Impact of Water Efficient Fixtures on Residential Septic Systems

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After reading this you should be able to:

- **Understand how indoor water use affects your on-site septic system.**
- **Identify water efficient fixtures for use in your home.**
- **Calculate the potential water savings from using efficient fixtures.**
- **Improve septic system operation using indoor water efficient fixtures.**

For most individual homeowners in the United States, the most enticing water conservation benefit is saving money. However, lowering your utility bills is not the only benefit derived from practicing water efficiency indoors. By implementing water efficiency techniques in homes utilizing on-site septic systems, homeowners can avoid costly repairs and potential sewage contamination of their property.

Introduction

Advances in government regulation of subsurface septic system design, construction, and installation has made the technology a sensible alternative for on-site wastewater treatment. In many instances, decentralized septic systems are a better alternative in lieu of conventional sewer systems. For small, rural communities septic systems can be considered more economical and efficient. On-site systems are less environmentally disruptive than installing miles of sewer pipe for transporting wastewater to a treatment plant. Properly functioning septic tanks replenish groundwater and conserve energy that would otherwise be used in the transportation and processing of sewage in a remote centralized treatment plant. In spite of these facts, septic systems have a poor reputation for being undependable, old-fashioned, or a temporary solution until a conventional sewer is available.

Among many misconceptions of septic systems, one serious problem linked to their ownership is infrequent failures of old septic tanks. In isolated cases, malfunction due to poor maintenance and system overloading has been implicated in pollution of groundwater. Yet, with a little education and proper maintenance most septic problems can be averted or old systems can be rehabilitated. In addition to standard operation and maintenance of septic systems, owners can implement inexpensive water efficient products to optimize the effectiveness of wastewater treatment and prevent failures. Ultimately, water efficiency benefits all humankind, both economically and environmentally, and will also help to ensure the sustainability of water resources.

Septic Tank Function

A septic tank is simply the storage component of an underground wastewater disposal system. The tank is a watertight collection container constructed of a durable material resistant to corrosion or decay. The septic tank is the vessel where primary treatment of household wastewater takes place. Primary treatment is the sewage management process of separation and settling of solid waste from wastewater. As a residential septic system is used the accumulated solids in the bottom of the tank is referred to as sludge and the floating material, such as grease and oil, is called scum. The septic tank removes solids by holding wastewater in the tank for at least 24 hours, allowing the solids to settle and scum to rise to the surface of the wastewater. The settling process is measured as retention time and is often enhanced by a series of baffles inside the tank. Proper retention time is critical to achieving the efficient separation of solid material from wastewater. According to the U.S. Environmental Protection Agency (2002), up to 50 percent of the solids retained in the tank will decompose over time while the remainder accumulates on the bottom of the tank. Tank effluent water, now mostly clarified, is discharged to perforated drain pipes. After it drains from the series of pipes the effluent water infiltrates through the subsurface soil of the constructed absorption or "leach" field. As the water is treated through soil processes, it eventually percolates through the subsoil to groundwater.

Septic Tank Capacity

Septic tank capacity is related to the hydraulic loading rate of the subsurface wastewater infiltration system, e.g. drain field. Site specific factors such as soil percolation, groundwater characteristics, and wastewater quality affect tank design capacity (EPA, 2002). Additional factors in sizing a septic tank include the rate at which wastewater is produced, organic composition of waste, and retention time. As the final septic system stage for wastewater treatment, the soil infiltration rate determines the loading capacity of the system. During normal septic tank operation, for every drop of wastewater introduced to the tank a drop of effluent water is discharged for infiltration. As the septic tank capacity is filling up with sludge less room is available for influent liquid and the retention rate decreases.

A typical method for maintaining the required retention time is to periodically pump out sludge from the tank. Properly designed tanks typically allow for 3 - 5 years of safe accumulation before the need for pumping (EPA, 2002). Once the sludge has reached this level, the separation of solids and scum is no longer effective, and sewage may overflow into the infiltration system. As sewage overflows, organic matter flowing out of the tank will clog the perforated pipes. Clogged pipes will lead to wastewater backup in the tank and eventually overflow saturating the subsoil. Saturated septic systems can lead to wastewater pooling above ground or sewage backup into the home.

Septic Tank Operation and Maintenance

A septic system is doomed to fail if the tank is not initially designed to manage the flow of wastewater for proper primary treatment. During the course of operation, as sludge builds up the retention time of the wastewater must be preserved to avoid system failure.

Wastewater composition determines flow and sludge accumulation rate which, in turn, affects retention time. In properly operating tanks, the wastewater flow will not exceed the hydraulic loading rate of the system allowing for solids to properly settle. Occupant influence on wastewater composition and flow directly impacts retention time and effluent clarification. Therefore, septic tank efficiency is directly dependant on the following factors:

- Occupant water use behaviors
- Flow of wastewater through the tank
- Internal capacity of septic tank
- Volume of solids in wastewater

Septic tank efficiency depends on the retention time parameters of wastewater flow and volume of solids. The wastewater flow is determined by the type and frequency of household water use activities. For example, repetitive occupant activities like toilet flushing often require more water to dispose of solids whereby increasing wastewater flow. The volume of solids in wastewater is directly dependant on the materials occupants dispose of down the drain. Occupant behaviors such as using an in-sink garbage disposal or flushing objects other than human waste in toilets increases the volume of accumulated solids in the septic tank.

To maintain internal septic tank capacity conducive to primary treatment, solids eventually have to be removed from the tank. Many septic tank owners pay for commercial contractors to regularly pump out their sludge to ensure continued tank performance. Some septic system users indiscriminately dispose of solid waste down the drain and periodically pump on a regular schedule regardless of the accumulated sludge level. The actual frequency for when you should pump out your septic tank can be variable according to system design, number of occupants, and waste generation habits. For most users, sludge pumping is relied upon to be the only means of maintenance. While pumping is a required maintenance activity, it is not the only approach to ensuring proper retention time in your septic tank.

Since sludge pumping is the responsibility of the owner and is a continual maintenance cost, many septic system owners avoid or prolong the need to pump out sludge. Other owners ignorantly believe they can avoid pumping by using septic tank additives. Biological and chemical septic tank additives are unnecessary and do not eliminate the need for pumping. In fact, septic system owners should avoid septic tank additives such as yeasts, bacteria, enzymes, and chemicals (EPA, 2010). These additives are sold with the claim of helping septic systems work better; however, there is no scientific evidence that additives are effective. In fact, some cleaners allow the solids in an overloaded tank to be re-suspended and clog the drainage lines. Additives are not an alternative to proper maintenance and do not eliminate the need for routine pumping of a septic tank. Commercial biological additives are not even necessary for restarting decomposition after pumping because sludge residues contain active microorganisms.

Both sludge accumulation and wastewater flow can be greatly influenced by employing simple septic tank operation techniques. Limiting the amount of solid waste to only human excrement and septic safe tissue paper can decrease sludge accumulation. Individual practices such as refraining from flushing a toilet when only urinating or not running the faucet during tooth brushing are effective for conserving water. However, these personal efforts depend on a conscientious consumer continually moderating their water usage. Although most of the public are not inclined to actively regulate their own water use, such efforts will promote more efficient septic system operation. If one considers the hierarchy of controls for mitigation of water overuse, an engineering intervention is the most desirable solution. Administrative controls like tracking usage and ensuring timely maintenance, while more desirable than personal behavior modification, is still not as effective as installation of an engineered remedy such as water efficient fixtures.

Although sludge pumping is the primary practice used to maintain appropriate retention capacity, water efficiency fixtures can seamlessly be integrated to moderate wastewater flow. Whereas solids generation is moderated by exercising personal operating precautions, the amount of water generated by indoor activities can be significantly reduced with simple, self-limiting devices. More efficient indoor water use tempers flow, significantly improving septic tank operation. Passive water conserving fixtures save money on utility bills while ensuring proper septic system function.

Importance of Water Efficiency

Some of the universal benefits for using water efficiently include:

- Conservation of fresh water supplies for future generations.
- Protection and preservation of our economic future and human health.
- Water conserving products and services offer equivalent or superior performance.
- Water efficient products conserve energy saving money on utility bills.
- Reduction in energy and chemicals used for treating water, protecting our natural resources and the environment.

On an individual level, practicing water efficiency indoors creates lasting benefits for septic system owners. One can determine the benefits derived from water efficiency by knowing their current water usage rates. With historical records, such as home water metering, data pertaining to water usage rates can be more readily acquired than wastewater generation rates (Mihelcic et al., 2009). Since only negligible amounts of indoor supply water are actually consumed by residents, the wastewater generation rate can be approximated to equal the water usage rate. For the purposes of this brief, wastewater flow to the septic system is equal to water usage rates. Usage rates are important to septic system suitability because as more water is used in the home, the same amount of wastewater is introduced to the septic tank and an equal amount of effluent water is discharged to the drain field. This concept demonstrates the importance of water efficiency with regards to the performance of interrelated components in septic systems.

Water Efficient Fixtures

According to the Alliance for Water Efficiency (2008), the following list describes four techniques and related examples for implementing water efficiency:

- Improved indoor water use: high efficiency toilets (or HET), clothes washers, dishwashers, showerheads, and faucet aerators.
- Improved outdoor water use: smart irrigation controllers, improved irrigation equipment, and real-time irrigation efficiency monitoring.
- Commercial/industrial/institutional water use efficiencies: cooling tower retrofits, plumbing fixture replacement, and process water improvements.
- Water utility efficiency improvements: system leak detection and control, energy efficiency audits, and water rate reform.

For the purpose of this brief, the techniques most relative to septic system functioning is indoor water use improvements. Yet, as plainly seen in each suggested method for improving water efficiency is the installation of water efficient fixtures. Whereas some of the improvements require time consuming system reengineering, monitoring, or process reform the replacing of home fixtures is quick and easy. Installation of water efficient fixtures immediately improves septic tank operation by actively minimizing wastewater generation. With less wastewater flowing into the septic tank, retention time is maximized whereby optimizing primary treatment. Water efficient fixtures work continuously to enhance the primary treatment goal of settling solids which improves effluent clarity.

According to the EPA (2010), water use from toilets, showers, and faucets accounts for over 60 percent of the daily indoor water used in a typical U.S. household. Analysis of water usage amounts by indoor fixtures shows toilets are by far the largest users of water in the home at nearly 30 percent of the total water used daily. At 17 and 15 percent, respectively, showers and faucets are the fixtures with the next highest rate of daily water use in a typical home. The following table lists the water usage for typical U.S. households and those designed for water efficiency:

Table 1. End Water Usage in U.S. Households: Typical and Efficient Alternatives

	Water Usage in Gallons per Capita per Day (GCD)	
Activity	**Conventional Homes**	**Water Efficient Homes**
Showers	11.6	8.8
Clothes washing	15.0	10.0
Dishwashing	1.0	0.7
Toilets	18.5	8.2
Baths	1.2	1.2
Leaks	9.5	4.0
Faucets	10.9	10.8
Other domestic uses	1.6	1.6
Total Water Used	69.3	45.3

Adapted from: Mihelcic et al. (2009)

From Table 1 water usage values, we can estimate the total volume of wastewater generated using conventional fixtures compared to the volume generated from more water efficient ones. The following example calculations demonstrate the potential water gallons saved when installing common water efficient fixtures (toilets, faucets, and showerheads) in a four bedroom home with two and one-half bathrooms, kitchen sink, and 4 family members.

Calculations for Conventional Fixtures:

Toilet Use:	18.5 gallons X 3 toilets X 4 people =	222 gallons per day
Faucet Use:	10.9 gallons X 4 sinks X 4 people =	174.4 gallons per day
Shower Use:	11.6 gallons X 2 showers X 4 people =	92.8 gallons per day
	Total Water Used:	466 gallons per day

Calculations for Efficient Fixtures:

Toilets Use:	8.2 gallons X 3 toilets X 4 people =	98.4 gallons per day
Faucets Use:	10.8 gallons X 4 sinks X 4 people =	172.8 gallons per day
Showers Use:	8.8 gallons X 2 showers X 4 people =	70.4 gallons per day
	Total Water Used:	341.6 gallons per day

Typical Water Use – Efficient Use = 466 – 341.6 = **124.4 Gallons Saved per Day**

Percentage Saved: 124.4/466 = 0.266 (or) **27%**

These simple calculations illustrate a potential water savings of more than 124 gallons per day. The amount of water used daily is about 27% less by installing water efficient fixtures. As this comparison demonstrates, the amount of water introduced into the septic tank can be reduced significantly by just replacing conventional fixtures with water efficient ones.

Identifying Water Efficient Fixtures

Research has shown that using water-efficient products and practices will reduce water consumption and save money. In order to realize these savings, consumers must be able to identify products that use less water while performing as well as conventional models. Plumbing and building codes play an important role in governing water efficient products. Codes are mandatory regulations promulgated by various authorities and adopted by jurisdictions in order to protect the health and safety of the citizens. Plumbing standards are consensus guidelines which play an important role in advancing water efficiency in household fixtures. Codes and standards for plumbing fixtures are important to developing water efficient homes which assure water savings and effective septic system operation.

The National Energy Policy Act passed by Congress in 1992 adopted maximum flow standards for showerheads, faucets, urinals, and toilets. With those standards, manufacturing of large volume water fixtures like 3.5 to 7 gallon-per-flush toilets and 4-

12 gallon-per-minute showerheads was phased out. As illustrated by the calculations performed, the efficient water fixtures developed in response to the Act enabled the average household to reduce its per-capita indoor water use from about 70 gallons per day to less than 50. While the 1992 plumbing standards represented a tremendous improvement, there are many new technologies available today that allow homeowners and builders to save even more water without sacrificing performance. Due to modern concerns for water scarcity and energy expenses, the demand for water efficiency is gaining in popularity for citizens and water suppliers alike. Local water utilities are increasingly becoming involved in standard setting, but overall the water efficiency community needs a better understanding of standards if they are to improve water efficiency in affected fixtures

In today's water fixture market, the EPA has created a program to enable the average consumer to more easily practice water conservation. The EPA's national WaterSense program is intended to make water efficient products, those compliant with current standards, more accessible for the typical U.S. homeowner. The program makes approved water efficient fixtures identifiable with a label backed by independent testing and certification (see Figure 1). According to the EPA (2010), products bearing the WaterSense label are intended to:

- Perform as well or better than their less efficient equivalent.
- Be about 20 percent more water-efficient than average products.
- Provide measurable water savings results.
- Achieve water efficiency through several technology options.
- Be effectively differentiated by the WaterSense label.
- Be independently certified.

In order to be considered for the WaterSense label, products must meet criteria in the WaterSense specifications for water efficiency and performance. For companies to use the label, they must sign a WaterSense partnership agreement. The partnership agreement defines the roles and responsibilities of EPA and the participating organization, as well as proper use of the label on products, packaging, and in marketing and other promotional materials. In the following sections WaterSense products available for home installation which, in turn, can improve septic system operation are discussed.

Figure 1. Example of EPA WaterSense Label

High-Efficiency Toilets (HET)

Toilets are by far the main source of water use in the home, accounting for nearly 30 percent of an average home's indoor water consumption. Older toilets are much less efficient than modern ones and often waste large amounts of water. The 1992 plumbing standards established a toilet water use rate of 1.6 gallon (6-liter) per-flush. Recent advancements have allowed toilets to use 20 percent less water than the federal standard, while still providing equal or superior performance. The WaterSense program mandates HET use only 1.28 gallons per flush (EPA, 2010). Unlike some first-generation, "low-flow" toilets, WaterSense labeled toilets combine high efficiency with high performance. Design advances enable WaterSense labeled toilets to save water with no trade-off in flushing power. In fact, many perform better than standard toilets in consumer testing. The EPA estimates that if a family of four replaces its home's older toilets with WaterSense labeled models, on average, they can save more than $90 per year in reduced water utility bills, and $2,000 over the lifetime of the toilets (2010). WaterSense labeled HET are available at a range of pricing and a variety of styles.

Water Efficient Sink Faucets

Faucets account for more than 15 percent of indoor household water use; more than 1 trillion gallons of water across the United States each year (EPA, 2010). WaterSense labeled faucets and faucet accessories (such as aerators) help home owners reduce faucet water flow by 30 percent or more without sacrificing performance. By installing WaterSense labeled bathroom sink faucets or faucet accessories, an average household can save more than 500 gallons each year (EPA, 2010). Achieving these savings can be as easy as twisting on a WaterSense labeled aerator, which cost just a few dollars. Other options for increasing the water efficiency of bathroom sink faucets include installing a high-efficiency WaterSense labeled laminar flow or spray device.

Water Efficient Showerheads

Showering is one of the leading ways of use water in the home, accounting for nearly 17 percent of residential indoor water use. The average household could save more than 2,300 gallons per year by installing WaterSense labeled showerheads (EPA, 2010). WaterSense showerheads use 20% less water than the current standard of 2.5 gallons per minute (gpm). Although these showerheads only use 2.0 gpm, the WaterSense label ensures these products provide a satisfactory shower experience equal to or better than conventional showerheads.

Conclusion

A cost effective and sustainable method to reduce wastewater flow is by installing water efficient fixtures. Not only can water efficiency conserve resources and save money, it will promote efficient septic system operation. By maintaining a nominal wastewater generation rate a septic tanks functioning can be enhanced. Too much water introduced to the septic tank from the home may not allow enough time to separate out the organic matter from liquids, causing solids to pass out of the tank and into the drain field,

eventually clogging the pipes. Using less water indoors will increase retention time promoting the efficient decomposition and settling of solids in the bottom of the septic tank. Modern advances in plumbing standards and demand for water conservation have led to economical, yet high performance, water efficient fixtures. Homeowners can easily identify and acquire cost effective, water efficient fixtures that save considerable amounts of money on utility bills compared to conventional products. While the installation of inexpensive water efficient fixtures takes minimal effort it can result in 30% less flow of wastewater into your septic system. Reducing the amount of wastewater entering your septic system may increase its life span, as excessive water is a major cause of system failure. Water efficiency is a benefit for all mankind ensuring the sustainability of the world's water supply.

Further Reading

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Contact

This document was prepared for one of the following two classes at the University of South Florida (Tampa): CGN6933 "Sustainable Development Engineering: Water, Sanitation, Indoor Air, Health" and PHC6301 "Water Pollution and Treatment". Please contact the instructor, James R. Mihelcic (Department of Civil & Environmental Engineering) for further information (jm41(at)eng.usf.edu. (learn more about our mission and development education and research programs at: www.cee.usf.edu/peacecorps).