by Anish Jantrania

Alternative Septic Systems

Sand filters and biofilters can effectively treat wastewater — even in areas with poor soils

Around a quarter of America's homes have an on-site sewage disposal system, usually consisting of a septic tank and leach field. On-site septic systems are popular because they cost much less than connecting to a sewer line, especially in spread-out suburban or rural areas.

But on many sites, the classic septic tank and leach field system won't work because the soils aren't suitable for adequately treating septic effluent. In soils that drain too slowly, septic systems can fail by causing effluent to pond on the surface or even to back up into the house (an "operational failure"). In soils that drain too fast, or in locations that are too close to groundwater or surface water, septic systems may allow pollutants to enter groundwater, streams, lakes, or the ocean (a "treatment failure"). Even when soils are ideal, crowding too many systems into too small an area can cause excessive pollution.

The pollution problem can be very extensive. In Massachusetts, for example, the state Department of Environmental Protection (DEP) estimates that of the approximately 650,000 on-site waste-

water systems in use, roughly half are substandard conventional septic systems or cesspools. Due in part to those pollution sources, about two-thirds of Massachusetts surface waters are unsuitable for swimming or fishing. A similar situation exists in Rhode Island, where more than 13,000 acres of salt ponds, tidal rivers, and coastal waters are closed to shellfish harvesting.

In the effort to replace failed systems, homeowners often come up against unsuitable soil or groundwater conditions. Fortunately, wastewater treatment technology has come a long way in recent years. A number of tested alternative systems can purify water much more effectively than conventional systems, even on small lots or lots with problem soils. In this article, I'll explain two of these systems — the single-pass sand filter and the biofilter — each of which I've found to be practical in the field.

I've helped to design and monitor sand filters and biofilters as a faculty member at the National Small Flows Clearinghouse at West Virginia University (Morgantown, W. Va.). I've also installed and monitored both systems, along with some other alternative systems, as part of a pilot project funded by the U.S. Environmental Protection Agency (EPA) in Gloucester, Mass.

Gloucester is under federal court order to fix a serious pollution problem caused by failing on-site systems. Placing city homes on central sewers is so far costing about $20,000 per house, but our project has been able to show that alternative on-site systems can solve the problem for half that cost, or less.

Conventional System: Out of Sight, Out of Mind

First, let's take a quick look at a standard on-site wastewater treatment setup: a septic tank and leach field.

The septic tank provides primary treatment: Scum floats to the top and slowly breaks down, sludge settles to the bottom and also decomposes slowly, and liquid effluent containing microorganisms, nutrients, and other pollutants flows or is pumped into the leach field.

The leach field does most of the work of treatment. Microorganisms in the soil act on the contaminants in the effluent, breaking some of the pollutants down into harmless substances before they leave the treatment zone.

Regulations in most states require you to put the leach field in deep trenches, so that effluent won't rise to the surface. But science doesn't support that requirement: More than 90% of the biological and chemical activity of soil occurs in the top 16 inches. Deeper in the soil, there is very little oxygen for microorganisms, so not much treatment happens. Deep trenches may prevent operational failure, but to get the most effective treatment, the top surface layer is where you ought to put the wastewater. The first improvement you can make to the traditional septic design, if regulations permit it, is to construct the leach field in shallow trenches.

To work properly, a shallow drainfield system should include pumps or siphons that pressure-dose the soil at regular intervals. This ensures that the septic effluent is applied evenly over the disposal area and allows the soil to reach unsaturated conditions between doses.

However, if you have poor-quality soil, a high water table, or ledge near the surface, you may not be able to build a working leach field. And even the best soil has only a limited capacity to treat wastewater. If your site is too small for a properly sized field, the soil won't adequately treat the septic effluent.

So in many cases, something other than a standard system will be needed. We've tested lots of options in Gloucester, but I'll stick to two "advanced systems": the intermittent sand filter and the biofilter. Both the sand filter and the biofilter are easy to build on site using readily available materials. With the advanced systems, we still use a septic tank for primary treatment. But while the traditional leach field relies on naturally occurring microorganisms in the soil to reduce pollutants, in the advanced systems we provide another medium (sand or an artificial substance), outside the soil, for the bacteria to live on. We apply the effluent to this medium at a controlled rate, and the bacteria purify the water as it passes through the system.

The treated effluent, which has significantly fewer contaminants, can then be dispersed into the soil or, if you get the correct permit, disinfected and discharged into surface water.

Sand Filter

Our demonstration single-pass sand filter in Gloucester is a 10x10-foot box built out of pressure-treated 2x4s and

Sand Filter Construction

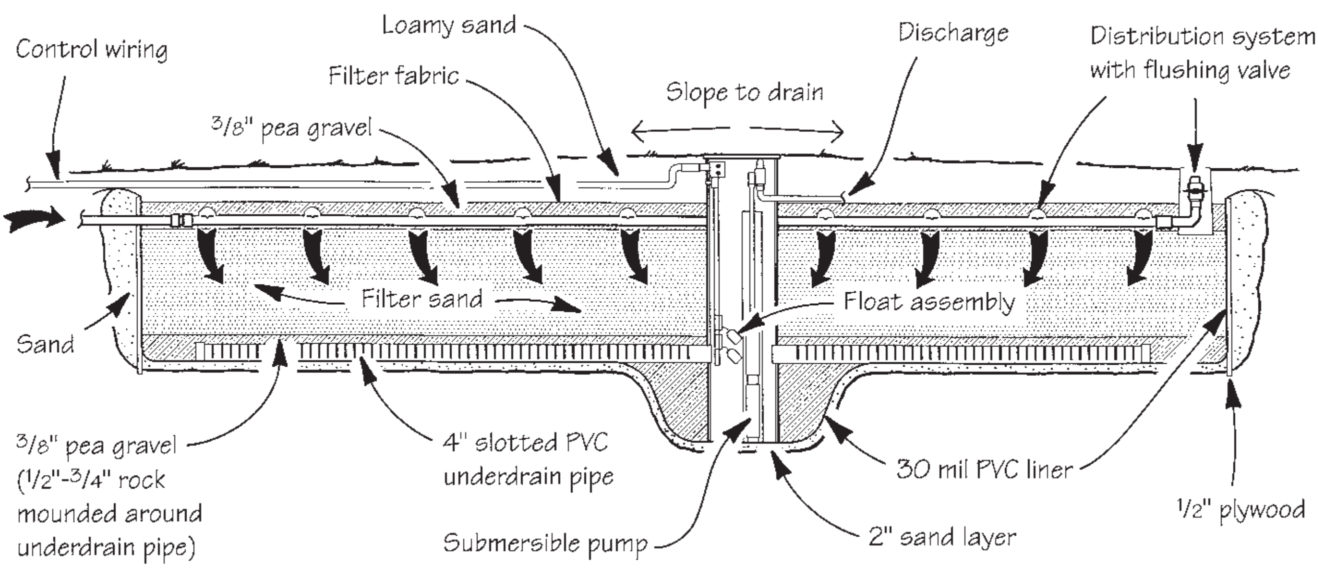

Figure 1. Construction of a sand filter begins with a pressure-treated wood box lined with tough plastic (see photo, page 36), with an optional pump chamber in the center. A foot-deep base layer of gravel is topped by a 2-foot layer of clean sand. Another foot-deep gravel layer supports and covers the grid of emitter pipes (left).

plywood, set about 4 feet into the earth (see Figure 1). It is lined with high-strength 30-mil PVC, the same kind of liner that is used in a landfill. The liner will not decompose, so wastewater can't escape into the environment without getting treated. In the center of the tank is a pump that moves treated effluent out of the filter into a shallow below-ground drain field.

Into the lined box, we placed a layer of gravel for drainage, then 2 feet of high-specification sand. To work properly, the sand should be clean (containing no fine material), with a uniform size between 1 and 2 millimeters. A second layer of gravel is added, the spray grid is installed on top of the gravel, and more gravel is placed on top.

A grade-level hatch allows access to the pump chamber for pump maintenance and also allows us to sample the treated water for testing.

The pump in the septic tank pumps a dose of septic effluent to the top of the sand filter at regular intervals. After a single pass through the filter, waste water that started as gray septic effluent has been turned into clear water.

A sand filter does not have to be below ground. At other sites, such filters have been built above grade. Because a sand filter does not create an odor, you can build it right next to the house, hidden beneath a deck or disguised as a raised flower bed.

In fact, for one lakeside house in West Virginia with no available outside space, we built a sand filter in the home's basement. That system is operating with no problems and produces effluent clean enough to be discharged directly into the lake after disinfection.

Sand filter kits that include all the necessary components except the sand and gravel are available from OSI, Inc. (see "For More Information," page 41).

Biofilter

One step beyond the sand filter is the biofilter, developed at the University of

Biofilter Construction

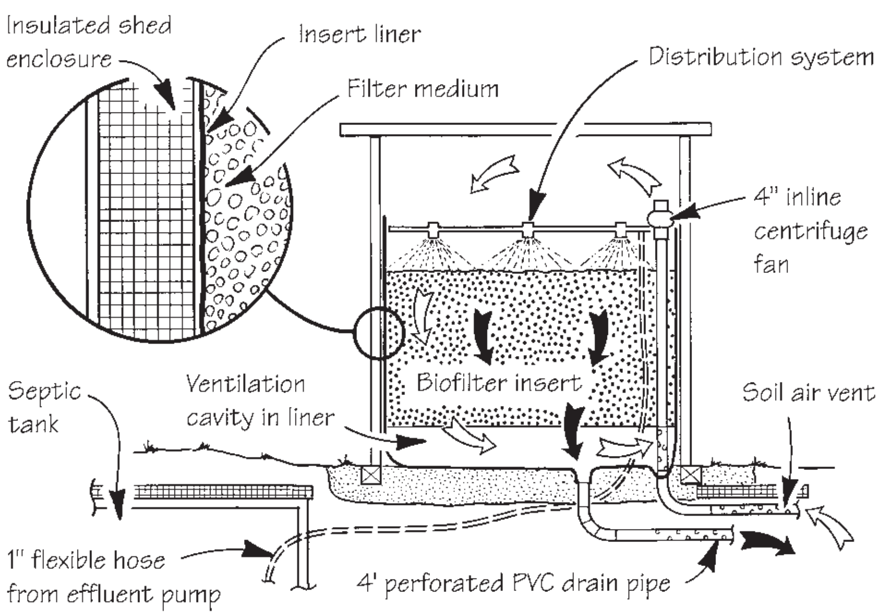

Figure 2. **For the author's EPA-sponsored demonstration project, a Waterloo Biofilter was custom-built in a 6x6-foot aboveground shed on a concrete foundation (above left). Special foam cubes are dumped in by hand (above right). In use, a grid of pipes and nozzles sprays effluent over the cubes (above).**

Waterloo in Ontario, Canada. Instead of sand, this system uses porous cubes of synthetic plastic foam.

Waterloo Biofilters are available as modular units from Waterloo Biofilter Systems, Inc. For above-grade installations, the filters can be placed inside a pressure-treated box. For below-grade installations, the company likes to install them in a concrete box (they will fit inside a precast concrete septic tank unit). Including the pumps and controls, a Waterloo system costs less than $5,000. The primary septic tank, drain field (which can be relatively small), design or permit fees, and any disinfection system that is needed will add to the cost.

Our pilot system in Gloucester is housed in a 6x6-foot aboveground structure that looks like a garden shed (Figure 2). It's an insulated box built of pressure-treated studs and plywood, and, once it's lined with PVC, is like the sand filter. The foam comes in plastic bags and can be dumped in by hand. No backhoe or excavator is required.

In operation, a pump in the septic tank pumps septic effluent onto the top of the foam at regular intervals through a grid of spray nozzles (in our system, about eight gallons of effluent is applied every half-hour). After trickling down through the foam, the effluent is clean enough to be released into the soil (our demonstration system uses a gravity-fed drain field).

We're not sure how long a biofilter's foam medium will last. Some biofilters have been operating for eight years and are still working fine. However, we think the foam may have to be changed after about ten years. But the foam itself does not decompose — it can be washed and reused. When it does need replacing, this lightweight foam is easier to handle than several tons of sand.

However, the sand in a sand filter may never have to be changed if you match the dispersal of waste into the filter to the rate of waste decomposition. I have seen sand filters in California that have

Effluent Disposal

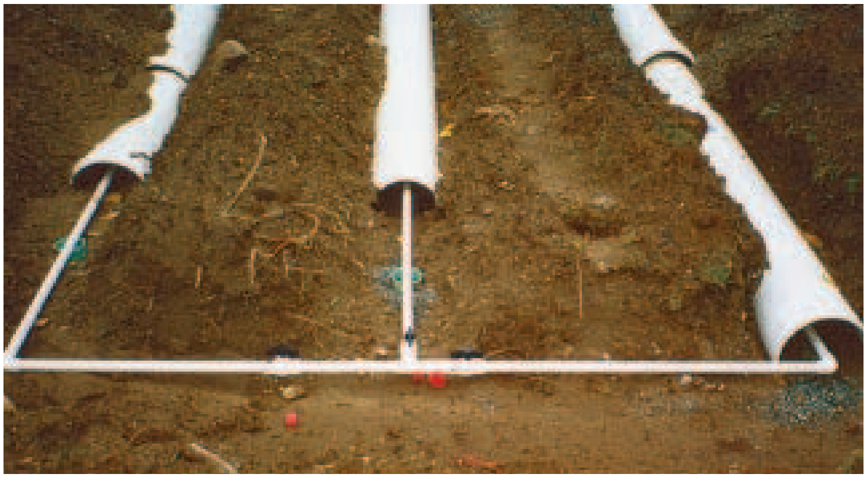

Figure 3. **A shallow pressure-dosed trench can easily handle the effluent from the author's demonstration sand filter (above). Under a half-round cover pipe, pretreated effluent spraying from small holes in the distribution pipe spreads evenly over the sand in the foot-wide trenches. Another method of hauling effluent uses drip irrigation tubes, installed by a tractor (left). Here, the irrigation tubes are ready to be connected to a main effluent line.**

been operating for about 18 years and still produce clear water. On the other hand, I've known sand filters to clog in one year because they were not designed correctly or the septic tank wasn't working properly.

Whether the unit is a sand filter or a biofilter, someone should inspect it once a year. Usually it'll be working fine, but if there is any clogging on the top, you can just take the top layer out and put in some new sand or foam medium.

Disposing of Treated Effluent

Both sand filter and a biofilter reduce the contaminants in septic effluent to low levels. There are two main ways to handle the treated effluent: Discharge it into surface water or into the soil.

Any surface discharge is considered a point source of pollution and falls under the provisions of the National Pollution Discharge Elimination System (NPDES), regulated by federal law. Many states can give NPDES permits for surface discharge, but some can't. In any case, to get a permit to release treated wastewater on the surface, you'll have to disinfect the effluent to kill any remaining traces of fecal coliform bacteria. This requires either a chlorinator/dechlorinator or an ultraviolet disinfecting unit.

The disinfection step adds some cost to the system, but in some cases it may be worth it. In several West Virginia installations, we chose that option and obtained the required permits. The treated water those systems release is harmless to the environment.

In Gloucester, surface discharge was not an option: Massachusetts can't issue an NPDES permit. So we had to put the effluent into the soil. The soil keeps the contamination away from human contact, and provides further treatment that eliminates remaining fecal microorganisms. But the traditional deep trench system, which is very costly, is not as good as the current state-of-the-art systems. There are several new ways to disperse the wastewater into the soil.

In Gloucester, we're experimenting with a shallow trench system. To construct this, we dig a trench about 15 inches deep and a foot wide, then run a 1-inch pipe with evenly spaced spray holes along the top (Figure 3). A pump doses the field with effluent under pressure. Over the top of the system, we place a half-cut PVC pipe, 1 foot in diameter. Then we bury everything. The technique does not require removing or adding any fill, so site disturbance and heavy-equipment costs are reduced.

Codes in many areas may call for an excessively large drain field, based on the idea that the soil is treating septic effluent. But since the effluent we are placing in the ground is already treated, these design prescriptions can be modified.

For example, given the type of soil found at our demonstration site, Massachusetts septic code requires 150 square feet of leach field trench to handle this house's design flow of 330 gallons per day (gpd). But the soil hydrology at our test location indicated that only about 40 feet of trench is technically needed to absorb that quantity of water.

To test out the code's assumptions, we built the code-required 150 feet of trench, but in three sections. The pipes supplying each section can be independently shut off with a ball valve. For 20 months, this system has been relying on only one 40-foot section of drain field. Continuous monitoring of the groundwater next to the trench shows that the system does not contribute any microbial or nitrogen contamination to the groundwater. A 40-foot trench has proved adequate.

With a shallow field like this, people have expressed concern about the pipes freezing. But effluent comes out of the filter at 50°F to 60°F, and the trench is dosed with 10 gallons of that warm water every hour and a half. So far, we haven't had any freezing problem in Gloucester, and people who installed a shallow trench system in Montana tell me that they have not experienced any freezing, either.

Drip irrigation. Another disposal method that has been successfully tested in the southern U.S. is drip irrigation. For this method, the effluent is filtered, then pumped into a grid of plastic irrigation pipes with built-in drip emitters every 2 feet. The irrigation pipe is installed 6 inches below grade with a vibrating plow attachment on a small tractor — no digging is needed. In situations where steeply sloping ground makes a standard trench impractical, drip irrigation lines can be successfully placed along the contours of the slope.

Pretreated effluent from a sand filter or biofilter is much more readily absorbed by soil than is straight septic effluent. Even failed leach fields that have been clogged by septic effluent may still be able to absorb effluent from a sand filter.

In Ontario, Canada, where sand filters have been approved since 1970, the 12x12-foot area under the typical sand filter itself is enough to absorb the treated effluent on many sites, so sand filters often need no additional drain field.

Bells and Whistles

Traditional septic systems have few moving parts — they generally rely on gravity to move the effluent. But the advanced treatment systems I've described need to be equipped with sensors, pumps, and control boxes. The septic tank needs a pump to move the effluent to the sand filter or biofilter, and a second pump may be needed in the treatment unit to pump the effluent into the drain field. These pumps must be controlled by programmable electronic timers and float switches.

Studies show that advanced systems have a high failure rate whenever homeowners fail to maintain them. The pumps and control devices should be regularly inspected and maintained by a qualified technician — in much the same way as heating systems require annual maintenance.

Advanced systems are equipped with alarm systems. A flashing light and a bell or buzzer warns the homeowner if the pumps malfunction and the water level in the tank rises too high or falls too low. In most systems, it is then the homeowner's responsibility to call a service technician.

However, modern communications and computers have allowed these alarms to become very sophisticated. A few systems have been equipped with circuitry to monitor the system's performance and send data to a central computer every day through a dedicated telephone hookup. These units will also automatically dial the service company when a problem is detected, without disturbing the homeowner at all. In my opinion, this automatic monitoring and warning system, which relieves the homeowner of the maintenance burden, is the next step we have to introduce everywhere if we want homeowners to accept the new treatment technology.

Regulations

While sand filters and biofilters have proved themselves effective, they are not always accepted by state and local building officials. Or, where they are accepted, sometimes their capabilities are not understood. For instance, in Massachusetts, sand filters are among the approved technologies for replacing systems that fail state inspections, but the state still requires a large leach field that isn't technically needed for the system to work. Such requirements have been slow to change in many states.

However, when properly operated and maintained, advanced systems like the sand filter and biofilter have been proven effective. Where the state is interested in protecting surface water and groundwater, they can be the best treatment system — or even the only practical system. So as time passes, more and more states are accepting them. To find out about the situation in your state, you will have to contact the state agency responsible for environmental protection. ■

Consulting engineer Anish Jantrania has worked with the Small Flows Clearinghouse and is currently a technical services engineer with the Virginia Department of Health.

For More Information

National Onsite Wastewater Recycling Association
P.O. Box 647
Northbrook, IL 60065
fax: 847/559-9235
Technical and educational material; send inquiries by fax or mail

National Small Flows Clearinghouse
West Virginia University
P.O. Box 6064
Morgantown, WV 26506
800/624-8301
Newsletters, technical and regulatory databases, technical assistance, and lists of equipment suppliers and technical consultants

OSI, Inc.
814 Airway Ave.
Sutherlin, OR 97479-9012
541/459-4449
Sand filter kits, pumps and control systems, design specifications

Waterloo Biofilter Systems, Inc.
2 Taggart Court, Unit 4
Guelph, Ont. N1H 6H8, Canada
519/836-3380
Modular Biofilter units, design, and installation