

Homeowners' Knowledge and Responsibilities of Residential Wastewater Treatment Systems in Rural Texas

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This research study evaluated residential homeowner knowledge of different types of common rural residential wastewater treatment systems, their operational requirements and restrictions, maintenance errors, and the resulting outcomes of improperly operating systems. Nearly 25% of all homes in the United States use an onsite septic system for wastewater treatment. Successful onsite wastewater treatment is the result of proper maintenance of a correctly installed septic system designed for the site. Failure rates have been estimated up to 20%. Homeowners in a rural Texas subdivision in Parker County were surveyed and the results were analyzed to form conclusions that may be helpful in improving septic system operation and maintenance. The following themes were studied through the results of a 10-question web-based survey: (1) What do you know about your septic system? (2) Do you maintain it correctly? and (3) Do you know the consequences of system failure? Water quality was sampled at three locations downstream of the septic systems of the surveyed homeowners. The results of the water quality surveys were evaluated considering the knowledge demonstrated by the homeowners in the survey.

Keywords: Maintenance, Rural, Septic System, Wastewater, Water Quality

Introduction

Nearly one in four households in the United States use a septic system to dispose of their wastewater and up to 20 percent of these systems fail each year (EPA, 2014). When a septic system is operating correctly, wastewater is treated and discharged so that disease transmission is minimized, there are no unpleasant nuisances (i.e. strong odors), and it does not harm the environment. Prior to the advent of modern wastewater treatment, sewage was discharged into underground wells, streams, or rivers. This method of disposal frequently contaminated the water supply, and people were regularly sickened from drinking polluted water. Entire ecosystems were harmed and some valuable aquatic resources were permanently destroyed.

Water resources need to be managed so that they are efficiently used, returned to nature, and reused. About 40% of U.S. residents rely on groundwater as a source for drinking water. Groundwater is vulnerable to contamination from infiltration of septic system effluent. In areas with a prevalence of septic systems, aquifers are frequently contaminated with nitrates (Oakley, Gold, & Oczkowski, 2010) antibiotics, surfactants, hormones, and other endocrine disrupting compounds (Schaider, 2014). The high volume of wastewater discharging from individual septic systems contributes to non-point source pollution of rivers, groundwater, and the oceans (Rosario, 2014).

Research Objective

The objective of this study was to explore homeowner awareness of common types of septic systems, their methods of operation and limitations, and the results of improperly operating systems. The study focused their onsite residential systems and determined if the operation of a large number of septic systems within a subdivision would have an adverse impact on nearby aquatic resources. The answers to these questions may influence the way homeowners are trained to use and maintain onsite septic systems:

- What do homeowners know about their septic systems?
- How do they operate and maintain them?
- Is there evidence of impact to water quality as a result of onsite septic system usage?

Millions of homeowners rely on onsite septic systems to treat their wastewater because they do not have access to large scale municipal wastewater treatment facilities. Most homeowners who buy a home with a septic system receive little to no training on how the system works. People who are first time owners of septic systems often ignore them until something goes terribly wrong and sewage backs up into their home.

However, for months before major septic system failure, there are adverse impacts to neighbors and the environment. Regulating authorizes have emplaced a wide range of rules for installation, inspection, and maintenance of septic systems. However, up to 20 percent of all septic systems are failing to operate as designed and the price of system malfunction is costly on many fronts. An important question for all regulating agencies continues to be, "What additional efforts could reduce the number of failing residential onsite septic systems?"

Background

Before a home can be constructed, a Professional Engineer or Registered Sanitarian must complete a soil analysis and design a septic system based on the square footage of the home, number of bedrooms, soil analysis, and site evaluation. Once the system design is approved by the county, they will provide a building and septic permit. A septic permit is required to obtain a building permit in areas without municipal wastewater treatment systems (Texas On-Site Wastewater Association, 2013).

Types of Septic Systems

There are many types of septic systems; however, the most common types of septic systems are anaerobic and aerobic. Aerobic systems are more complex than anaerobic systems, cost more to maintain (motors and pumps require electricity), and require more maintenance; however, they are the best option for wastewater treatment in areas with clay or rocky soils. All of the septic systems in our subdivision are aerobic, and none are anaerobic due to the prevalence of clay and rocky soils within the area.

An aerobic system consists of a pre-treatment tank, aerobic treatment unit, chlorinator, and pump tank. Sludge is captured in the pre-treatment tank. Wastewater then enters an aerobic chamber where air is compressed and forced into the wastewater to increase the growth of beneficial bacteria to consume dissolved solids in the water. Next, the treated water moves to a pumping chamber where it is treated with unstabilized chlorine tablets. The chlorine tablets are very reactive and will kill 99% of the bacteria present in the effluent within 10 minutes. A float valve within the pump chamber signals the pump to discharge the water to absorption field. The treated water is piped to the field and dispersed through sprinklers (Pipeline, 1996).

The system is designed with an alarm and control box to ensure that it is functioning properly at all times. Aerobic systems require electricity for the alarm, control box, aerator, and pump. Typically aerobic systems cost more than conventional anaerobic septic systems to install and maintain, however they work well with most soil types. Aerobic systems demonstrate an overall performance advantage over conventional anaerobic systems (Kassab, et al., 2010) because the wastewater effluent is much cleaner than that of an anaerobic system (Tarrant County, 2014).

Regulations, Inspections, and Maintenance

The Environmental Protection Agency (EPA) regulates these systems under the Clean Water Act, National Pollutant Discharge Elimination System (NPDES), however, States and Tribes are largely responsible for regulating individual onsite septic systems (TCEQ, 2014). Most States require maintenance contracts for residential septic systems, but there is a wide variance in the frequency inspections. For example, the State of Maryland requires annual septic system inspections, but the State of Wisconsin requires inspections every three years. The State of Massachusetts requires an inspection within two years prior to sale of a property or within six months after the sale of a property (Cary, 2013). States can delegate the authority to regulate septic systems to the local governments (Tarrant County, 2014). Some regulating authorities are proactive and contact homeowners of registered septic systems to increase compliance with maintenance requirements. For example, one city sends a postcard reminder to homeowners with a list of septic system sludge pumping companies (Laur, 2013).

Regulations created and enforced by the Texas Commission on Environmental Quality (TCEQ) require regular inspection and maintenance of permitted onsite septic systems. The maintenance provider must evaluate the system three times per year. According to a telephone conversation with a TCEQ representative, who is a part of the Onsite Septic System team, regulatory requirements for maintenance inspections have resulted in overall improvements to the operation and maintenance of septic systems (J. McCaine, personal communication, 15 July 2014).

In Texas, in-depth septic system courses are offered as training for professionals responsible for septic system installation and inspections. It takes specialized training to identify the cause of system malfunctions and the State's requirement for inspections aims to prevent system failure. Recent regulatory changes in Texas allow homeowners to become their own maintenance service provider by completing required training and obtaining the certification from the State (Septic Solutions of Texas, 2014). Each local regulating authority has the option to allow or disallow this method of maintenance and inspection. According to the Weatherford Democrat, Parker County homeowners can choose to do septic system inspections and maintenance themselves, provided they complete the 16 hour Basic Maintenance Provider Training Course through the Texas Onsite Wastewater Association (Weatherford Democrat, 2011).

Even with regular maintenance, septic systems generally have a lifespan of 15-20 years before replacement is required (TCEQ, 2014). In some cases, residential homeowners lack even basic knowledge about the type of system installed at their home, and without professional inspections, use it improperly and perform little to no maintenance on the system. The homeowner is responsible for ensuring the following maintenance is accomplished:

- Regular addition of chlorine in aerobic systems (monthly);
- Replacement of non-functioning sprinkler heads or drip lines;
- Repairing broken pipes;
- Cleaning the filter on the aerator (twice per year);
- Cleaning the filter on the effluent pump (once per year);
- Pumping accumulated sludge (every 3-5 years); and
- Replacing pumps (every 6-10 years) (Helton-Ingram Septic Systems, 2014).

Common Causes of System Failure

Homeowners usually become aware of system malfunction because of disagreeable sewage odors from the effluent spray. The odor is caused by decomposition of organic matter in the effluent pump chamber. Decomposition of organic matter should take place in the sludge chamber (where gasses can be vented) or the aerobic chamber (decomposition occurs without production of odiferous gas). General causes of system failure include: hydraulic overloading, rapid accumulation of organic material and solids, use of antibacterial chemicals, and poor maintenance (Ready, 2008).

Hydraulic overloading occurs when too much water enters the septic system at one time. Common overloads can be caused by washing several loads of laundry in a short period; running several showers or baths back-to-back; or there are leaks within the plumbing system. This can clog piping, dilute the beneficial bacteria in the septic tank, cause contamination in the leach field, create strong sewage odors, spread disease, create insect breeding grounds, and harm wildlife. Being conservative with water and properly maintaining plumbing and fixtures can prevent hydraulic overloading.

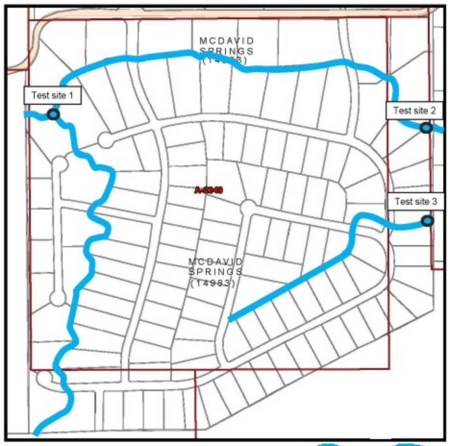
Accumulation of organic material and solids can occur when too much waste or grease flows into the septic tank. A system is organically overloaded when there is more organic material than the microorganisms can treat and digest. This results in a quick buildup of solids and the need for more frequent and costly maintenance. Use of a kitchen garbage disposal can significantly increase the amount of organic loading and may reduce the pump intervals by 1 to 2 years (Texas A&M Agrilife Extension, 2014). Any materials that cannot be decomposed by the bacteria or enzymes in the septic tank should never enter the system.

Caustic chemicals and excessive use of anti-bacterial cleaning products can cause the healthy biological processes in the tank to fail. Bacteria are very small single cell organisms found throughout our environment. Most bacteria can decompose organic materials and receive nourishment in the process. Such bacteria “eat” decaying matter and are critical in the breakdown of organic matter. Septic systems optimize this ability of bacteria by creating ideal conditions for their growth. After solids are removed from the wastewater, it is moved into the aeration tank where oxygen is introduced and bacteria growth flourishes. The bacteria remove the majority of the organic material in the wastewater (Missouri Department of Natural Resources, 2014). Moderate amounts of household cleansers and detergents should not harm the overall balance of beneficial bacteria in the system; however, commonly used harsh chemical de-cloggers should not be used in conjunction with a septic system. Solvents, pesticides, herbicides, motor oil, antifreeze, and paint must be disposed of at an appropriate waste collection facility because they will significantly harm the function of the septic system (TCEQ, 2014).

Many people take daily medications, and some of those (antibiotics or chemotherapy) are not completely metabolized and will pass through the digestive tract. In some cases, they will harm the bacteria in the septic tank (University of Minnesota, 2014). Water softener brine discharges change the consistency and chemistry of the wastewater stream in ways that pose a problem for onsite treatment systems and the dispersal field. Water softener brine contains a high concentration of chloride salt, which can prevent the needed stratification (scum, liquid, and sludge) in the tank (Gross and Bounds, 2007).

Research Methodology

The need for wastewater treatment crosses all economic and social boundaries. In order to study the knowledge of homeowners, their methods of operation and maintenance, and resulting impacts to aquatic resources, a survey and water quality tests of downstream waters were conducted. The study area is within an approximately 200-acre, 125 parcel subdivision located in Aledo, Texas (Figure 1). All of the homes have been constructed in the last five years and have an onsite aerobic septic system with spray dispersion. The survey was open for five days. Downstream water quality was tested to determine if there is evidence that operation of a large number of septic systems has had a negative effect on water quality. Water samples were tested for fecal coliform, dissolved oxygen (DO), DO saturation, nitrate, phosphate, temperature, pH, and turbidity. Tests were completed with a commercially available water quality test kit.



Legend: Stream Channel

Figure 1: Map of Water Quality Test Sites within the McDavid Springs Subdivision, Aledo, Texas

Homes cover between 3,000 – 5,500 square feet and many residents are first time septic system owners. Septic systems were professionally installed and were covered by a warranty from the installer for two years. The systems were included in the construction of each home and little information was provided to the home buyers about operation and maintenance requirements for the septic system. The wastewater effluent from the onsite septic systems either evaporates or flows into one of three streams that cross through the neighborhood. Soils in the subdivision are generally shallow clays, although in some areas, there is minimal topsoil and the underlying Walnut Formation bedrock is exposed at the surface.

There are numerous water springs within the subdivision. As a result of spring and effluent flows, two of the streams in the subdivision typically flow year-round. The streams support aquatic life including fat head minnow, sunfish, frogs, snakes, and crayfish. The streams flow to the Clear Fork of the Trinity River, which flows to the Gulf of Mexico.

Data Analysis

Homeowner System Knowledge

Approximately 30% of the 125 occupied homes completed an online survey related to their knowledge and operation of their septic systems. Homeowner knowledge was evaluated with four survey questions, as shown in Table 1:

Q #	Question	Responses		
1	What type of septic system is installed at your house?	Aerobic Septic System	Anaerobic Septic System	I don't know
		81.82%	6.06%	12.12%
2	Do you know how your septic system works?	Yes	No	
		69.70%	30.30%	
7	The State of Texas regulates septic tanks. Do you know how that applies to you?	Yes	No	
		24.24%	75.76%	
10	What are the potential results of a poorly operating septic system? Select the option that is most likely to occur.	Stream Contamination	Groundwater Contamination	Sewage Odors
		45.45%	30.30%	24.24%

Table 1: Homeowner System Knowledge

Based on analysis of the survey results, it is evident that a large percentage of homeowners do not have basic knowledge of their septic system and do not understand how the State of Texas regulates their system. Over 18% of those surveyed did not know, or misidentified their type of septic system.

Thirty percent of respondents acknowledged that they do not understand how their septic system works. Homeowners are aware (more than 75%) that a poorly operating septic systems would result in environmental contamination (stream or groundwater contamination). Lack of knowledge is a major barrier to correct system operation and maintenance, and can result in system malfunction and failure. In the majority of cases in the McDavid Springs subdivision, the home builder or developer contracted with a septic contractor for installation. The homeowners had little to no interaction with the septic contractor during or after installation. After occupancy homeowners would receive periodic inspection notes from the septic contractor. Most homeowners received did not receive any information about how to operate or maintain their septic system.

Homeowner Operation and Maintenance

Homeowner system operation and maintenance activities were evaluated with six survey questions:

Q #	Question	Responses		
3	How often do you use antibacterial or disinfecting soaps or spray cleaners in your household?	Everyday 48.42%	Sometimes 48.48%	Never 9.09%
4	Do you use your garbage disposal?	Everyday 40.63%	Sometimes 56.25%	Never 3.13%
5	Do you flush or pour medicine or prescription medication into the sink?	Yes 0.00%	No 100.00%	
6	Do you (or a septic service) put chlorine into your septic tank?	Often 63.94%	Sometimes 15.15%	Never 21.21%
8	I have been negatively affected by someone else's septic tank (spray, odor, etc.).	Yes 27.27%	No 72.73%	
9	Have you had any problems with your septic system that required repairs or non-routine maintenance?	Yes 27.27%	No 72.73%	

Table 2: System Operation and Maintenance

About 70% of homeowners state that they understand their system and how it operates. Yet the results of the survey questions about system operation and maintenance show that almost 90% of system users have regular behaviors that interfere with successful operation overloading the system with solids and using harsh chemicals. On a positive note, none of the respondents dispose of medication into their septic system.

Twenty-six percent of users either inconsistently or never put chlorine tablets into their septic tank chlorinator. In cases were wastewater effluent is not treated with chlorine, there is the strong likelihood that the spray is contaminated with bacteria and viruses. Similarly, 27% of those surveyed state that they have been negatively affected by someone else's septic tank system.

Another 27% had system problems that required repairs or non-routine maintenance. Septic system maintenance and repairs can be extraordinarily costly. In extreme cases, entire septic systems need to be replaced due to poor maintenance, which can cost between $15 – 20,000. Without some form of training, it is inevitable that homeowners will produce septic inflows that will harm the septic system. Homeowners who are adjusted to large scale municipal wastewater treatment have no awareness of the limits to their routine behaviors when using a septic system. Homeowners typically begin to perform their own research into septic system operations, after paying for non-routine maintenance (early pumping) or repairs (broken pumps, filters, piping, or sprinklers.

Water Quality

Downstream water quality was tested at three locations (Figure 1), and the results are shown in Table 3:

Test Site	Fecal Coliform (Yes/No)	Dissolved Oxygen (ppm)	DO Saturation (%)	Nitrate (ppm)	Phosphate (ppm)	Temperature (Celsius)	pH	Turbidity (JTU)
1	Yes	4	53	5	2	32^0	7.5	40
2	Yes	4	53	5	1.5	32^0	7.5	0
3	Yes	4	53	20	2.5	37^0	7.5	40

Table 3: Water Quality Testing Results

Test sites were selected to pinpoint potential areas of contamination within the subdivision based on the topography. All wastewater effluent either evaporates, seeps into the groundwater table, or flows into the streams identified on Figure 1. Water was sampled on 5 July 2014 and tested with a commercially available water quality test kit for the parameters identified in Table 3. Test site one is at the confluence of an unnamed intermittent stream and Turkey Creek. Test site 2 is at the downstream end of Turkey Creek before it exits the subdivision. Test site 3 is at the downstream end of an unnamed ephemeral stream that originates within the subdivision, within an on-channel stormwater detention basin.

All samples tested positive for fecal coliform bacteria, based on a fermentation tube testing technique. This bacterium originates in the intestines of warm-blooded animals. Generally, the presence of fecal coliform in an aquatic environment indicates that the water has been contaminated with fecal material from humans or other animals. It can be used as an indicator for other pathogens that may be present in sewage (Bartram & Pedley, 1996). Contamination of groundwater from sewage overflows or septic system inundation by floodwaters can cause cholera and salmonella (McKenzie-Mohr & Associates, 2014).

Samples from Test Site 3 were positive for nitrate and phosphate and the temperature of the water was very warm. Most sources of excess nitrates and phosphates come from human activity and in residential areas can usually be traced to fertilizers and human wastes. Large quantities of phosphates in stream and ponds will accelerate algae and plant growth and will deplete the water body of oxygen (eutrophication). This can lead to the degradation of habitat and fish kills. Eutrophication is responsible for 50% of impaired lake area and 60% of impaired river area in the United States (McKenzie-Mohr & Associates, 2014).

Conclusions

The results of this study show that many homeowners within the McDavid Springs subdivision in Aledo, Texas, do not understand how their individual onsite septic systems work and as a result, they do not operate and maintain them correctly. Generally, improvements in onsite septic system function would result from:

- Owner Training: Mandatory operation training for owners of a licensed system within 3 months of a real estate action that includes the purchase of a septic system;
- Professional Chlorination: Regulation of aerobic system chlorination by mandating system maintenance by a licensed professional, instead of simply requiring regular inspections and allowing homeowner chlorination; and
- Increased Frequency and More Detailed Inspections: Influent, effluent, and the soil within the dispersion area should be tested at least quarterly by a trained professional to confirm that the system is not causing harm.

Some permitting authorities in Texas have adopted stringent requirements, which require homeowner training or even prohibit homeowner maintenance (TCEQ, 2014). After review of numerous websites and available training from many regulating or permitting authorities, the Parker County, Texas, website was found to be among those with the least amount of information for homeowners. The County offers no training or instructions for system maintenance by homeowners (Parker County, 2014).

It is recommended that the State of Texas apply the most stringent requirements across all local permitting authorities, to gain consistency across the State and minimize adverse impacts of poor wastewater treatment across entire watersheds. All homeowners with a septic tank should be required to complete basic training that covers system functions and impacts of routine household activities that could negatively affect the system. Currently, the State allows homeowner maintenance two years after installation with no requirement for training. Homeowners are allowed to even perform their own septic tank system inspections, although completion of an educational course is required.

In the State of Texas, septic system inspections are required three times per year. These inspections include examination of the following: intake filter on air compressor, bio-filter in clarifier, effluent filter (drip systems), pH level in pump tank, chlorine residual, sludge level, control box, water pump and distribution system, alarm systems, timer, and tank lids. The Inspector must send a copy of the report to the TCEQ and provide a summary for the homeowner.

Future Research

There is a lack of rigorous research on the barriers and benefits to the proper maintenance of septic systems (McKenzie-Mohr & Associates, 2014). This research could be used to develop wastewater treatment systems that would be less affected by normal homeowner operation errors. Ideally, systems would be designed so that they were less sensitive and could successfully operate with a wider range of inflow variables.

These complex systems can be imbalanced by regular household activities. There should be more study on the cumulative impact of many malfunctioning systems. This study could be used in areas with clay or rocky soils, with a prevalence of aerobic septic systems. These regions may require greater study of water quality and focused enforcement by the regulating authority to ensure quality effluent discharges. In cases where negative impacts cannot be corrected, then the state should require installation of municipal wastewater treatment systems. Areas with the highest performing wastewater systems should be studied to determine the most effective forms of homeowner training, system maintenance, and professional inspections.

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