Texas Water Resources

Texas Water Resources Institute

Summer 1986
Volume 12
No. 2

How Safe Are Septic Tanks?

CONTAMINATION RISKS

More than 4 million Texans, especially those in rural areas and small towns, rely on septic tanks and other onsite wastewater treatment systems as a means of treating domestic sewage and other household wastes. Nationally, an estimated 20 million homes use onsite systems to treat and discharge as much as 2.55 trillion gallons of effluent into the ground annually.

In Texas, the Texas Department of Health (TDH) is responsible for writing state construction guidelines, establishing standards through city and county health departments, and working with the Texas Water Commission (TWC) to certify ordinances for onsite systems. The TWC approves septic tank ordinances of counties, river basin authorities, water supply districts, and individual wastewater treatment systems capable of discharging more than 5,000 gallons per day.

In most cases, onsite systems are safe and effective ways to dispose of wastes. Under certain circumstances (Figure 1), system failure can lead to surface and groundwater contamination, causing disagreeable odors and human health problems such as gastrointestinal illnesses, dysentery, typhoid fever, and even hepatitis.

Discharges from onsite systems are potential health problems because they contain high levels of nitrates and phosphates as well as disease-causing bacteria, viruses, and other microorganisms. Sources of contaminants include household and garden chemicals, human wastes, and foodstuffs.

Nitrate is a major concern because it moves quickly through many soils and can easily contaminate groundwater supplies. Applications of nitrates from human wastes in onsite systems may be as great as 2,400 pounds per acre, according to a report by Dr. Kirk W. Brown, a professor in the Soil and Crop Sciences Department at Texas A&M University. This is as much as 10 times the amount typically applied by agricultural fertilizers on a per-acre basis, Brown says.

A 1984 study by the Environmental Protection Agency Research Laboratory in Cincinnati, Ohio, surveyed the major causes of water-borne diseases across the nation and determined that untreated groundwater was the major cause of most outbreaks. Almost 58,000 persons suffered illnesses because of water-borne diseases between 1971 and 1979. More than 43 percent of the outbreaks and 63 percent of groundwater-related illnesses were caused by overflow or seepage of sewage, primarily from septic tanks.

Another EPA report, Protecting the Nation's Groundwater from Contamination, stated that disease-causing organisms found in groundwater include bacteria (cholera, typhoid, dysentery), viruses (hepatitis), and parasites (worms, fungi). Diseases of the intestinal tract were the most frequently reported illnesses. Bacterial contamination occurred when raw or partially treated sewage from septic tank systems leaked into groundwater, polluting nearby water wells, or overflowed, creating surface water pollution. The study also noted that viruses and parasites have been detected as groundwater contaminants in only a few instances, but this may be due more to the lack of monitoring programs than the capacity of these organisms to cause contamination.

There have been relatively few reported events of groundwater contamination by septic tanks in Texas, but failure of onsite systems does take place. In many instances, contamination occurs in isolated rural areas where the septic systems are unregulated. In others, the incident may have been deemed too small or insignificant to report, or the person operating the malfunctioning system did not want to turn himself in.

Although there have not been any reports of illness that can be directly attributed to septic system failure, some areas have reported potential health problems when septic systems have malfunctioned. In Montgomery County_just north of Houston_septic system failures were reported to the Texas Department of Water Resources (now the TWC) and the Texas Water Development Board in the spring of 1982. An article in the April 11 Houston Post quoted an assistant to the Attorney General as saying, "The soils in the area are not suitable for the absorption of septic tank effluent, and much of this liquid surfaces and flows into the roadside ditches or stands in the yards." That same article mentioned reports of "pungent odors" resulting from septic tank effluent that had surfaced, and a regional health official termed the situation a "serious health hazard" and likened it to "walking in sewage."

Onsite systems still fail on a regular basis in areas where there is high rainfall and high humidity and where there are a large number of units per acre. An official with the Harris County agency that issues septic tank permits said that septic tanks and other onsite systems work well during the hot and relatively dry months from May through September. During the rest of the year, when heavy rainfall and high humidities are common, however, he estimated that as many as half the systems failed occasionally.

There have been other instances in the state where levels of fecal coliform were high enough to cause gastrointestinal illnesses. The most notorious of these was in

Georgetown in the summer of 1980 when 10 percent of that central Texas city's population came down with diarrhea, and more than 30 persons later contracted hepatitis. In Georgetown, the public water supply was contaminated by leaks in the city sewage system, not septic tanks. However, fecal coliform levels present in septic systems can cause similar disorders if they contaminate water supplies.

TASK FORCE

The Texas Rural Water Task Force was created in 1985 as a joint venture of the Texas Department of Agriculture and the National Demonstration Water Project. The task force has investigated aspects of rural water issues including water supply problems, water treatment problems in low-income areas of south Texas, and wastewater treatment systems.

The task force created the Onsite Wastewater Management Working Group to investigate policy issues and to review current state laws and construction guidelines concerning onsite systems. A final working group report is expected to be approved by the task force in June.

At the same time, TDH is in the process of revising its construction standards for septic tanks and other onsite systems. TDH is accepting input from professionals in the field, and the revisions are expected to be published later this year.

Two of the major contributors to the Working Group are Dr. John M. Sweeten, a waste management specialist with the Texas Agricultural Extension Service in College Station, and Dr. Bob L. Carlile, a research soils specialist with the Soil and Crop Sciences Department at Texas A&M University. Other contributors to the Working Group include Robert King, director of the Office of Natural Resources of the Texas Department of Agriculture; Jim Dodds, attorney for the Texas Homebuilders Association in Austin; and Mark Hoelscher, manager of the Glasscock County Underground Water District in Garden City in west Texas.

There are two major types of limitations to more efficient use of onsite systems in Texas: 1) physical constraints such as soils, climatic conditions, and seasonally high water tables, and 2) institutional constraints such as the insufficiency of statewide training programs and certification for those designing, installing, and constructing onsite systems.

PHYSICAL CONSTRAINTS

Before going any further, it is helpful to provide a brief overview of how septic systems function. A typical domestic septic system has two components: a septic tank and a soil absorption system (Figure 2). The septic tank receives both solid wastes and wastewater. Heavy solids (sludge) settle to the bottom of the tank, and lighter materials (scum) float to the surface. Anaerobic bacteria (not requiring oxygen) break down the sludge and scum. While sludge and scum remain in the tank and eventually must be removed, treated effluent flows into a network of perforated pipes, which spread throughout a soil absorption field. The absorption field uses crushed rock, gravel, and native soil to filter and degrade bacteria, viruses, parasites, and suspended organic solids for further decomposition and absorption. Some potential contaminants will be removed through evaporation and transpiration. In a properly functioning septic system, the remainder will be diluted to safe levels before percolating to groundwater supplies.

Sweeten says that soils are the single most important factor in determining which type of onsite system will be appropriate for a given location. A typical onsite system should work well on moderately permeable soil at least 3 to 4 feet deep. This soil layer must be permeable enough to absorb liquids and transfer oxygen, to allow decomposition of organic materials by oxygen-requiring bacteria, and to adsorb plant nutrients and other chemicals. At the same time, it must filter out suspended solids and disease-causing organisms. Most disease-causing organisms do not survive long in soils where native soil organisms abound. Organisms in the soil prey on the disease-causing organisms and consume most of the critical nutrients the pathogenic organisms need to survive and flourish.

Suitable soils for onsite systems are deep sandy loams and sandy clay loams that allow for adequate absorption of waste products. (Loams are soils that are composed of balanced amounts of sand, clay, and silt, plus organic matter). According to Carlile, problems can result from clay soils, shallow soils underlain by gravel and fractured limestone formations, seasonally high water tables, and caliche (a hard soil layer consisting of calcium carbonate). Typical clays are slowly permeable and resurfacing of raw sewage can result. Slowly permeable clays are common near the Texas Gulf Coast, the Blackland Prairie from Dallas to San Antonio, and in some parts of the High Plains.

Shallow soils offer a contrasting problem. If untreated sewage reaches fissured rock horizons lying underneath some of these soils, liquid wastes can enter and rapidly contaminate groundwater supplies. Areas with shallow soils include the Edwards Plateau (where septic tanks have been prohibited in some areas) and most of west Texas. Seasonally high groundwater tables are a problem along the Texas Gulf Coast and in many parts of west Texas.

Sweeten says that the percolation (perk) test, currently used by TDH to evaluate soils, is not as complete as it needs to be. In this test, holes are dug to the depth of the proposed absorption trench_usually less than 3 feet. The holes are filled with water and are monitored the following day after saturation or swelling has occurred. The holes are later refilled, and measurements are taken to see how much water is absorbed into the soil within a 30-minute period. Although this method is a standard procedure, Sweeten asserts that the perk test overestimates the percolation rate under a continued load of sewage, that it does not allow sufficient time to detect shrink-swell characteristics of clay soils, and that it cannot detect soil variability over a large area.

Carlile and Sweeten recommend that topography, subsoil texture and structure, soil depth, internal and external soil drainage, and soil permeability be included among the criteria for determining where onsite systems can be located. The researchers also recommend that soils be examined by certified soils scientists before septic fields or other systems are installed.

There are questions as to whether sufficient data on Texas soils exist to begin implementing the recommendations of Sweeten and Carlile on soil testing. Excellent county-by-county soil surveys have been produced by the Texas Agricultural Experiment Station in cooperation with the United States Department of Agriculture and the Soil Conservation Service. These surveys are useful guides in determining soil characteristics in a general location, but they are not as site-specific and precise as an onsite evaluation by a trained soils scientist.

A report by Carlile states that "there is a very limited existing data base in which to evaluate the capacity of (Texas) soils . . . for accepting and treating septic tank discharges." Carlile suggests that "data must be developed within Texas or obtained from other areas or states before system design criteria can be developed to optimize the capability of a soil resource area to treat and dispose of wastewater." He recommends that efforts be undertaken by state and federal agencies to develop and expand knowledge about Texas soils and their suitability for wastewater treatment.

Weather conditions, especially rainfall, humidity, and evaporation, are all important factors. If amounts of rainfall and humidity are excessive, the likelihood of effluent surfacing increases. Some systems such as evapotranspiration beds are restricted to areas in which a high rate of evaporation occurs. Sweeten has recommended that other rainfall and moisture deficit data also be included in revised standards for evapotranspiration bed systems to insure their safe operation.

Another critical factor_some would argue the most important factor_is the density of units over a given area. Many areas with septic tank problems are high growth regions in which a once sparsely populated rural area has been rapidly transformed into a sprawling suburb. If the density of septic tanks is too high, the volume of sewage and treated effluent generated may be too great to safely treat. Surfacing and groundwater contamination may result.

TDH currently recommends that lot sizes for septic tanks be a minimum 15,000 square feet for homes that receive drinking water from a central treatment facility, and 20,000 square feet for those that get water from an individual well. Proposed TDH revisions will require almost double that amount: a half-acre and an acre, respectively.

INNOVATIVE ALTERNATIVES

A recurring criticism from all members of the working group concerns the failure to use existing alternatives to septic tanks statewide. Other states have successfully implemented improved technologies for alternative disposal of onsite waste, but these alternatives are not widely used in Texas. TDH officials argue that some systems such as pressure dosing and alternating absorption fields are "as common as houseflies" in many parts of the state.

Many of the new alternatives to septic tanks center around two basic concepts. First, soils can be "rested" by extending the timespan between applications of treated effluent. This allows microorganisms in the soil sufficient time and oxygen to degrade nutrients and organic materials. Second, permeable soil mounds can be created in areas where shallow soils exist. A description of some alternative technologies follows.

- Pressure dosing of soil absorption fields and alternating field absorption systems are management features designed to retard soil clogging. Pressure dosing consists of pumping treated effluent to absorption fields in controlled doses (Figure 3). This spreads liquid evenly and gives fields a chance to dry between closings. Alternating field absorption systems use two or more absorption fields, but only one field is in use at a time. This method allows other fields to rest, provides a standby if one field fails, and extends the life of a field. Fields are usually switched every 6 months to a year.

- Above-ground mounds can be useful in areas where there are shallow soils or seasonally high water tables (Figure 4). Liquid is pumped from a storage tank to perforated plastic pipe in a sand or soil mound that covers native soil. Vegetation on the mound helps evaporate liquids, and a soil layer provides a barrier to nearby rock formations or perched water tables. The idea of using mounds covered with turfgrasses and other vegetation to speed transpiration and maintain soil permeability has also been researched by Brown. He investigated the ability of common bermudagrass to remove nitrogen from soils lying over three absorption fields to determine if vegetative cover on a mound system would reduce nitrate seepage into groundwater supplies. Common bermudagrass removed only 5 percent of the nitrogen when sandy soils were used in the mounds, but the grass removed up to 10 percent from loamy soils and up to 45 percent from clays.

- Aerobic systems mix air and wastewater in a tank. Oxygen-using bacteria grow, digest sewage, and liquefy most solids. The liquid is then discharged to an absorption field. Several houses may be served by a common absorption field in a cluster system (Figure 5). Each house has a separate septic or aerobic tank, but the houses share the field for disposal of liquid wastes. The cluster system can be adapted for use with mounds and pressure dosing. Cluster systems, however, can only be used if all houses in the system are owned by the same person, if one of the homeowners assumes responsibility or liability for the system, or if a homeowners association is formed to insure that the system will be properly operated and maintained.

An excellent EPA brochure, Small Wastewater Systems: Alternative Systems for Small Communities and Rural Areas, provides basic information about many of these systems and situations where they may be applicable. Another EPA publication, Design Manual-Onsite Wastewater Treatment and Disposal Systems, is a 400-page book that gives an in-depth look at various conventional and alternative wastewater treatment systems.

All alternative treatment systems mentioned have been authorized by TDH on a case-by-case basis. Revised rules supporting use of some of these systems are currently being prepared by TDH, and more alternative systems are being approved on a statewide basis.

INSTITUTIONAL CONSTRAINTS

A few institutional problems identified by the working group have already been mentioned: more site-specific soil data and criteria need to be developed, and the responsible agencies should more actively encourage adoption of new onsite systems in areas with special soil needs. Other institutional issues identified by the working group included the following:

- Regulations for onsite systems are only in effect when these systems come under the direct jurisdiction of local health departments, county commissioners courts, municipalities, river basin authorities, or water districts that have adopted enforcement standards. If an onsite system is not located within the boundaries of one of these political subdivisions, it is unregulated unless a situation develops where a "public health nuisance" is created. Enforcement standards are needed for onsite systems that are not located within political subdivisions and are not regulated.

- There is currently no state certification program for soils scientists, builders, installers, engineers, health professionals, and others directly involved with design, installation, and maintenance of onsite systems. Training programs and licensing of personnel could ensure that effective systems are properly installed and that correct procedures, operation, and maintenance are followed.

- Data collection efforts to identify and monitor failing systems need to be bolstered. There is no accurate count, or ballpark figure, of the number of failing systems, the nature of the failure (groundwater contamination or surface pending), or the extent of contamination caused by the malfunction. A monitoring effort would be useful to document the extent of system failure, identify and penalize offenders, and correct malfunctions. Such a program at this point, however, would be costly and manpower-intensive.