BEYOND THE BASIC SEPTIC SYSTEM: PRACTICAL ALTERNATIVES

by Bruce Coldham

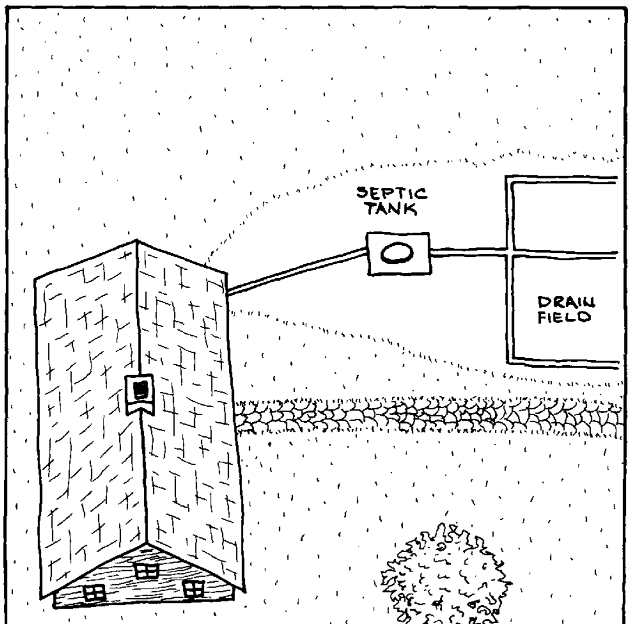
New solutions tackle marginal sites and concerns over groundwater

Since the late 19th centurv. when bathrooms moved from the garden to the back of the house, the main goal of wastewater treatment has been to keep the organic solids from becoming smelly and infectious. With the growing environmental concern today comes a second goal—to avoid groundwater contamination. The nitrates and phosphates found in domestic effluent (wastewater) must be contained.

The basic septic tank and soil absorption system, which graces almost one-third of all U.S. housing, is the time-honored, on-site solution to achieving goal #l. But, in its current form, it does little to satisfy the second. A 500- to 1,500-gallon tank receives sewage, and holds it for a few days during which its contents separate. The scum floats, the sludge sinks, and a clarified solution (basically water) that is left in between is pushed out into the drain field by the force of the most recent flush. The critical component is the absorption capacity of the drain field. It takes the form of either a line, bed, or pit. A pit is preferred if site conditions permit because it is cheaper and can last longer. But it's often not possible. In fact, only about 32 percent of the land area of the U.S. is suited to *any* form of drain field. Sites are rated unsuitable for many reasons, including high ground water, ledge, aquifer sensitivity, and steep slopes.

Lastly, as housing densities are everywhere increasing, there is pressure to down-size, eliminate, or consolidate drain fields.

So the good old septic/soil absorption system is on the ropes. What would Joe Palooka do—apart from getting out of the ring? Well, there are two approaches we'll consider here: improvements in drain field design, and improvements in the overall septic system design. (A third alternative, which disposes of the sewer entirely, seems an unlikely solution for all but the most committed householder—see "Composting Toilets: Not for Everyone.")



The critical component in the typical septic system is the drain field. Improving its absorption capacity can make a difficult site buildable, but it won't reduce environmental pollutants, such as nitrates and phosphates.

Improving the Drain field Design

The drain field receives clarified sewage and discharges it into the soil, where its biodegradable components are broken down. But first, the effluent must move through a mature layer of soil, which acts as a filter—or an obstacle if it gets too clogged up. By "articulating" this layer with nooks and crannies you can increase the size of the discharging surface (visualize the difference between the surface of a 2x4-inch piece of tissue and a 2x4-inch egg carton), avoid clogging, and increase the efficiency of soil absorption. The drain field's efficiency can also be improved by making sure the *distribution* of effluent across the field is even, rather than heavy in some places, and light in others.

There are several drain field systems available in the Northeast that claim these improvements. They promise up to four times the efficiency. These new drainage modules are constructed of concrete, fiberglass, and plastic, and make it easier to construct a leach line, especially on sloping sites, because they eliminate the need for trenches of washed stone. As far as the codes are concerned (in Massachusetts, at least) drainage modules are "unofficially" approved. In some cases, however, the inspector requires that the washed stone be installed as well, which can blow away any money saved. About the systems specifically:

Ecol-Clean. This system relies upon 10-foot-long concrete leaching channel modules, which are available in three

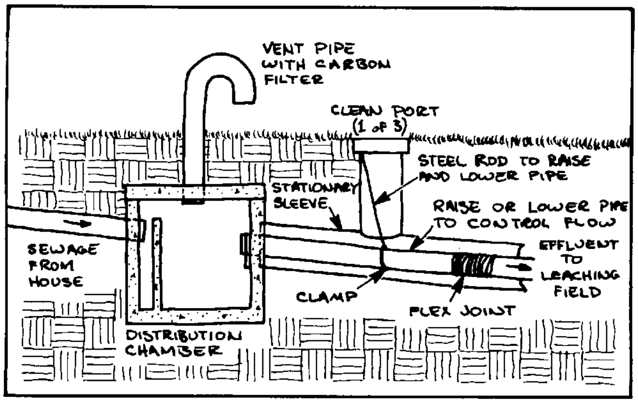


Figure 1. *The "Ecol-clean" system lets you easily "rejuvenate" a clogged channel without interrupting use of the system. By elevating the feed pipes, you stop flow into the channel, allowing it to dry out. The section is then brushed out and put back in service.*

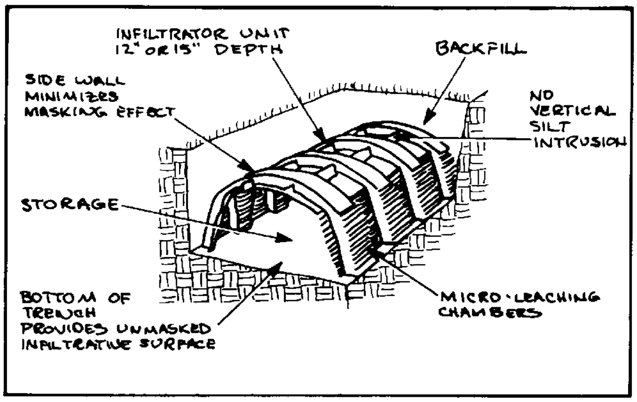


Figure 2. *"Infiltrator" modules, made of molded plastic, are light enough (33 pounds) to be placed by hand. They promise up to three times the efficiency of a gravel trench.*

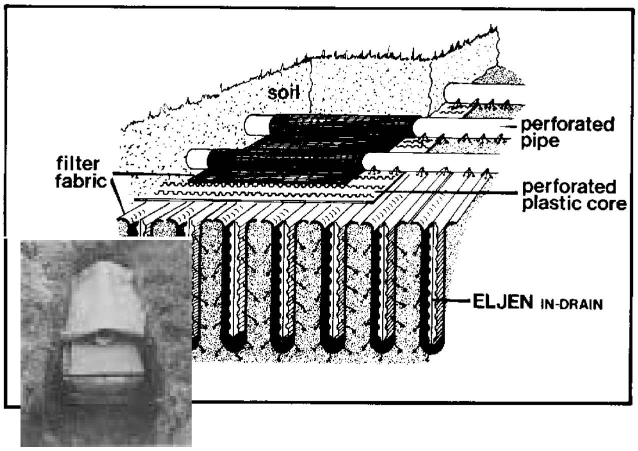


Figure 3. *The waffle-like sections used in Eljen's "In-Drain" system add dramatically to the amount of surface available for absorption. The plastic sections, wrapped in fabric (photo inset), are laid in parallel in the sand. A perforated plastic pipe-and-core material, and filter fabric, go on top.*

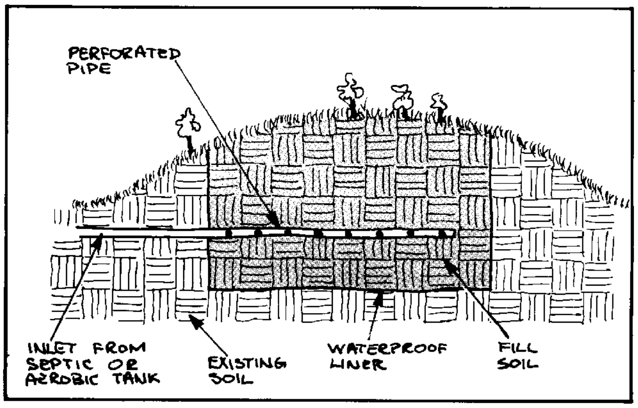


Figure 4. *When a conventional absorption field is not possible, one alternative is to use "evapotranspiration" —the process by which trees and plants absorb moisture from the soil and evaporate it to the atmosphere. A sand bed, which can be mound or level, is lined with plastic or other waterproof material. The liner prevents the effluent from passing through the natural soil, forcing it to evaporate. The plant canopy above speeds the evaporation.*

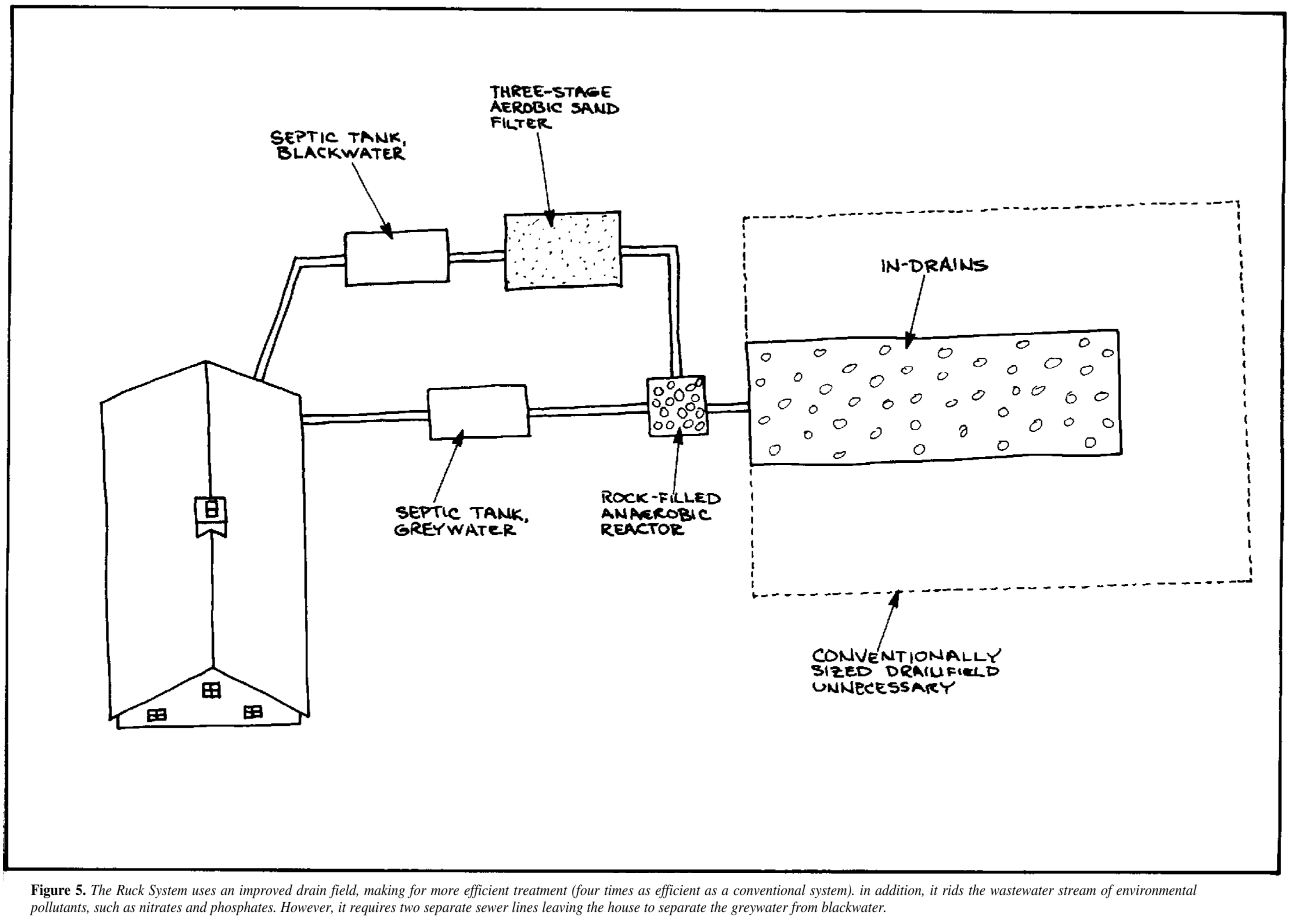


Figure 5. *The Ruck System uses an improved drain field, making for more efficient treatment (four times as efficient as a conventional system). in addition, it rids the wastewater stream of environmental pollutants, such as nitrates and phosphates. However, it requires two separate sewer lines leaving the house to separate the greywater from blackwater.*

sectional sizes from 18x36 inches to 48x48 inches. A good feature of Ecol-Clean is the ease with which a clogged channel can be rejuvenated. You don't have to dig the whole thing up. Each channel is fed by a 4-inch diameter pipe from a distribution box. The feed pipes can be elevated to stop flow into a given channel, allowing that particular section of the drain field to dry out. The drain field modules can then be brushed out rather like a sweep cleans out a chimney (see Figure I).

Infiltrator. This is similar in concept, except that the drainage modules are of molded plastic. They are therefore light enough to be placed by hand, but still strong enough to withstand a dump truck—if that's where you want to park it (see Figure 2).

In-Drain. The modules in this system consist of waffle-like, fabric-wrapped, plastic-cored sections 48 inches long, 5 inches deep, and about 18 inches wide. These are laid in parallel in sand with a perforated plastic pipe-and-core material over it, and a filter fabric over that (see Figure 3). The waste flows across the distribution layer, down the plastic core of the filter bags, and out through the fabric into the sand. Again, this is a lightweight system which can be placed by hand.

In some situations where the subsurface conditions limit soil absorption, wastewater can be returned directly to the natural water cycle by evaporation, and by transpiration ("breathing") through plant foliage. This is generally known as *evapotranspiration* (see Figure 4) and it requires conditions of high temperature, low humidity, wind, and a lengthy growing season to work well. As such, it is better suited to the Southwest than the Northeast.

The drain field is the critical component of a good septic system, but the tank itself should not be neglected. What should you look for in good tank design? Well, its objective is to reduce the B.O.D. (biological oxygen demand) and to remove suspended solids. Therefore, minimal turbulence in the tank is an asset. Shallow tanks with greater surface area are preferred, and recent trends favor multiple compartments rather than single compartments.

The Ruck System

So far we have made some unsuitable sites suitable and improved the quality of the soil absorption. But the contaminating nutrients are still flowing free.

The Ruck System is a passive, underground wastewater treatment system which removes these nutrients—nitrogen (75 percent) and phosphorous—from the wastewater. It features separate "black" and "grey" water streams to two separate (smaller) septic tanks. This of course means that there are *two separate sewer lines* leaving the house, with waste pipes from sink and wash basins running separately from the waste pipes which are hooked to the toilet bowls (see Figure 5).

For those with a biological bent, here's how it works. The black water stream from its septic tank passes through a three-stage sand filter where the nitrogen is oxidized; (nitrogen to nitrate). This is called nitrification and it acidifies the wastewater. These acid conditions in the sand filter enhance phosphorous and micro-organism removal. The anaerobic greywater effluent stream from its septic tank is combined with outflow of the sand filter in a rock-filled anaerobic reactor. Here denitrification takes place, releasing nitrogen to the atmosphere. The denitrification process adds alkalinity to the effluent stream restoring a neutral pH. The effluent passes to a seepage field containing "In-Drains" (see above), which provide the same infiltration surface as a conventional field up to four times larger.

A total of about 100 of these have been installed in the Northeast since 1977. They have generally performed quite well. The system has been approved by the relevant agencies in Connecticut, Rhode Island, New Jersey, and Maine on a case-by-case basis. Other state regulatory bodies are monitoring various Ruck system installations with a view to setting standards for their use. Dr. Rein Laak, who has developed the Ruck system over the past ten years, describes the advantages of his system. He rates its low maintenance and zero energy use highly, along with its vastly improved capacity to remove eutrophying (phosphorous and nitrogenous) pollutants. And, he adds, "you can safely develop at greater density—Ruck systems have been approved for lots in the Pinelands of New Jersey down to 1.5 acres. A conventional septic system would have required 3.7 acres." By safely allowing a more economical land use, the system contributes to savings on roads, gasoline, utility lines, and perhaps—to less consumption of valuable farmland.

The New Alchemy Institute in Falmouth, Mass., has been researching on-site wastewater treatment options for two years, and after evaluating them on the basis of several factors—public health, environmental quality, public acceptability, cost, and energy use—they chose the Ruck system. (See table, next page, for their cost data.)

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What Does the Future Hold?

Conservation. The first element in improving waste treatment efficiency ought to be flow reduction, especially using water-saving toilets, metering-type showers with low-flow heads, aerated faucets, and lower water pressure. (See "Focus on Energy," *NEB* 11/87 for info on low-flush toilets.) These elementary water saving technologies, along with some basic prudence on the part of the occupants, and timely maintenance of leaks, can cut domestic water consumption in half. However, most controlling authorities ignore: these conservative gestures and routinely size systems according to the number of bedrooms in the house. This situation is ripe for change. The Commonwealth of Massachusetts is about to mandate low-flow toilets (in the Boston area at least) in an effort to stretch the: existing water supply. It makes sense to have gallons, rather than bedrooms, determine the size of septic system components.

Mid-scale systems. The incidence of planned unit development, multi-family condominiums, and cluster development is increasing. A recent issue of *The Atlantic Monthly* reports that 10 percent of the U.S. population lives in clustered planned unit developments, These will require mid-scale opera.-tions—smaller than standard municipal systems but larger than the on-site techniques discussed here. As the scale of on-site treatment increases, a wider range of treatment options will emerge:

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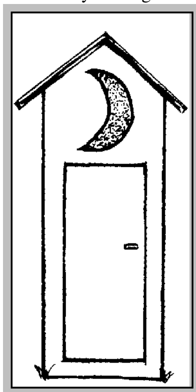
Emerging techniques. One technique of particular interest is Solar Aquatic Wastewater Treatment. These SAWT systems are proven in applications in the Southwest, but John Todd (Ocean Arks International) is pioneering the introduction of these to the Northeast. SAWT systems employ solar energy in the form of heat and light drive a number of aquatic eco-systems that transform the sewage wastes to various forms of biomass. The end product is a very high quality effluent (suitable for re-use for things like flushing toilets, etc.), a harvest of potential commercial value (plants and/or fish), and virtually no sludge (a real bonus as landfill costs skyrocket).

A similar system is being developed Bill Jewel1 at Cornell University. Jewell observes that "...currently most sewage treatment systems use aerobic bacteria and a large amount of energy for first-stage treatment and end up with a lot of sludge." In Jewell's system the initial stage of anaerobic treatment gets rid of most of the suspended solids and some of the toxic materials. The wastewater is then ready for hydroponic agriculture using a "nutrient film" technique—plants are grown in a series of long, shallow troughs, or gutters. The hydroponically grown plants remove nutrients, and most of the remaining pollutants, from the



Composting Toilets: Not For Everyone

Back in the late 60s and early 70s, many environmentalists sought to solve on-site sewage problems by eliminating the sewer altogether. The solution took the form of composting toilets. The desired process for composting toilets is "aerobic, thermophilic, biological decomposition." Despite the fancy vocabulary, however, a method of handling the grey water stream is still needed.

Usually this means a septic system, which, in order to satisfy code, must be capable of handling the *entire* domestic wastewater load. Moreover, composting toilets have a record of poor performance. Failure is principally due to fluid buildup in the composting chamber, causing anaerobic (no oxygen) conditions to develop. Add to this that they frequently run too cold, too acid, or at the wrong carbon/nitrogen balance, and you begin to hesitate hooking one of these privies up. The California Department of Health Services reported "...based on field observations and laboratory testing, none of the 34 composting toilets studied successfully performed their function."

Zero out of 34! Things are looking grim for the sewerless option.

Of course, the committed owner can get these units to work through careful management. Bernard Kaplan of Westbrook, Conn., has been using two of these for ten years and is looking forward to the next ten. "It works fine," he says, "although there are a couple of drawbacks." There is a bit of fluid buildup in one of them which he drains once a year, and he "shakes the pile in the other every now and then" (once a year). In ten years, he has emptied the chambers only once. But in general, it seems that the operation and maintenance requirements of composting toilets are best left to the more committed type. — BC

Treatment System Cost Comparison

Option	Construction Cost ($/dwelling)	Operating and Maintenance Cost ($/year)	Energy Use (Kwh/day)
Standard septic system	2,500 to 8,000	25	0
Composting toilet (with septic greywater system)	11,000 to 16,000	0 to 190	0 to 3.0
Ruck system	6,000 to 10,000	25	0
Constructed Wetland	11,000 to 16,000	90	?

wastewater stream. It does it very quickly, and in the process, it produces a marketable combustion product.

At our latitude in the Northeast, both these hydroponic-based options require a climate-tempering enclosure—a greenhouse. That's expensive. Another alternative for small communities and residential clusters is an artificial marsh, or "constructed wetlands" system. It uses marsh growth, such as cattails and bullrushes, instead of floating aquatic plants, to take up the nutrients. A greenhouse is not required, but it takes a greater land area (approximately 300 square feet per dwelling). Pio Lombardo of Lombardo and Associates, a Boston-based engineering firm, believes that these have a future in the Northeast. (See New Alchemy's cost data in table.)

Mixed Reviews

If you build a better mouse-trap, the world will rush to your door, we are told. But in the case of septic systems, improved design brings a mixed crowd—some enthusiastic and some outright hostile. For the humble perc test has become one of the more powerful land-use controls.

Improvements that reduce groundwater contamination will generally be well received. But ironically, by enabling development on previously unbuildable sites, the same improvements will aggravate others. Although they potentially reduce development pressure on valuable farmlands, some concerned citizens fear that they will be used simply to create more buildable sites. Others just don't want a new neighbor. ■

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Septic System Resources:

Drain-Field Module Manufacturers:

Ecol-Clean leaching system by J.F. Flynn Co. of Concord, Mass., 617/369-5514

Infiltrator system by Infiltrator Systems of Old Saybrook, Conn., 203/388-6639

In-Drain system by Eljen Corporation of Storrs, Conn., 203/429-9486

Books and Manuals:

EPA Design Manual: On-Site Wastewater Treatment and Disposal Systems, by R. Otis, et. al., EPA-625/1-80-012, 1980.

Home-Scale Wastewater Treatment Systems, by T. Montgomery, New Alchemy Institute Technical Bulletin No. 6 NAI, Falmouth, Mass., 1987.

Septic Systems Handbook, by O.B. Kaplan, Lewis Publishers, Chelsea, Mich., 1987.

Other Resources:

Alternative Wastewater Management Association, P.O. Box 32240, Washington, DC 20007.

Four Elements Corporation/Ocean Arks International (SAWT), 10 Shanks Pond Rd., Falmouth, MA 02540; 617/548-8161.

Dr. William J. Jewell (Anaerobic Treatments). Cornell University, Ithaca, NY 14853.

Dr. Rein Laak PE (Ruck System), 149 Browns Rd., Storrs, CT 06268; 203/486-4014.

National Sanitation Foundation. Ann Arbor, MI 48104; 313/769-8010.

National Small Flows Clearinghouse, 258 Stewart St., West Virginia Universitv, Morgantown, WV 26506; 800/624-8301.

National Environmental Health Association, 1200 Lincoln St., Suite 704, Denver, CO 80203.

New Alchemy Institute, 237 Hatchville Rd., E. Falmouth, MA 02536; 617/564-6301.

Rocky Mountain Institute *(Water Savers Handbook),* 1739 Snowmass Creek Rd., Snowmass, CO 81654; 303/927-3128.

Thetford Corporation (Cycle-Let), P.O. Box 1285 Ann Arbor, MI 48106; 800/521-3032.

Dr. John Todd (see Ocean Arks International).