Greywater Recycling via Separation Technology

By Clint Elston

Summary: *As the planet continues to grow in population, an overriding concern is where to put all organic waste. In the past, this has been a quite involved and complicated issue involving many steps. One company thinks it may have come up with a feasible solution using "separation technology."*

Pressure is growing globally to introduce pollution-reducing, water-conserving and recycling measures for sustainable residential and small community water/wastewater systems. Not only are media accounts of inadequate water quality and quantity reported daily but, since 9/11, community water supplies and reserves are now seen as potential bioterrorism targets. Systems utilizing separation of blackwater—wastewater from toilets and garbage disposals—and filtration/disinfection technologies for partial or total reuse represent a logical, economic option for reducing and eliminating these pressures and improving national security.

Human waste and associated health problems have been with us since the origins of man. These problems increased at the point in history when we started using water to clean things. About 3,300 B.C., we began using water to move human waste to a different spot from where it originated, further complicating the issue. Wastewater treatment didn't really begin until we realized there were problems with how we disposed of untreated wastewater.

For almost 100 years, the "standard and traditional" multi-gallon flush toilet transportation system, used in conjunction with either a septic or sewer type wastewater treatment system, removed only a small part of this waste from the honey bucket and outhouse. According to a 1995 American Housing Survey by the U.S. Census Bureau, about a fourth of the estimated 109 million housing units in the country are served with septic tanks or cesspools receiving and discharging 175 billion gallons of wastewater per year.

Debunked myth

Septic tanks or cesspools receive a co-mingled waste stream comprised of greywater—water from showers, laundry and dishwashers—polluted further by toilet wastes moved with copious amounts of clean drinking quality water—an average of 75 to 125 gallons of water per person per day. It's still assumed that by diluting and transporting the wastes to the septic tank and then passing the discharged wastewater through soil, it filters out the pathogens and reduces health risks associated with human wastes. In reality, it actually increases the pollution problem and energy requirements for the water pumping system.* It also creates a greater demand and shortens the life of the treatment and disposal system.

In 1995, more than 2.5 million septic tanks in America were reported as malfunctioning (or having a total system breakdown). As you read this, there will be some 7,000 septic tank malfunctions reported. According to the housing survey, 10.2 percent of septic systems for occupied housing units malfunctioned at least once a year. Groundwater has historically been assumed to be safe without treatment to kill microorganisms. Current evidence indicates virus contamination (i.e., rotaviruses, hepatitis A and coxsackieviruses) from fecal sources in 20 percent of groundwaters tested nationwide. One small drop of fecal matter can contain millions of pathogenic (disease-causing) microorganisms. And viruses can move through the septic tank system—from the toilet to adjacent surface water—within 18 hours. According to one report, repair-

* NOTE: Consider, utilizing ultra-low flush toilets, which consume less than a cup of water per flush instead of 1.6 gallons per flush, reduces overall water consumption by 30-to-40 percent. This then reduces the amount of water required to be pumped, thereby, reducing energy requirements for and extending the life of the water pumping system.

ing water and sewer pipes may cost the United States over $1 trillion. Meanwhile, TV, newspapers and magazines continue to report on "drought conditions" plaguing the entire East Coast from Maine to Florida.

At the World Summit on Sustainability, the United Nations, World Bank and several key professional groups stated the current way in which wastewater is handled in the developed world is probably not sustainable, and hence the technologies in use are—in their present form—not appropriate for transfer to the developing world.

Pioneering endeavors in Alaska

During the mid 1980s, under contract with the Alaska Army National Guard, one company manufactured and installed over 50 non-automated, waterless composting toilet systems for remote Alaska Native Village Army National Guard Armories. These villages were predominately located on Alaska's west coast—above and below the Arctic Circle—and lacked any form of conventional running water and wastewater treatment systems. The result of those experiences produced an automated version for the composting process to help reduce maintenance requirements and increase its efficiency.

Water supply and wastewater treatment problems aren't unique to Alaska's bush villages, but exist throughout Alaska and the lower 48 states. Having developed an effective technology for separation and treatment of organic wastes in the late '80s, the company became interested in researching and developing a greywater treatment system to provide an alternative to traditional septic systems, which frequently freeze and fail because of Alaska's extreme environmental conditions and frigid soils. Over a four-year period, the company came up with a miniaturized version of an extended aeration wastewater treatment system, coupled it with a toilet separation system, and received its first patented "Apparatus for Composting Organic Waste Materials and Method" in 1992.

In early 1998, Olmsted County Water Resources Center (Rochester, Minn.) tested and documented that the company's separation/composting tank (SCT) and greywater treatment system could reduce water consumption by 40 percent, carbonaceous biological oxygen demand (CBOD) and total suspended solids (TSS) by 90 percent, nitrates by 99 percent, and bacteria by 1,000-fold when compared to septic tank effluent. The quality of the treated water is compared to septic effluent in Tables 1 and 2.

Table 1. Comparison of effluent with typical domestic wastewater loadings

Parameter	Olmsted County Effluent*	Typical Raw Greywater*	Typical Raw Blackwater*	Typical Raw Combined*	Calculated Reduction
TSS**	3.3	17.2	53.5	70.7	95%
TKN**	1.0	1.9	9.3	11.2	91%
BOD5**	3.7	28.5	34.7	63.2	94%
COD**	18.9	—	—	120	84%
TOC**	4.7	—	—	28	83%

* Grams/capita/day per USEPA, 1980.
** TSS=total suspended solids, TKN=total Kjeldahl nitrogen, BOD5=biological oxygen demand, COD=chemical oxygen demand, TOC=total organic carbon

Table 2. Comparison of treated greywater at Chester Woods to septic tank effluent (mg/L)

Parameter	Olmsted County Effluent*	USEPA Rpt. Septic Tank Effluent**	U of M Rpt. Septic Tank Effluent***	Calculated Reduction
TSS	19	39 – 155	46 – 65	50 – 88%
TKN	6	36 – 40	50 – 60	83 – 90%
BOD5	21	95 – 240	140 – 175	78 – 93%
Fecal coliform	1,893	10(5)	10 (3) – 10 (6)	0 – 1000 fold

* Mean values
** USEPA, 1980.
*** University of Minnesota, 1994.
NOTE: Based on these monitoring data, the system is calculated to have achieved a 90 percent reduction in loadings of total nitrogen, BOD and suspended solids to the drainfield compared to primary treated wastewater effluent from a septic tank. Measured water use, measured pollutant loadings and lack of ponding in drainfield trenches are consistent with the original design, allowing a 40-percent downsizing of the soil disposal area simply for the reduction in water usage.

Recycling development

Armed with these results and sufficient data from testing in Alaska and Minnesota from 1990 to 1998, in 1999, the company began researching existing water conditioning and purification technologies and equipment. By assembling tested and certified off-the-shelf components, an energy efficient prototype was manufactured to meet National Pollution Discharge Elimination System (NPDES) standards for surface discharge to bodies of water. Realizing the treated, filtered and disinfected discharge water quality of this newly developed system far exceeded intake water qualities for most cities and communities on rivers or with bad wells, the company decided to add more filtration, disinfection and membrane equipment to its initial prototype. Initial test results of the prototype with the additional equipment conducted by Olmsted County's well water testing department documented safe drinking quality water. In 2001-2, the company received two other patents on its newly developed waste and wastewater treatment and recycling system.

How the system operates

Stylish gravity or vacuum (one pint of water per flush) porcelain toilet fixtures with a rotating-ball-and-water type of trap are installed and plumbed to the SCT. The toilets utilize a hand or foot pedal-operating flushing mechanism that rotates a ball/trap device. The flushing mechanism can also be lifted, allowing more water to fill the toilet bowl, thereby totally eliminating any toilet staining problems usually associated with conventional 1.6 gallon low-water flushing toilets. The gravity toilet model requires a steeper plumbing angle than conventional toilets (25 degrees from horizontal or 2-½" per foot drop) to transport the toilet refuse and paper to the SCT. The vacuum toilet incorporates the same toilet fixture but utilizes a small vacuum tank and a 12- or 24-volt, bellows-type pump to create a vacuum, which is capable of lifting the toilet refuse eight feet vertically and transporting it horizontally up to 100 feet to the SCT.

Utilizing the vacuum flushing toilet model allows flexibility in locating the SCT instead of having to design the house or facility around the system. For existing homes without basements, or for homeowners who don't want or have a location where an aboveground building can be located, an underground structure or concrete vault is recommended. The structure can be insulated and heated for cold climate installations. In addition, maintenance personnel can easily service the systems without having to enter the home. Locating the systems outside the home maintains that "out of sight, out of mind" mentality for wastewater treatment.

Two-thirds of all organic refuse that's produced in the household comes from the kitchen. On standard septic or sewer types of wastewater treatment systems, the garbage disposal adds additional load and requires additional maintenance and pumping costs. Utilizing decomposition principles, the SCT biologically converts 90-to-95 percent of all toilet and kitchen garbage disposal, organic wastes into odorless carbon dioxide and water vapor. Aerobic organisms (oxygen consuming) thrive in the fan-driven, air-assisted and double-walled tank, converting the remaining portion into a valuable soil additive. Aerobic organisms don't produce the methane gas and hydrogen sulfide odors common with anaerobic (non-oxygen consuming) septic systems.

The aerobic / composting environment kills 90-to-99 percent of viruses and pathogens utilizing time and temperature. About 10-to-15 gallons of finished compost are produced by a family of four per year, which is easily removed by the homeowner or maintenance personnel with the auger system designed for this purpose. Programmable timer-driven agitators gently distribute the fresh wastes on the top surface of the tank to aid the organisms in their natural decomposition process. Such a system can handle up to 12 adults full-time and accommodate larger numbers for brief periods. Unlike septic tanks, it's highly recommended that a garbage disposal be installed on a small separate sink and plumbed to the SCT tank to keep plumbing separate from the greywater treatment system and avoid it being flooded. Doing this also eliminates all undesirable kitchen organic refuse, reducing the total amount of garbage created daily and lowering costs of rubbish hauling and disposal.

Dispersing greywater

Greywater is plumbed to a series of separate wastewater settling and treatment tanks. This system consists of a surge tank for flow control, an aeration tank to produce aerobic conditions and a clarification tank to return the settled solids back to the surge tank. An energy-efficient air compressor provides an abundant amount of air to continuously provide oxygen and circulate the wastewater.

Using the standard wastewater treatment technology of extended aeration, the water is aerated and bacteria grow on the interior surface walls of the tanks. As water enters the surge tank, it's lifted into the clarifier with a 67-watt, 110-volt linear air compressor, or airlift. In the clarifier, two additional airlifts pump water from the bottom and top of the tank back to the surge tank. As the water is circulated, the bacteria clean it in a natural process. By separating toilet flow from the greywater, the estimate for water consumption and greywater treatment is 40 gallons of wastewater per person per day. Based on 24-hour retention for adequate treatment of the greywater, the estimated treatment capacity of each greywater treatment system is 250 gallons per day. For flows over 250 gallons per day, additional greywater systems are added and installed in parallel. The aeration and circulation process biologically treats the wastewater, producing a high wastewater effluent quality that can then be efficiently and economically filtered and disinfected for reuse.

The treated greywater flows into a storage tank, which is aerated with ozone to kill bacteria. When the potable water storage tank needs more water, a high-pressure stainless steel pump directs the ozonated water through filters, ultraviolet light, ultrafiltration, carbon filtration, another ultraviolet light and reverse osmosis for additional treatment to make it potable. That water is stored in the potable water storage tank, which supplies water to the entire household The waste concentrate is plumbed back into the ozone tank and recycled for further removal of permeate water. When the TDS quality reaches a designated level a solenoid valve opens and that water is either discharged to a small absorption area or an evaporation / distillation system. Because water used for toilet flushing is evaporated* in the SCT and not connected in any way to the greywater treatment system, makeup water is re-supplied from a cistern, well or city water supply. An installed monitoring / control panel is programmed to activate pumps and valves and reports to the company's central monitoring facility if any alarms are activated or any of the com-

Figure 1. Greywater treatment system schematic

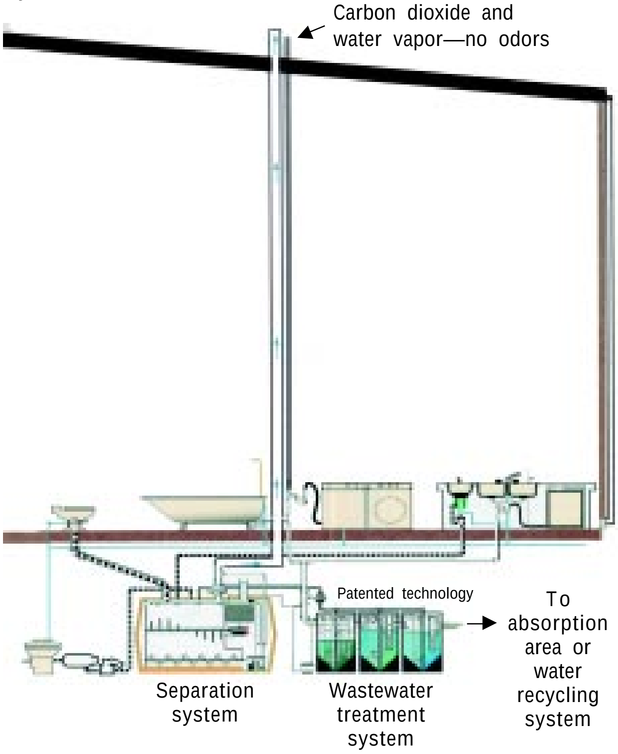
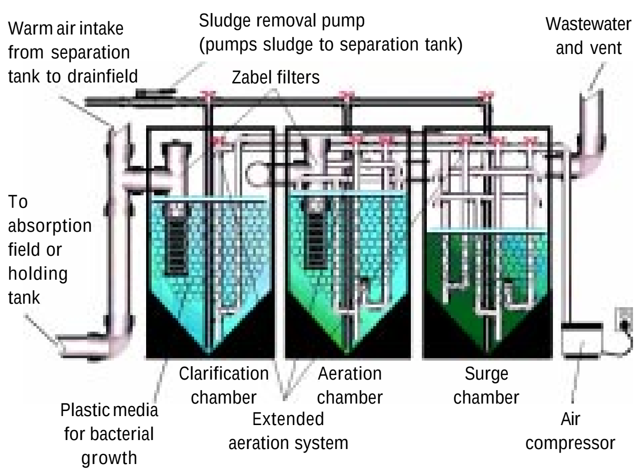


Figure 2. Wastewater tanks schematic



* NOTE: Either through the aerobic/composting process with circulation of air by the fan or if excess quantities of water are being introduced into the SCT it can automatically be pumped to the evaporation/distillation system.

Complete system

Water recycling system

Separation/composting, greywater treatment and ozone contact tanks

ponents aren't achieving design parameters.

Conclusion

Separation technology combined with the described components provide for the total treatment of toilet and organic kitchen wastes, as well as greywater, and produces water quality for landscape irrigation and/or household reuse. This revolutionary approach to water conservation, wastewater treatment and eventual reuse has the potential of reducing water consumption by 40 percent to 95 percent. It eliminates the need to design and construct large soil treatment areas for septic systems or expensive collection, distribution, and treatment facilities for piped water and sewer systems. Such separation technology is the world's first and only decentralized, closed-loop, zero-discharge wastewater treatment and water recycling system available for commercial, public and military use.

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About the author

Clint Elston is president of Equaris Corp., of Afton, Minn. He invented and received his first patent in 1992 for the AlasCan Composting Toilet and Greywater Treatment System and received two additional patents in 2001 and 2002 for the ClearWater Closed Loop, Zero Discharge Potable Water Recycling System. He also coined the term "separation technology" in regards to toilet, organic waste and greywater treatment." The systems discussed in this article are the Equaris Biomatter Resequencing Converter (BMRC), Greywater Treatment System (GTW) and the Water Recycling System (H20RS). He can be contacted at (651) 337-0261, email: celston@equaris.com or website: www. equaris.com