On-Site Sewage Systems: A Look at the Options

by Henri de Marne

Although municipal sewer systems keep creeping out beyond the suburbs, the number of houses that handle water disposal on site remains much the same as 40 years ago. In fact, about one-fourth of all houses built today are equipped with private septic systems. Nationwide, approximately 15 million on-site septic systems serve 20 percent of the population.

In addition, there are still millions of outhouses (dubbed "Ameri-can" by Jack Miller, a poetic, longtime acquaintance of mine from Maryland) and "straight-pipers"—people who simply run a pipe from the house to a nearby river or lake (a practice that now is strictly illegal in most states).

Today's septic systems are a considerable improvement over our earlier cesspools, which consisted of a deep hole in the ground lined or filled with stones, into which we dumped our wastes directly from the house.

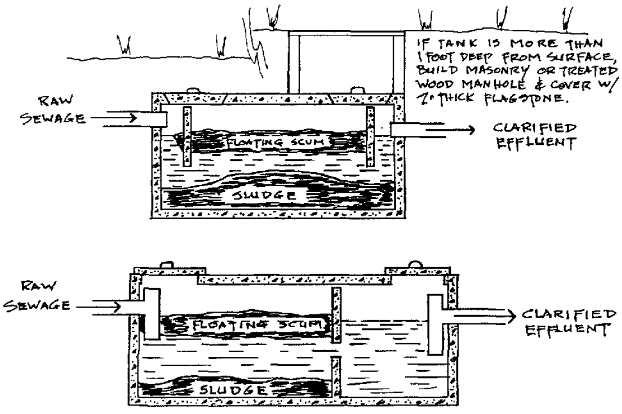
Raw sewage dumped into cesspools clogged the pores of the soil rapidly, requiring us to dig new holes to replace the failed ones. Worse yet, because they were dug so deep, cesspools endangered the water table and polluted the drinking supplies of large areas.

Fortunately, some bright soul eventually figured out that if the solids were trapped in a watertight tank, it would give nature (in the guise of bacteria, gas, gravity, etc.) a chance to "clarify" the waste. The resultant "liquor," as it is called in the trade, could then flow, reasonably clear of solids, into various other leaching devices. Thus, the birth of the septic tank—a deep, dark, malodorous container buried underground that most of us would prefer to ignore.

Most of us who live in the country and must depend on individual, on-site disposal systems have had to contend with the same life-and-death struggle of maintaining a septic system—digging one miserable pit after another and laying new pipes and gravel every few years because our favorite excavator and septic-system contractor says that's the way it is.

I must admit to a certain flush of anger when I drive by neighbors and see, almost on a regular three- to five-year schedule, the same guy digging up the lawn to replace a system that has failed once again.

Often these failures could have been avoided if the contractor who installed it in the first place had known what he or she was doing. Health departments have attempted to remedy this lack of know-how with percolation tests, regulations, requirements, design criteria and the like. They may have been helpful, but they also have stymied the advance of science and technology—and perpetuated the don't-rock-the-boat attitude of many of our state sanitarians. (The most farsighted such official with whom I have spoken minces no words in accusing his colleagues of hiding their heads in the sand—certainly an unpleasant pastime in some locations!)



Two types of commonly used and approved precast-concrete septic tanks.

Of course, some soils, especially mountainous ones, are totally unsuited for waste disposal. But there are far too many failures that cannot be blamed on the soil—failures that are entirely due to a lack of care and understanding on the part of the installers and the users.

Septic-Tank Basics

What exactly is a septic system? The word "septic" comes from "sepsis," meaning bacterial action without benefit of air—an action also known as anaerobic. Wastewater from a house is carried through a pipe, generally made of cast iron and four inches in diameter, first to a septic tank buried in the ground several feet from the building, and then to percolation devices.

Although a tank can be "job built" (that is, formed and poured in place or built of masonry units properly cement-coated, or "parged," to ensure water-tightness), it is far more common and much easier to buy a precast, wire-reinforced concrete tank. Steel tanks, if properly coated with asphalt paint inside and out, will give good service and still are used widely, but their life expectancy is in direct relation to the thoroughness of the coating. Without it, a steel tank cannot be expected to last more than 10 years.

One of the most important features of a septic tank is its size; it must be big enough to allow a large volume of liquid to be "clarified" while chemical processes take place to digest the solids. A 750-gallon tank is suitable for up to four people, while a 1,000-gallon tank will accommodate a household of five to eight people. The requirement goes up 250 gallons for each additional two persons.

It also is helpful to understand what is happening inside the tank. As sewage from the house reaches the tank, the solids will either sink to the bottom and form sludge, or rise to the top as scum, depending on their composition and weight. Anaerobic bacterial action begins to digest these solids, producing gases in the process. These gases, in turn, lift some of the smaller solid particles from the sludge to the scum, where digestion continues, and forces other particles to sink. As this interaction takes place, solids are liquified, and the effluent flows out of the tank in direct proportion to what is being flushed into it.

This is where the size of the tank comes in. Although a septic tank per se does not normally fail—the leaching devices do—a tank that is too small contributes to the failure of the absorption field by allowing undigested solids to enter and clog its surface.

If the tank is not large enough, as solids build up from the top and bottom, the amount of space for the liquid is greatly diminished. As a result, additional incoming sewage causes the partially treated effluent to rush out, carrying with it large quantities of undigested solids still in suspension or scoured from the sludge and scum. This partially treated sewage then is disposed of in the leach field or pits, which is where most of the failures occur.

Leaching Safeguards

In addition to ensuring that the septic tank is adequately sized, several criteria must be met to prevent leach-field failures.

- The ground must be able to absorb and completely treat the effluent before it enters the water table or any other water course.
- The leaching system must be of adequate size in relation to the composition of the ground and the amount of effluent it will be required to treat.
- The effluent reaching the leaching area must have received primary and a bit of secondary treatment within the tank. Primary treatment is the removal of solids; secondary treatment is the reduction of biochemical oxygen demand (BOD) by digestive processes, some of which take place in the tank.

If any of these conditions are not met, the system is in trouble. If the ground is impervious or unable to absorb the effluent at the rate at which it flows, or if the leaching area becomes clogged because of poor construction or abuse, the familiar black, odoriferous liquid will rise to the surface and create a health hazard. It will be washed away by rain into the watershed or form pools that become breeding grounds for disease-carrying insects.

If the ground is overly porous, the effluent will find its way to the water table too quickly—especially if the water table is very close to the surface. While four feet of suitable ground generally will treat septic effluent adequately, if the effluent reaches water before it is treated, it will mix with the water and travel hundreds of feet down, contaminating groundwater supplies.

So it is imperative for our health and the purity of our water supply that the leaching process be adequate and thorough. Mother Earth will take care of it if only we give her a chance.

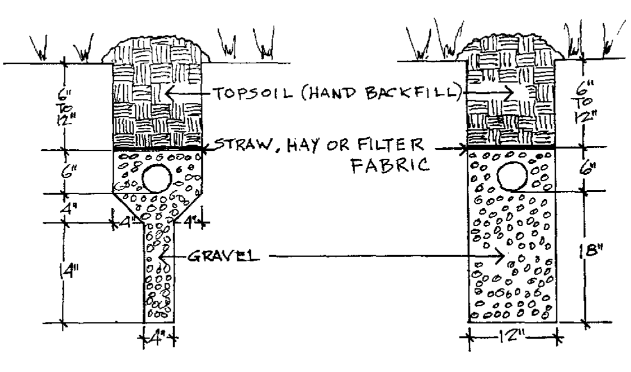
Types of Leaching Systems

There are three types of leaching devices in general use: leaching pits, the deep-trench method, and leaching trenches or lines.

The first, a leaching pit, consists of large holes lined with unmortared bricks or blocks surrounded by a ring of gravel. Pits should be used only when trenches are not feasible for one reason or another. They need to be deep and therefore can endanger the water table; they also have a tendency to clog rather quickly, as the absorptive areas they offer are actually very small. The suspended solids carried in the effluent soon seal the bottom of the pit and gradually the sides as well, so that only the circumference of the water line comes in contact with new absorptive areas as the liquid level rises.

The deep-trench method has some of the disadvantages of pits and requires more land, but deep trenches will last longer. They may be as much as 10 or more feet deep and two to four feet wide; their length is determined by the composition of the soil and the number of occupants using the system. These trenches are partially filled with large gravel or crushed stone, on top of which a perforated soil pipe is laid and covered with straw or one of the newer filter fabrics. (Avoid rosin or felt paper, however.) Next, the trench is backfilled with dirt, which should be mounded to allow for settlement, and seeded.

The third alternative, leaching trenches or lines, is a much more effective method of effluent disposal. The thinking a few years ago was that they should be about two or three feet wide and one and a half to two feet deep to allow a large bottom area for absorption. However, recent studies have shown here as well that the bottom surface will seal rather quickly, forcing the walls to take on a much greater part of the load.



Two types of leach trenches recommended by the state of Vermont and based on an engineering study by Dartmouth College in New Hampshire.

Hence, a trench up to three feet deep and no more than 12 inches wide now is recommended. In fact, it even is suggested that the trench be only four inches wide on the bottom third or so. This reduces the amount of dirt to be disposed of and gravel to be used and can be accomplished with a trenching machine or a tiling spade.

Leaching-Trench Construction

When digging the trench, it is important to avoid several common but serious errors that can shorten the life of the system.

To function properly in a soil that has passed the necessary percolation test and been deemed suitable for absorption, trenches must not be dug when the soil is excessively wet. This can cause mechanical compaction, leaving smeared surfaces through which liquid cannot pass. When a fistful of soil can be molded only under considerable pressure, the time is ripe for digging.

Trench bottoms should be clean and free of loose material. Inspect the bottom and sides for signs of compaction, and scar them with a sharp instrument to a depth of one inch if any is found.

After taking these precautions, fill the bottom 18 inches of the trenches with washed, hard gravel or crushed stones 1½ to 2½ inches in diameter; marble and limestone are not suitable. They must be free of fines (rock dust), as these will clog the pores of the soil under the washing action of the effluent.

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Next, lay a perforated pipe on top of the gravel bed. In the past, short lengths of four-inch drainage tiles were used, but the development of fiber pipes (such as Orangeburg, which no longer is used), plastic coils (such as ADS or Hancor) and rigid plastic pipes have greatly simplified the task. (The coil types by far are the easiest and fastest to install and the least expensive, and they come with an almost infinite variety of couplings, adaptors, reducers, tees and sumps that are especially helpful when installing a leaching system on a slope.)

Surround and cover the perforated leaching pipe with two inches of the same gravel. Follow this with a layer of straw (or, better yet, one of the new filter fabrics), which prevents the topsoil from washing through, then backfill.

When backfilling the trench, the topsoil should be hand-tamped and heaped several inches over the trench so that rainwater will not cause it to settle. (This could lead to erosion or early saturation of the field.) Backfilling or tamping by machine is an absolute no-no. Top it all with a generous sprinkling of grass seed, or let nature take its course if you're in no hurry.

Distribution Systems

How are these trenches laid out, and how is the effluent from the septic tank distributed to them? Although it has fallen into disfavor as a result of recent research, many contractors still rely on the distribution box to channel the effluent to the trenches. The idea was good, but either through poor installation practices or settling, the box often would not stay level. This caused it to favor one or more distribution lines rather than dispense its bounty evenly.

A serial distribution system is a better option. The solid pipe from the septic tank tees into the perforated leach-field pipes, which are laid level on gravel beds. The bottom of the trenches also must be level. All pipes are interconnected into loops so that the entire system is used to its full capacity.

If a leach field must be built on sloping ground, the serial distribution system is the only way to go. In this case, however, the pipes are not laid out in interconnecting loops. Instead, parallel lines follow the contours of the land and connect to each other at the alternating far end of each line. This is accomplished by the use of inverted solid pipes or "drop boxes" interconnected by solid pipes.

When laying out a septic system, great care must be taken not to pollute the underground water supply or nearby streams and lakes. To this end, sanitary engineers recommend distances that should be maintained between components of the system and the various water sources.

No part of the leaching system can be closer than 100 feet from a well or spring, or 50 feet from a stream or other body of open water. The tank itself must be at least 50 feet from any water source and five feet away from the house. Tree roots should not cause problems if there are at least 10 feet between the trunks of large trees and the leaching trenches and at least 12 inches of gravel under the pipes. (Willows are an exception and never should be grown near sewage-disposal systems.)

Adhering to these distances is no guarantee that the underground water supply will not be contaminated, however. Fissures in rock strata still can channel untreated waste directly into these supplies.

Alternating systems of absorption have been recommended and designed as a way to increase the longevity of on-site disposal fields. If a system of leach lines fails and a new distribution system is to be built next to the sick field, for example, the old lines should not be abandoned. Instead, block off the old system and use the new one for a couple of years, then switch between the systems every year. Allowing the lines to dry up and the air, bacteria and plant roots in the ground to carry out a "cleanup detail" will restore them to good use again.

Use a distribution box (or rework your existing one) to tie the two systems together, and place a fire brick (which is a full four inches wide) in front of the entrance to each of the sick lines. Better yet, install an alternator valve to make the yearly change easier.

Move the fire brick or operate the alternator valve to close off the lines to be "rested." This is a form of "dosing," a highly successful way to preserve a leaching system.

The Aerobic Alternative

Aerobic technology, an advanced method of on-site sewage treatment, was developed a long time ago, but it began to appear commercially only in the late '60s and early '70s.

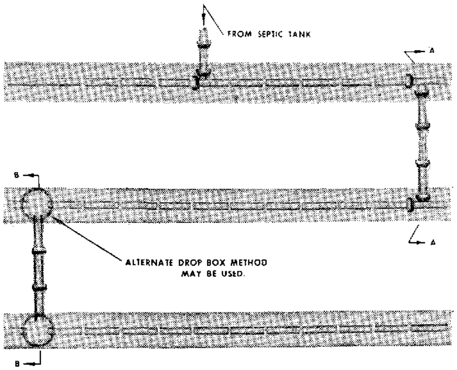
Aerobic treatment of human wastes makes all the sense in the world. By injecting oxygen into the receiving tank, a totally different spectrum of oxygen-loving, voracious bacteria develop that can treat our wastes effectively in hours instead of months, satisfying 90 to 95 percent of the BOD (biochemical oxygen demand) instead of the 50 percent or so accomplished in a septic tank. The result is a sweet-smelling, chocolate-milkshake-like turbulent mix with a clear, odorless final product that carries few, if any, solid particles to clog a leach field. In fact, surface discharge of this treated effluent was allowed in some states as early as the beginning of the 1970s.

The original aerobic units with which I was involved were quite primitive compared to the models that came on line in the mid-'70s, but the results were nonetheless impressive. By installing an aerobic treatment plant and 30 feet of leaching line in those early days, I was able to build several houses on sites that could not accommodate regular septic systems.

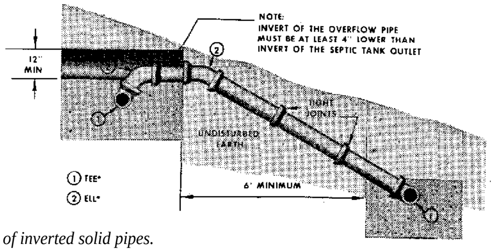
Aerobic treatment plants work particularly well in combination with "evapotranspiration" beds developed many years ago by Dr. Alfred P. Bernhart of Toronto, a leading authority on advanced wastewater treatment. They also are used for nonresidential projects, including one I visited in the early '70s at Bromley Ski Area in southern Vermont.

The major drawback of these advanced treatment plants has been the reluctance of state sanitation officials to accept them, thus making it very difficult for dealers to distribute or service them. Unfortunately, the blessing of state officials generally is essential to make any system a commercial success, and officials in many states wear blinders when it comes to aerobic systems. (I recall a letter I received from a former state environmental commissioner stating that he would never agree to residential wastewater systems that rely on moving parts. Yet I am sure he owns a refrigerator and drives a car—both of which are far more complicated machines than aerobic wastewater-treatment plants.)

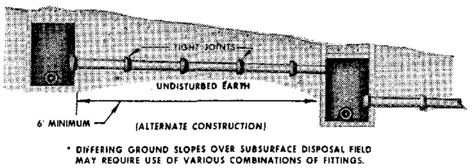
In states with more enlightened officials, these plants are common for both residential and commercial use. They also are widely used in the Caribbean Islands, Saudi Arabia, and other countries to conserve water, which is used to irrigate gardens and flush toilets again after treatment. And some state parks are installing them because ordinary septic systems



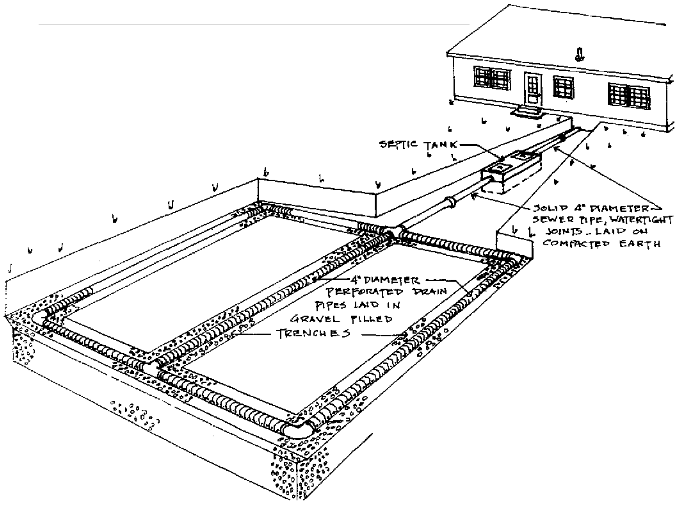
An overhead view of two serial distribution systems (A and B) using bell pipe.



A: The use of inverted solid pipes.



B: The drop-box system.



Schematic detail of a complete subsurface absorption system for a flat area using the preferred serial distribution method.

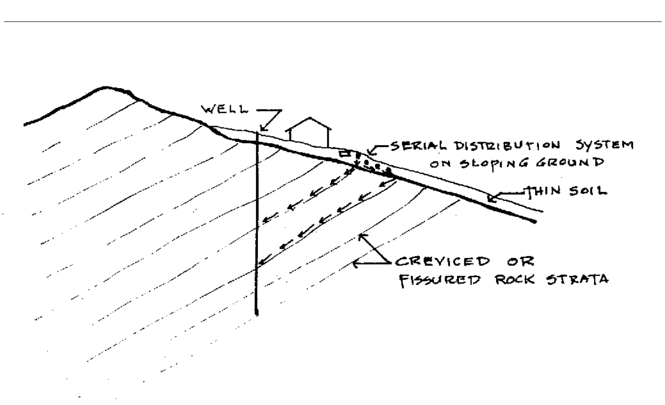


Illustration showing how cracks in the rock strata can permit the contamination of an uphill well by a lower leaching system.

cannot handle the loads during peak use.

The irony is that the considerable reduction of federal funds available for standard municipal plants since 1984 has caused sanitary engineers and local officials to look at aerobic systems with great interest—particularly since the feds will pay 75 percent of the cost of installing these "innovative technology" systems, while the federal share for conventional municipal systems is only 55 percent.

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Sand-Filter Systems

Another alternative for residential use—and one that requires no moving parts as long as the lot geography permits its use—is the sand filter.

When I built our new, energy-efficient house in 1979 and had to decide how to handle the wastewater, I seriously considered an aerobic plant. It would have worked very well, but the original cost, the cost of maintenance, and the frowns of state officials prompted me to look at alternatives.

Recalling my early education in France, when my science teacher demonstrated the cleansing properties of sand by running dirty, polluted water through a bed of sand and collecting clear water after it had passed through, I discussed the concept with a geologist friend who had a great interest in sand filters. We decided to install and field test a residential system on my family's lot.

Our lot is quite steep, so a five-foot-deep sand filter was easy to engineer. The septic tank is positioned at its normal place near the house and empties into a distribution box with three outlet lines set on top of the sand filter.

The sand filter consists of a large, wooden box built of rough-sawn lumber. It is five feet deep and lined with a layer of 18-mil plastic sandwiched between two layers of sand for protection. A perforated pipe at the bottom collects the treated effluent. The pipe is laid in a bed of crushed stone and is connected to a solid pipe that is taped to the plastic liner where it goes through. The solid pipe leads to the leaching trench.

Several feet of coarse sand to meet certain size and screen criteria are topped with a foot of crushed stones, into which the three pipes from the distribution box are laid. We used Typar as a filter fabric and covered it with a layer of bank-run gravel to keep it porous. Then we graded and crowned it with native soil and planted grass.

The treated effluent is dispensed into the native soil by means of a perforated pipe laid in a trench filled with crushed stones and covered with hay, native soil and grass.

If you decide to go with a sand-filter system, keep in mind that underground curtain drains or water-diversion swales must be built if ground or surface water poses a problem to the sand-filter bed itself.

Where the land is flat and the considerable depth of the sand filter poses a problem for leach-field disposal, a pump or dosing tank can be used. In impervious or nearly impervious soils, mounds or modified mounds can be built to receive and disperse the treated effluent.

All these constraints require proper design from an engineer familiar with the options, but they may be well worthwhile.

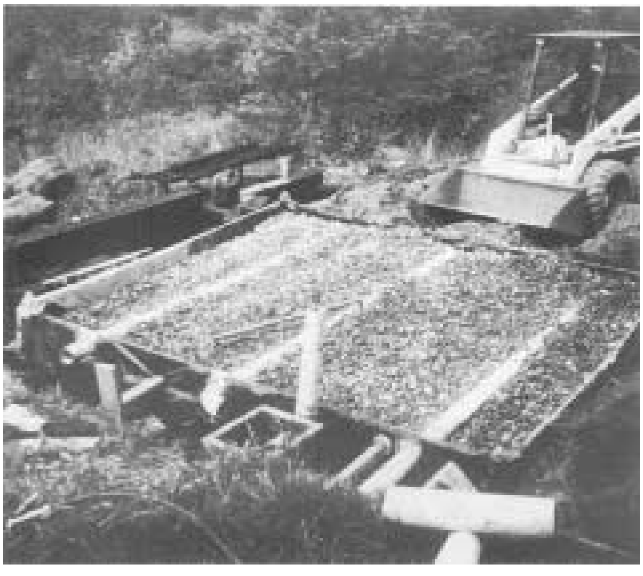
So why did we go to this trouble instead of simply building a regular system? We live about 200 feet uphill from a house with a private well. The slope is steep, and the soil is hardpan with a very shallow layer of topsoil amid numerous stones and rocks. Because of our concern about the effects of our system on the neighbors' water supply (and about the ecology in general) we insisted on advanced wastewater treatment—despite vociferous complaints from our excavating contractor, I might add.

(Even though the contractor was paid by the hour, he complained that he would be tied up at our site for a week and that he couldn't afford the time. As it turned out, the entire operation took one day. To his credit, the excavator later acknowledged that he had made a lot of noise about nothing. He even said he wished everybody had such a system.)

Despite the cost of the special sand that had to be trucked in from some distance, the entire system cost less than a large, modified mound system. We also avoided having to destroy valuable native trees, which we otherwise would have had to cut. (The leach line consists of 100 feet of single lateral line following the contour of the land.)

Readers who are intrigued by this system should retain a sanitary engineer or hydrogeologist familiar with sand filters to design and spec a system suitable to the site involved. I can suggest two people to contact: David Tarbox in Florida (the man who designed my system; phone 305/896-1575) and Chris White in Vermont (phone 802/388-6667).

So, if the ground slope permits it, with a little effort and a few dollars for a set of customized plans from an engineer versed in this technology, you can install a non-mechanical system such as this—one that will assure years of trouble-free service for your clients, and one that will guard against the contamination of the water table and our increasingly fragile ecology. ■



The construction of a sand filter. This one, for a home that uses water-conserving methods, is half the usual size. Normal sand filters are of the same width and depth, but twice as long.