

TODAY'S FUEL CELL AND CELL PHONE OF WATER AND WASTEWATER TREATMENT

Clint Elston*

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

Conventional wastewater treatment assumes that a co-mingled stream of toilet wastes mixed in with greywater from sinks, showers and the laundry can be eventually separated at the end of the sewer or septic pipe. With the daily reports of water shortages, environmental pollution and contamination from new sources, such as pharmaceuticals, resulting from those traditional methods, in order to solve those problems steps should be taken to separate and treat the pollutants at the source.

Pressure is increasing to introduce pollution reducing, water conserving and recycling measures for sustainable residential and small community water/wastewater systems. Media accounts of inadequate water quality and quantity are being reported daily. Since the terrorist acts to the New York World Trade Center and Pentagon, community water supplies and reserves have become potential targets for bio-terrorism. Systems utilizing blackwater (wastewater from toilets, urinals and garbage disposals) separation and greywater treatment—filtration and disinfection technologies for partial or total reuse—represent a logical and economic option for reducing and eliminating these pressures and improving national security.

With threats of bio-terrorism of our water supplies, present day wars being fought over water related issues, billions of people worldwide without sanitation and clean water, a new sustainable paradigm of “Doing More With Less” offers the most logical, economic and environmental approach for enhancing people’s standard of living while reducing the impact on the water supplies.

KEY TERMS: blackwater/greywater separation & treatment, pollution prevention, water recycling, water conservation, closed-loop/zero discharge

INTRODUCTION

Many communities throughout the U.S. are approaching or surpassing existing sewage treatment plant capacities and are not able to satisfy service demands for new residential and commercial users. Individual states and the federal government cannot provide the trillions of dollars that are required to repair and expand wastewater treatment facilities and infrastructure systems, and the situation is causing economic stagnation in many communities, contributing to as well as contamination of groundwater, lakes and streams. Neither septic systems nor municipal piped water and sewage systems are capable of removing most chemicals from the wastewater stream. Pharmaceuticals, nitrates and other untreated chemicals discharged by sewage treatment plants are damaging the environment all over the world, with effects that include water quality compromises and genetic damage to wildlife.

In many communities sewage treatment system decisions are commonly made in the private sector on the basis of financial considerations. In communities with no centralized facilities, developers typically select the most familiar, affordable and easily-installed on-site systems. Once installed, such systems may not be maintained or inspected unless malfunctions occur, which can result in contamination of ground and surface water.

Unfortunately, outdated state and local regulatory codes discourage the use of new technologies, even those with proven performance, and this results in economic loss as well as inferior waste treatment performance. Even at their best, conventional waste treatment systems cannot meet reasonable performance standards. They do not reduce nutrient pollution or pharmaceutical contamination, they require large volumes of water and substantial land area, and rely on dilution rather than removal, and cannot be sustained indefinitely.

The U.S. operates with an aging infrastructure for both municipal water and sewer systems, which is stressed by population growth and increasing demand. The pressures on wastewater treatment and municipal water resources will place increasing financial pressure on states, cities, businesses and individuals. There is a clear need for new options and process technologies to deliver these important services.

DEBUNKED MYTH

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, has removed only a small part of humanity from the honey

*President, Equaris Corporation, P.O. Box 6, Afton, MN 55001, 651-337-0261 phone, 651-337-0265 fax, mail@equaris.com

bucket and outhouse. According to a 1995 American Housing Survey by the U.S. Census Bureau, approximately one-fourth of the estimated 109 million housing units in this country are served with septic tanks or cesspools receiving and discharging 175 billion gallons of wastewater per year.

Septic tanks or cesspools receive a co-mingled waste stream comprised of greywater 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 (the solution to pollution is dilution) and transporting the wastes to the septic tank and then passing the discharged wastewater through soil, it would reduce health risks associated with human wastes and filter out the pathogens. 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 breakdown of the system). Today, 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 the microorganisms. Current evidence indicates virus contamination (i.e., rotaviruses, hepatitis A and coxsackieviruses) from fecal sources in 20 percent of the groundwaters tested nationwide. One small drop of fecal matter can contain millions of pathogenic (disease-causing) microorganisms. Viruses can move through the septic tank system—from the toilet to adjacent surface water—within 18 hours.

According to one report, repairing water and sewer pipes may cost the United States \$1.6 trillion. Television, newspapers and magazines continue to report on the “drought conditions” that are plaguing one-third of US. At the World Summit on Sustainability, the United Nations, World Bank and certain key professionals stated that 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

During the mid 1980s, while 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 the 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 the traditional septic systems, which frequently freeze and fail because of Alaska's extreme environmental conditions and frigid soils. Over a period of four years, the company developed a miniaturized version of an extended aeration wastewater treatment system, coupled it with the toilet separation system, and received its first patent “Apparatus for Composting Organic Waste Materials and Method” in 1992.

Looking for a solution for reducing nitrate pollution to their ground waters Olmsted County (Rochester, MN) purchased and installed a separation/composting tank, two ultra-ultra low flushing toilets and a greywater treatment system in their new caretaker's residence at the Chesterwoods' County owned park from the company in 1992. In early 1998, Olmsted County Water Resources Center tested and documented the company's separation/composting tank (SCT) and greywater treatment system at a single family residence owned by the county. 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 (grams/capita/day)*

Parameter	Olmsted County <u>Effluent</u>	Typical Raw <u>Greywater</u>	Typical Raw <u>Blackwater</u>	Typical Raw <u>Combined</u>	Calculated <u>Reduction</u>
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%

*EPA 1980

Table 2 illustrates the degree of reduction calculated for TSS, TKN, BOD5 and coliform compared to reported septic tank effluent (in mg/L). While these concentration comparisons may not exactly relate “one to one” to per capita loadings, they do show the same general pattern of nitrogen and organics reduction as described above. Calculated reductions for the Olmsted County site are less when compared to septic tank effluent (Table2) than when compared to raw domestic wastes (Table 1), as would be expected since some settling and removal of nitrogen and organics occurs in septic tanks.

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

Parameter	Olmsted County Effluent*	US EPA 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

** US EPA 1980

*** University of Minnesota, 1994

Based on these monitoring data, the system is calculated to have achieved a 90% reduction in loadings of total nitrogen, BOD and suspended solids to the drainfield compared to primary treated wastewater effluent from a septic tank. Fecal coliform levels are calculated to be up to 1,000-fold less than effluent from conventional septic tank effluent. Measured water use, measured pollutant loadings and the lack of ponding in drainfield trenches are consistent with the original design. The drainfield was reduced in size by 40% simply for the reduction in water usage by utilizing the ultra-ultra low flushing SeaLand toilets.

HOW THE SYSTEMS WORK - A PROCESS SOLUTION

Fortunately, technological advances have been made in separating and treating pollutants at the source that offer great promise for improving wastewater treatment and meet global health and environmental needs.

A new proprietary treatment process, called separation technology wastewater treatment, has the ability to serve as a viable, long-term alternative to on-site and centralized wastewater facilities, for residences and commercial properties.



Complete System Displayed at Manufacturing Facility

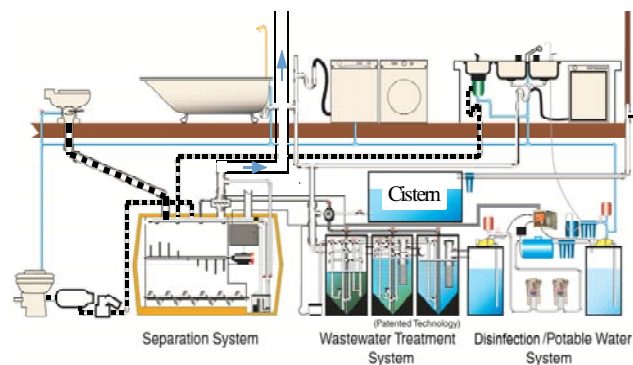


Diagram of Separation Technology

This separation technology combines patented waste treatment systems with ultra-ultra low flush toilets and garbage disposals. Blackwater from these sources is plumbed to a Bio-Matter Resequencing Converter (BMRC), and greywater is treated separately using aerobic biological treatment. Total water recycling is then possible utilizing ozone, ultraviolet, ultrafiltration and reverse osmosis.

Utilizing the principles of decomposition, the BMRC biologically converts 90 to 95% 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 amendment. 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% of viruses and pathogens utilizing time and temperature. Approximately 10 to 15 gallons of finished compost are produced by a family of 4 per year and are 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. The BMRC can handle up to 12 adults full-time and accommodate larger numbers for brief periods.

Utilizing SeaLand Technology's ultra-ultra low flush toilets that consume between a pint and a gallon per flush instead of 1.6 gallons of water per flush reduces overall water consumption by at least 30 to 40%. This would then reduce the amount of water that is required to be pumped, thereby reducing the energy requirements for and extending the life of the water pumping system.



Magnum Opus



Concerto



Traveler

Stylish SeaLand gravity or vacuum (one pint to one gallon of water per flush) porcelain toilet fixtures with a rotating-ball-and-water type of trap are installed and plumbed to the BMRC (composting tank). The toilets utilize a hand or foot pedal-operating flushing mechanism that rotates the ball/trap device. The flushing mechanism can also be lifted, to raise the water level in the toilet bowl for defecation, 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 2-1/2" per foot drop) to transport the toilet refuse and paper to the BMRC. 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 8' vertically and transporting it horizontally up to 100' to the BMRC.

Utilizing the vacuum flushing toilet model allows flexibility in locating the BMRC instead of having to design the house or facility around the system. For existing homes that don't have 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.



Chester Woods Park, MN



Ceramic Bar Style Sink with Garbage Disposal



Healy, AK

Two-thirds of all of the 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. Unlike septic systems, it's highly recommended that a garbage disposal be installed on a small separate sink. If the garbage disposal is installed on the conventional two compartment kitchen sink and the garbage disposal plumbing piping is plumbed to the BMRC and the other sink plumbing is plumbed to the greywater treatment system it would be possible for someone to let water run down the garbage disposal and flood the BMRC. By installing a separate sink

for the garbage disposal and plumbing that sink to the BMRC it helps reduce the problem of flooding. Also instead of installing a traditional faucet, a sprayer is installed which physically needs to be triggered to spray the water. Doing this also eliminates all of the undesirable kitchen organic refuse, reducing the total amount of garbage that's created daily and lowering the costs of rubbish hauling, disposal, landfill space and highway infrastructure repair.

TREATING GREYWATER AND WATER RECYCLING DEVELOPMENT

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 extremely energy-efficient air compressor provides an abundant amount of air to continuously provide oxygen and circulate the wastewater.

Utilizing the standard wastewater treatment technology of extended aeration, the water is aerated and bacteria grow on the interior surface walls of the tanks. The 80 watt, 110 volt linear air compressor aerates the water with 2 air diffusers and circulates it between tanks with 3 air lifts. As water enters the surge tank it is lifted into the clarifier with an airlift. Water then gravity flows into the clarifier where two additional airlifts pump water from the bottom and top of the tank back to the surge tank. The bacteria clean the water in a natural process. By separating the toilet flow from the greywater, the estimate for water consumption and greywater treatment is 40 gallons of wastewater per person per day. The estimated treatment capacity of each greywater treatment system is 500 gallons per day. For flows over 500 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 disposed of in a very small absorption field or filtered and disinfected for reuse.

Armed with the Olmsted County results and sufficient data from previous testing in Alaska in 1999, the company researched 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 Pollutant Discharge Elimination System (NPDES) standards for surface discharge to bodies of water. Realizing that the treated, filtered and disinfected discharged 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 additional filtration, disinfection and membrane equipment to its initial prototype. Testing by the Olmsted County Public Health Service's Environmental Laboratory of the Separation System's "Water Recycling Technology", documented the filtered and disinfected water as being safe quality drinking water.

WATER QUALITY TESTING PERFORMED BY OLMSTED COUNTY, MN

Date Tested	Testing Location	Coliform Bacteria	E.coli Bacteria	Nitrate-nitrogen	Nitrite-nitrogen	Chloride	Sulfate	Fluoride
				in mg/L	in mg/L	in mg/L	in mg/L	in mg/L
9/10/01-6/13/02	Potable Water Tank 1878 Cheater Rd SE Rochester, MN 55904	N.D.	N.D.	0.4-6.1	N.D.-<.3	10 - 39	1.5-29.4	N.D.
Health Impacts Can Occur At These Levels		Present	Present	10	1.0	250	250	4.0

In 2001-2, the company received two additional patents on its newly developed "Waste and Wastewater Treatment and Water Recycling System."

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 an ultraviolet light, carbon filtration, nanofiltration, another ultraviolet light, an ultrafilter and a reverse osmosis membrane. That water is stored in the potable water storage tank, which supplies water to the entire household. The concentrate from the ultrafilter and reverse osmosis membrane is plumbed back into the ozone tank and recycled for further removal of permeate water. When the Total Dissolved Salts (TDS) quality reaches a designated level a solenoid valve opens and the concentrate water is either discharged to a small absorption field or to an evaporation system. Because water used for toilet flushing is evaporated in the BMRC 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 with an alarm light and/or sound device if any of the components are not achieving design parameters.

Separation technology wastewater treatment and "point-of-use reuse" (POUR) applications may be equipped with smart control capabilities so that equipment performance can be monitored remotely via the internet. Such a wire or wireless monitoring infrastructure insures the water and wastewater system's operational effectiveness, helps ensure healthier indoor and outdoor environments, and can be provided in conjunction with other remote services such as fire and security protection.

INSTALLATION EXAMPLES



Robert Redford NRDC, Santa Monica, CA Water Recycling System Two Greywater Treatment Systems in Parallel

A recent greywater treatment and water recycling commercial installation at the Robert Redford Natural Resources Defense Council (NRDC) office building in Santa Monica, CA, has been awarded a platinum rating under the Leadership in Energy and Environmental Design (LEED) Green Building Program, which pronounced this structure the “Greenest Building in the USA”. Documented testing of this installation demonstrates that this separation technology treatment system produces safer and better quality water than that provided by the city of Santa Monica municipal water supply for drinking.

TESTING PERFORMED ON EQUARIS WATER RECYCLING SYSTEM AT ROBERT REDFORD NRDC, SANTA MONICA, CA – JANUARY 2004 – FEBRUARY 2005*

PARAMETER	METHOD	REPORTING LIMIT	RESULT
Total Coliforms	SM 9223B	1	< 1 MPN/100 ml
E. Coli	SM 9223B	1	< 1 MPN/100 ml

*Pat-Chem Laboratories, 11990 Discovery Ct., Moorpark, CA 93021



Building with Separation Systems Greywater Vacuum and Blackwater Systems 3' x 16' Chambered Leachfield

A residential separation technology blackwater/greywater treatment installation (8'W x 8'H x 16' L building attached to the mobile home housing the technologies) with a very small (3' W x 16' L) greywater leachfield serves a family in southern Virginia. This remote location could not accommodate conventional septic treatment because of heavy clay soils. This waste handling approach is a cost-effective alternative and can accommodate a variety of site situations and soil conditions.



Hovland, MN Blackwater, Greywater and Water Recycling Systems Ceramic Vacuum Toilets

In another residential installation, this one at a picturesque and challenging site along the rocky shore of Lake Superior in northern Minnesota, separation technology wastewater treatment makes it possible for the owners of a large year round occupied home to handle human and organic waste and deliver high quality drinking and household water while having minimal impact on the home's pristine north woods environment.

CONCLUSION

In contrast with conventional treatment systems, decentralized separation systems reduce water consumption, protect groundwater resources, eliminate viruses and pathogens, and isolate resources from bio-terrorism threats.

Separation technology is able to substantially reduce nutrient and pharmaceutical pollution. It does not require large water and land area volumes or costly piped infrastructure, does not rely on ineffective and unsustainable dilution, and effectively safeguards ground and surface water resources. Such systems can be sited, sized, designed, installed and operated to exceed federal, state and local water quality requirements, and are suitable for confined lot sizes and in locations with poor soil drainage, underlying bedrock and shallow water tables.

Separation blackwater and greywater treatment combined with water recycling technologies produces high-clarity, mineral-free, biologically clean water suitable for total reuse. This allows the residential or commercial property owner to reduce wastewater pollution by as much as of 99% and overall water consumption by 95% by recycling all household greywater. Tests show that with proper blackwater handling using separation technology, 95% of all organic wastes, pharmaceutical residues and flush water in the waste stream are converted aerobically and biologically to H₂O and CO₂, leaving only a small volume of odorless and biologically neutral byproduct (amounting to 5% of original volume).

Separation technology wastewater treatment offers a logical, effective, economical and environmentally sound approach for improving the standard of living worldwide while reducing consumption and pollution of the world's fresh water supply. Properly managed decentralized separation wastewater treatment is a viable long-term and sustainable alternative to centralized wastewater facilities and septic systems. Separation Technologies coupled with "Point of Use Reuse" (POUR) applications, operating with "Smart" control capabilities for the equipment as well as the building are remotely monitored with individual IP addresses to insure the water and wastewater system's operational effectiveness and at the same time can provide "Smart House" controls and healthier indoor and outdoor environments with optional fire and security protection.

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