ACHIEVING WATER CONSERVATION GOALS THROUGH GREYWATER RECYCLING

February 7, 2018 | By Jennifer Cisneros | 1] HORIZONS

The state of water resources varies greatly around the globe. Innovative water treatment technologies, green infrastructure, and improved management approaches can help change the current paradigm, allowing stormwater, municipal wastewater, and other 'post-use' water to be valued as a resource for fit-for-purpose water reuse, energy, nutrients, metals, and other valuable substances. A 'water-resource-recovery' strategy utilizing onsite greywater recycling can provide not only efficient irrigation, runoff mitigation, and pollution prevention for individual buildings, but also both economic and environmental benefits to larger communities.

According to a 2015 study by the American Water Works Association (AWWA), the "financial tools (*e.g.* a rebate program and a third-party ownership model) could lower cost hurdles for greywater recycling." In their report, "Cost-Benefit Analysis of Onsite Residential Greywater Recycling: A Case Study on the City of Los Angeles[2]," Zita Yu et al further explain a city-wide greywater reuse program "could be developed to satisfy regulatory requirements by monitoring system operations and maintenance by certified contractors."

On a smaller level, greywater recycling systems can help property owners substantially reduce their building's water consumption. Although the water going down the drain is not potable, it can still be useful for other purposes. Greywater recycling systems are specifically engineered, and extensively proven and tested, to collect the used water from showers and baths, filter and disinfect it, and then plumb it straight back into toilets, washing machines, or outside taps.

Typical water use at home

Bath	A "full bath tub" varies, of course, but 36 gallons is good average amount.
Shower	Old showers used to use up to 5 gallons of water per minute. Water-saving shower heads produce about 2 gallons per minute.
Teeth brushing	<1 gallon. Newer bath faucets use about 1 gallon per minute, whereas older models use over 2 gallons.
Hands/face washing Face/leg shaving	1 gallon each activity
Dishwasher	6-16 gallons. Newer, EnergyStar models use 6 gallons or less per wash cycle, whereas older dishwashers might use up to 16 gallons per cycle.
Dish washing by hand:	About 8-27 gallons. This all depends on how efficient you are at hand-washing dishes. Newer kitchen faucets use about 1.5-2 gallons per minutes, whereas older faucets use more.
Clothes washer	25 gallons/load for newer washers. Older models might use about 40 gallons per load.
Toilet flush	3 gallons. Most all new toilets use 1.6 gallons per flush, but many older toilets used about 4 gallons.
Glasses of water (drank)	8 oz. per small glass (not counting water for Fido or your cats). Also, note that you will be using water for cooking.
Outdoor watering	2 gallons per minute, depending on the outdoor faucet. This may not sound like too much but the large size of lawns and yards means outdoor water use can be a significant use of water.

Residential Indoor Water Use

Source: Water Research Foundation, Residential End Users of Water, Version 2, 2016

Capturing water from a five-minute shower allows a toilet to be flushed up to 10 times—up to 19 L (5 gal) of water used per minute. (For more information, see "How much water does the average person use at home per day?" from the United States Geological Survey [USGS] Water Science School's "Typical water use at home[3]" reference table.) At the current rate, one's water bills are expected to double in the next decade. The U.S. Environmental Protection Agency (EPA) estimates that about 25 percent of indoor household water is used for toilet flushing. Showers/baths and washing machines can be around 20 percent each of total indoor water usage. Sinks, leaks, and other water activities make up the remaining amount. For those employing treated greywater, this gives an annual average water consumption savings of more than 34,070 L (9000 gal) per person.

This reduction is substantial in a single-family home, but can be far more impressive in potential hospitality projects and university residences. (The average water usage in buildings of commercial properties varies greatly depending on the nature of industry of its occupants.)

Water recycling options

Wastewater is defined by NSF/ANSI as human body waste and liquid waste generated by the occupants of an individual residence. Wastewater is also generated from any facility occupied by humans. Wastewater can be subdivided into blackwater and greywater sources. Blackwater is the portion of wastewater from a residence or facility generated by toilets, urinals, bidets, kitchen sinks, and dishwashers. NSF/ANSI defines graywater as wastewater from water-bearing fixtures, including laundry—such as clothes wasters and laundry sinks—and bathing, such as bathtubs, showers or sinks, but excluding toilets, urinals, bidets, kitchen sinks, and dishwashers.

Untreated greywater contains significant to trace amounts of soaps (*e.g.* body wash, shampoo, liquid hand soap, and bar soap), detergents, lotions/conditioners, cleaners/cleansers, dirt/particles, toothpaste, and deodorant, among other things depending on the activities of the occupants. It should not be stored for long periods—no more than 48 hours—as pathogens can quickly breed.

The volume of water used to flush toilets closely matches the volume of greywater produced in a day from bathing. This allows for a smaller tank size since all the greywater generated is used that same day.

If greywater is collected, for example by washing up in plastic tubs, or bucketing out of a bath, it should only be emptied directly onto soil, not onto plants. It should also be put on different parts of the garden in rotation, to avoid a buildup of salts that damage the soil.

With greywater recycling systems, the water is purified through several treatment processes to a level safe for a variety of beneficial uses. A number of regulatory agencies have adopted requirements that must be followed when producing, distributing, and using recycled water. Water quality is strictly monitored and routinely reported to the respective Regional Water Quality Board. The resulting highly treated effluent can be used for irrigation of landscaped areas, water features/fountains, and dust control. Such applications not only help conserve natural resources and protect ground/surface water, but also enable buildings to overcome land constraints.

The first stage in filtering greywater is to remove large particles (*e.g.* hair and lint) through using a cloth bag or old stocking to prevent clogging of the next filter. (Kitchen water should pass through a grease trap first.) This can occur using several different types of decentralized technologies.

Wastewater treatment is a complex process that demands a combination of solutions, rather than a one-size-fits-all approach. All septic systems require oxygen so bacteria can properly convert complex molecules into basic ones like carbon dioxide (CO_2), water (H_2O), and nitrogen, as well as eliminate viruses like E. Coli. Therefore, the major difference between the tertiary systems is how the oxygen gets to the bacteria. Some pump air into the sewage, while others put the sewage into an area with oxygen.

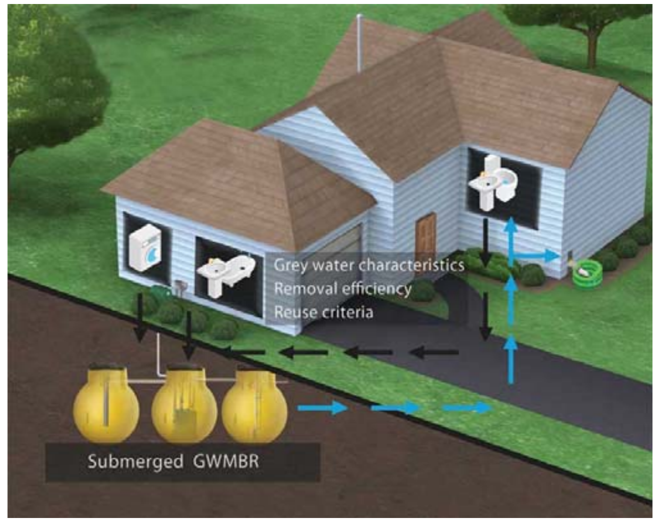
With residential projects, all daily flow calculations start with the number of bedrooms and an approximation of water use for each person, but this is not the case when it comes to other factors. Other considerations include terrain/soil site conditions, along with the fixtures used—including the types (low-flow, high-efficiency, or not) and number of washers (dish/laundry), faucets, showers, tubs, and floor drains used or installed on the premises.

Whether it is for toilet flushing, onsite irrigation, or for cooling towers, reused water must meet the applicable local code for its intended use.

For most advanced treatment systems, whether they are integrated fixed-film activated sludge treatment, trickling filter systems, extended aeration systems, or onsite membrane bioreactors (MBRs), the technology easily scales up to accommodate the flows between small-scale packaged systems (as low as 1-m^3 [35-cf] daily flows) and full-scale wastewater treatment plants (beyond 600 m^3 [21,190 cf]). Each system has a slightly different setup, depending on the site conditions and the level of maintenance willing to be undertaken.

Other types of adaptive, onsite wastewater technologies employing highly efficient treatment processes include:

- effluent screening (provides pre-treatment)—septic-tank deflection devices designed to screen (down to 3-mm [118-mil] solids) insoluble debris from wastewater to promote natural attenuate flow and sedimentation (and has a cleaned-in-place swabbing feature);



- submerged aeration (typical treatment)—fine- or coarse-bubble supplementary aeration that creates a vortex circulation, mixing the liquid in the wastewater to promote removal of biological oxygen demand (BOD);
- extended aeration (typical treatment)—a complete mixed-activated treatment system utilizing submerged aerators for suspended-aeration wastewater treatment process;
- trickling filter (enhanced treatment)—automated, recirculating, pre-engineered, advanced wastewater treatment system employing a spray function to saturate textile media;
- fixed-film technology (integrated, enhanced treatment)—submerged, oxygenated, attached growth media system to create robust growth with naturally occurring bacteria and a nitrified/denitrified recirculation action to treat wastewater; and
- MBRs (ultrafiltration)—membranes and aeration process act as an impenetrable physical barrier to produce water filtrate that is 99.9 percent removed of pollutants.

Residential and commercial blackwater and greywater recycling systems have entered the U.S. marketplace with continual support from certifying bodies like NSF International, PIA GmbH, and the U.S. Environmental Protection Agency Environmental Technology Verification (EPA ETC) program—third-party agencies that review the technologies with testing and provide certification to global safety standards.

NSF establishes criteria to improve awareness and acceptance of water reuse technologies that reduce impacts on the environment, municipal water and wastewater treatment facilities, and energy costs. Onsite MBRs certified to NSF 350, *Onsite Water Reuse,* dramatically simplify the settling, screening, direct aeration, and ultrafiltration of the wastewater treatment process to remove 99.9 percent of the contaminants and result in high-quality effluent.

The treated wastewater from an MBR can be used for restricted indoor water use and/or unrestricted outdoor water use. Such membrane bioreactor systems can be suited for water reuse applications due to the low-flow, durable, flat-sheet membranes that use micro-sized pores for physical separation of solids from the wastewater.

These systems also meet water quality requirements for the reduction of chemical and microbiological containments. They typically have a recirculating feature to aid in nitrate removal. This decentralized treatment system offers lower costs than centralized sewering, and is often ideal for single homes or small communities. Proprietary products with low maintenance needs can be especially ideal for the residential market, but other membrane bioreactor systems have mandatory chemical 'clean-in-place' (CIP) control for cleaning every two weeks.

Commercial projects

Capturing and treating the indoor greywater to be reused for outdoor applications can halve water usage, decreasing the freshwater demand of the home. Of course, homes are not the major consumers of local water sources—commercial and major manufacturing facilities have far bigger impacts. For instance, in Prineville, Oregon, Apple Inc. used 102,000 m^3 (133,400 cy) of water last year to run its facilities and evaporative cooling systems in its data centers. (See Sara Jerome's article, "Apple Enters the Wastewater Business[6]," in *Water Online*.) Due to the high volume of water consumption, many large corporation campuses and high-rise buildings look to develop their own wastewater treatment facilities and reroute the piping to reuse water.

For projects facing challenges with topography, small lots, or distance to groundwater, water recycling helps to push approvals through for permitting.

Recycling greywater onsite could potentially increase project density, unit counts, or reduce onsite sewage system due to less water to manage and treat. The lower infrastructure costs with utility connections can also be attractive for the initial investment of greywater treatment systems, in addition to requiring smaller potable water meters. Better water management of the water onsite means less water discharging into stormwater drains, thrown away in sanitary sewer systems, or polluting local waterways.

Under the Leadership in Energy and Environmental Design (LEED) rating program, greywater systems can help a project team earn points for water use reduction and innovative wastewater technologies.

Only available as guidelines (rather than standards), the criteria for these points can be found in the sections on Sustainable Sites (SS) and Water Efficiency (WE), under Innovative Wastewater Technologies. Other areas as outlined in green building guidelines can include credit for innovative or adaptive reduced generation of wastewater and potable water demand, while increasing the local aquifer recharge.

Ideas and typical water use efficiency categories within many of the national green building programs promote sustainable wastewater management to include reusing a building's wastewater onsite. For commercial buildings, water reuse activities can use recycled wastewater (onsite or municipally supplied), as well as other nonpotable sources such as:

- swimming pool backwash operations;
- air-conditioner condensate;
- rainwater;
- cooling-tower blow-down water;
- foundation drain water;
- steam-system or ice-machine condensate;
- discharge from fluid coolers, food steamers, and combination ovens;
- industrial process water;
- fire pump test water; and
- municipally supplied treated seawater.

Reused water must meet the applicable local code for its intended use (*e.g.* onsite irrigation, toilet flushing, or cooling tower) to demonstrate the system design and location with how much of the water type was reused. Greywater systems with control panels can easily monitor this and provide the necessary data information to satisfy the requirements.

Most state 'greywater requirement section' codes allow treated greywater to be used for toilet flushing. The term 'treated' usually means a method that kills 100 percent of bacteria, virus, coli phage, and other pathogens, removes suspended solids down to 100 μm, and greatly lowers turbidity—this is an expensive endeavor. When a lush, green landscape is sought, it might be wise to skip this expense and instead use untreated greywater to irrigate the grounds.

Additionally, greywater-reuse systems can help meet increasing regulations and water rationing in some jurisdictions; these requirements are the result of growing cities requiring new water infrastructure, restrictions on the amount of water a city can withdraw, and increases in the cost of energy to treat and supply water.

Ultimately, however, it is not solely about the cost of water—it is the amount of fresh water sources that can be saved due to the volume and frequency of greywater produced and the number of times the toilet is flushed.

Jennifer Cisneros is the director of marketing at Bio-Microbics Inc., and formerly chaired the Marketing Committee for the National Onsite Wastewater Recycling Association (NOWRA). She has worked for the past 10 years with the regulatory, engineering, and environmental technical practices (field services) departments at Bio-Microbics to create content for the water industry. Cisneros presented "Small Lot? BIG Options!" on the various options available to villages and small municipalities during Wastewater Education's Earth Month Earthy Matters series. She can be reached via e-mail at jcisneros@biomicrobics.com[8].

Endnotes:

1. [Image]: https://www.constructionspecifier.com/wp-content/uploads/2018/02/JenniferCisneros_bio_namecard-e1518034264443.jpg
2. Cost-Benefit Analysis of Onsite Residential Greywater Recycling: A Case Study on the City of Los Angeles: http://www.awwa.org/publications/journal-awwa/abstract/articleid/53151606.aspx
3. Typical water use at home: http://water.usgs.gov/edu/qa-home-percapita.html
4. nwdistrict.ifas.ufl.edu/nat/files/2017/06/Residential-end-use.png: http://nwdistrict.ifas.ufl.edu/nat/files/2017/06/Residential-end-use.png
5. [Image]: https://www.constructionspecifier.com/wp-content/uploads/2018/02/BioBarrier-GWMBR-3d.jpg
6. Apple Enters the Wastewater Business: http://www.wateronline.com/doc/apple-enters-the-wastewater-business-0001

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8. jcisneros@biomicrobics.com: mailto:jcisneros@biomicrobics.com

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