Decentralized wastewater reuse goes mainstream

The future outlook is promising for decentralized recycling projects as the demand for recycled water increases. **Geoff Salthouse**, **Bill Hensley**, and **Brian Cohen** of Orenco explain the reasons for the recent surge in its acceptance as a mainstream solution and present four case histories to illustrate its benefits in a wide range of non-potable applications.

Decentralized wastewater management, when coupled with reuse or recycling of treated sanitary sewage, increases treatment options, creates even greater value than when employed alone, and allows solutions to serve a larger audience and customer base. As the demand for water recycling continues to grow, and an increasing number of successful water reuse projects prove that recycling can be done safely at smaller scales, the future looks bright for decentralized recycling projects to become mainstream.

Since the term “reuse” can apply to a wide range of applications with different treatment requirements, it’s important to clearly define the input parameters and desired outcomes of any recycling system, so as to match the treatment level with the intended use. Non-potable reuse applications range from sub-surface landscape irrigation, where risks to human health and the environment are very low, to washing vehicles or firefighting with recycled water, where full contact is expected and should be planned for. While treatment of recycled wastewater to potable, drinking-water quality is technically achievable, it is not within the scope of this article.

The range of typical reuse applications can be visualized through the use of a tiered structure, or ladder (Figure 1), where each rung represents a different level of treatment required to meet increasingly rigorous risk mitigation standards. In general, lower rungs on the ladder require less advanced treatment, as the potential for human contact is low. Higher rungs represent uses where human contact is much more likely, so additional treatment is required to reduce the potential for adverse health effects.

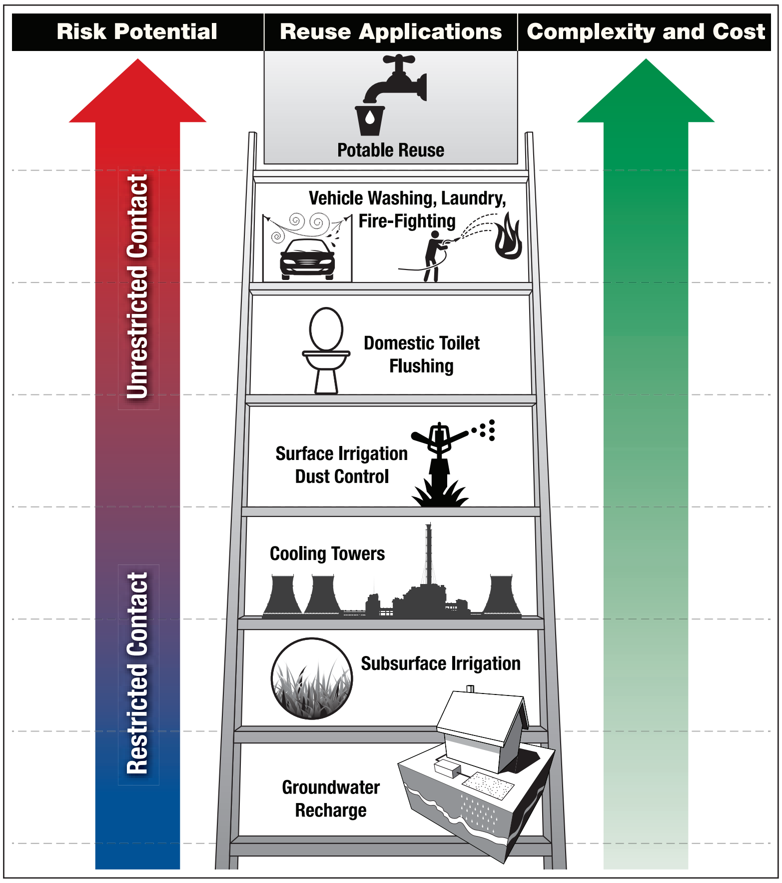

Figure 1. Typical reuse applications are presented in the above tiered structure in terms of level of treatment required to meet risk mitigation standards. Graphic provided by Orenco

Higher levels of treatment can also include redundant systems, such as pairing two different methods of disinfection to reduce risks from pathogens in case of sub-optimal performance at this critical treatment stage. Greater complexities and operational oversight needs are associated with these higher levels and additional stages of treatment. As one proceeds higher up the reuse ladder, systems require more knowledgeable and available operators as well as more robust monitoring systems in order to minimize response times in case of treatment equipment or process faults.

Reasons for reuse expansion

The level of acceptance and implementation of wastewater reuse and recycling strategies varies dramatically across geographic regions. Several drivers affect the perceived necessity for regulatory structures that allow – or sometimes encourage – the treatment of sewage to levels for reuse.

Key Terms in Decentralized Recycling

Decentralized Wastewater Management: The collection, treatment, and disposal/reuse of wastewater from individual homes, clusters of homes, isolated communities, industries, or institutional facilities, as well as from portions of existing communities at or near the point of wastewater generation.

Recycled Water: Treated domestic wastewater that is used more than once before it passes back into the water cycle. The terms “reused” and “recycled” are often used interchangeably depending on geographic location. Reclaimed water is not considered reused or recycled until it is put to some purpose.

Non-potable Reuse: Reclaimed water that is not suitable for drinking but is safe to use for irrigation, industrial uses, or other non-drinking water purposes.

*Source: https://watereuse.org/water-reuse-101/glossary/

Water scarcity is one of the primary reasons that local or regional populations recycle water. Even when regulations and enforcement may not exist, creative ad hoc reuse plans may be put in place to meet needs that are not addressed by formal water supply schemes. In some regions, regulations are strictly enforced to reduce water usage, which encourages both conservation and recycling of treated water. For example, the Building Sustainability Index (BASIX) in New South Wales, Australia, requires all new homes to be designed and built to achieve a 40 percent reduction in water use compared to the average pre-BASIX home.

According to the World Bank, there will be a 40 percent global shortfall between supply and demand of water by 2030. And by 2025, approximately 1.8 million people will be living in regions with "absolute water scarcity." The World Bank also estimates that 70 percent of water use today is for agriculture. A projected global population of 9 billion by 2050 is expected to require a 60 percent increase in agricultural production and a 15 percent increase in water withdrawals. Recycled water can meet some of this need, benefited by the nutrient content inherent in wastewater. And only mid-range treatment levels would be required, as irrigation can be accomplished while minimizing the potential for human contact with the recycled water.

Water scarcity has a significant impact on populations where clean, drinkable water is not readily available. As water is a fundamental need, administrative and governmental rule could be threatened if people tried to use force to secure adequate sources. This response could also lead to internal and cross-border tensions, creating unstable situations that could lead to violence.

As the scarcity of potable water increases its value, the recycling of treated wastewater is more accepted and encouraged. Small-scale, decentralized treatment can be implemented to serve local populations by keeping water within their boundaries and within reach for reuse, particularly in less dense, non-urban communities. Assuming that clean water is shared equitably among the residents, this approach helps alleviate some of the water security issues.

Technology improvements, such as wide-spread cellular networks and high-speed internet connectivity, along with significant reduction in the cost of electronics, now allow ongoing monitoring of treatment processes on a small scale. For example, SCADA-related technology – which was previously financially feasible only at large municipal treatment plants – is now in use with decentralized recycling systems. Therefore, the oversight necessary to reduce the potential risks associated with reuse can be provided to small communities and even to single-building recycling systems.

As the perceived value of water has generally increased, investors have seized upon the water sector as a new avenue for investment. This response has resulted in an influx of entrepreneurial activity, with new companies involved in research and development, and new products on the market, particularly in the reuse sector. According to one report, the global decentralized packaged/containerized treatment plants market is expected to reach revenues of $6.08 billion by 2023.

Resort spa treats effluent for onsite irrigation

Problem: The luxury resort Miraggio Thermal Spa was planned in a picturesque location just outside the small Greek village of Paliouri in Chalkidiki. However, since there was no existing municipal sewer system, an onsite wastewater treatment solution was needed to treat the combined flow of graywater and raw sewage. The treatment system would need to allow for future expansion, provide low operational costs, and produce effluent that would consistently meet strict discharge limits and allow for irrigation reuse throughout the resort. In addition, the effluent would be used to recharge groundwater. Due to the close proximity of the treatment plant to the resort, the system could not produce noxious odors and would need to be aesthetically acceptable.

Solution: In 2016, Orenco's AdvanTex treatment system, comprised of 22 AdvanTex AX100 units, was selected as the secondary treatment system, followed by a tertiary polishing pressurized sand filter and chlorine disinfection. The system is designed to treat a daily flow of 200 cubic meters (m^3). It has achieved all design requirements and consistently meets performance standards while going practically unnoticed by guests to the resort.


Photo by Dialynas, S.A.

Mining camp reuse for industrial dust control

Problem: A mining camp was being constructed approximately 20 miles outside of Carrizo Springs, Texas, United States (US), in an unincorporated area called Catarina. Because of the temporary nature of the camp and its distance from any municipal wastewater treatment system, a mobile treatment system was needed to treat raw sewage that could meet discharge limits as set by the Texas Commission on Environmental Quality.

Solution: In 2011, an AdvanTex AX-Mobile unit was installed that could provide secondary treatment of up to 44.3 m^3 of wastewater per day. Following tertiary treatment using UV disinfection, the treated effluent was then suitable for spray irrigation of nearby fields for dust control. When the temporary camp was closed a few years later, the mining company resold its AX-Mobile system to an RV park in Texas.


Photo by Orenco

Recycling of wastewater has been a driver for implementation of decentralized wastewater infrastructure solutions. For example, the Kingdom of Jordan's Decentralized Wastewater Management Policy, established by the Ministry of Water and Irrigation, identifies enforcement of environmental laws and technical standards to "expand the safe reuse of treated effluent" as the primary incentive for moving toward decentralized systems.

Decentralized wastewater solutions have also gained acceptance because they have real potential to reduce the overall energy costs associated with moving and treating sewage. Retaining water and solids near their point of origin, especially through reuse, is a cost-effective strategy that contributes to one of the primary objectives of decentralized management. According to the California Energy Commission, more than 4 percent of all energy consumed in 2015 in the state of California, United States (US), was used to move water and sewage. Given the large proportion of energy associated with transporting water, noticeable cost reductions can result from decreasing the distance that sewage must be pumped for treatment and decreasing the distance that recycled water must be transported.

Solutions

The most basic form of reuse for wastewater is subsurface dispersal, a very common practice throughout the decentralized wastewater management industry that results in the recharge of groundwater. In contrast, surface discharge into watercourses is more common in larger-scale centralized treatment systems and significantly reduces the options for local reuse.

Subsurface dispersal requires the lowest level of treatment, typically only the removal of gross solids and organics to preserve dispersal fields. Sometimes additional treatment is needed to remove nutrients in more sensitive groundwater environments and in areas where the soil cannot provide any additional treatment that may be needed before the water is extracted from the groundwater supply.

The next step up on the reuse ladder specifically targets irrigation of landscape plants, such as grass, bushes, and trees where the plant and its fruits are not for consumption. The nutrients are not purposefully removed during the recycling treatment process if they are beneficial to the plants. Pathogen removal is also not required if the irrigation water is kept subsurface and restricted from access and possible human contact.

While the lowest rungs on the reuse application

ladder are those that have very little or no chance of human contact with treated water, higher rungs include applications with increased potential for contact. Any increased risk can be mitigated by adding highly understood, proven stages of treatment to prevent adverse health implications. As the possibility for human contact increases, redundancy can also be added to critical processes, along with increased monitoring of system performance. Proper management, monitoring, and regulatory enforcement are crucial to ensure safe and reliable performance.

As the sidebar case studies illustrate, decentralized reuse systems can be successfully implemented in various locations and at varying scales, providing different levels of water quality and preserving potable drinking water. Nutrients can be beneficially reused, and energy can be saved by applying the recycled water close to its point of generation. Ultimately, wastewater no longer needs to be wasted – and can instead be viewed as a resource, rather than a pollutant.

Look to the future

Just as solar and wind power have put mini power plants on roofs and in backyards – reducing reliance on centralized, grid-distributed electricity infrastructure – there has been widespread acceptance and implementation of decentralized wastewater collection and treatment systems. Starting as a niche within the industry, these systems have flourished since the US EPA's declaration in 1997 that "[a]dequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas." Technological improvements now allow decentralized systems to incorporate additional treatment to reuse standards, so small-scale recycling systems are expected to grow in number to cost effectively meet specific local needs.

More and more decentralized water recycling projects are proving that water reuse can be accomplished safely at smaller scales. This development is particularly important given the increasing demand for water recycling solutions in a wide range of applications. Several other trends support this movement, providing more treatment options to developers, municipalities, and building owners.

According to a 2018 World Economic Forum report "From Linear to Circular – Accelerating a Proven Concept," the circular economy is defined as "an industrial system that is restorative or regenerative by intention and design." The circular economy seeks to replace the linear, end-of-life concept with restoration and aims to eliminate waste through the superior design of materials, products, systems, and business models.

The International Water Association (IWA) estimates about 80 percent of the world's wastewater is discharged into waterways, often partially or completely untreated. The IWA considers used water to be "one of the most under-exploited resources we have," and it identifies water as having a critical role in transitioning to the circular economy, including decentralized solutions.

The proliferation of organizations, conferences, and trade shows emphasizing green building provides evidence of a significant global trend in the design and construction of buildings that focuses on minimizing adverse impacts on the environment and society. Examples include Greenbuild in the USA, India, and Brazil; Green Expo in Mexico; IGBC 2018 in Singapore; PCBC in California, USA; and others around the world.

Certification and accreditation programs for building materials and systems provide guidance for sustainable buildings and infrastructure. This approach includes planning for sensible and sustainable water use, where recycling is a critical component. Some program examples include the United States Green Building Council's LEED®, EarthCheck, GreenCheck, and the Living Building Challenge. Additional trends include changing public perceptions and acceptance of reusing treated wastewater; breakthroughs in treatment with nanoparticles, forward osmosis, and graphene; and political acceptance and support of reuse and decentralized systems. New terms such as "sewer mining" offer a glimpse of future opportunities with multiple benefits, including financial, social, and environmental preservation.

Challenges still exist, particularly the problem of persistent chemicals and emerging contaminants in the water stream, which can be difficult to detect and treat. And many people still object to the idea of reusing treated wastewater, despite the fact that all water is ultimately recycled on a large scale in the natural environment. But human ingenuity and determination, motivated by increasing stress on the supply and quality of water, should prevail over these challenges. Decentralized wastewater solutions have gone mainstream to overcome the historical shortcomings of the big-pipe sewer approach, and the recycling of wastewater for reuse at any scale is becoming a common discussion point, as water has arguably become the world's most precious resource.

Graywater used for irrigation, toilet flushing

Problem: For the owners of the Cedar Springs Apartments in the US state of California, sustainable building practices are an important part of an overall development strategy that includes more than forty properties in and around Los Angeles. For this reason, owners wanted an advanced wastewater system that could treat graywater from residents' bathroom sinks, tubs, and showers for non-potable reuse.

Solution: Biohabitats, an ecologically focused design firm, recommended an AdvanTex AX-Max unit in 2016 for secondary treatment to produce the high-quality effluent that is reused for toilet flushing and drip landscape irrigation. The firm's design shows that low-income housing and sustainability can go hand in hand. The AX-Max unit handles an average daily flow of 9.8 m^3 from 36 apartments, and another unit can easily be added if the owners ever want to expand the complex. The effluent receives tertiary treatment using UV and ozone disinfection.


Photo by Biohabitats, Inc.

Ecovillage reuse for vehicle washing

Problem: Developers of the Currumbin Ecovillage in Queensland, Australia, wanted to build an eco-friendly community that would minimize the environmental impact on the beautiful Currumbin Valley. Their plan included a wastewater treatment system that incorporated a gravity-fed collection system and would consume very little electrical power, minimize odors, be simple to operate and expand, and provide exceptional advanced treatment levels. With a daily design flow at 57 m^3, the system's high-quality treated water would be suitable for non-potable reuse throughout the community, reducing the demand on potable water resources.

Solution: Orenco's AdvanTex technology was selected in 2006 as the secondary treatment system, including six AX100 treatment units with a pre-anoxic return line, followed by tertiary treatment consisting of microfiltration and UV and chlorine disinfection. The treated water is plumbed back to each home for non-potable reuse, including car washing, toilet flushing, garden/yard irrigation, and laundry. Any residual water is used for irrigating green areas throughout the community. In 2008, the developers were awarded the Prix d'Excellence from the International Real Estate Federation for the "World's Best Environmental Development." As of June 2017, the system had 93 connections and will serve 110 residences at full buildout.


Photo courtesy of Landmatters Currumbin Valley Pty Ltd

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