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Office of Water Washington, D.C.
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Decentralized Systems Technology Fact Sheet

Septic Tank - Soil Absorption Systems

DESCRIPTION

An estimated 30 percent of all U.S. households use on-site treatment methods (Hoover *et al.*, 1994). Septic tank/soil absorption has been the most popular on-site method (U.S. EPA, 1980a.) The septic tank is an underground, watertight vessel installed to receive wastewater from the home. It is designed to allow the solids to settle out and separate from the liquid, to allow for limited digestion of organic matter, and to store the solids while the clarified liquid is passed on for further treatment and disposal. Though septic tank effluent can be treated in a variety of ways, this Fact Sheet describes the distribution of effluent wastewater into a subsurface soil absorption area or drainfield.

APPLICABILITY

Septic tank/soil absorption systems are an option to consider wherever a centralized treatment system is not available. Since subsurface soil treatment and disposal relies upon gradual seepage of wastewater into the surrounding soils, these systems can only be considered where favorable soil characteristics and geology exist for treatment and subsequent disposal of the treated wastewater into the environment.

For effective wastewater treatment, prospective soils should be relatively permeable and should remain unsaturated to several feet below the system depth. Moreover, the soil absorption system should be set well above water tables and bedrock. Further, it cannot be easily located in steeply sloped areas (U.S. EPA, 1980a.) For regions with high water tables or shallow bedrock, other systems using more advanced technology may be better options for wastewater treatment. (See *Wastewater Technology Fact Sheet: Mound Systems*.) In cases where impermeable soils exist, fill systems and sand-lined trench systems—in which fill material is brought in to replace unsuitable soils—may be a feasible alternative.

To avoid contamination of drinking water sources and other problems, soil absorption systems must be situated at prescribed distances from wells, surface waters and springs, escarpments, property boundaries and building foundations (U.S. EPA, 1980a). These regulations may restrict the feasibility of septic system installation, depending on property size, shape, and proximity to the features noted.

Conventional septic systems are designed to operate indefinitely if properly maintained. However, because most household systems are *not* well-maintained, the functioning life of septic systems is typically 20 years or less. In contemporary practice, it is commonly required that a second area of suitable soil be reserved at the site as a "repair area" in the event that the initial system fails to operate properly or to allow for the possibility of a future home addition project (Hoover, 1999.)

Since the soil absorption area must remain unsaturated for proper system functioning, it may not be feasible to install septic systems in regions prone to frequent heavy rains and flooding, or in topographical depressions where surface waters accumulate.

ADVANTAGES AND DISADVANTAGES

Advantages

- Simplicity, reliability and low cost.
- Low maintenance requirements.
- Nutrients in waste are returned to soil.
- A properly designed, well-maintained system can last for more than twenty years.

Disadvantages

- Siting limitations for septic systems include natural soil type and permeability, bedrock and groundwater elevations, and site topography.
- Regulations pertaining to set-backs from water supply, lot lines, and drainage lines must be taken into account.
- Restrictions on the character of influent wastewater must be included in project planning.
- Improperly functioning systems can introduce nitrogen, phosphorus, organic matter, and bacterial and viral pathogens into the surrounding area and groundwater.

DESIGN CRITERIA

A septic system usually includes three components: the septic tank, a drainfield and the soil beneath the drainfield. The tank must be a watertight container constructed of a sound, durable material resistant to corrosion or decay (concrete, fiber reinforced plastic, fiberglass, or polyethylene). The septic tank is connected to a piping system that distributes wastewater effluent into subsurface soil for absorption and subsequent treatment.

Wastewater generated from a household is collected and transported through the house drains to the buried septic tank, where most of the solids settle while grease and scum float to the surface. Inlet baffles or effluent screens help to force wastewater down into the tank, preventing short-circuiting across the top. Outlet baffles keep the scum layer from moving into the soil absorption system. Collected solids undergo some decay by anaerobic digestion in the tank bottom. The capacity of a septic tank typically ranges from 3,785 to 7570 liters (1,000 to 2,000 gallons).

Clarified septic tank effluent exits the septic tank and enters the soil absorption system (also called a “leachfield” or “drainfield”) where a biological “clogging mat” or “biomat” forms, contributing to even distribution of the waste into the drainfield (U.S. EPA, 1980a; Hoover et. al., 1996.) State regulations usually require between two and four feet (or sometimes less) of unsaturated soil beneath the drainfield to renovate wastewater before it reaches a “limiting layer”—the point at which conditions for waste renovation become unsuitable. The limiting layer may be bedrock, an impervious soil layer or the seasonal high water table.

Absorption beds and trenches are the most common design options for soil absorption systems. Trenches are shallow, level excavations, usually from 0.305 to 1.524 meters (one to five feet) deep and 0.305 to 0.914 meters (one to three feet) wide (see U.S. EPA, 1980a.) The bottom is filled with at least 15.24 centimeters (six inches) of washed gravel or crushed rock over which a single line of 10.16 centimeters (four-inch) perforated pipe is placed. Additional rock is placed over and around the pipe. A synthetic building fabric is laid on top of the gravel to prevent backfill from migrating into the gravel trench. Beds are constructed analogously to trenches, but are more than three feet wide and may contain multiple lines of distribution piping. While beds are sometimes preferred for space savings in more permeable soils, trench designs provide more surface area for soil absorption (U.S. EPA,1980a; Hoover, 1999.)

The size of a soil absorption system is based on the size of the house and the soil characteristics. Traditionally, soil is evaluated using a “percolation rate”, a measure of the water migration rate through the candidate soil. Acceptable limits of percolation for drainfield suitability range between 23 seconds and 24 minutes per centimeter (1 and 60 minutes per inch) (U.S. EPA, 1980a.) Percolation rates of

1.18 and 24 minutes per centimeter (3 and 60 minutes per inch) would correspond to absorption areas of about 70 and 340 square meters respectively per bedroom of the house to be serviced (Harlan and Dickey, 1999.) Though the number of bedrooms has typically been used as a rule-of-thumb measure for tank sizing, it should be noted that this is only an approximation; by itself, it is an unreliable way to gauge anticipated waste volume (U.S. EPA, 1980a.)

While some states continue to use the percolation rate as a criterion for site suitability, many use a more comprehensive measure, the long-term acceptance rate (LTAR), as part of a thorough site evaluation (Hoover, 1999). The LTAR accounts for the texture, structure, color, and consistency of all soil layers beneath the drainfield, as well as the local topography, to make a determination of the wastewater loads the area is able to accept on a long-term basis once the biomass has formed.

The character of wastewater flowing into the soil absorption area is a critical variable for proper functioning of septic systems. Soil absorption systems work most effectively when the influent wastewater does not contain significant levels of settleable solids, greases and fats (U.S. EPA, 1980a), which can accelerate clogging of the infiltrative soil. Accordingly, the use of household garbage disposals and pouring of grease down domestic drains can reduce the effectiveness of septic tank/soil absorption systems (Gannon *et al.*, 1998). To avoid infiltrative soil clogging, septic tanks are fitted with outlet baffles to prevent floating grease, scum, and entrained particles from moving into the soil absorption system. Also, the use of two-compartment tanks is recommended over single-compartment designs. Even so, tanks must be properly sized to avoid hydraulic overload and the passing of unwanted materials into the soil absorption system.

Digestion of wastes is a temperature dependent process, and colder temperatures may hinder effective breakdown of wastes in septic tanks (Seifert, 1999.) Therefore, in cold climates tanks may need to be buried more deeply, and/or insulated.

Septic systems can act as sources of nitrogen, phosphorus, organic matter, and bacterial and viral pathogens, which can have potentially serious environmental and health impacts (Gannon *et al.*, 1994.) Failure of systems to adequately treat wastewater may be related to inadequate siting, inappropriate installation, or neglectful operation. Hydraulic overloading has been identified as a major cause of system failure (Jarrett *et al.*, 1985). Since septic wastewater contains various nitrogen compounds (e.g., ammonia, ammonium compounds, and organic forms of nitrogen) (Brown, 1998), installation of septic systems in areas that are densely developed can, in combination with other factors, result in the introduction of nitrogen contaminants into groundwater. Groundwater impacts can occur even when soil conditions are favorable because the unsaturated aerobic treatment zone located beneath the drainfield—a zone required for pathogen removal—promotes conversion of wastewater-borne nitrogen to nitrates (Hoover, 1999.) If nitrate contamination of groundwater is a concern in the region, control methods or denitrifying technologies may be required for safe operation of a septic system.

Symptoms of a failing septic system can include strong odors, ponding of improperly treated wastewater or backup of wastewater into the home (Hoover, 1999.) Less obvious symptoms arise when systems are operating less-than-optimally, including a measurable decline in water quality, leading over the long term to local environmental degradation (Brown, 1998).

Solvents, poisons, and other household chemicals should not be allowed to flow into a septic system; these substances may kill beneficial bacteria in the tank and drainfield, and lead to system failure (Montgomery, 1990.) Though some organic solvents have been marketed as septic system cleaners and substitutes for sludge pumping, there is little evidence that such cleaners perform any of their advertised functions. It is known that they can exterminate useful microbes, resulting in increased discharge of pollutants (Gannon *et al.*, 1999; Montgomery, 1999.) In addition, the chemicals in these products can contaminate receiving waters (U.S. EPA, 1993). Additive restrictions are most effective when used as part of a Best Management

Practice system involving other source reduction practices such as phosphate bans and use of low-volume plumbing fixtures.

Design of subsurface disposal beds and trenches varies greatly due to specific site conditions. In sloping areas, a serial distribution system configures the trenches so that each is used to its capacity before effluent overflows into the succeeding trench. A dosing or pressurized distribution system may be installed to ensure complete distribution of the effluent to each trench(U.S. EPA, 1980a.) Alternating valves permit switching between beds or trenches to allow drying out or resting of the system (U.S. EPA, 1980a; Gannon *et al.*, 1999). A dosing system, such as a low-pressure pipe system, is useful in areas of both high groundwater and permeable soils, where shallow gravel ditches installed from 22.86 to 30.48 centimeters (9 to 12 inches) below grade are employed. Another option is the use of drip irrigation (Hoover, 1999.)

For systems that are properly sited, sized, constructed, and maintained, septic tank/soil absorption has proven to be an efficient and cost effective method of onsite wastewater treatment and disposal. Operating without mechanical equipment, properly maintained soil absorption systems have a service life in excess of 20 years. Several important steps must be taken during construction to ensure system reliability:

- Keep heavy equipment off the soil absorption system area both before and after construction. Soil compaction can result in premature failure of the system.

- Divert rainwater from building roofs and paved areas away from the soil absorption system. This surface water can increase the amount of water the soil has to absorb and lead to premature failure.

- Ensure that the alternating device and the trench bottoms are level to provide even distribution of the septic tank effluent. If settling and frost action cause shifting, part of the soil absorption system may be overloaded.

- Avoid installing the septic tank and soil absorption system when the soil is wet. Construction in wet soil can cause puddling, smearing, and increased soil compaction, which greatly reduces soil permeability and the life of a system.

- Install water-saving devices to reduce the amount of wastewater entering the soil absorption system.

- Have the septic tank pumped at least every three to five years, and inspected regularly.

PERFORMANCE

When correctly installed and maintained, septic tank/soil absorption systems are an effective way to treat and dispose of domestic wastewaters. Nevertheless, even under the best of circumstances septic systems allow a "planned release" of contaminants into the groundwater (Tolman *et al.*, 1989) and must be designed and operated to minimize the impact of this release. While hydraulic overloading been identified as a major cause of septic system failure (Jarrett *et al.*, 1985), contamination due to system failure can be caused by a variety of factors. In one study, widespread septic failures in Illinois were primarily attributed to unsuitability of soils, age of system, lack of maintenance, and improper design and installation of systems (Smith and Ince, 1989.) Likewise, a study of septic systems in the Borough of Hopatcong, New Jersey, found poor soil conditions and shallow bedrock to be significant contributors to system failure (HSAC, 1997.) By one estimate, only 32 percent of the total United States land area has soils suitable for waste treatment by traditional septic tank/soil absorption systems (U.S. EPA, 1980a.)

Frequency of use also affects system performance. Drainfields installed on seasonally used properties have been found to develop an incomplete biological clogging mat, leading to uneven distribution and absorption of wastewater (Postma *et al.*, 1992.)

A critical factor in optimal system performance is the depth of unsaturated soil beneath the soil absorption field. A septic system performance study conducted on a coastal barrier island (characterized by variably high water tables and sandy soils—conditions unfavorable for septic system operation) found that a 60-cm soil layer provided adequate microbial treatment, even at the highest loading rate studied (Cogger *et al.*, 1988.) By contrast, the same study found that another system of the same design having a 30-cm soil layer beneath the leachfield suffered from rising water tables and ineffective treatment. For the loading rates studied, the depth of unsaturated soil beneath the system was determined to be a more decisive factor in system performance than hydraulic loading.

Despite the limitations discussed above, septic systems tend to be preferred over other on-site treatment methods for long-term domestic use. A 1980 study found septic tank/soil absorption systems to offer the lowest cost and the highest level of performance among six on-site treatment techniques tested (U.S. EPA, 1980b). In addition to septic tank/soil absorption, the other five techniques included incinerating toilets, recycling toilets, extended aeration units followed by open sand filters, septic tanks followed by open sand filters, and septic tanks followed by horizontal sand filters).

OPERATION AND MAINTENANCE

To keep the system healthy, care must be taken to avoid putting high-solids or grease containing materials down drains or toilets, including paper towels, cigarettes, cat litter, feminine hygiene products, and residual cooking fat (HSAC 1997). In the past, pump-out of accumulated solids from septic tanks every three to five years has been recommended, however solids loading has been shown to be extremely variable and for modern tanks, pump-out may not need to occur as often (U.S. EPA, 1994). Pump-out every four years should be planned, but actual practice should be determined by inspection.

Inspections should be conducted at least biannually to confirm that baffles are operating correctly, that no leaks are occurring, and to check the levels of sludge and scum in the tank (U.S. EPA, 1994). The tank should be pumped out if the sludge layer thickness exceeds 25 percent of the working liquid capacity of the tank (Hoover, 1999), or if the bottom of the scum layer is within 7.62 centimeters (three inches) of the bottom of the outlet baffle (U.S. EPA, 1994). More frequent inspections are required for systems using more advanced on-site technologies (Hoover *et al.*, 1995.)

Though many enzyme additives are marketed as septic system digestion aides, the effectiveness and usefulness of many of these products is questionable. (Seifert, 1999.) If waste products are not being properly digested before they are discharged, the most likely cause is hydraulic overloading. In cold climates, lower average tank temperatures can also inhibit digestion.

Similarly, many chemical additives are available for system cleaning and rehabilitation. However, many of these products are not effective (see Bicki and Bettler, 1988, on use of peroxide for rehabilitation of septic systems) and some may even harm the system (Gannon *et al.*, 1998.) The use of chemical additives should be avoided.

COSTS

Costs for installation and maintenance of septic systems vary according to geographical region, system size and type, and the specific soil and geological characteristics of the selected site. Installation of a new bed or trench septic system on a site meeting the criteria for such systems varies widely in cost. Figures range from as low as $1,500 to more than $8,000 (Montgomery, 1990; Anchorage HHS, 1999; Ingersoll, 1994.) An average installation cost of $4,000 is assumed for a traditional septic tank/soil absorption system in a geologically favorable area.

The cost of tank pump-out varies from as low as $60 to(Ingersoll, 1994) to as much as $260 (HSAC, 1997.) For a pumping cost of $150, assuming pump-out every four years, the total pump-out cost over a 20-year period would be $750 (subject to inflation). Biannual inspections cost between $50 and $250 (Scott County, 1999); for a $125 fee, the cumulative inspection cost over 20 years would be $1,250. Non-inflation adjusted inspection and maintenance costs for a properly functioning septic system average $100 per year for a hypothetical 20-year system life.

The total (non-inflation adjusted) cost including purchase price averaged over a 20-year period comes to $300 per year. It should be noted, however, that if a system is properly maintained, its life should exceed 20 years.

The value of proper maintenance is further underscored by the costs associated with repairing failing septic systems. These can range widely, depending on the nature of the problem and on the location of the site. A typical range would be $1,200 to $2,500 for revitalization or repair of an exhausted drainfield. Complete removal and replacement of existing systems can cost five to ten times more than this (see, for example, HSAC,1997; Ingersoll, 1994.)

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ADDITIONAL INFORMATION

Contact your local county extension office and your state department of health for information and region-specific details. Additional information is available from:

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