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Sustainable Wastewater Reuse for Homes and Communities

Gail Elber[1]

Approaching water reuse in a sustainable way means getting the most value for the energy, material, and dollars expended. With the technology currently available, this means

- integrating all possible sources of water – rainwater, wastewater, non-potable wells, streams, springs, and even air-conditioning condensate
- choosing passive, low-energy methods of treatment whenever possible
- treating water only to the level of purity actually needed

Filling non-potable needs with reclaimed water in this way can substantially reduce consumption of potable water, without requiring householders to be either microbiologists or millionaires.

To achieve this objective, several reuse-friendly wastewater treatment alternatives are within the reach of any homeowner or community. Packed-bed advanced treatment systems and effluent sewer systems make it easy to divert purified effluent for irrigation and other beneficial uses. Both technologies have been proven through decades of use, and they're now contributing to Platinum LEED ratings and other environmental recognitions for new homes, renovations, and low-impact developments.

Primary Treatment in the Tank

Whether wastewater will be treated onsite or at a community plant, designing for reuse usually begins with an underground tank (called a *septic*, *primary*, or *interceptor* tank) at each property. There, the raw wastes naturally separate into settled solids, floating material, and liquid effluent – a process called *primary treatment*.

Primary treatment is a passive and very reliable process, requiring no energy input. The organic biosolids remain in the tank for years, while microorganisms slowly break them down to a fraction of their volume. Every decade or so, the remaining solids are pumped out of the tank and managed appropriately, as local regulations permit – in many cases, becoming a valuable resource as a soil amendment.

[1] Gail Elber, a former Orenco employee, is a freelance writer based in North Bend, Oregon.

In contrast, the clarified liquid effluent remains in the tank for only a couple of days. Then it is pumped (or flows by gravity, if possible) from the tank to the next treatment step.

Advanced Treatment with Packed-Bed Treatment Systems

After primary treatment, the liquid effluent must receive *secondary* or *advanced treatment* before it can be reused. This treatment can happen onsite, or homes can be clustered onto a community system for greater efficiency. In either case, secondary treatment of wastewater is done in packed-bed filters by naturally occurring organisms that convert the nutrients in wastewater to gases and inert solids.

Many of these organisms need oxygen to do their work. In a conventional municipal wastewater treatment plant, and less efficient onsite treatment systems, machinery continuously aerates the liquid effluent to supply the necessary oxygen. However, a more energy-efficient practice is to trickle the effluent over a bed of porous material, called a *packed-bed filter*. The filter media develops a thin coating of microorganisms. Nutrients continuously wash over them, and oxygen from the air passively permeates the thin layer of moisture. Periodically trickling effluent with a small pump uses much less electricity than continuously aerating liquid with a blower. Treatment efficiency is also considerably greater, with residual biosolids production and management significantly reduced.

The original packed-bed filters, developed more than a hundred years ago, were made of sand and gravel. Sand filters are still used at some central treatment facilities and at rural homes with spacious yards. However, engineered filter media provides more surface area than sand to facilitate the growth of microorganisms, and provides more open pore space for the movement of oxygen. For example, in AdvanTex® Treatment Systems, manufactured by Orenco Systems®, Inc., effluent circulates over hanging curtains of special fabric. The large internal surface area of this material allows a three-by-eight-foot AdvanTex pod to treat an average household's wastewater, which would require hundreds of square feet of sand filter to treat.

Tertiary Treatment for Reuse

After advanced treatment, effluent is usually clear and odorless, but it still contains pathogens at levels that can cause illness if ingested. At this point, it can be reused in applications where people will be unlikely to come into contact with it. For example, it can be used for subsurface drip irrigation of landscape vegetation. Here, the nutrients remaining in the effluent are put to use by plants and other soil organisms. Using treated effluent for this purpose saves potable water for other purposes.

However, many reuse applications, such as toilet flushing and industrial process water, require a higher level of purity. For these applications, the effluent must undergo *tertiary treatment*. This may include micro-, ultra-, or nanofiltration through membranes or reverse osmosis, and chemical or ultraviolet disinfection.

The Debs Park Audubon Center in Los Angeles, the first LEED Platinum building, has an onsite treatment and reuse system that incorporates Orenco's AdvanTex Treatment

System. Here, the goal was to purify water to a degree where it could be used for toilet flushing, to educate visitors about reuse technologies. Also, the purification process had to use a minimum of energy, because the Audubon Center is entirely solar-powered. Accordingly, an AdvanTex Treatment System provides secondary treatment. Subsequently, the treated effluent is disinfected using peracetic acid and then treated further with ultraviolet light. This building, which serves eight staffers plus a stream of visitors, has achieved a 70% reduction in potable water use compared with a normal building, and has no connection to the city sewer system.

The Audubon Center's system fulfills its purpose of demonstrating water reuse to the public. However, this type of onsite tertiary treatment is not practical for most homes and businesses. The higher the level of purity required, the more expensive the treatment is. It also requires more oversight, either by the property owner or a trained operator. "Instead of using electricity or chemicals to purify wastewater to toilet-flushing level, it's more economical, for example, to flush the toilets with rainwater, which requires less processing, and use wastewater for irrigation, where its nutrients are beneficial," said Geoff Salthouse, a Project Engineer at Orenco Systems, who has advised designers of wastewater treatment and reuse systems in drought-affected areas such as Australia.

Clustered and Centralized Treatment for Reuse

To obtain higher purity at a lower cost per gallon, and to allow an operator to monitor the process, wastewater can be treated at *cluster* facilities. For example, in a residential neighborhood, each house would have an interceptor tank, from which the liquid effluent would flow or be pumped to a packed-bed filter serving 50 or 100 houses. This approach is used at Habitat Acres, an environmentally conscious housing development near Edmonton, Alberta. The development consists of 29 single-family homes on 24 acres, surrounded by a 44-acre nature reserve. From the tank at each house, effluent is piped to an array of three AdvanTex AX100 filter pods for secondary treatment, then used to irrigate part of the common area. In a system of this type, it would also be possible to treat the effluent further and send it back to the houses via a "purple-pipe" system, segregated from other plumbing, for toilet flushing, irrigation, or car washing.

Wastewater can also be treated for reuse on a larger, community-wide scale in an *effluent sewer system*. Again, each home or business has a tank where primary treatment takes place naturally. Effluent is collected via a network of small-diameter pipes and brought to the central municipal treatment plant. If reuse were included in the plan, the reclaimed water would be distributed via a purple-pipe system, as is the case in several Florida and California cities, and used for irrigation or industrial purposes.

The designers of The Ecovillage at Currumbin, in Queensland, Australia, have taken a different approach. Instead of each house having its own septic tank, sewage from the 144 homes and community facilities is collected in a large central primary tank. It passes through two additional tanks for settling. Then, after secondary treatment in an array of six AdvanTex pods, the effluent passes through a Siemens Memcor® continuous flow microfiltration system, followed by UV and chlorine disinfection. It is then piped back to individual houses for toilet flushing, car washing, garden watering, and landscape irrigation. The Ecovillage has won several awards, including the International Real Estate Federation's Prix d'Excellence as The World's Best Environmental Development for 2008.

Challenges for Reuse

Some constituents of wastewater do not break down during biological treatment. These include pharmaceutical compounds, heavy metals, and salts. In a closed reuse system, where reused water flushes the toilet or washes clothes and returns to the septic tank, these contaminants must be removed by ultrafiltration or reverse osmosis, or they will build up in the system. In open reuse systems where the reclaimed water is used for irrigation, the soil provides additional treatment, but some of these compounds can eventually find their way into the water table. Research is ongoing to understand the prevalence and potential impacts of these other compounds. As reuse becomes more common, adaptations in technology and lifestyles may be needed to keep these intractable pollutants out of the water supply.

Regulating and Managing Emerging Technologies

As interest grows in reuse of wastewater, new technologies for the purpose are coming to market. Naturally, some are more reliable than others. Therefore, regulatory agencies must be able to monitor the effectiveness of household systems to safeguard public health. Regulation must be conservative enough to protect health, but flexible enough to accommodate technological innovation.

To accomplish this, the U.S. Environmental Protection Agency recommends that a community's inventory of privately owned onsite treatment systems be managed by a *responsible management entity* (RME), much as municipal sewer systems are. A management entity may simply regulate the permitting and maintenance of these systems, as a county health department does, or it may contract with property owners to install and maintain individual systems itself, as in the case of a homeowners' association or a public utility.

Web and telemetry technology make the RME's job easier. For example, most of Orenco's AdvanTex Treatment Systems include the VeriComm® "smart" control panel, which monitors the system and alerts the designated service provider via telephone. The service provider can often correct malfunctions from the office, by adjusting settings using a Web page that transmits the corrections via phone. The homeowner may never notice either the problem or the solution.

To manage thousands of treatment systems in a community — systems that may be low-tech, high-tech, or anything in between — regulators are turning to Web-based tools. For example, one of these, OnlineRME, developed by OnlineRME, LLC, allows regulators to track the maintenance and performance of all kinds of onsite wastewater treatment systems. Service providers enter data from service calls or periodic inspections. Systems with telemetry capability can upload data directly to OnlineRME. Management tools of this type help public health officials protect health and water resources while allowing them to accommodate the development of increasingly sustainable technologies.

Regulatory changes such as this will enable society to benefit from the full potential of water reuse technologies.

Sustainable Technologies Bring Reuse into the Mainstream

The importance of water in our lives is paramount, and pressures on clean water supplies are mounting everywhere. Safe reuse of what used to be called "waste" water has been proven, and can now be done cost-effectively with technology currently available.

"It is important to place the proper value on water, and keep in mind how critical it is to us and the rest of the planet," Salthouse adds. "We can no longer afford the old ways of 'big-pipe' thinking, with the inherent risks and inefficiencies that continue to cause too many problems. The ability exists today to treat and reclaim used water to various levels of purity appropriate for the type of reuse desired. And this can be done using technologies that effectively use natural processes and have low impacts on society and the environment."

Given the availability of these sustainable technologies, and the continual emergence of new ones, one thing is clear: Reuse is coming soon to a community near you.