

Pipeline



Small Community Wastewater Issues Explained to the Public

Alternatives to Gravel Drainfields

More than one-fourth of all American homes use some type of onsite wastewater treatment system, and thousands of new onsite permits are issued each year. The most common system involves a watertight septic tank followed by a conventional subsurface soil absorption system. Soil has a considerable capacity to transform and recycle wastewater. Subsurface soil absorption systems are reliable and the least expensive disposal option.

Septic systems are wastewater treatment systems that collect, treat, and dispose of wastewater generated by homes or businesses. Inadequate treatment of sewage allows bacteria, viruses, and other disease-causing pathogens to enter surface and groundwater.

The conventional septic system consists of two main parts: a septic tank and a soil absorption system, also known as the drainfield. The drainfield provides the final step in the wastewater treatment process. A standard field is a series of trenches or a bed lined with crushed stone or gravel and buried one to three feet below the ground surface. Perforated pipes or drain tiles run through the trenches to distribute the wastewater onto the aggregate. See the diagram at right.

The primary purpose of the drainfield is to efficiently deliver effluent to the soil for absorption and subsequent treatment. Bacteria and viruses in the effluent are removed by filtration and naturally occurring microscopic

organisms. Nutrients are absorbed by soil particles or taken up by plants. However, these processes only work in soil that has air in it; the soil cannot be saturated with water.

Traditional drainfields use gravel or crushed stone and perforated pipes as a means to deliver the wastewater to the soil. Gravel provides structural support for the excavated trench, storage capacity during peak wastewater discharges, and a home for the growth of a bacteria layer where the treatment of the wastewater occurs.

Across the U.S., engineers call for the use of aggregate (usually rock chips called gravel, most often crushed limestone) in association with onsite wastewater systems in many capacities. Gravel is the most common media used in soil absorption trenches. Gravel and sand are the main elements in subsurface-flow

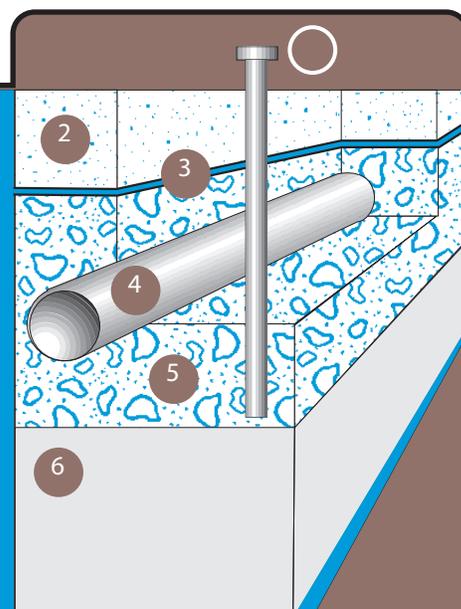
constructed wetlands. There are many advantages to using rock chips in these situations; it is generally available and reasonably priced. But there are regions of the country where gravel is scarce, therefore expensive, and existing supplies are being used up by the construction industry, thus the hunt for alternative materials for use with onsite systems.

Properties of drainfield media

There are certain physical characteristics that an aggregate should have in order to be an effective media in a wastewater distribution system. An aggregate used with onsite wastewater treatment systems must be able to be crushed or chipped to meet certain size specifications, yet not contain too many "fines"—tiny particles that can

Figure 1

- 1 Inspection Port
- 2 Soil Backfill
- 3 Barrier Material
- 4 Perforated Distribution Pipe
- 5 Gravel/Alternate Aggregate
- 6 Original Soil



block flow between the larger pieces. The aggregate should be reasonably priced and handy to the location. (The shipping cost for hauling gravel over long distances is one of the detriments to using that media in some parts of the country.)

Another required characteristic of a good media is that the chips or pieces must remain separate from each other (in other words, not pack down) to allow the flow of water through the substrate. Effective media should not react chemically with the water or degrade over time.

Most natural aggregates are obtained by quarrying, which produces a number of environmental problems. Quarrying creates large cavities in the landscape and the mining and processing produces noise and dust pollution. At the same time the gravel sources have become scarcer and more expensive, a search has begun for the re-uses of bulky products such as used tires, glass, and concrete rubble, instead of sending them to a landfill. These products have poten-

tial as being excellent substitutes for common gravel in onsite wastewater treatment systems. This issue of Pipeline will investigate the use of crushed glass, broken concrete, and rubber tire chips to replace gravel in areas where the supply is limited. Gravelless drainfields systems as optional effluent treatment are also presented.

Shredded Tires

Worn automobile tires have been accumulating at an alarming rate. A small percentage of these tires are recycled into other rubber-based uses; shredded or chipped tires are being used for a wide variety of products including playground covers and doormats. But an estimated 250 million tires are discarded annually in the United States. This equals about one tire per person per year. The disposal of these tires presents a difficult problem for solid waste authorities.

There are several drawbacks to discarding used tires into landfills: Whole tires sent to landfills require a large amount of space, tires tend to float or rise in a landfill and come to the surface, and the void space provides potential sites for rodents and mosquitoes. In response, a variety of innovative research projects have attempted to find good ways to use them. Tire chips as a substitute for stone aggregate in septic system drainfields is one of these possibilities.

The number of discarded tires used in onsite systems is significant. For example, approximately 30 percent of used tires in Oklahoma are now being used in septic systems.

Tires can be cut into small pieces by various techniques, and the physical characteristics of the tire chips, such as size, wire protrusion and fines can be controlled. Tire shreds are stable in composition, meaning they do not break down into other elements and other elements do not leach from them when exposed to the sun and water over time. There seems to be no difference in performance between new and used tire chips.

Tire chips are three times lighter than stone aggregate (i.e., a cubic yard of stone aggregate weighs 2,800 pounds



Problematic discarded tires can be turned into useful drainfield media.

compared to a cubic yard of tire chips that only weighs 800 pounds), making it much easier to work with. Tire chips are much cheaper than gravel and have the added benefit of not creating dust. (Dust is a nuisance and health concern associated with the production and transport of gravel). There is no significant compaction of the shreds; therefore, 12 inches of tire chips equals 12 inches of gravel. Porosity (the desirable quality of large open spaces between the individual pieces) was found to be higher with tire chips than stone.

More than 17 states currently permit the use of tire chips or shreds as a substitute media in septic system drainfields. The major differences in state regulations are in the percent

of tire chips meeting specifications required and the oversight, inspection, and/or certification of the tire chip specifications. Regulations in states where tire chips are approved as a substitute for stone aggregate in onsite systems require them to be of similar size as stone aggregate (approximately 2 inch pieces), with wire protrusions of one-half inches or less.

Concerns for tire chip use include the handling of the chips with protruding wires. Thick gloves and appropriate clothing and boots are required for handlers. Current tetanus protection is also advised for workers. A layer of geotextile fabric should be placed over the tire chips in the trenches before being buried with soil.

Performance studies have been conducted, comparing drainlines using gravel to ones using tire chips. Due to the higher porosity of tire chips, less ponding was recorded. In fact, tire chips increase the drainfield storage capacity by 30 percent because the void space between the tire chips is greater than the void space for gravel (60 percent for tire chips; 40 percent for stone).

Several studies have shown that effluent showed similar values for most of the important biological parameters used to measure effectiveness (such as biological oxygen demand, total suspended solids, ammonia-nitrogen, nitrate, fecal coliforms, and pH), were similar for the gravel and the tire chips in the trenches. Actually, these trials have been so successful that the demand for tire chips has grown faster than the number of processors; in some areas, making tire chips a scarce commodity.

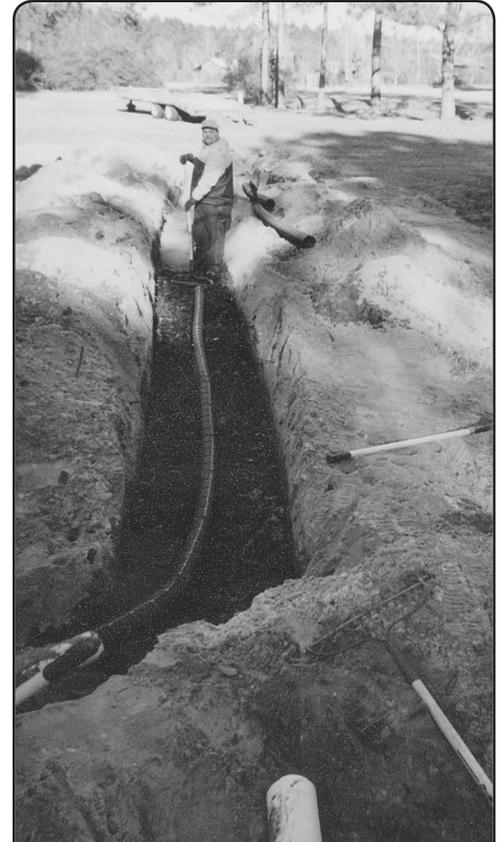
Using tire chips as an aggregate in onsite systems has gained favor in many states. It would seem to be a win-win situation if a beneficial use could be found for a material that has been an environmental liability. While tire chips are a proven alternative to gravel, it will be up to approval from appropriate state agencies to allow the market to expand to its fullest.

Recycled Crushed Concrete

Another promising substitute for common gravel for use in drainfields is recycled crushed concrete (RCC). Waste concrete makes up more than 50 percent of all demolition waste. The recycled crushed concrete results from the demolition and subsequent crushing of such structures as curbs, sidewalks, parking lots, and buildings. There have been many uses developed for this product (ranging from driveways, road base and as rip rap along waterways as an erosion barrier) rather than disposing of it in a landfill. There are companies who deal exclusively in recycled concrete, replacing native stone with cost saving recycled aggregates.

In the early 1990s, two Florida counties (Duval and Volusia) had given local approval for the use of RCC as media in onsite wastewater treatment drainfields, although neither county had actually evaluated the product's performance. As the state's concrete recyclers requested state-wide approval, state environmental specialists conducted field evaluations to determine the reliability of RCC in place of conventional aggregate.

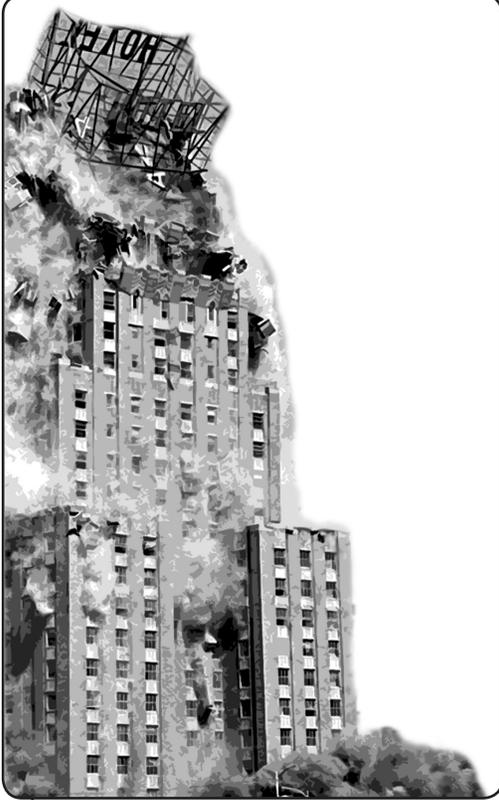
RCC appeared to have all the qualities required of an effective media:



Bottom layer of trench with six inches of tire chips and four-inch pipe.



Pipe covered with two inches of tire chips.



Controlled demolition of abandoned buildings creates tons of rubble. If graded and sized properly, this waste material can be used as a substitute for native gravel in drainfields.

it could be crushed to specific sizes with few fines, retained good porosity, and had strength so it would not pack down after installation. Anecdotal observations suggested that the concrete pieces were becoming cemented together upon exposure to effluent, restricting the movement of the wastewater through the media. The important question was: did the RCC break down when exposed to effluent, reducing the effectiveness, causing the drainfields to fail?

An investigation into the performance of 45 systems that were using RCC as drainfield aggregate was undertaken. The systems in the study were both subsurface soil absorption installations and sand mounds systems.

Of this group only two systems were actually classified as failing (4.4 percent). The report defined failure as: any system that had been expanded beyond the original installation, sys-

tems replaced after the original system displayed obvious signs of failure (effluent surfacing, sewage backing up into household plumbing). A third definition of impending failure included systems with effluent ponding above the perforated pipe inlet.

It was concluded that the failed systems had used inappropriately sized RCC which included significant 'fines.' The smallest particles had worked their way down to the bottom of the trench, packing together and restricting the flow, eventually forcing the effluent back up to the ground surface. The systems that used RCC from crushing facilities with superior quality control were experiencing no difficulties and were producing a high quality effluent.

Researchers concluded that there were no signs of deterioration of the concrete chunks in the trenches. As long as quality control is of the highest standards in the production (i.e., fines are controlled), RCC is an effective substitute for ordinary gravel in soil absorption systems.

Recycling of waste materials eliminates the disposal costs associated with the material, and reduces the demand for virgin material. In addition, supplies of natural mineral aggregates are diminishing as their usage increases. From the previous discussions, it appears that wastewater engineers can consider using recycled products such as tire chips, crushed glass, and broken concrete for media in drainfields with confidence as long as their state regulations allow for their use.

Crushed Glass

A study in the state of Washington was recently initiated to evaluate the use of crushed recycled glass for the biological treatment of residential wastewater. The primary focus was a direct comparison between two biological filters: the first using standard sand as the treatment medium and the second using crushed recycled glass.

The researchers were hoping to seek

approval to use crushed recycled glass in place of sand for intermittent sand filters from the state's technical review committee. There were two points of interest for this effort: the state of Washington has large stockpiles of recovered glass that are very under utilized, and sand of suitable quality is not available in all areas of the state.

The researchers anticipated that a demand for excess waste glass as filter media would increase to the point where portable crushers would be developed for rural collection sites to provide a local market for the glass. Just like gravel, it is not cost-effective to transport glass for any distance.

The sand is not simply a mechanical filter. Other benefits of the sand layer include slowing the flow of the effluent and providing a surface for the microorganisms which break down the organic matter and remove pathogens.

Sand filters have proven to be quite effective in the treatment of residential wastewater, producing very clean effluent. Sand filters are one of the best options for additional onsite treatment where septic tank/soil absorption systems have failed or are restricted due to high groundwater, shallow bedrock, poor soils, or other site restrictions.

A residential sand filter sewage treatment system generally consists of a standard septic tank, a sand filter and a disposal system (drainfield). The septic tank allows the solids to settle out and the floating scum is removed. The effluent is dosed evenly over the sand bed. The sand filter is usually lined and the effluent is drained off at the bottom and sent on to the drainfield for final treatment.

Excessive biomat development is the main cause of sand filter failure. The smallest of the sand particles move together and pack down as the effluent flows through. These areas of packed "fines" restrict the movement of the effluent, encouraging the formation of a biomat. Eventually,

the filter clogs completely and does not allow any water to flow through, requiring the filter to be repaired. Reducing the quantity of fine material should increase the functioning life of the filter system

In addition to the problem with "fines," sand of the best quality is not readily available in many parts of the country. The availability of appropriate filter medium has the greatest impact on the construction cost of sand filter systems. If crushed recycled glass can extend the life of the system, is cost competitive and is readily available, it would be a bonus to both the recycling and construction industries.

A "split-filter," which is effectively two filters installed side by side, was installed at a private single-family home that had a history of system failure. The site had poorly draining underlying soil and a history of high ground water. Equal portions of sand and crushed glass were loaded into the filter. One half of the filter was filled with sand, and one half with glass ground to a similar specification. The filter was monitored for two years and the output was analyzed for various biological and chemical values.

The overall performance of both filters was exceptional, with the sand filter only slightly out-performing the glass filter for biochemical oxygen demand, and total suspended solids (refer to Table 1.) The minor differences in results were not considered to be significant. The researchers determined that there was no clear indication that the glass is any better or worse than sand medium. There were several reasons for preferring glass however, including much higher infiltration capacity and pore space, cleanliness, and use of a "low value recycled product."

Gravelless Systems

In areas of the country where good quality, native gravel is scarce or prohibitively expensive, designers and contractors might consider installing a gravelless drainfield system where permitted.

Gravelless systems can be designed for a variety of homesites and under various conditions. These systems require the same maintenance as traditional drainfields and should include ports for inspection and clean out.

As the name suggests, a gravelless systems is an onsite system that does not use gravel in its drainfield trenches or beds. Instead, these systems use large-diameter, fiber-wrapped pipe, expanded polystyrene foam, or chamber technology.

Advantages of gravelless and chamber systems include faster installation and increased volume of void space per unit length compared to conventional gravel-filled trenches. Soil compaction is reduced since the need to use heavy equipment to haul and place gravel is eliminated. They are also good for remote sites where transport options are limited.

This alternative media functions similarly to gravel by supporting the perforated piping, storing a heavy surge of effluent until the soil can absorb it, and helping to distribute the wastewater along the length of the trenches.

Some of the gravelless systems use special pipes which are corrugated and slotted, and/or wrapped in special filter fabric. Chamber systems use molded high-density plastic seg-

Table 1
Alternate Aggregates (mg/l)

Source	BOD ₅	TSS	O&G	pH
Glass Medium effluent	7	4	6	6.4
Sand effluent	4	3	4	5.8

BOD = Biochemical oxygen demand
TSS = Total suspended solids
O&G = Oil and grease

Source: *Crushed Glass as a Filter Medium for the Onsite Treatment of Wastewater 1997*

ments. Both pipes and chambers must be made of materials not subject to decay, and must have a load bearing capacity of more than 1,000 pounds per linear foot.

In gravelless chamber systems, chambers are made of a sturdy plastic molded into a dome shape in six foot lengths with an open bottom; the sides of the chamber forms are slotted to allow for the seepage of wastewater into the soil. Some systems include pipes within the chamber, others do not. Chambers vary in width from 15 to 36 inches. Native soil is used as backfill instead of gravel. The depth of a gravelless trench with a chamber system must be equal to the height of

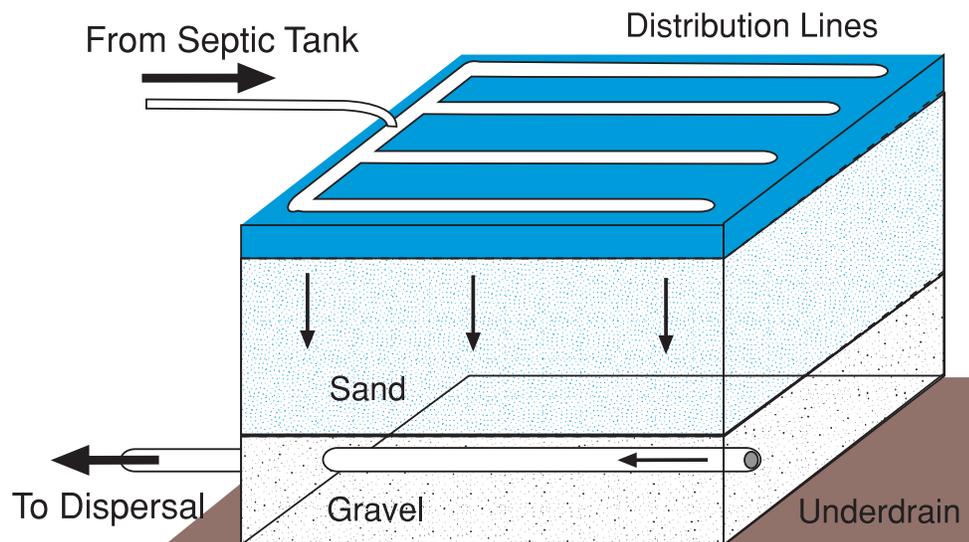
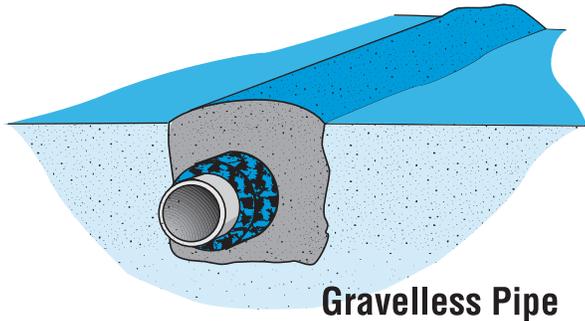
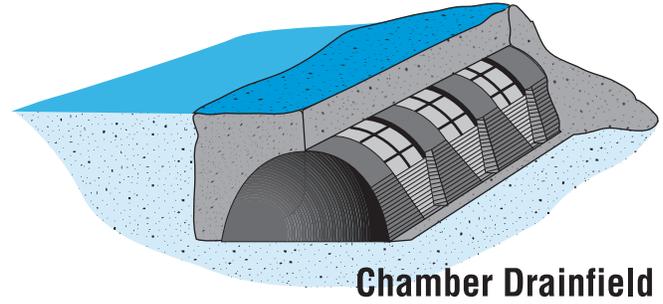


Figure 2



Gravelless Pipe



Chamber Drainfield

the chamber plus eight to 36 inches. Since these chambers are commercially produced and vary from company to company, manufacturer recommendations should be followed regarding system installation, design, operation and maintenance.

One advantage of the chambered system is its ability to hold much larger amounts of water than traditional gravelled drainfields. This is useful in areas where the water table can rise close to the surface and in situations when there is a temporary surge of effluent, as a result of extra guests for instance.

In states where these pre-fabricated chambers are permitted, the required drainfield area using chamber systems may be allowed to be smaller than that for conventional systems, in many instances, up to 40 percent smaller. This is an important advantage for property owners with small lots, but if space is available, it is recommended to construct the maximum drainfield. The reduced size of the drainfield can also provide more spacing between the drainfield and sensitive areas, such as water bodies, wetlands, or depressions where the depth to groundwater may be shallow.

Because the chambers are lightweight, heavy equipment is not needed to haul the media to the installation site. The light weight media is easier to handle, which can reduce labor costs and allows the systems to be constructed in areas inaccessible to heavy machinery. The chambers are flexible, allowing them to conform to curved trenches.

A key disadvantage of leaching

chambers is that they can be more expensive than gravel drainfields if a low-cost source of gravel is readily available.

Maintenance requirements for these gravelless systems are similar to those for standard aggregate systems. Follow a routine tank pumping schedule, maintain lawn grass over the trenches to encourage evaporation, prevent heavy equipment from driving over the drainfield to keep from crushing the chambers, and conserve water to prevent overwhelming the system. The Summer, 2001 Pipeline titled "Gravelless and Chamber Systems: Alternative Drainfield Designs" provides more information about these innovative systems.

References

"Analysis of Tire Chips as a Substitute for Stone Aggregate in Nitrification Trenches of Onsite Septic Systems," Small Flows Quarterly Fall 2003. Volume 4, Number 4.

"Crushed Glass as a Filter Medium for the Onsite Treatment of Wastewater," Report No. GL-97-2. Aqua Test, Inc. and Stuth Co., Inc. On the Web at http://www.cwc.org/glass/gl_html/g1972rpt.htm.

"Gravelless and Chamber Systems: Alternative Drainfield Designs," Pipeline, Summer 2001, Volume 12, No. 3.

Lesikar, Bruce and Russell Persyn., "Leaching Chambers," The Texas Agricultural Extension Service. (<http://agpublications.tamu.edu/pubs/ewaste>)

"Sand Filters Provide Quality, Low-Maintenance Treatment," Pipeline, Summer 1997, Volume 8, No. 3.

Sherman, K.M., P. Hextell, J.L. Massicotte. "Evaluation of Drainfields in Florida Using Recycled Crushed Con-

crete Aggregate," Seventh International Symposium on Individual and Small Community Sewage Systems Proceedings, 1994. (#L003841)