RS 04/1995 approved the Technical Standard No. 001/1995, which establishes wastewater discharge standards for the petrochemical industry. For large water reuse projects, companies usually assume international water reuse standards or follow technical guidelines created by private institutions.

The state of São Paulo is proactive in terms of water reuse regulations. Since 2002, the Municipality of São Paulo has required the use of reclaimed water for cleaning and irrigation. In 2010, several regulations were implemented to promote the use of reclaimed water in agriculture. Most recently, in 2012, a task group was formed to propose a norm for non-potable urban reuse in São Paulo. The norm, once published, would regulate the quality requirements for two classifications of treated effluent for nonpotable urban reuse – less restrictive (i.e. for urban irrigation) and more restrictive (i.e. washing streets, buildings, pipe unplugging, car washing). While this norm still has to be published, it provides evidence that São Paulo is moving toward more disciplined water reuse governance.

In August 2014, in the middle of a severe water crisis, the city of Campinas published a resolution to encourage the use of recycled water. The resolution was published 28 months after Sanasa, the municipal state-owned water concessionaire of Campinas, started up the first membrane bioreactor to treat domestic sewage in Brazil. Regulatory changes were necessary to further support the use of high quality water being produced in the EPAR (Reuse Water Production Stations) Capivari II plant. Resolution SVDS/SMS No. 09/2014 established general guidelines and quality requirements for the direct reuse of non-potable water, with two classes of reuse: restrictive Class A (e.g., for firefighting purposes and external automated car washing) and the less restrictive Class B (e.g., landscape irrigation and washing streets). Specifically, for Class A, the resolution states that ultrafiltration membranes must be part of the sewage treatment process.

In terms of industrial use, Brazil has specific industry-by-industry wastewater regulations as well as voluntary standards. With no overarching industrial reuse regulations at the country level, FIESP, the association of industries from São Paulo state, published a manual for the rational use of water in the industrial sector. The manual contains management tools to identify water reuse opportunities, information on available technologies, and quality requirements for common equipment, such as boilers and cooling towers, to help industry professionals to manage water wisely. While the document is not a governmental norm, it provides best practices and general technical recommendations that have helped to guide FIESP associates and other industries in São Paulo.

The National Confederation of Industries (CNI) has also been pursuing actions to stimulate water reuse. CNI has led a dialogue with the Brazilian business community in order to find a consensus on the proposal of a Bill of Law (PLS 12) that would regulate water reuse in the industry, defining water reuse production as an appropriate final destination of treated sewage, and creating financial and fiscal incentives to water reuse.

Going forward, the Brazilian government will formulate a plan of action proposal to implement a treated wastewater reuse policy. Recently, the Minister of the Environment, Izabella Teixeira, revealed that the Brazilian government is considering a national regulation to govern the reuse of industrial waste.

Potable reuse is also gaining attention in Brazil. For example, in 2014, national and international experts convened in São Paulo to discuss the feasibility of potable reuse.

Finally, other growing trends in Brazil's water sector include the concept of zero discharge, the use of public-private partnerships, and increased water reuse in irrigated agriculture.

Policy initiatives to promote water recycling

Latin America is by no means standing still in the face of water challenges. Brazil, Mexico, Peru and other countries in the region have developed sophisticated policy regimes and invested billions of dollars to implement solutions. Many other countries are choosing water recycling and reuse as part of their response to water scarcity. While policy options for encouraging this approach are many, a list of four types of initiatives provides a general understanding of those policies being implemented by governments around the world to increase water recycling and reuse:

- Education and outreach
- Removing barriers
- Incentives
- Mandates and regulation.

1. Education and outreach

One of the tools commonly used to promote water recycling and reuse is public education. Education and outreach are generally perceived as critical to advancing water recycling, not only to encourage its use but also to overcome possible public concerns regarding the safety and quality of recycled water.

Local communities raise awareness through a number of common techniques used by governments worldwide. For example, awards are presented to individuals and entities that have voluntarily made significant contributions to water recycling, and local governments can officially recognize private water recycling efforts to promote examples for other water users.

2. Removing barriers

Barriers to water recycling and recycling systems come in several forms: technological, financial, and regulatory. Certain regulations intended to protect the public or programs providing services to the community may have the unintended effect of discouraging or even preventing voluntary water reuse.

One of the largest barriers to water recycling is a municipal, state, or regional water code that does not recognize the use of recycled water.

3. Incentives

Communities can encourage water recycling by using the following economic incentives:

- Direct incentives in the form of tax credits, grants, or low-interest loans
- Reductions in payments such as tax deductions, rate reductions
- Pricing that imposes higher charges for potable water consumption
- Competitive financing for private sector industrial projects
- Regulatory relief by eliminating certain requirements for recycled water users.

4. Mandates and regulation

Communities facing severe water restrictions have frequently adopted two common approaches to mandating the use of recycled water:

- Requirements targeting the supply of recycled water by regional or local wastewater treatment or water supply districts
- Requirements affecting the use of recycled water by residents or businesses.

Conclusion

Water reuse offers a water source that is dependable and locally controlled. It allows communities to become less dependent on groundwater and surface water sources. They can then decrease the division of water from sensitive ecosystems, such as the Amazon.

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Building resilience to ensure safe, clean water into the future

Cities must take action to strengthen their resiliency against water scarcity in order to cope with environmental challenges and changing demographics. Xylem's North America Water Reuse Leader, **Keel Robinson**, explains how innovative technologies such as water recycling and desalination pretreatment technologies are helping Los Angeles, USA; Mumbai, India; and Jeddah, Kingdom of Saudi Arabia, to secure clean water supply.

Water stress is one of the most pervasive challenges facing communities around the world. Currently, approximately one-third of the globe experiences water scarcity at least 1 month per year. By 2050, the global population will rise to 9 billion people, and 66 percent will live in urban areas. This rapid urban growth coupled with changing weather patterns will put even greater strain on our natural resources and challenge our ability to deliver fresh, safe, and clean water where it is needed. As community leaders around the world seek to enhance their ability to anticipate, prepare for, respond to, and recover from extreme weather events, natural disasters, and ongoing environmental challenges, increasing water security must sit at the heart of the resilience-building agenda.

Resilience is one of three key pillars of global water technology provider Xylem's corporate vision, which includes increasing water productivity, improving water quality, and building water resilience. Xylem also works closely with municipalities and community stakeholders around the world, helping them to build resilient cities, a commitment borne out through innovative, sustainable water technologies that are underpinned by clear frameworks and varied case examples to bring the abstract concept of resilience to life. In this context, Xylem's recently published white paper, "Building Resilience: Creating Strong and Sustainable Cities and Communities," highlights four categories of actions to build resilience through the lens of water: ensuring water security, strengthening critical infrastructure, driving response and recovery, and engaging community stakeholders. The first category addresses the critical need for cities to supply clean water to the public continuously and reliably in all conditions.

In the face of growing water needs and increasingly variable supply, a sustainable water future will require a range of solutions including economic incentives, regulatory measures, and advanced technologies. Many municipalities are taking significant steps to build a water-secure future for their communities, including investing in sustainable, innovative solutions such as water reuse and desalination. These proven approaches can help meet growing water demands while safeguarding existing water supplies.

In Los Angeles, California, the Terminal Island Water Reclamation Plant's expanded Advanced Water Purification Facility (AWPF), now under construction, will be the first greenfield AOP design using UV light with chlorine for indirect potable reuse. Photo by Xylem

Water reuse

Water reuse is a common-sense solution: It reduces the demand for additional water resources and is often more cost effective than treating a raw water resource. After treating a waste stream to discharge level, it may require significantly less energy and less additional treatment to bring it to a potable drinking water standard than to treat a raw water stream, making reuse both a sustainable and cost effective option. With less energy consumption, water reuse reduces an operator's carbon footprint as well as its water footprint.

The following case studies describe innovative technology-based programs developed to address water stress in Los Angeles, California, USA, and in Mumbai, India.

Case study: Innovative water reuse solutions for the City of Los Angeles

Between the autumns of 2011 and 2015, the US state of California experienced its worst drought on record since 1835. The drought was the result of record-low precipitation levels and record-high temperatures; in fact, 2014 and 2015 were the two hottest years in California's recorded history.

In May 2015, emergency regulations were introduced with the aim of decreasing water use in urban areas by 25 percent. In addition to conservation measures, certain municipalities turned to water reuse as a sustainable solution to help meet this reduced water use threshold. Xylem was commissioned to deliver a unique water reuse system to increase the supply of purified, recycled water in Los Angeles. The proposed system, which is part of the city's Terminal Island Water Reclamation Plant (TIWRP), includes a groundbreaking expansion of the Advanced Water Purification Facility (AWPF) that treats non-potable recycled water. The process includes microfiltration and reverse osmosis (RO) followed by an Advanced Oxidation Process (AOP) to produce non-potable reuse water. Xylem's MiPRO photo Advanced Oxidation Process will ensure that the City of Los Angeles' TIWRP complies with California's stringent groundwater recharge regulations for indirect potable reuse in the safest, most cost-effective way possible.

The customized solution, validated through extensive pilot scale testing, will be the first greenfield AOP design using ultraviolet (UV) light with chlorine for indirect potable reuse. The solution will enable the Terminal Island Water Reclamation Plant to use its existing chlorination facility without having to add any new chemicals, while significantly reducing the lifecycle cost relative to other types of AOP, such as UV with hydrogen peroxide.

The TIWRP currently treats wastewater from more than 130,000 residents and 100 businesses in the Los Angeles harbor area, including the communities of Wilmington, San Pedro, and a portion of Harbor City. The plant purifies the tertiary effluent to potable water quality levels for use in industrial applications. Additionally, the purified water is used for recharging the stressed drinking water aquifers – which is particularly important in the wake of the drought. Through aquifer recharge, the recycled water serves as a barrier against seawater intrusion, protecting the groundwater from increased salinity.

Construction for the second phase expansion began in 2015, with operation expected to commence in mid-2017. Upon completion, the plant will provide approximately 45 million liters per day of highly purified water for beneficial use.

Additionally, Xylem will be supplying an aeration system to the Terminal Island Water Reclamation Plant to enhance the performance of the existing wastewater biological treatment system. The fine bubble aeration system enhances oxygen transfer, reduces energy costs, and improves the quality of the water feeding the Advanced Water Purification Facility. Xylem has provided fine bubble diffused aeration to all of Los Angeles Sanitation's wastewater treatment plants.

Water reuse technology will bring many benefits to the growing Los Angeles community, including the ability to meet growing water demands, safeguard existing water supplies, and produce high-quality water at a lower life-cycle cost than developing a new water supply. The result is a resilient, drought resistant water source with valuable economic and environmental benefits.

Case study: Mumbai metro rail reuse and recycling system

India, home to 16 percent of the world's population yet only 4 percent of the world's freshwater, faces a particularly severe water-scarce future. Spectacular economic growth, fueling a population and consumption boom, has resulted in increased demand for municipal, industrial, and agricultural water. Mumbai, with a population of 20 million, is India's financial capital. As with other cities of its size, Mumbai faces complex water challenges – one of which is the inefficient water use in municipal transportation operations. Xylem is helping Mumbai address these challenges by making its mass transportation system more sustainable and water-efficient.

In India, Mumbai's metro rail design includes a water reuse and recycling system, which uses Xylem's continuous flow Intermittent Cycle Extended Aeration System (ICEAS) process to treat water by aerating, settling, and decanting the water. Photo by Xylem

Mumbai's metro rail design includes a water reuse and recycling system capable of turning the metro system's nearly 1.2 million liters of daily wastewater into clean water for new uses, such as washing and irrigation. To turn this vision into reality, Mumbai's metro rail team selected advanced wastewater treatment solutions from Xylem, including its continuous flow Intermittent Cycle Extended Aeration System (ICEAS) process. ICEAS treats water by aerating, settling, and decanting the water in a single system with reliable, energy-efficient, and cost-effective technologies, followed by integrated disk filtration and disinfection. Xylem's engineering capabilities ensured that this compact water reuse plant would fit in the small space available by customizing it for the metro system's needs.

In addition to the metro rail system, another Xylem initiative underway in India is the country's first water reuse plant to turn wastewater into potable drinking water. Located in Vadodara, Gujarat, the plant integrates the ICEAS process with ultra-filtration membranes and a UV disinfection system to produce clean drinking water. By recycling water, the plant makes a valuable contribution to the creation of a water-secure future for India.

Desalination

In water-stressed areas of the world near saltwater or brackish water supplies, removing salt from water through desalination is sometimes the only option to supply communities with potable water. Xylem was an early innovator in membrane technology designed to produce freshwater from the world's oceans and has provided reliable membrane-based water desalination technology and components worldwide since 1975.

The following case study describes how Saudi Arabia has embraced desalination to ensure a secure water supply for the state's citizens.

Case study: Jeddah desalination pre-treatment

In Saudi Arabia, deposits of crude oil fuel economic activity in the country, but groundwater resources are increasingly depleted by the needs of the oil industry, human consumption, and food security. Experts around the world estimate Saudi Arabia's groundwater supply will be completely depleted in mere decades.

However, the country's long coastlines provide access to plentiful seawater, which makes desalination a logical choice. In 1927, Saudi Arabia installed its first desalination facility. Since then, the nation has increased its desalination production from 300 million liters per day to more than five billion liters per day today. When Saudi Arabia's second largest city, Jeddah, located on the western Red Sea coast, began to face the dangerous combination of water scarcity and growing water demand, the city's leaders turned once again to seawater desalination as a solution.

The Jeddah Phase 3 Plant, which is owned by the Saline Water Conversion Corporation, Kingdom of Saudi Arabia, produces 690 million liters per day of potable water. The water is treated by reverse osmosis (RO) membrane technology, which extracts salt from seawater, creating high quality potable water. RO membranes are intended for removing salt and dissolved ions, but seawater is a soup of debris, silt, microscopic aquatic life, and other materials that can rapidly clog membranes, which results in increased energy consumption and potential membrane malfunction. Pre-treatment technologies are necessary to ensure that RO systems function reliably and efficiently over time.

To solve the pre-treatment challenges of the Jeddah plant, Doosan Heavy Industries and Construction Company, the prime contractor, selected Xylem's Leopold filter technology to pre-treat source water from the Red Sea by removing debris and contaminants that could disrupt the final stage of treatment. This additional technology is enabling the Jeddah plant to operate more efficiently and reliably, ultimately helping Jeddah to meet the needs of a growing population.

Conclusion

As cities around the world frequently face environmental challenges and natural disasters that threaten human lives, ensuring the supply of clean and safe drinking water represents an urgent challenge. As illustrated in these case studies, building resilience is a multi-faceted task that requires innovative technology, expert advice, and a collaborative approach. More than anything, it demands the investment of time, expertise, and resources today to ensure that our cities are prepared to manage the challenges of tomorrow.

Author's Note

Xylem's North America Water Reuse Leader, Keel Robinson, is based in Bend, Oregon, USA. He holds a degree in chemical engineering from the University of Wisconsin. He has over 20 years' experience solving water treatment challenges including many high-profile reuse projects. Keel currently serves on the reuse research advisory committee for the Water Environment & Reuse Foundation and is helping the WateReuse Association and its members advance the reuse market.

Harnessing the power of waste in municipal wastewater

Municipalities partner with private industry to harness the value of wastewater. **Nanette Hermsen** and **Verónica García Molina**, PhD, of Dow Water & Process Solutions report on available decentralized wastewater treatment technologies that can be used to achieve the water purity required for various purposes.

As demand for finite supplies of freshwater resources for residential, commercial, agricultural, and industrial use increases worldwide, wastewater recycling is a growing trend and will continue to lead the way to improve water management strategy across markets. While wastewater – roughly 99 percent water and one percent suspended, colloidal, and dissolved solids – is increasingly recognized as a valuable byproduct, it still remains an untapped and underutilized resource. In fact, globally, more than 80 percent of municipal, industrial, and agricultural wastewater still flows back to nature without being treated or reused, according to United Nations Water. This wastewater not only has the potential to pollute rivers and oceans, but it also represents significant mismanagement of a precious resource: water. UN-Water coordinates UN and international organizations that work on water and sanitation issues.

Both municipalities and industrial market segments have found that safely treated wastewater is an affordable, sustainable source of water, energy, nutrients, and other recoverable materials. In most decentralized wastewater treatment plants, raw wastewater is treated close to or directly from its source, making it easy to reuse for a variety of industrial purposes. With a few notable exceptions, such as Singapore, public perception and regulations around the world still prohibit the use of treated wastewater for agricultural or residential purposes.

While some countries and major cities have solved this challenge by constructing sophisticated wastewater treatment plants, smaller municipalities struggle to build adequate facilities due to lack of money and resources. However, small- and medium-sized cities have found that partnering with local industry is an economical means of creating decentralized wastewater recycling systems that advance water efficiency, reduce the total cost of water, and increase access to safe, clean water.

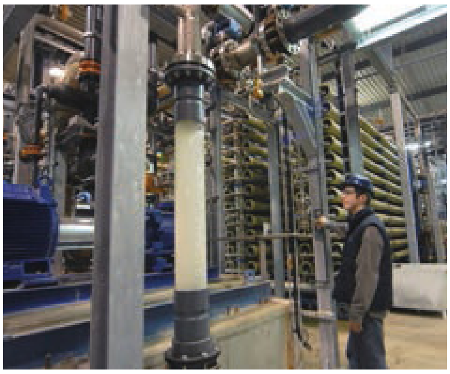
Application savvy is critical

The world already has the core technologies to solve water challenges. For instance, Dow's portfolio of water treatment solutions alone includes technologies for every level of purification including:

- Pressurized ultrafiltration (UF) for removal of particles, macromolecules, and bacteria
- A wide range of biocides for control of bacteria and viruses
- Nanofiltration (NF) for separation of mono- and di-valent ions and very small molecules
- Reverse osmosis (RO) and ion exchange (IX) for desalination and the most rigorous purification challenges.

However, every wastewater treatment plant faces different challenges based upon the source and content of the intake water and upon local, national, or regional regulations. While the content of municipal wastewater is generally consistent worldwide – with the exception of tourist areas with sudden population increases – the content of industrial wastewater varies greatly. The key to successful, cost effective wastewater recycling, whether it is decentralized or not, is devising the optimal technology matrix for achieving the water purity required in each situation. Ironically, the regulations in most jurisdictions for complying with water suitable for sending back to rivers or oceans are less rigorous than the demands for industrial purposes.

Case histories from Dow's direct experience demonstrate the economic and operational efficacy of decentralized wastewater treatment based on partnering among municipal, water utility, and private industrial interests.



An innovative water reuse project, carried out in collaboration with the nearby City of Lake Jackson, is expected to enable Dow's manufacturing facility in Freeport, Texas, USA to reduce freshwater use by more than 4.9 billion liters a year, which would otherwise come from the Brazos River. Photo by The Dow Chemical Company

Reducing freshwater use

Dow's manufacturing facility in Freeport, Texas, USA, is the largest integrated chemical plant in the Western Hemisphere, but it could not function without sufficient supplies of fresh water from the Brazos River. Neither could other businesses, the local communities, or the area's ecosystem function without fresh water. To help reduce waste, conserve resources, and realize cost savings, Dow collaborated with the neighboring City of Lake Jackson to divert its treated wastewater effluent to Dow's raw freshwater canal rather than discharging it to the river. The water is then further treated and used within Dow's operations for a variety of purposes.

This simple yet innovative water reuse project is expected to reduce Dow's freshwater use by more than 4.9 billion liters a year – 4.9 billion liters that would otherwise come from the Brazos River. For perspective, the equivalent freshwater savings represented by this project could supply a community of approximately 30,000 people for one year.

By treating wastewater for reuse, Dow improved its flexibility and water supply resilience, resulting in both business and community benefits. The City of Lake Jackson has realized significant operational savings, and this project has also helped enable new growth opportunities for Dow at the Freeport site.

Triple-use of water yields energy reductions

The port of Terneuzen, The Netherlands, is bordered on three sides by water, including the sea and the vital Ghent-Terneuzen Canal. Unfortunately, Terneuzen, population 55,000, faces the constant threat of saltwater intrusion into its shallow aquifers. Brackish groundwater and the regular influx of seawater minimizes local fresh water availability, and the city has imported fresh water for several years from a source 120 kilometers away to meet its needs.

Dow Terneuzen is the largest Dow facility outside of the US, and it must share water resources with the area's residential users and a variety of agricultural and industrial neighbors. In 2005, Dow collaborated with the municipal water board and Evides, the local water company, to implement an innovative wastewater recycling program that uses every liter of water three times.

Small- and medium-sized cities have found that partnering with local industry is an economical means of creating decentralized wastewater recycling systems that advance water efficiency, reduce the total cost of water, and increase access to safe, clean water.

The beauty of the system is its simplicity. Dow Terneuzen accepts 10,000 cubic meters of municipal household wastewater each day that has been purified by Evides. This water is used to generate steam to feed into its manufacturing plants. After the steam is used in the various production processes, the condensate water is again used in cooling towers until it finally evaporates into the atmosphere.

This system improves the city's overall water stability. Dow Terneuzen has also experienced benefits by reducing its energy use associated with water treatment by 95 percent – the equivalent of reducing carbon dioxide emissions by 60,000 metric tons each year, which is comparable to removing 12,000 passenger vehicles from the road for a year. Other planned projects position the Dow Terneuzen site to become freshwater intake-free by 2023.

Industrial wastewater partnering in Spain

A much larger wastewater partnership is taking place in Tarragona in the Catalonian region of Spain, which often suffers from rainfall shortages. During tourist season, population in the Tarragona area soars from 200,000 to 600,000, placing additional stress on local water supplies from the UNESCO-protected Ebro River Basin.

Camp de Tarragona is a large chemical complex that is home to Dow and nearly 30 other chemical companies, all of which are high-volume users of Ebro River water. For many years, the Camp de Tarragona complex has used fresh water to power its industrial processes, but public and private pressures led to a more sustainable and more reliable water supply for industrial, commercial, agricultural, and residential purposes.

One of ten DEMOWARE projects funded by the European Union (EU), the Camp de Tarragona Advanced Water Reclamation Plant (CTAWRP), was built by Veolia Water Technologies and is operated by Aguas Industriales de Tarragona S.A. (AITASA) and the government-owned Catalan water agency, L'Agència Catalana de l'Aigua (ACA). The DEMOWARE initiative is a research project that seeks to stimulate innovation and improve cohesion within the evolving European water reuse sector.

The three entities collaborated on a plan to reclaim and reuse municipal wastewater for industrial use. Dow joined the project both as an end-user of the reclaimed water and as a member to provide advanced water technology and expertise.

In this system, wastewater from the Spanish cities of Salou, Tarragona, and Vilaseca is processed and purified by the

helping to minimize water stress and free up fresh water to meet local municipal, tourism, and agricultural demands in the Tarragona region – and it's just getting started. The Tarragona project became one of the few EU DEMOWARE projects to stimulate further innovation and improve cohesion in Europe's water reuse sector.

CTAWRP water reclamation plant to the specified quality before it is redirected for use in industrial processes instead of discharged into the Mediterranean Sea. Veolia's technology is used as a pre-treatment, followed by DOW FILMTEC™ extra fouling resistant RO membranes in the system's first pass and DOW FILMTEC™ low energy RO membranes in the second pass. The first-pass RO membranes offer stable quality permeate, while the extra fouling resistance feature increases plant availability and reduces operational expenses, as fewer cleanings are needed. The design of the second pass with low-energy RO membranes has helped the plant deliver higher salt rejection at 33 percent lower pressure, reducing overall energy use.

As a result of the project, water used in the cooling towers at Dow's ethylene cracker is comprised of 40 percent reclaimed water, or 160 cubic meters per hour (m^3/h) of reused wastewater from the reclamation plant. The plan is to eventually raise the level of reclaimed water in the blend to 90 percent, freeing up even more Ebro River water for other uses.

Even at a 40 percent blend, the higher quality of the recycled water compared to the river water means that the cooling towers have increased the number of cycles they can operate with the same amount of water with decreased scaling, corrosion, or bio-growth tendencies. In fact, blowdown has been reduced by 49 percent, which has also cut the cost of treating the resulting wastewater. The current 40 percent blend of treated wastewater has limited the volume of chemicals needed in Dow's cooling towers by about 23 percent, again due to the higher quality water.

This innovative water reuse initiative is

Toward a circular economy

As the world moves toward a circular economy based on virtually no waste – with raw materials continually recycled and reused in a virtuous circle – companies, countries, and municipalities will be driven by costs to close loops. Sustainability is no longer a separate pillar of national, local, or business strategies – it is the strategy. Water availability and variability impacts the bottom line of virtually every human endeavor. Without clean, potable water, we would perish.

Optimizing the use of water, reducing consumption, and recycling wastewater are critical steps for both public and private organizations. This is why the trend of decentralized municipal-industrial partnering to make efficient use of wastewater will continue to gather momentum in the years ahead.

But technology alone cannot help us achieve a circular economy. We need disruption and innovation in the way we approach water. Among the many innovations stemming from the Tarragona water reclamation project is the idea of using Dow's Minimal Liquid Discharge (MLD) approach as part of water project cost-benefit analyses. Simply put, MLD is an approach that can help industrial and municipal leaders address their water footprints and move toward a circular economy without breaking budgets.

Reaching the final 3 to 5 percent of liquid elimination to achieve Zero Liquid Discharge (ZLD) is an admirable goal, but it has proven to be prohibitively expensive in terms of capital and operating costs. Aiming for a 95 percent water recovery rate using the MLD approach can achieve results for a fraction of the cost of ZLD. The MLD process relies on a core set of proven, existing water technologies, but the real key is evaluation of situational needs to identify sources and types of wastewater followed by combining appropriate technology systems for optimal, and economical, results.

MLD and many other innovative approaches will be important as we evolve toward the circular economy ideal. Someday, decentralized systems may come to describe individual households, with every family automatically treating and recycling its own water supplies. In the meantime, expect to see many more decentralized public-private collaborations worldwide to capitalize on the value of wastewater.

Author's Note

Nanette Hermsen is the residential marketing director of Dow Water & Process Solutions, and Verónica García Molina, PhD, is the technical service and development manager of Dow Water & Process Solutions, headquartered in Edina, Minnesota, United States.

Taking anammox out of the box for mainstream water reuse

New pilot-study results enhance understanding of how the water industry can apply deammonification to develop sustainable, fit-for-purpose reuse portfolios. **Sandeep Sathyamoorthy** of Black & Veatch and **Hongkeun Park** of BKT United share findings and insights about the role of biofiltration in facilitating the use of anammox for mainstream as well as sidestream treatment.

In years to come, wastewater treatment plants across the globe will be transformed into Integrated Resource Recovery Facilities (IRRFs). These IRRFs will incorporate a suite of resource recovery solutions to transform incoming wastewater and non-wastewater-derived (e.g., from municipal organic waste) raw material resources into valuable products as part of an integrated circular economy. In arid regions of the United States and other water-scarce areas of the world, key resource transformations will undoubtedly include development of water portfolios that include wide-array water reuse.

Potable water reuse is a critical transformative approach to sustainably and effectively provide water for the world's growing population. Central to effective potable reuse is use of an advanced water treatment facility (AWTF) to prepare high quality supply water for potable reuse. Management of nitrogen is an integral part of providing high-quality supply water advanced water purification, and anammox processes are an attractive option for total nitrogen management.

Deammonification (partial nitritation with anaerobic ammonia oxidation) offers the possibility of replacing conventional nitrification and denitrification processes to remove ammonia nitrogen from wastewater. Deammonification eliminates the need for an external carbon source (such as methanol), reduces energy consumption, and lowers sludge production. In addition to lower operations and maintenance costs, the process yields high-quality supply water for agricultural reuse, urban agronomic use, and potable reuse. It is now well proven for treatment of reject water from anaerobic digestion after centrifugation (i.e., centrate). However, key questions remain regarding deammonification as a viable process for mainstream treatment primarily due to the lower wastewater temperatures, lower ammonia concentrations, and competition for nitrite from nitrite-oxidizing bacteria (NOB).

Fortunately, the results of a pilot study completed in December 2016 at the Los Angeles County Sanitation District's Joint Water Pollution Control Plant (JWPCP) in Carson, California, USA, offer promising proof-of-concept for mainstream deammonification. Operation of a pilot-scale upflow anammox biofiltration process at the JWPCP for more than 6 months shows that the mainstream anammox process can consistently and effectively produce a filtered effluent well suited to developing a broad water reuse portfolio including potable reuse.

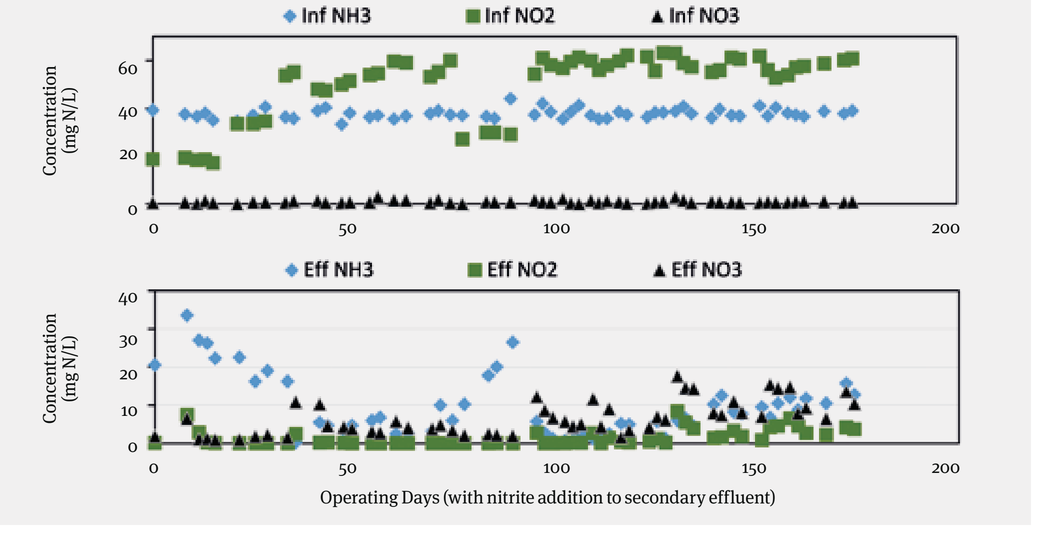
Behind the pilot

Over decades, anammox processes have been successfully implemented for nitrogen removal from centrate. Anammox processes typically require 60 percent less energy and no external carbon source compared with conventional treatment processes. The low specific growth rates and high susceptibility of anammox bacteria (AnAOB) to high dissolved-oxygen or nitrite concentrations are among the key challenges to mainstream applications.

Potential solutions to manage AnAOB in mainstream applications include decoupling the solid retention time (SRT) from the hydraulic retention time (HRT) of the AnAOB process using, for example, fixed-film media or anammox granules. Still, the low AnAOB growth rate in mainstream systems due to lower temperatures, limited substrate availability, and competition from other bacterial actors (e.g., heterotrophs and nitrite oxidizing bacteria) remains a challenge for mainstream applications. Researchers have previously reported success with mainstream anammox applications using fixed-film bioreactor and suspended growth systems. However, these systems require a large footprint due to downstream clarification prior to membrane filtration for direct/indirect potable reuse.

A pilot study was originally conducted by BKT in collaboration with the wastewater research group at JWPCP to assess BKT's BioFiltration (BBF), an upflow biological filtration process for nitrification-denitrification. The results from that study suggested a total inorganic nitrogen (TIN) reduction of approximately 25 percent across the nitrifying BBF. Additionally, red granules – the telltale sign of anammox bacteria – were discovered in the backwash waste holding tank. Although the nitrifying BBF was

Figure 1. Influent (top panel) and effluent (bottom panel) ammonia, nitrite, and nitrate concentrations during the pilot study



provided with sufficient oxygen to support nitrification, the research team hypothesized that deammonification may have been occurring within the BBF biofilm or granules within the biofilter due to substrate and oxygen diffusion limitations. The pilot was therefore extended to evaluate the feasibility of a mainstream deammonification for sustainable mainstream nitrogen management.

Testing the mainstream solution

Black & Veatch and BKT collaborated for the mainstream pilot study. The AMX BBF pilot unit constructed by BKT was an upflow biofilter consisting of expanded polystyrene media with an area of 0.2 square meters (m^2), or approximately 2 square feet (ft^2), and a media depth of 3 meters (m), or 10 feet (ft). Secondary effluent from the JWPCP was the influent to the AMX BBF. The JWPCP secondary effluent is of high quality with a relatively low chemical oxygen demand (COD) (Table 1). During the study, the secondary effluent had an average COD:NH_3-N ratio of 1:1.4. Initially, the two biofilters were operated in series, with the intention of promoting partial nitritation in the first, and deammonfication in the second. However, operation in this mode with direct application of secondary effluent (i.e., and influent with low biochemical oxygen demand [BOD] and high ammonia-N) showed poor and highly variable nitrogen removal. Furthermore, the effluent contained high nitrate-N and low nitrite-N concentrations, suggesting the presence of nitrite oxidizing bacteria (NOB) rather than the preferred anammox bacteria.

To test the concept of deammonification application for mainstream conditions, the research team added sodium nitrite to the secondary effluent to increase the nitrite concentration and achieve an ammonia-nitrogen to nitrite-nitrogen ratio favorable to promote anammox activity. Nitrite was only added to the secondary effluent to validate the proof of concept of mainstream anammox application. A full-scale solution would integrate a nitritation process upstream of an anammox biofilter.

Knowledge gained

The AMX BBF process was operated at a range of hydraulic loading rate (HLR) conditions during the pilot study ranging from ~0.5 gallons per minute per square foot (gpm/ft^2) to ~2.3 gpm/ft^2. This corresponded to TIN loading rates from ~1.7 kilograms Nitrogen per day per cubic meter (kg-N/m^3.d) to ~6.8 kg N/m^3.d. The lower end of the TIN loading rates have been previously tested in sidestream systems, but to the authors' knowledge, this is the first testing of TIN loadings at the higher end of this study. A low concentration of supplemental nitrite was initially added, resulting in a Nitrite-Nitrogen to Ammonia Nitrogen (i.e., NO_2-N/NH_3-N) influent ratio of approximately 0.5. The nitrite feed was increased in a step-wise fashion to ~1.45 over a 50-day period. Nitrogen removal performance improved significantly following initiation of the temporary, exogenous supplemental nitrite addition (Figure 1) with the pilot operated at a HLR of ~0.53 gpm/ft^2 and TIN.LR of ~1-2 kg N/m^3.d. Within approximately 50 days, the average effluent TIN concentration was less than 10 mg-N/L. Under these conditions, the AMX BBF process consistently achieved 90 percent nitrogen removal.

Table 1. JWPCP secondary effluent quality during the pilot study

	N	Average	Std. Dev.
NH_3-N (mg-N/L)	57	37.83	2.02
NO_2-N (mg-N/L)	57	0.23	0.17
NO_3-N (mg-N/L)	57	0.83	0.61
TN (mg-N/L)	57	38.89	2.15
TCOD (mg/l)	15	51.10	8.04
SCOD (mg/l)	53	44.40	7.95
TCOD/NH_3-N (mg/mg-N)	15	1.39	0.24
SCOD/NH_3-N (mg/mg-N)	53	1.18	0.22
pH	50	7.14	0.07

In subsequent phases, the process was tested at more challenging loading conditions by increasing the flowrate and, as a result, the TIN loading rate (Figure 2). Increasing the flow and loading rate initially resulted in poor performance largely due to NO_2-N/NH_3-N ratio not favorable for anammox bacteria. Alleviation of this pressure, however, soon resulted in excellent nitrogen removal efficiencies even at the high loading rates.

The finding that the nitrite-nitrogen fraction increased at higher TIN loading rates (Figure 3, page 33) requires consideration where chlorine disinfection is a possibility. Furthermore, the results suggest that the AMX BBF application would require additional nitrogen polishing for facilities that need to meet very stringent TIN limits (e.g., TIN < 5 mg-N/L with full nitrification). However, such low nitrogen levels are typically not required for wide-array water reuse applications.

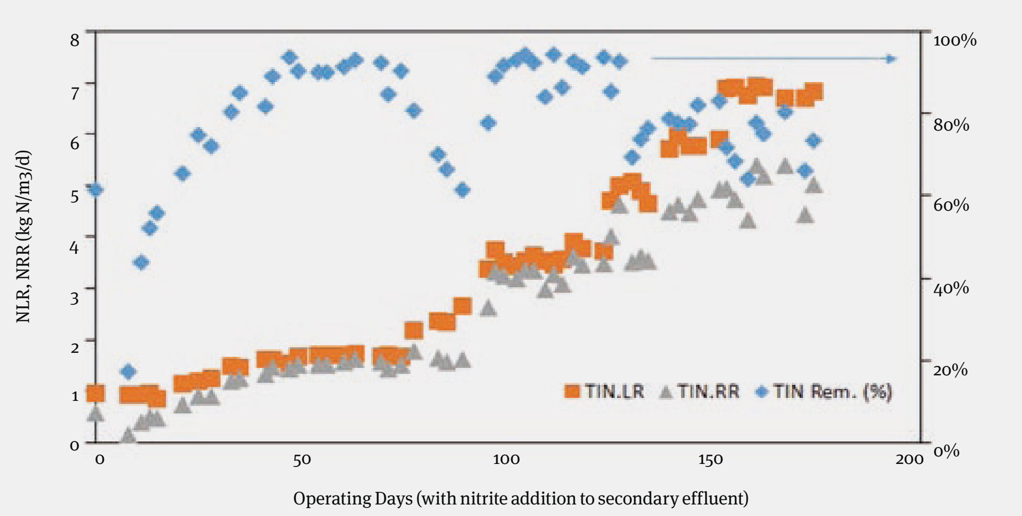
Therefore, the AMX BBF process and other coupled anammox-filtration processes may hold significant value for utilities that seek to implement or expand water reuse opportunities.

The future of anammox

The pilot-study results helped fill key knowledge gaps about the applicability of mainstream deammonification as part of a sustainable water reuse scheme. The results suggest that a mainstream anammox process can consistently and effectively achieve a TN of <10 mg N/L with no supplemental carbon addition when combined with an appropriate upstream nitrogen management strategy to support deammonification. The longer-term research objective of this research is to integrate a partial nitritation process upstream of the anammox biofilter.

As utilities expand their reuse portfolios to include agronomic reuse, industrial reuse, agricultural reuse, and potable reuse (indirect or direct), there is value in producing an array of fit-for-purpose effluents to meet each of these needs. Sustainable, low-cost, easy-to-manage solutions are critical for effective management of overall water and water-reuse portfolios. The anammox solution evaluated in this study provides an important tool to effectively achieve a high-quality effluent for various reuse applications. The relatively low nitrogen concentration, coupled with low TSS and turbidity, makes the filtered effluent highly suitable for multiple water reuse applications. Additional investigation is warranted to evaluate the performance of a downstream membrane-filtration process.

Figure 2. TIN loading and removal rate and nitrogen removal performance during the deammonification pilot study



Continued on page 33

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The Water Reuse Roadmap to be released at WEFTEC '17

More than 60 water reuse implementation experts representing corporations, utilities, municipalities, and nonprofit organizations offer their recommendations on best practice standards in *The Water Reuse Roadmap*, which will be released at the Water Environment Federation's Annual Technical Exhibition and Conference (WEFTEC®) event, held in Chicago, Illinois, United States in September 2017.

In February 2016, leading experts on water reuse met at a workshop sponsored by the Water Environment Federation at the Orange County Sanitation District in Fountain Valley, California, United States, to brainstorm and provide their recommendations on practical guidance to water managers interested in implementing municipal, agricultural, or industrial water reuse projects. *The Water Reuse Roadmap*, slated for release in September 2017, includes their input and expanded guidance based on years of experience navigating the technical, financial, social, and health-related challenges associated with reuse.

The Water Reuse Roadmap (referred to as the *Roadmap*) provides safe, reliable shortcuts within the natural water cycle for harnessing water where it is needed and treating it to appropriate levels for use, depending on the application.

The purpose of the *Roadmap* is to provide concise guidance on how to holistically evaluate reuse opportunities and benefits and implement or expand a program to reuse the most underused water resource: wastewater.

The *Roadmap* begins with initial concept development and then describes stakeholder engagement, regulatory risk assessment, and planning processes. It concludes with advice on financing, implementing, operating, and maintaining water reuse infrastructure. The *Roadmap* is a practical water reuse planning and project implementation guide, not a design manual. As such, primary audiences for this guide are water resource planners and managers serving municipalities, utilities, industries, and the commercial sector (i.e., the people responsible for and managing the water resources available to a specific community and/or enterprise).

The *Roadmap* is designed to help water managers achieve their goals by (1) determining the social, technical, and financial feasibility of water reuse options in their specific situation; (2) initiating a water reuse program when appropriate; or (3) expanding an existing reuse program based on new approaches and opportunities for innovation. Initiating a water reuse program or expanding an existing program into new areas of reuse can be a daunting task.

The challenges, opportunities, and benefits of water reuse are broad and diverse. A successful water reuse program is multifaceted and engages elements of strategic planning, decision-making, technology, communications, financing, monitoring, and maintenance management. Although technologies and regulations provide solutions and pathways, ultimately the community selects and implements the appropriate water reuse solution. Therefore, clearly communicating the value and long-term benefits of water reuse – including the safeguards, technologies, and management approaches – is essential to any successful water reuse program.

Water reuse projects provide a reliable new water source, enhance resiliency and water security, control seawater intrusion and land subsidence, alleviate water stress, help us in preserving pristine water sources in their natural state, and much more. Conventional thinking has been to collect and treat wastewater to acceptable standards and move it quickly downstream via effluent disposal methods. The new paradigm is to recover, manage, and generate value from wastewater resources – including water, nutrients, and others – and not waste them via traditional disposal methods that are becoming increasingly expensive. Even today, without considering long-term holistic benefits, water reuse projects may have a lower cost than wastewater disposal projects. As an example, rather than implementing expensive wastewater nutrient removal processes to treat and dispose the wastewater, redirecting it to agricultural use (where water and nutrients are both needed) may have lower capital and life cycle costs.

The focus of the *Roadmap* is beneficial reuse of wastewater from communities, industries, and the commercial sector. The *Roadmap* intentionally does not address other potential water resource-enhancing projects such as stormwater capture and reuse, on-site residential water reuse systems, and in-facility industrial water reuse projects.

The *Roadmap* is organized into nine chapters, each focusing on the specific elements that facilitate a successful water reuse program, from concept development through implementation and maintenance:

Chapter 1 – Introduction provides a general introduction to water reuse, why it may be needed, the spectrum of water reuse opportunities supported by case studies, and concepts related to integrated water resource management.

Chapter 2 – Development of Purpose and Needs Statement summarizes the development of the purpose needs statement for a water reuse project.

Chapter 3 - Strategic Planning and Concept Development lays out the conceptual elements involved in planning a water reuse project.

Chapter 4 – Regulations and Risk Assessment provides guidelines for identifying and addressing regulatory requirements and for identifying and managing risk in water reuse projects.

Chapter 5 – Financial Sustainability lays out financial sustainability elements of water reuse projects. Ultimately, the chapter seeks to help define the water reuse value proposition.

Chapter 6 – Communication and Outreach lays out the public outreach and communications elements of water reuse projects.

Chapter 7 – Implementation: Treatment Technologies and Other Project Elements reviews the implementation of water reuse projects, specifically focusing on treatment technologies that can reliably meet water quality criteria requirements and achieve the identified treatment goals for nonpotable and potable reuse projects.

Chapter 8 – Monitoring and Control summarizes monitoring and control elements of water reuse projects.

Chapter 9 – Ongoing Maintenance and Monitoring Progress lays out maintenance management elements of water reuse projects and provides guidance for how to integrate water reuse facilities into the community.

The *Roadmap* was prepared to be a concise, one-book reference for water reuse planning and implementation for the foreseeable future. For more information, visit www.e-wef.org.

Leading utilities share best practices, future outlook on potable reuse

The Potable Reuse Leadership Forum, held in conjunction with the IWA International Conference on Water Reclamation & Reuse in Long Beach, California, United States (US) on July 23, 2017, featured roundtable discussions on the topic of source control. CH2M highlights some of the viewpoints on source control shared by leading utilities in Singapore and in the US while outlining the path ahead for potable water reuse.

Utility leaders from around the globe joined professional services firm CH2M in a forum to discuss current challenges, lessons learned, and innovations and trends in potable reuse at the International Water Association's (IWA) International Conference on Water Reclamation & Reuse. CH2M's global drinking water and reuse practice team, which has and continues to partner with each of the participating utilities, hosted the event.

"Populations continue to grow, regulations are changing, infrastructure is aging, and there's a greater need for increased security," says Russell Ford, CH2M global drinking water and reuse practice director, commenting on factors that are affecting utility leaders' decision-making. "There's a constant push to find more innovative and cost-effective solutions to these issues – and the worldwide leaders at this forum are driving these advancements every day," he adds.

Prior to the forum, CH2M asked five utilities to share their key areas of interest. Topics included technology innovations, source control, regulatory considerations, online monitoring, and direct potable reuse.

The leading utilities included:

- Singapore Public Utilities Board, which began piloting its NEWater Initiative in 2001 and now operates five NEWater factories, treats more than 379 million liters per day (mld) to ensure that every drop of water is used to meet growing supply demands.
- Hampton Roads Sanitation District in the US state of Virginia, shared its plans to add advanced treatment capabilities to multiple wastewater treatment plants and inject more than 379 mld of purified reclaimed water into the Potomac Aquifer to alleviate depleted groundwater levels.
- Upper Occoquan Service Authority, located in northern Virgina, owns and operates a regional advanced water reclamation facility that consolidated and replaced 11 small plants in the 1970s. It is one of the largest and first planned and recognized surface water augmentation type potable reuse plants in the world, with a capacity of 204 mld.
- Metropolitan Water District of Southern California is a regional wholesaler that supplies water to 19 million people in southern California. MWD detailed plans for a proposed 568-mld regional groundwater recharge project and 1.9-mld advanced water treatment demonstration facility, currently undergoing design and construction.
- Orange County Water District, in Southern California, operates the world's largest ground-water replenishment system for indirect potable reuse – producing 379 mld of high-quality water for nearly 850,000 residents.

Reverse osmosis array installation. Photo by NWRI

Challenges and lessons learned

Regardless of the type of reuse program used, sampling and monitoring to measure and record treatment process effectiveness are critical to meeting regulations and program goals, the utilities agreed. Several utilities highlighted best practices in the area, including online monitoring for critical control points.

At Upper Occoquan Service Authority (UOSA) in Virginia, online monitoring is especially important to advanced water treatment plant efforts, said Bob Angelotti, UOSA's deputy executive director for technical services. Angelotti explained that online instruments are being used at various locations throughout the advanced water treatment plant to quickly alert operators of shifts in process water quality and initiate appropriate response procedures.

Online monitoring is also an important portion of his district's Groundwater Replenishment System, said Orange County Water District (OCWD) Director of Water Production, Mehul Patel. OCWD has incorporated the critical control point methodology into routine operations. A strong team of well-trained operators to analyze and respond to online monitoring is critical to OCWD's success in meeting requirements imposed by the California Division of Drinking Water under 2014 Groundwater Recharge Regulations, he said.

Although online monitoring is important for their plants, neither OCWD nor UOSA have control system logic that will automatically shut down their plants based on results from online analyzers. Instead, they said, they rely on a tiered approach that requires plant operators and managers to make decisions based on the data reported by online monitoring in conjunction with other triage information collected early on in troubleshooting an event –

The CH2M roundtable discussion on potable water reuse and source control brought together executives from leading utilities to discuss best practices in source control and direct potable reuse. Photo by CH2M

because in many cases, a shutdown would not be necessary or prudent, such as in the case of an analyzer error. They reinforced the need for operators to be well trained in site-specific responses to process disturbances at their treatment facilities.

"There's a big push, especially in California, for specific operator certification for potable reuse facilities," says CH2M Water Reuse Technologist Jason Assouline. "It doesn't matter if it's a conventional potable water facility or an indirect or direct potable reuse application—having well-trained operators is key," he adds.

Source control

Source control was a major topic of the forum as the different agencies discussed challenges and best practices. At Hampton Roads Sanitation District (HRSD), detailed sampling was conducted at all landfills in the system to look for the mass contribution of the 1-4 dioxane coming from the landfill leachate to the plants, said Tyler Nading, CH2M project engineer for HRSD's Sustainable Water Initiative for Tomorrow (SWIFT) program.

"We were at least interested in doing something to understand if there was some small segment of industries or an industry that was contributing substantially to, say, 1-4 dioxane – and there are," says Hampton Roads Sanitation District Water Technology and Research Specialist Chris Wilson.

"Source control is interesting because we do have a well-defined pollution prevention and control program, but it's very uniform across the district, and the way the industries are distributed is not," says Wilson of HRSD's approach. "And the way the industries are impacting us is not really uniform either, so we had to figure out how to make that program stay uniform but still address contaminant control. That's something we're still making our peace with – that maybe there's a more uniform way we need to apply limits rather than targeting a specific thing, on a compound by compound basis," he adds.

Angelotti echoed the importance of source control for UOSA, which uses a multi-pronged approach. "We're not only interested in protecting public health but also the aquatic ecosystem, our biological treatment processes, and beneficial use of biosolids or reclaimed water, so anytime there's an industry or other contributor in our sewershed that may increase risks to one of those, it's important to us," he says.

OCWD's successful approach to source control – open communication with everyone involved – is based on close coordination with its upstream sanitation district, Orange County Sanitation District (OCSD), and remains close to the same as when it brought its Groundwater Replenishment System online a decade ago.

OCWD communicated clear limits to Orange County Sanitation District based on findings from extensive pilot testing that established expected removal, and also helped OCSD find alternative chemicals to use in its onsite processes, said Patel.

"We found that you have to give your partner agencies some kind of target so that they can support your goal limits with their sewer discharge programs," says Patel. OCSD is also a joint partner on the Groundwater Replenishment System, he added.

In OCWD's experience, partnership on the reuse project strengthened its relationship with OCSD, which in turn became committed to the program's success since it is tied directly to OCSD's own sewer discharge programs and importantly reduced ocean wastewater discharge, key economic drivers for sanitation districts.

Metropolitan Water District of Southern California Water Treatment Manager Heather Collins echoed the sentiment of forming close, integrated partnerships with the Sanitation Districts of Los Angeles County (LACSD). She says, "Over the years, with the benefit of others in the region implementing potable reuse, there has been greater focus on source control, and LACSD has increased the robustness of its source control program. We see that LACSD is invested in enhancing its wastewater treatment systems to ensure the plants continue to protect public health and the environment as the ocean discharge transitions to reclamation."

Perspectives on the future of potable reuse

All utilities agreed that the continued outlook ahead for reuse advancements is promising.

OCWD Director of Research Megan Plumlee shared enthusiasm for the reuse industry's continued innovations. "What's exciting for us about the direct potable reuse effort is that the work being done advances industry knowledge for other reuse categories, like our indirect reuse project. As a result, considerations for source control and online monitoring are talked about more frequently, as is benefits reuse in general," she says.

"Direct potable reuse kind of drives what our R&D [research and development] does now," says Patel. "When before we had more leeway to look into a wide variety of things, now we're trying to consider the R&D on the specific topics inspired by direct reuse because these issues are starting to hit us from multiple angles."

At HRSD, working first with a pilot-scale led to selection of the best treatment train to meet discharge requirements, Wilson said. The district is also optimistic about the benefits of reuse programs in areas severely affected by climate variability.

In the last century, for example, groundwater levels in the Potomac Aquifer have rapidly depleted – dropping 61 meters, Nading explained. The SWIFT program is the answer to provide a more resilient water supply to meet current and future needs in the region, an area that is second at risk to climate variability in the nation, he said.

And even at UOSA, which has experienced decades of success, with its potable reuse system that supplements the drinking water supply for approximately 1.5 million people, there's still work to do. Angelotti adds, "We're always interested in improvements that come with technology innovations."

The engaging conversation on reuse is set to continue, with CH2M leading the development of a white paper that will discuss the challenges and practices covered during the forum and the future innovations, which will give more people access to safe and abundant water supplies.

Author's Note

CH2M Communications Strategist Kathryn Weast wrote this article with contributions from CH2M Water Reuse Technologists Jason Assouline and Tyler Nading and CH2M Global Technology Leader for Water Reuse, Larry Schimmoller. The company is headquartered in Englewood, Colorado, United States.

Recovery process creates assets in addition to water – not brine waste

One of the major issues revolving around desalination has been the fact that desalination typically creates a waste that has disposal concerns. This issue has been solved by an innovative process being employed in El Paso, Texas, USA, in which useful and marketable commodities are produced in place of brine waste. **J. Hubble Hausman** and **Craig D. Pedersen** of Enviro Water Minerals Company and **Bill Norris** of Norris Leal report.

What was once determined to be unusable and a detriment to desalination, the City of El Paso, Texas, USA, has turned into a benefit. The City is eliminating its brine disposal issues while increasing its water supply through Full Recovery Desalination^{SM}, an award-winning process created, owned and implemented by Enviro Water Minerals Company (EWM), that cost effectively produces potable-quality water and recovers marketable products without creating any waste brine.

From the beginnings of desalination technology, one of the biggest concerns has been how to dispose of the by-product associated with the treatment process. This by-product, most commonly referred to as concentrate or brine, contains the salts that are concentrated to approximately four times the original content of the brackish well water supply.

A breakthrough came when Paul Wallace, a veteran in the oil and gas refining industry and co-founder of EWM, began envisioning the use of contaminants (including salt) in the water stream as an asset, not a problem. Wallace joined with Hubble Hausman, co-founder and CEO of EWM, to begin using this more effective process within in a short period of time.

EWM's process removes the contaminants to create marketable commodities and returns 99 percent of the source water to the customer. The concept that the contaminants in the water could be used in this way was unheard of and represented a paradigm shift in the desalination world. Many entities studying zero liquid discharge (ZLD) had solutions that were expensive and would still have a solid waste product,

Above: (l-r) David Pettry, Principal NorrisLeal; Veronica Escobar, El Paso County Judge; Oscar Leeser, Mayor of El Paso; J. Hubble Hausman, EWM CEO; and Paul Wallace, EWM Chief Technology Officer at the ribbon-cutting ceremony of the El Paso EWM plant on April 25, 2017. Photo by Bill Norris, NorrisLeal

but EWM's process uses the contaminants as a product source.

Finding a willing participant was the first step in testing the theory that desalination without the creation of brine could happen as Wallace envisioned it could. To some, the concept of full recovery was considered unfeasible, but to others this concept had a chance to change the view of desalination and open up the opportunities for inland desalination while reducing cost to the end users. EWM first approached URS (now AECOM) and NorrisLeal in early 2013 about the concept and Wallace's proposed solution (which basically was to perform desalination in combination with a refinery-type system that removes contaminants at different points in the process and creates products from them). URS was hired to review its feasibility. After several weeks, URS issued a report indicating a favorable outcome for a full-scale plant.

Aerial view of EWM facilities in El Paso during March 2017. Photo by Bill Norris, NorrisLeal

Left: Acid/caustic heat exchangers and evaporator installation
Right: Installation of demineralization membranes
Photos by Bill Norris, NorrisLeal, taken in March 2017.

The EWM process chemically separates the contaminants into high-purity, industrial-grade, mineral products for use in commercial markets and manufacturing.

EWM then pitched the concept to several entities that have current desalination operations, including El Paso's Kay Bailey Hutchison (KBH) Desalination Plant, one of the world's largest brackish water reverse osmosis (RO) plants. Disposal of concentrate, or brine, is the single most technical hurdle for this plant and for other inland desalination plants.

After responding to a request for proposals by El Paso Water Utilities (EPW) in mid-2013, EWM won the right to conduct a pilot/demonstration project that would take brine from EPW's desalination plant and deliver potable-quality water in return. This was the first step in the process to create a partnership between the two entities, ultimately leading to a contract for services. The arrangement was modified to also treat brackish groundwater along with the brine from the KBH Desalination Plant as Full Recovery Desalination can be used on a variety of high TDS waters.

How it works

Full Recovery Desalination extracts the dissolved solids contained in a variety of water sources for beneficial use. Using proven, commercially available technologies in unique and innovative configurations, the EWM process chemically separates the contaminants into high-purity, industrial-grade, mineral products for use in commercial markets and manufacturing.

Full Recovery Desalination is directly applicable to a variety of water sources with high TDS as mentioned above, including:

- Brackish water desalination
- Seawater desalination
- Wastewater brine disposal
- Industrial water (e.g., power plant cooling tower blowdown)
- Oil field produced water/ flowback water
- Agricultural runoff.

While many in the desalination business look at ways to dispose of brine, EWM's Full Recovery Desalination technology eliminates the brine dilemma because no brine is produced. Importantly, this environmentally friendly service is provided to customers at a cost-effective rate and increases desalination opportunities to many municipalities and industries.

Pilot work and preliminary design

In July 1013, EWM contracted with NorrisLeal (NL) to develop the pilot plant protocols for the Texas Commission on Environmental Quality (TCEQ) approval on the potable water process portions of the plant. During that year, NL identified potential vendors to be utilized in the pilot plant process. The primary equipment to be tested included cartridge filtration, nano-filtration, reverse osmosis, electro-dialysis reversal (EDR), degasification, ion exchange, pumps, SCADA, and chemical feed processes.

By December 2013, TCEQ approved the protocols necessary to begin the piloting process on site at the KBH plant. NL then began ordering equipment and constructing the pilot facilities.

Piloting for the EPW project commenced in January 2014 and was completed in April. The pilot plant report was approved by the TCEQ in August 2014, at which time NL was authorized to prepare preliminary plans for the potable water treatment system. Additionally, AECOM and NL continued the development of process and instrumentation drawings (P&IDs) for the entire system, and minerals recovery testing took place during this time as well. A hazard and operability study (HAZOP) review took place at the end of the year.

After the completion of piloting, which concluded in June 2015, the contract between El Paso Water Utilities and EWM was negotiated for a full-scale plant. The parties executed a 30-year agreement wherein EPW sends 4.9 million liters per day (MLD) of RO brine and 4.9 MLD of brackish well water to EWM for processing, and EWM returns 9.5 MLD of potable-quality water to EPW. The water not sent back to EPW will be contained in the other commercial products

EWM creates. In addition to potable water, the plant produces caustic soda, gypsum, hydrochloric acid, and magnesium hydroxide.

In 2015, the full development of engineering plans for the potable and industrial water system began. Plans were completed and submitted to TCEQ for approval, which was granted in the fall of 2016. During the last half of that year, many activities were taking place simultaneously in an effort to begin construction in January 2016, including final development of P&IDs, contracting for natural gas services, obtaining quotes for all equipment and NL construction/installation, initializing long-lead item purchase orders, and developing financing for the project. By December, project financing was in place, and full authorization was given for project implementation.

Construction and commissioning

NL was hired as the design-build engineer/general contractor, performing mechanical installation and construction management. Construction began in January 2016. The negotiations for purchase orders and contracts had begun in addition to those contracts that were executed during the funding stage of the project. Key El Paso subcontractors working on the project included Lloyd Hamilton Construction (building and civil) and Ideal Electric (electrician labor).

With more than 350 purchase orders and a project value of approximately US$70 million, the coordination and timely ordering of equipment was necessary to complete the mechanical installation within 14 months. Some specialized equipment was ordered and shipped from Spain and Sweden. Throughout the year, crews regularly worked 7 days per week and 10- to 12-hour days.

The final project includes:

- 50,000 square foot building with offices, lab, control room, electrical gear, and process equipment
- Inside processing equipment including reverse osmosis, nano-filtration, electrodialysis reversal (EDR), ion exchange, electro-dialysis bipolar membrane (EDBM), and precipitation
- External process and equipment including a 6.5-megawatt combustion turbine and steam generation, acid/caustic concentrators, a cooling water system, a products tank farm, and truck loading stations.

Construction was declared mechanically complete in late March 2017, and commissioning of individual process units began in April 2017.

In addition to the design and construction, NL assisted in the commissioning of the individual unit process and ultimately in the production of potable water and chemicals. Samples of the product chemicals were taken in July 2017 and sent to NSF for evaluation and approval. EWM is currently implementing a step approach in its operations beginning with 30 percent and increasing to 50 percent, 75 percent, and 100 percent production levels at approximately 2-week intervals.

Like any engineering and construction activity, there are opportunities for improvement, particularly for an innovative project. Lessons learned during construction include allocating additional time for commissioning and improving construction and equipment purchasing timing. Additionally, greater understanding has been gained about the process equipment delivery timetable and vendor startup assistance, reflected more completely in contracts, which will assist in planning the unit operation startup with more efficiency. Overall, an 18-month construction-to-operation start-up timeframe is quite remarkable considering that this is the first project of its kind and that multiple unit processes were involved.

Above: The gypsum and magnesium hydroxide settling and filtering section of the facility nears completion in December 2016.
Left: One of the acid evaporators in the acid/caustic evaporator section of the facility is being erected in April 2017.
Photos by Bill Norris, NorrisLeal

> Construction was declared mechanically complete in late March 2017.

New opportunities for El Paso and inland desalination

With the implementation of Full Recovery Desalination by EWM, El Paso has increased its water supply at a low cost and has eliminated its disposal problem. The project will increase water supply to the City by approximately 9.5 million liters per day, and the process makes full use of the source water. The cost of developing new water supplies far exceeds the nominal fee EWM receives for processing this water for EPW. The project also allows EPW to expand its existing brackish water desalination plant without the need for new and costly disposal methods. The project may be expanded in the future.

As a local business, the project adds new jobs to the community and adds commercial value in the production and sale of usable commodities locally. Although one project does not fit all water supply challenges, Full Recovery Desalination certainly opens up the opportunity for inland desalination plants, which have been stalled due to the cost or the inability to dispose of the brine created from traditional treatment of salty waters, to move forward.

Authors' Note

EWM CEO J. Hubble Hausman, EWM Senior Vice President Craig Pederson, and NorrisLeal Principal Joseph W. (Bill) Norris, PE wrote this piece in early August 2017 when operations were beginning at the El Paso facility. EWM is evaluating locations for new plants and considering providing desalination to municipalities and industries both inland and along the coast. The authors would like to thank the City of El Paso for its willingness to use the EWM process and demonstrate a new technology. For more information, visit envirowaterminerals.com.

New framework to establish DNWR program within an urban utility

Small utilities with limited technical, financial, and regulatory resources face significant challenges in developing and implementing distributed non-potable water reuse (DNWR) programs. Authors **Dotti Ramey** of ADC Wastewater Engineering; **Frank Dick** of the City of Vancouver, Washington; and **Tzahi Cath** of Colorado School of Mines explain how a framework based on the US Clean Water Act's Industrial Pretreatment program can help urban utilities develop DNWR programs.

Demographic changes, prolonged drought, and decaying infrastructure are creating significant pressure on water supply resources and services in many countries. In response, some utilities, especially those with adequate financial resources, are developing a new approach, known as an integrated water catchment management, that uses distributed water supply, stormwater management, and wastewater treatment to manage water within a utility basin.

One aspect of integrated catchment management is that it uses reclaimed water within the basin to offset water demand for end uses such as irrigation, groundwater replenishment, and wetland restoration, where non-potable water is appropriately and safely used. Integrated catchment strategies can be implemented as part of a utility expansion or as part of infrastructure refurbishment. By definition, integrated catchment is a locally based strategy implemented within a wastewater collection sewershed or distribution pressure zone. Implementation success depends on tailoring water treatment (i.e., matching source water with end-use in a manner that reduces the cost of constructing and operating facilities) and on expanding opportunities to harvest resources such as nutrients and energy from the source water.

Large utilities with abundant financial and staff resources and pressing needs are able to incorporate reuse projects into their water portfolio, but most water utilities are small and have limited resources to implement such programs. For example, based on the most updated data from 1996, roughly 80 percent of wastewater treatment plants in the United States (US) were designed for flows below 4 million liters per day, according to the US Environmental Protection Agency (EPA). For these small utilities, technical, financial, and regulatory resources may not be available to develop and implement a distributed non-potable water reuse (DNWR) program. Most importantly, these smaller utilities with aging or failing infrastructure could realize the greatest benefit from a DNWR program. For example, a small utility may defer capital improvement projects to augment water supplies by substituting potable resources with reclaimed water for non-potable applications.

A DNWR program incorporates a planning tool for assessing water demands and reuse opportunities, criteria for evaluating the applicability of treatment technologies, and a regulatory framework to ensure that DNWR facilities are constructed and operated in a manner that protects the community and environment.

Industrial pretreatment model

The challenge of developing locally driven DNWR programs may be met by using a proven model that has a demonstrated success since its establishment: the Industrial Pretreatment (IP) program promulgated under the US Clean Water Act as part of the National Pollutant Discharge Elimination System (NPDES) program. The IP program regulates facilities that discharge non-domestic wastewater to a local sewer utility/district. The program has been effective in reducing toxic chemicals in wastewater treatment plant effluent and biosolids for more than 30 years now, according to the EPA.

The IP program has two key components that transfer well to a DNWR program. First, a technology assessment program conducted by the EPA defined standards for effluent limits for different categories of industries such as pulp and paper or aluminum forming. These effluent guidelines defined the best treatment technologies that were economically feasible for the removal of specific priority pollutants from industrial discharges, establishing common requirements for all facilities, regardless of their location. This approach can be applied to source water for reuse including blackwater, graywater, wastewater, roof runoff, stormwater, condensate, foundation water, and blended water. It can also provide a structure to evaluate tailored water treatment technologies for DNWR. Second, a regulatory framework for local IP programs was developed with federal funding and expertise, but the regulations require local implementation specific to individual utility needs. These two elements provided technical and regulatory expertise to local utilities and were key to the success of the nationwide IP program, as they can be applied to a DNWR program, assisting local utilities in plan development.

The challenge of developing locally driven DNWR programs may be met by using a proven model – the Industrial Pretreatment (IP) program.

Above: Soil amendment produced in the City of Vancouver, WA's Industrial Pretreatment lagoon are used to restore and maintain nearby habitat for migrating waterfowl. Industries contributing to the pond are permitted as Significant Industrial Users, which allows the City to inspect, monitor, and sample/analyze facilities to ensure successful operation of the pond and quality fertilizer product.
Photo by City of Vancouver, Washington, USA

Currently, permits for water reuse facilities are issued by state agencies under programs specific to water reuse. However, the IP program model can also be used as a means to energize the reinvention of the nation's urban water infrastructure. This aim could be accomplished by folding permitting and monitoring into the NPDES program, requiring an expansion of the local IP program to oversee the implementation of DNWR facilities. A core objective of the IP regulations is to increase the opportunities to beneficially reuse treated wastewater effluent and biosolids; therefore, there is no better way to accomplish this objective than to advance easily implemented changes to existing IP programs, assisting with the development of new technologies to recover resources from the wastewater and ensuring that DNWR facilities protect the public and environment.

Following the example of the IP program, state regulators will still have oversight of a local DNWR program, establishing appropriate standards for reuse water quality and reviewing the performance of DNWR facilities. Under the NPDES program, the state approves an IP program after reviewing the local utility's proposed ordinances and procedures. The same procedure can serve as a model for a DNWR program, and the IP program can be expanded to include non-potable water reuse.

Uniform treatment standards

During the development phase of the national IP program, the EPA agreed to control 126 priority pollutants from 21 industrial categories. The development process addressed specific industries separately, and a technical team reviewed the industrial waste streams, technologies that were available for treating those waste streams, and the costs of applying the technologies. The EPA then developed standards for the industry (Effluent Guidelines) and limits on the discharges (Categorical Standards) based on the best available technology that is economically viable. While industries are not required to use the specific technology, the technology they select must meet the same performance standards. This approach can easily be adapted to the DNWR facilities. For example, the National Sanitation Foundation (NSF) has developed a standard protocol to test and certify treatment technologies for reuse of residential wastewater and graywater; however, their work is intended for certification and has not been disseminated as standards. While the NSF protocol does not consider treatment cost or operational costs, the standards can serve as a foundation to more fully define the best available technology that is economically achievable. This example is one illustration of how existing data and procedures can be used to implement a nationwide baseline for DNWR technologies.

Dissemination of regulatory standards on a nationwide basis can provide important benefits to the water reuse industry. First, and most importantly, it can provide clear and transparent targets for technology development that can be applied across a multi-state reuse market, making the economic benefits for entrepreneurs more tangible and promoting innovation in the industry. Second, it reduces the resources required at local levels to develop regulatory mechanisms for approving non-potable reuse technologies, and in some cases the requirements can be easily incorporated into local plumbing or pretreatment codes. In the IP program, Categorical Standards can be applied verbatim, be made more restrictive in local use, or a proposal for less restrictive standards may be developed using an established protocol. Applying this aspect of the IP model to a DNWR program provides flexibility and autonomy to local programs while protecting the community's health and environment.

> IP staff evaluates the potential impact on the conveyance system and treatment plant.

Permitting and monitoring of a new DNWR program

In addition to developing an environment for innovation in tailored water treatment technologies, consolidating the permitting of DNWR facilities under the IP program is a natural extension of the IP program. As part of the development review process for new facilities, the IP staff evaluates the potential impact on the conveyance system and treatment plant. For example, conditions of low flow in a conveyance system near the facility may preclude the discharge of treatment solids to the sewers and require onsite solids treatment or solids trucking. Similarly, aqueous residuals with high salinity may be acceptable to some wastewater treatment plants but may adversely impact the biological process at other plants. It is the IP staff that develops discharge permits, and the extension of their responsibilities to developing a permit for the production of reuse water is a logical and efficient use of staff time.

Similarly, an IP discharge permit includes a monitoring and reporting plan to allow the IP staff to check flow, wastewater strength, and other specific concerns at the facility. In the event that a no-discharge permit is issued, there will still be reporting requirements to confirm that no wastes are discharged to the sewers. The local permit requirements can be expanded to include reuse water monitoring based on the facility's reuse permit, with the standards for quality of the reuse water developed at the state level but implemented at the local level. A vehicle for state oversight of the reuse water production can be provided in an annual report; IP programs are required to write an annual report, presenting an overview of industrial dischargers and the results of the discharge monitoring program. The annual report can be expanded to include data on production of reuse water and other resource recovery activities, as a means of addressing the IP program objective of increasing the beneficial reuse of treated effluent.

The streamlined permitting provides a cohesive permit vehicle for a DNWR facility, reducing the regulatory complexity of operating a water reuse plant and simplifying permit renewal procedures. The familiarity of the IP staff with an industrial facility (and by extension, a water reuse facility) is a valuable asset for troubleshooting plant discharge problems and developing solutions to minimize interruptions due to permit noncompliance. Having a single permit for a DNWR facility increases the efficiency of the operations and reduces potential conflicts that might arise from conflicting regulatory rulings.

One of the most difficult aspects of developing a new program at the state or local level is funding for the staff required to implement the program. Incorporating reuse facilities into an IP program allows the existing staff to administer the program when it is still new, avoiding new staff hires and making a new DNWR program more economically feasible. Furthermore, under the IP regulations, a utility is required to provide a funding mechanism to implement the program, which is accomplished through sewer use fees, permit fees, or enforcement fees. Incorporating a DNWR program into an existing IP program allows the funding to expand as the program grows and provides adequate funding for administering the non-potable reuse program.

Conclusion

The current state of DNWR is a patchwork of regulations, treatment strategies, and even regulatory language. From a technology innovation standpoint, this variability presents confusing and inconsistent requirements for treatment performance and impedes the development and rollout of new technologies for tailored water treatment.

From a local utility perspective, the effort and cost of developing and administering a new program may be prohibitive, and it may be difficult to garner sufficient stakeholder support for implementation. The basic facets of an IP program (nationwide and local) make it ideal for implementing a DNWR program. Although water needs vary across the United States, the basic characteristics of source water and needs for reuse water are consistent.

Expanding the NPDES program to include permitting and monitoring non-potable water reuse at the local level, under the auspices of the IP program, provides protection of human health and the environment as well as a sensible means to address the needs of the local community. Establishing a program similar to the Effluent Guidelines tailored to non-potable source water and reuse requirements would provide continuity and be a great stimulus for the development of new treatment strategies and technologies.

Authors' Note

Dotti F. Ramey is a senior engineer at ADC Wastewater Engineering, Inc. in Tacoma, Washington, USA, and recently completed her PhD degree at the Colorado School of Mines in Golden, Colorado, United States. Frank Dick is the wastewater engineering supervisor at City of Vancouver, Washington. Tzahi Y. Cath is a professor of civil and environmental engineering at the Colorado School of Mines. A complete list of references is available by contacting dramey@adcinfo.com

LANXESS RO membranes complete 1-year testing at pulp and paper facility

Reverse osmosis (RO) membrane elements from specialty chemicals company LANXESS, based in Cologne, Germany, have successfully completed a year-long practical test in the nation's largest industrial water treatment plant.

The new element grades with ASD feed spacers impressed Zellstoff Stendal GmbH, based in Arneburg, with their performance and consistently high level of rejection. Optimized for applications in brackish water, these Lewabrane-branded elements are characterized by very low energy consumption (LE) and high fouling resistance (FR).

One year ago, Zellstoff Stendal, one of the largest pulp manufacturers in Europe, launched a project to test LANXESS's newly developed Lewabrane ASD range of membrane elements. The process involved installing conventional RO elements, with a standard feed spacer and FR elements, with LANXESS's new ASD spacer in parallel in a single pressure vessel. The LANXESS spacers have special netting that reduces biological growth and particle fouling by minimizing dead zones. The netting has an alternating strand design (ASD) of thin and thick filaments, which is what gives the spacer its name.

After one year, the elements were removed and taken to the applications laboratory that LANXESS operates in Bitterfeld for an analysis. Compared to a standard element, there was hardly any increased pressure drop along the element when using the ASD grades, which indicates reduced blockage from fouling or biological growth.

In addition to the fouling-resistant Lewabrane B400 FR ASD grade tested by Zellstoff Stendal, LANXESS also offers Lewabrane B400 LE ASD, which features feed spacers that have improved productivity by 4 percent. For users, this improvement translates into potential energy savings of approximately the same percentage.

Computational fluid dynamic (CFD) simulations had previously indicated that RO elements with ASD feed spacers would be capable of achieving higher performance levels than standard grades. Furthermore, the tendency toward fouling in the element is reduced. “As we calculated, using the new elements reduces energy requirements while at the same time increasing service lives,” says Dr. Jens Lipnizki, head of Technical Marketing Membranes in the Liquid Purification Technologies (LPT) business unit at LANXESS.

Zellstoff Stendal, part of the American-Canadian Mercer International Group, is the largest and most cutting-edge manufacturer of Northern Bleached Softwood Kraft (NBSK) market pulp in Central Europe.

More than 50,000 cubic meters of water are needed every day for pulp manufacturing in Arneburg, and this amount is treated using RO and ion exchange resins. The Lewatit MonoPlus S 100 and Lewatit MonoPlus M 600 grades are used in the multistep process, while Lewatit MonoPlus SP 112 H and Lewatit MonoPlus MP 500 are used in the mixed bed.

Hybrid Proseries-M MD-3 Metering Pump at WEFTEC

Blue-White Industries' Proseries-M® MD-3 Hybrid Chemical Metering Pump provides precision chemical metering for municipal water and wastewater treatment and is NSF 61-listed. The company will exhibit this new pump at WEFTEC® 2017 in Chicago, Illinois, United States, which will be held on September 30 – October 4.

The pump features 2000:1 turndown that provides smooth chemical dosing with no pulsation dampener required. It is designed for drop-in-place installation and long service life, even at high pressures up to 145 PSI. Each pump is equipped with exclusive patented DiaFlex® diaphragm, sonic welded manifolds to prevent chemical leaks, and LED display for quick visual inspection.

Come and see it in action at WEFTEC 2017, Booth #3425.

Hydrophilic filtration membranes granted NSF/ANSI 61 certification

Arkema/Polymem report that their new Neophil™ polyvinylidene fluoride (PVDF) hollow fiber ultrafiltration membranes have been granted NSF/ANSI 61 certification for drinking water protection. This certification will accelerate the commercial development of this membrane technology developed jointly by French companies Arkema and Polymem in the global drinking water market, which is growing by 10 percent annually.

After several years of research, Arkema has developed an innovative Kynar® fluorinated polymer grade, which combines durable hydrophilic properties with the mechanical strength and chemical stability of PVDF.

Using this unique material from Arkema, Polymem, a manufacturer of membranes for water filtration, has developed ultrafiltration modules using Neophil™ PVDF hollow fibers that have now passed certification tests under standard 61 of the American National Standards Institute (ANSI) and NSF International (NSF) for drinking water quality.

The NSF/ANSI 61 certification now allows the Arkema/Polymem non-exclusive partnership to position itself immediately on the North American market and build the first facilities using Polymem Neophil™ PVDF hollow fibers for the production of drinking water.

When compared to conventional systems, the benefits of this durable hydrophilic technology include much finer filtration (suspended solids, bacteria, and viruses), higher (greater than 20 percent) volume of water filtered for constant energy consumption, and extended lifetime of filtration systems from 5 to 10 years.

This latest Kynar fluorinated polymer grade points the way to solve problems resulting from gradual loss of permeability and clogging of pores that membrane manufacturers encounter.

Numatics series supports up to 128 solenoid valves

The US company ASCO expanded its Numatics G3 Series and Numatics 580 Series electronic platforms to control up to 128 solenoid valves on a single valve manifold assembly. The platforms now feature flexible and cost-effective process control architecture that permits the design engineer or end-use specifier to optimize the size of the control cabinet for the number of required valves.

“The expanded functionality enables designers to minimize expensive cabinet space and have fewer nodes dedicated to pneumatic manifolds,” says Andy Duffy, Americas Region vice president of sales. “Now, designers can place more valves in a single cabinet or use a smaller enclosure to house the same number of valves. In addition, installers will only have to set up and configure one node, saving time and labor cost,” Duffy adds.

The expanded valve platforms can support 128 Numatics 501 Series solenoid valves and 80 Numatics 502 and 503 Series valves. They are the only products available that can support 80 18 millimeter (mm) and larger valve sizes on a single manifold.

To increase the valve platforms' capacity, ASCO added mid-station blocks with valve drivers and auxiliary power connectors. This flexible approach allows customers to pay only for the capacity and functionality required in their design.

Events 2017

September

24-28 Chicago, Illinois, USA
WEFTEC® 2017, Water Environment Federation's Annual Technical Exhibition & Conference. WEF Stormwater Congress will be held alongside WEFTEC.
www.weftec.org

29 Chicago, Illinois, USA
Microbiome Water Summit Organized by Microbe Detectives LLC
www.microbiomewatersummit.com

October

9-10 Bruges, Belgium
WRE's First Conference & Exhibition on Innovations in Water Reuse, organized by Water Reuse Europe
www.water-reuse.eu

26-27 Rome, Italy
Master Course on Best Practices for System Design and Development of Turnkey Desalination Projects. 2-day intensive course organized by European Desalination Society
eds@europeandesalination.org

October

30 – November 3 Toronto, Canada
Ontario Water Innovation Week Includes 3 events: 5th World Water-Tech North America Summit, Water Innovation in Action, and Ontario Municipal Water Association
www.rethinkevents.com

31 – November 3 Amsterdam, Netherlands
Aquatech Amsterdam, Co-located with Floodex Europe 2017 (Oct 31-Nov 1). Both will be held during Amsterdam International Water Week
Includes WEF International Pavilion
www.aquatechtrade.com/amsterdam

November

13-16 Buenos Aires, Argentina
IWA Water and Development Congress & Exhibition (WDCE), "Sustainable Solutions for Emerging Economies"
www.waterdevelopmentcongress.org

20-21 Eastern Province, Saudi Arabia
1st ISA Saudi Arabia Automation Conference & Exhibition Organized by International Society of Automation
www.isa-saudi-expo.org

Continued from page 10

are well suited for tackling harsh industrial wastewaters. Currently, polymeric membranes are still widely used; however, ceramic membranes are gradually gaining popularity on account of favorable total expenditures (TOTEX). Though the capital costs of ceramic membranes are high, ceramic membranes have laudable credentials from a TOTEX perspective. Few ceramic membrane manufacturers predict that their capital cost is likely to reduce and follow a trend similar to that of polymeric membrane, which once was envisaging a higher cost. Besides being employed in municipal/industrial water and wastewater treatment, ceramic membranes are gaining prevalence in digestate treatment and landfill leachate in Europe.

Although membrane systems are gaining in usage in Europe, membrane companies face the challenge of inadequate operation and maintenance skills, which can result in end-user dissatisfaction. A key requirement for the membrane to perform efficiently is that the influent, or raw water, quality should remain constant, and the plant should be operating under a steady-state condition. Failure to monitor the raw water quality in addition to the lack of technical skills in plant operators often results in membrane degradation, fouling, frequent cleaning, and use of membrane cleaning chemicals, which leads to higher operational costs. Most industrial plants in Europe with membrane technology are automated, and highly skilled, well-trained, and experienced personnel are required to analyze and restore the operations within a short period of time following any breakdown. Most end users scout for membrane treatment options that require minimum operator attention and have a longer lifespan. Thus, companies that can address these prevailing challenges with ease are expected to create an edge among the competition.

Author's Note

Deepthi K. Sugumar is a research analyst at Frost & Sullivan, who is based in Chennai, India. She analyses water and wastewater treatment technology market mainly for Europe and is very interested in environmental sustainability.

Reference
PWNT, 2017. Project Mayflower Water Treatment Works of South West Water UK. Retrieved from: https://pwntechnologies.com/portfolio-item/project-mayflower-water-treatment-works-of-south-west-water-uk/

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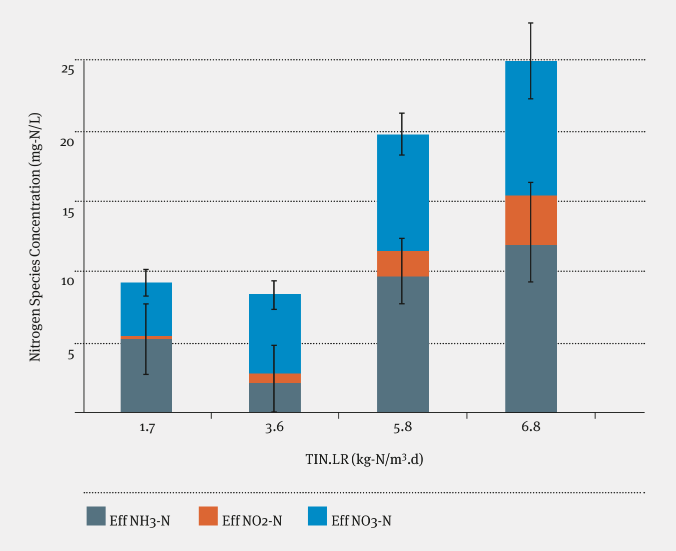
Additional Reading
Susanne Lackner, Eva M. Gilbert, Siegfried E. Vlaeminck, Adriano Joss, Harald Horn, Mark C.M. van Loosdrecht, Full-scale partial nitritation/anammox experiences – An application survey, *Water Research* 55(15) 292-303

T. Lotti, R. Kleerebezem, Z. Hu, B. Kartal, M.K. de Kreuk, C. van Erp Taalman Kip, J. Kruit, T.L.G. Hendrickx & M.C.M. van Loosdrecht (2015) Pilot-scale evaluation of anammox-based mainstream nitrogen removal from municipal wastewater, *Environmental Technology*, 36:9, 1167-1177

H. Park, D. Rhu, Mi-H. Kim and S. Sathyamoorthy (2017) The application of tertiary anammox biofilter for energy-efficient short-cut nitrogen removal, Nutrient Symposium 2017, Fort Lauderdale (FL)

Figure 3



Nitrogen fractions of the AMX BBF effluent in different phases of the pilot study

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